EIGHTH EDITION

# MAP USE

## READING ANALYSIS INTERPRETATION

A. JON KIMERLING
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# Foreword

Today, the world of creating maps is accelerating thanks to advances in digital cartography, geographic information systems (GIS), and web mapping. These technologies have become powerful engines for streamlining both the design and production of maps. They have also expanded the range of topics being mapped, as well as the actual number of maps being made. More important, they have broadened the community of people making and using maps.

But have the maps themselves changed?

Once primarily used as a tool to help people navigate their environment, maps today are increasingly used to help communicate and address the world's important challenges.

I personally see digital maps as a new kind of language that facilitates improved communication and collaboration in every aspect of society.

Mastering this language will become an essential skill set for 21st-century living.

Maps are abstractions of the earth—representations of the complexities of the world and useful for understanding the world around us. They distill and summarize information into a special type of graphic display. Creating these abstractions in such a way that they provide users with valuable information products that reflect and represent the complexities of the earth is the real challenge of those who produce the maps of today.

*Map Use*, now in its eighth edition, is a comprehensive primer for using maps effectively. By providing the keys to unlock the codes that cartographers use to represent the world around us, this book is an invaluable companion for college-level students and instructors, for professionals in a variety of fields where maps are important, and also for casual map users.

Jack Dangermond
President, Esri

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# Preface

Many books are written on mapmaking, but because map use isn't simply the offshoot of mapmaking, most of these books are of limited value to you as a map user. By contrast, this book is written for those who need to know how to use maps to build or enhance their spatial understanding of the world. Fully revised to better provide the context and demonstration of skills for reading and properly analyzing this complex form of communication, *Map Use: Reading, Analysis, Interpretation*, eighth edition, is a definitive resource for an introductory map use or cartography course.

*Map Use* is also a valuable tool for people whose vocation or recreation requires knowing how to read and use maps because it takes the reader beyond visual representations and into the decision-making processes of cartographers.

Academics tend to treat maps as indoor objects, rarely including in their textbooks the fact that one of the most exciting ways to use maps is in the field. Conversely, manuals and field guides on map and compass use focus narrowly on wayfinding, geocaching, and military map reading, virtually ignoring the role that maps play in how we think about and communicate environmental information. We depart from this tradition by bridging the gap between these two extremes, carefully weaving information from many fields into a coherent view of map use. This book offers readers a comprehensive, philosophical, and practical treatment of map use in three primary ways.

First, we define a map as a graphic representation of an environment that shows relations between geographic features. This encompassing definition lets us include a variety of important map forms that are otherwise awkward to categorize, such as mental maps, which are discussed in the introduction, or web maps, which may exist only ephemerally. Our definition should also accommodate new cartographic forms developed in the future. This book integrates discussions of a variety of map forms, including standard planimetric maps, perspective diagrams, aerial photographs, satellite images, interactive animated maps, and others, rather than partitioning each type of map into a separate category. This integrative approach, focused on commonality rather than uniqueness, showcases the enhanced insight into the environment that the variety of mapping perspectives can inspire. It helps the reader understand that the definition of a map is fluid. This fluidity lets us view our environment from countless perspectives to glean insights that would otherwise be lost.

Second, we make a clear distinction between the tangible cartographic map and the mental or cognitive map of the environment that we hold in our heads. Ultimately, it is the map in our minds, not the map in front of our eyes, that we use to make decisions. Throughout the text, we stress that cartographic maps are valuable aids for developing better mental maps. We should strive to become familiar enough with the environment that we can move through it freely, interact with it, and view it remotely, in both a physical and mental sense. Ideally, our cartographic and mental maps should merge so that our

spatial understanding, communication, and behavior have the greatest chance of being tuned to the reality of the environment.

Third, where appropriate, we reference commercial products and services of special interest to the map user. A few decades ago, discussing these commercial products would have seemed strange since most mapping was done by large government agencies, but times have changed. The strong recent trend toward commercialization of all things cartographic now makes these products indispensable to people who are intent on using maps efficiently and effectively. Computer software, web apps, and digital data for mapping on home computers and mobile devices are developed and made accessible not only by government agencies at all levels, but also by private companies, academics, and even nongovernment organizations (NGOs). What you do with maps in the future will be strongly influenced by the nature of these commercial products and services.

Finally, we show how map use is relevant to daily life. Whenever possible, we use examples and illustrations from popular sources and common practices. Maps touch so many aspects of our daily lives that it is simple and natural to make points and reinforce ideas with illustrations from topics of everyday interest. These illustrations are included in the text to demonstrate and reinforce basic map use principles and illustrate the universality of our relationship with maps.

Other books take a simplistic, mechanical view and treat the using and making of maps primarily in an engineering and technical context. In contrast, *Map Use* takes a unique approach in the depth of knowledge it offers in a clear and readable style. We believe that learning to understand the intentions or goals of a map leads to making better choices in your own map use and mapmaking.

Learning to use a map is a relatively easy and painless process, with an immense payoff—maps offer a look at the virtually invisible. They let us see the environment from vantage points that are distant from us in time and space. Maps also allow us to visualize aspects of our environment that are intangible, imperceptible, or purely conceptual. Most important, maps focus our attention on selected features by keeping the display free of distracting detail. Maps free us from our natural limitations, transcend our senses, and let us see the world anew.

## NEW TO THIS EDITION

The eighth edition of *Map Use* includes one new chapter and some 50 new four-color illustrations, added to the 500-plus in the previous edition. Several of the new illustrations are linked to online animated and interactive maps through QR codes (two-dimensional bar codes) printed with the illustration. The entire book is reindexed, and the glossary is enhanced to integrate the additional chapter and include acronyms. The new chapter, "Map Design Basics," is an important addition to the eighth edition of *Map Use* as it focuses on an integral component of map use—how to design your own map and to comprehend when someone else designs a good map.

Although many map design principles are built into modern mapping systems, the assumption is still that you are familiar with map design basics to the degree that you can make, or you understand how the mapmaker makes, wise choices among the design options available for the various components of your map. In this new chapter, we discuss the map design basics that are necessary to be a good mapmaker and that allow you to be a better map user. When you have a firm grasp of these principles, you are ready to make your own maps following the basic map design guidelines presented in chapter 6.

When *Map Use* was first published, very little mapping was done in a computer environment. Today, not only is most mapping done with the aid of computers, but the map user is often the one who guides the mapping process. Especially with the aid of geographic information system (GIS) software and applications, the map user is increasingly the mapmaker. Even more significant, the map user can establish insightful dialogues with maps by manipulating the digital data in various ways. To a large degree, GIS is responsible for this exciting interchange between people, maps, and environmental data, and has changed the essential nature of map use to our immense benefit. At the same time, maps contribute greatly to GIS by providing a familiar visual interface through which GIS technology's powerful computing resources can be fully realized. Now that GIS technology is so widely available, a broader population is using it in a variety of ways. Clearly, the ability to think and communicate visually through the medium of maps is more important than ever, and this book can enhance this ability in a broad range of users.

Yet for all the technological advances in map use and mapmaking, the philosophy underlying *Map Use* remains the same. As in earlier editions, we stress that a good map user must understand, at a basic level, what goes into the making of a map. From mapmakers, we ask for little less than a miracle. We want the overwhelming detail, complexity, and size of our surroundings reduced to a simple representation that is convenient to access. We also want abstract maps to provide us with a meaningful basis for relating to the real environment. In return, we must make a corresponding effort to become educated map users.

## HOW THIS BOOK IS ORGANIZED

*Map Use* is specifically designed and tested for use in a three-credit semester course of 15 weeks at the college freshman level. Presentation of the material is geared for the upper high school to intermediate college level. The book is aimed at both the specialized and general map user. You can use it with equal effectiveness as a basic reference work or as the textbook for a beginning map use or cartography course. We intentionally avoid the confusing terms and details that characterize so many cartographic texts.

We structured the material in the book into three main parts, under the headings "Map Reading," "Map Analysis," and "Map Interpretation." In most books, these terms appear with little more than vague definitions and are often used interchangeably. Here, they are defined precisely, and the relationship of each one to the other is clear. We also offer clear definitions for terms that may be new to you—these definitions are also presented in the book's extensive glossary.

Part 1, "Map Reading," helps readers develop an appreciation of how mapmakers represent the environment in the reduced, abstract form of a map. In map reading, you must mentally "undo" the mapping process. We discuss the geographic data that underpins a map, the process required to transform that information through mapping techniques, the basic principles of map design, and the importance of map accuracy.

Once readers grasp the degree to which cartographic procedures can influence the appearance and form of a map, they are in a position to use maps to analyze spatial patterns and relationships in the mapped environment. Part 2, "Map Analysis," includes chapters on distance and direction finding. Here, we also explore position finding and navigation. We examine cartometrics (making measurements on maps) to describe the properties of area, volume, shape, and more. And we look at analyses of the land surface form, spatial patterns, and spatial associations. With each of these topics, the emphasis is on estimating, counting, measuring, analyzing, and finding patterns in map features.

The results of map analysis come alive when you try to explain why the environment takes on one spatial characteristic over another. This is the subject of part 3, "Map Interpretation." The material is divided into four chapters: "Interpreting the Lithosphere" (landforms and geology), "Interpreting the Atmosphere and Biosphere," "Interpreting the Human Landscape," and "Maps and Reality." The emphasis in this final section is on environmental comprehension and understanding, for it is our surroundings, not the map, that is the real subject of map use.

Two appendixes, on digital cartographic databases and relevant mathematical tables, complement material presented in the text. The glossary is expanded in this edition. It includes terms in the book that are either newly introduced or are of special importance to map use. Glossary terms appear in boldface type at the point in which they are introduced.

Although a systematic development of subject matter is followed throughout the book, each part and chapter can be used independently and is cross-referenced to the rest of the material. This flexibility of design makes *Map Use* a versatile text, useful both for instruction in the classroom and as a reference for practicing users. The book's organization provides a logical development of concepts and a progressive building of understanding and skills, from beginning to end. More experienced map users may focus initially on sections or chapters of special interest, and then refer to other parts of the book to refresh their memories or clarify terms, concepts, and methods.

This book will serve its purpose if you finish it with a greater appreciation of maps than when you started. In even the simplest map, there is much to respect. Mapmakers have managed to shape the jumble of reality into a compact, usable form. They have done a commendable job. Now, map user, the rest is up to you.

A. J. Kimerling
A. R. Buckley
P. C. Muehrcke
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# Acknowledgments

In previous editions of *Map Use*, we acknowledged the importance of contributions made by special teachers and colleagues, teaching assistants, and students at the University of Washington, University of Wisconsin, and Oregon State University. We continue to be grateful for the inspiration and assistance provided by these people. To these students and colleagues, we add the valuable contributions made by Esri staff and colleagues. Our sincere thanks to everyone at Esri Press who worked hard to make this new edition possible.

To our delight, hundreds of individuals have taken the time to comment on earlier editions of this book. Some of these people are merely lovers of maps; others are professors responsible for teaching introductory courses in map reading, analysis, and interpretation; and many are students who had occasion to use the book in their studies. We are especially moved by letters from people who stumbled upon *Map Use* by chance at a friend's house or library and felt compelled to let us know how pleased they were with their discovery. All these responses are gratefully received, and many were useful in crafting this expanded and improved eighth edition.

This work reflects our deep love of maps and a desire to help others bring maps into their lives. We alone, of course, bear full responsibility for errors in the text or illustrations and for any controversial statements.

Acknowledgments would be incomplete without expressing gratitude to our families and many friends who helped us in so many ways. Particular thanks is given to Ann Kimerling and David Sandoval for their unending encouragement and patience during the creation of this eighth edition.

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# Map Use

*Reading, Analysis, Interpretation*

# INTRODUCTION

# Introduction

It should be easier to read a map than to read this book. After all, we know that a picture is worth a thousand words. Everyone, from poets to politicians, works from the assumption that maps are easy to understand and follow. The very term *map* is ingrained in our thinking. We use it to suggest clarification, as in "Map out your plan" or "Do I have to draw you a map?" How ironic, then, to write a book using language that is, supposedly, more complicated than the thing we are trying to explain!

The problem is that maps are not nearly as simple and straightforward as they seem. Using a map to represent our detailed and complexly interrelated surroundings can be deceptive. This is not to say that maps themselves are unclear. But it is the environment, not the map, that you want to understand. A map lets you view the environment as if it was less complicated. There are advantages to such a simplified picture, but there is also the danger that you will end up with an unrealistic view of your surroundings. People who manage critical natural and human resources all too often make decisions based on maps that inherently are oversimplified views of the environment.

In this book, we define a **map** as a spatial representation of the environment that is presented graphically. By **representation**, we mean something that stands for the environment, portrays it, and is both a likeness and a simplified model of it. This definition encompasses such diverse maps as those on walls; those that appear ephemerally and then are gone, as on a computer screen or in the form of holograms or virtual reality; and those held solely in the mind's eye, known as **cognitive** or **mental maps**. You may envision the environment by using **cartographic maps**, which are what most people think of as traditional maps drawn on paper or displayed on computer screens. Or you can use mental maps, which are often slighted although they are the ultimate maps that you use to make decisions about the environment. Now we will look more closely at mental and cartographic maps.

## MENTAL MAPS

As a child, your mental map was probably based on direct experience—for example, connected pathways such as the routes from your home to school or the park. You had a self-centered view of the world in which you related everything to your own position. The cartoon in figure I.1 graphically portrays this type of mental map. As an adult, you can appreciate this cartoon because you see how inefficient the child's mental map is. But the truth is, you will often resort to this way of visualizing the environment when thrown into unfamiliar surroundings. If you go for a walk in a strange city, you will remember how to get back to your hotel by visualizing a pathway like that in the cartoon. Landmarks will be strung like beads along the mental path. Even if you might be able to guess at a more direct route back, you may feel more comfortable following the string of landmarks to make sure that you do not get lost.

Most of your mental maps are more detailed than this cartoon path, however. You take advantage of indirect as well as direct experience. You acquire information through TV, photographs, books and magazines, the Internet, and other secondary sources. You can transcend your physical surroundings and visualize distant environments, even those on the other side of the planet at different historical periods. Your mental maps become incredibly complex as they expand to encompass places and times that you have never seen and may never be able to visit.

As you grow older, your self-centered view of the world is replaced by a **geocentric view**. Rather than relating everything to your own location, you learn to mentally orient yourself with respect to the external environment. Once you learn to separate yourself from your environment, you do not have to structure your mental map in terms of connected pathways and landmarks. You can visualize how to get from one place to another "as the crow flies"—the way you would go if you are not restricted to roads and other connected routes. It is your adult ability to visualize the "big picture" that makes the cartoon amusing.

Sharing your mental map with others, either in conversation or in maps that you draw, is much easier when you use a **geometric reference framework**, or a framework in which you can easily describe and determine locations, distances, directions, and other geographic relationships. The system of **cardinal directions** (north, south, east, and west) is such a framework. You can pinpoint the location of something by stating its cardinal direction and distance from a starting location. You can say, for example, that the store is two miles north of a particular road intersection, or the police station is 200 meters west of the courthouse.

This visualization of space is based on **Euclidean geometry**, the geometry you first learned in school. It is the geometry that says that parallel lines never cross, that the shortest distance is a straight line, that space is three-dimensional, and so on. The ability to visualize the environment in terms of Euclidean geometry is an essential part of developing a geocentric mental map. But even if you develop mental maps based on Euclidean geometry, they will only be correct over small areas. This limitation is because the earth is spherical, and the spherical geometry of the earth's surface

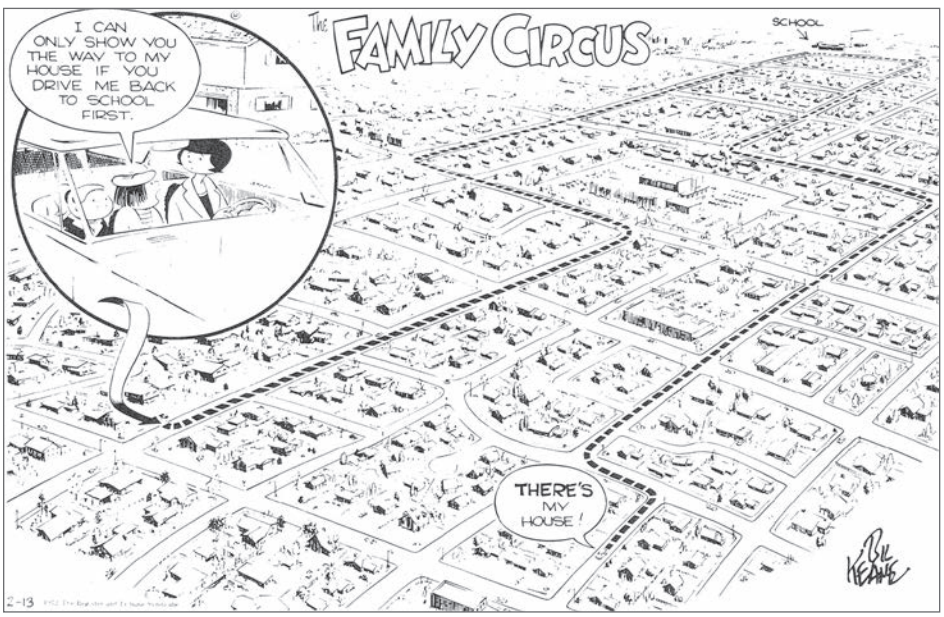


**Figure I.1. The geometry of a child's mental map is based on direct experience and connected pathways.** Courtesy of the Register and Tribune Syndicate.

is inherently non-Euclidean. (You will see in chapter 1, for example, that north–south lines on the earth, called **meridians**, are not parallel but, rather, converge to common points at the poles.) Very few of us have well-developed spherical mental maps simply because the small portion of the environment that we experience daily appears flat from our ground perspective, unless we are astronauts.

Even if you are able to visualize the world geocentrically in terms of Euclidean or spherical geometry, it is hard for most people to transform their mental map to a cartographic map in a geometrically accurate manner. Try drawing, from memory, a map of the area in which you live. The hand-drawn map will tell you a great deal about the geometric accuracy of your mental map. Not only will you probably draw the places you know best with the greatest detail and spatial accuracy, you will probably draw the things that are important to your life and leave out the things you do not care about.

Few people's mental maps correspond with cartographic maps. Figure I.2 shows the distorted visual image that a person from Michigan's Upper Peninsula might have of the country. Tongue in cheek as this map may be, it captures the fact that people visualize their own region as far more important than the rest of the world. In the same way, your mental maps emphasize your own familiar neighborhood, with distant places less well visualized.

It is important to recognize these biases in your mental maps. The quality of your mental maps is crucial, because your behavior in the environment largely depends on them. You relate to your surroundings as you visualize them, not necessarily as they really are. If the discrepancy between your mental maps and the real world is great, you may act in self-defeating or even disastrous ways. But you do not have to rely solely on mental maps, because cartographic maps are created for a multitude of places and features in the environment, and maps on mobile devices exist for nearly every place on earth.

## CARTOGRAPHIC MAPS

A cartographic map is a graphic representation of the environment. By graphic, we mean that a cartographic map is something that you can see or touch. Cartographic databases or digital image files are not, in themselves, maps but are essential to current methods for the creation of maps. In a similar vein, an exposed piece of photographic film or paper does not become a photograph until it is developed into a slide, paper print, or computer screen.

Cartographic maps come in many forms. Globes, physical landscape models, and Braille maps for the blind are truly three-dimensional objects, but most maps are two-dimensional representations that are cartographically enhanced. Cartographic maps have been carved, painted, or drawn on a variety of media for thousands of years, and print maps have been produced for the last five centuries. Today, maps displayed on a computer screen or mobile device are probably the most commonly seen and used maps. Maps are so intuitive and serve so many purposes that it is easy to forget that maps are one of our most sophisticated

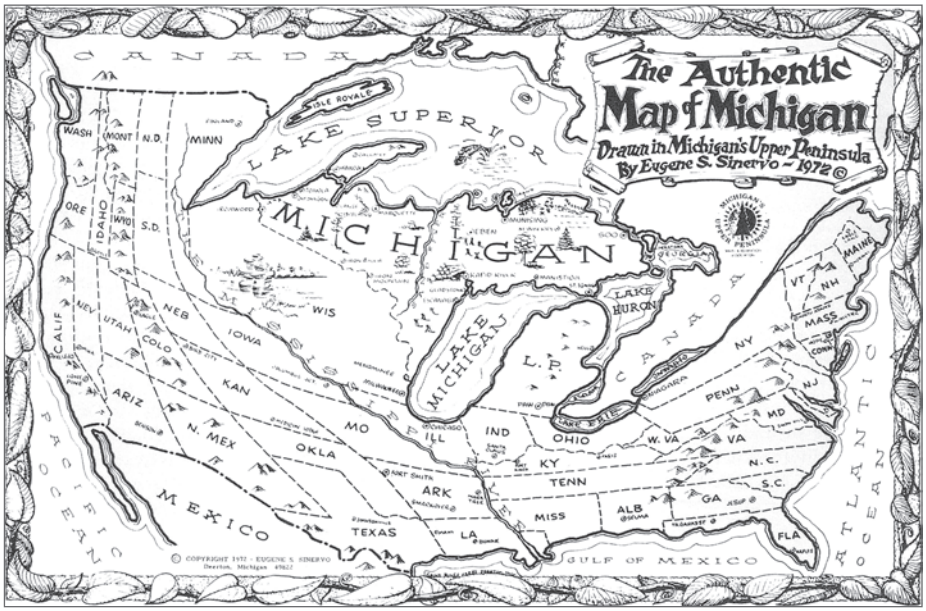


**Figure I.2. The United States as seen through the eyes of a resident of Michigan's Upper Peninsula.** Courtesy of Eugene S. Sinervo.

conceptual creations. They tell you as much about how people think and communicate as they do about the environment that is mapped.

What gives a graphic representation of the environment its "mapness"? Many mapmakers say that cartographic maps have certain characteristics, with the four most important being:

- Maps are vertical or oblique views of the environment, not profile views such as a photograph of the front of your home taken from the street.
- Maps are created at a certain scale, meaning that there is a systematic reduction from ground distance to map distance, as you will see in chapter 2.
- Except for 3D globes and landscape models that faithfully represent the earth's curvature, maps are made using a map projection, which is a mathematically defined transformation of locations on the spherical earth to a map surface, as we explain in chapter 3.
- Maps are generalized and symbolized representations of the environment. Mapmakers select a limited number of features from the environment to display on the map, and then display these features in a simplified manner. Insignificant features are not shown, the sinuosity of linear features and area boundaries is reduced, and several small ground features may be aggregated into a single feature on the map, as explained in chapter 6. The generalized features are then shown graphically using different map symbols. The mapmaker uses different point symbols, line widths, line patterns, gray tones, colors, and pattern fills to symbolize the features, as we describe in chapters 6 through 9. Names, labels, and numbers that annotate the map are also important map symbols.

A cartographic map does not need all four characteristics of maps, but it should have at least one. You can think of different types of maps as being at different places on a mapness continuum, defined by the degree to which they exhibit these four characteristics. This continuum is illustrated in figure I.3 for a gradation of map types that depict part of Crater Lake National Park in Oregon.

The aspect-slope and **topographic maps**, which show elevations or landforms as well as a limited set of other features, in the left third of the illustration strongly reflect all four characteristics and are good examples of what most people think of as a map. The **orthophotomap** in the center of the illustration also has all four characteristics because topographic map symbols are printed over a geometrically

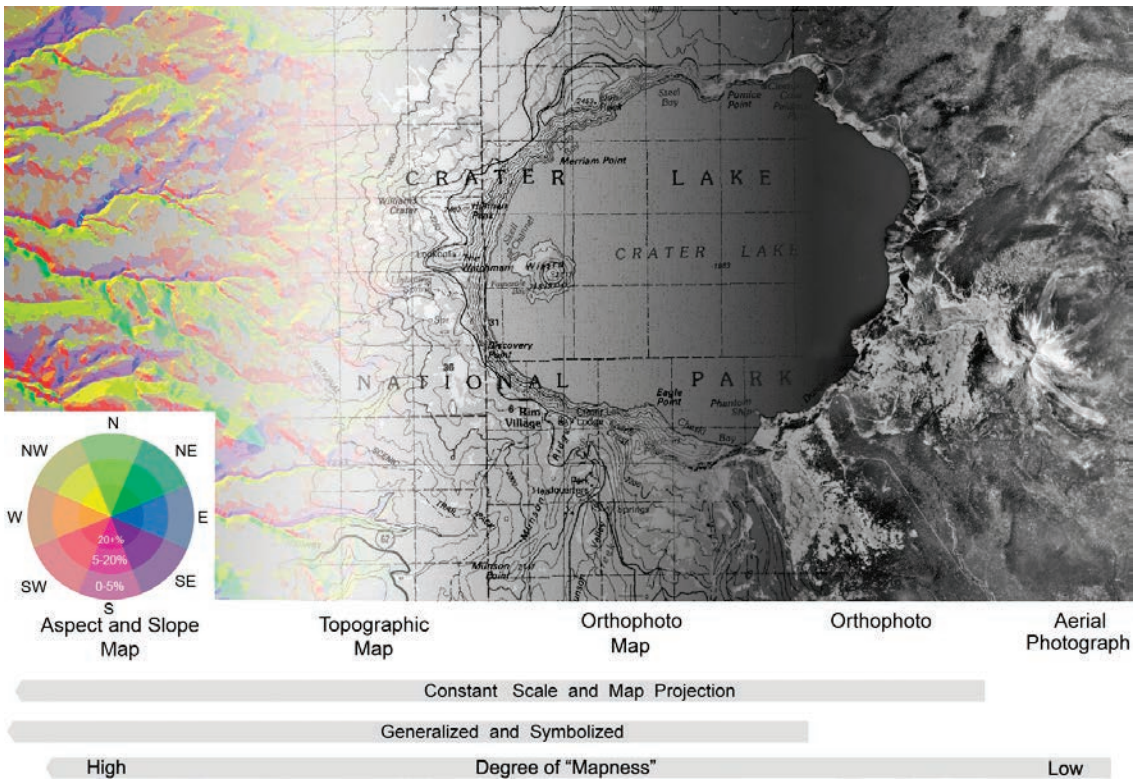


**Figure I.3. Different types of maps lie along a mapness continuum. Their position on the continuum is defined by how many characteristics of maps they possess. All the examples in the figure are vertical views.** Courtesy of the US Geological Survey.

corrected aerial photograph called an **orthophoto**, which you will learn more about in chapter 11. An orthophoto is corrected to a constant scale on a map projection surface and hence has three of the four characteristics. Finally, the aerial photograph from which the orthophoto is made is not on a map projection surface and varies in scale with elevation differences on the ground. The aerial photo has only the characteristic of being a vertical view of the environment but is still a form of cartographic map. All the other maps are also vertical views.

As you can see from this illustration, there are multitudes of cartographic maps, each somewhere along the mapness continuum. The variety is so great that from now on, we will shorten the term *cartographic map* to simply *map*, in accord with what you are used to hearing these products called.

## THE MAP TRANSFORMATION PROCESS

Mapping, like architecture, is an example of functional design. Unlike an artist's representation of the environment in which geometric liberties are taken to convey an idea or emotion, a map is expected to be true to the location and nature of our surroundings. Indeed, our willingness to let maps stand for the environment is because of this expected adherence to reality. Figure I.4 illustrates the process that cartographers use to transform data collected about the geographic environment, through surveys, by the Global Positioning System, from remote sensing, and more, to a map. Maintaining the highest possible fidelity in the **map transformation process** assures that the map is an accurate representation of reality. You, the map user, also play a part in the map transformation process through reading, analysis, and interpretation, and high fidelity must also be maintained in these activities. For example, you as a user are responsible for checking the map against reality, as features may change from the time the map is created.

## WHAT MAKES MAPS POPULAR?

In scrutinizing the nature of maps, the obvious question is, what accounts for their widespread popularity? There are four main factors:

- Maps are convenient to use. Paper maps are usually small and flat for ease of storage and handling. Maps on computer screens and mobile devices are easily accessible and often integrated into other apps, such as an Internet search engine. Thus, maps bring reality into a less unwieldy proportion for study.
- Maps simplify our surroundings. Without them, our world often seems a chaos of unrelated phenomena that we must organize to understand our environment. The selection of information found on a map is clear at a glance. The world becomes intelligible. Web maps provide varying levels of detail, revealing more features and information as you zoom in.
- Maps are credible. They claim to show how things really are. The coordination between symbol and reality seems so straightforward that we are comfortable letting maps

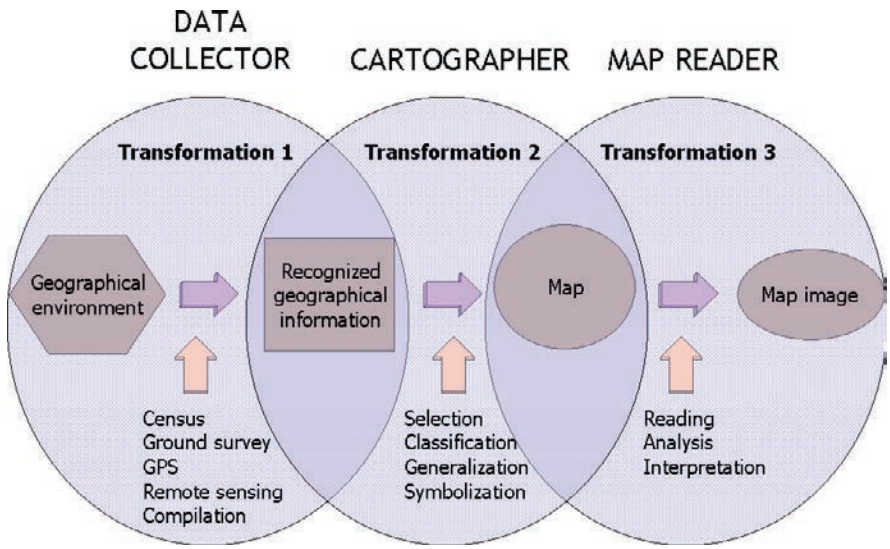


**Figure I.4. The map transformation process (after Tobler 1979) begins with the collection of data about our environment. This data is transformed into a map through selection, classification, generalization, and symbolization. The map user completes the transformation process when he or she reads, analyzes, or interprets the information in the map.**

stand for the environment. When you manipulate maps, you expect the results to apply to your surroundings. Maps, even more than the printed word, impress people as authentic. We tend to accept the information on maps without question. This blind acceptance is potentially disastrous when using maps indiscriminately—for example, using GPS to navigate by car without checking other information such as road signs or even looking at your surroundings.

- Maps have strong visual impact. Maps create a direct, dramatic, and lasting impression of the environment. Their graphic form appeals to our visual sense. It is axiomatic that "seeing is believing." Web maps can dynamically show change over time and space, and they also allow you to interactively change the display to show the map you want to see.

These factors combine to make a map appealing and useful. Yet these same four factors, when viewed from a different perspective, can be seen as limitations.

Take convenience. It's what makes fast food popular. When we buy processed foods, we trade quality for easy preparation. Few would argue that the result tastes like the real thing made from fresh ingredients. The same is true of maps. We gain ease of handling and storage by creating a prepared image of the environment. This representation of reality is bound to make maps imperfect in many ways.

Simplicity, too, can be seen as a liability as well as an asset. Simplification of the environment through mapping appeals to our limited ability to process information, while at the same time it reduces the complexity and—potentially—the intricacies that we need to understand. By using maps, you can reduce the overwhelming and confusing natural state of reality. But the environment remains unchanged. It's just your view of it that lacks detail and complexity.

You should also question the credibility of maps. The mapmaker's invisible (to you) hand isn't always reliable or rational. Some map features are distortions, others are errors, and still others are omitted through oversight or design. So many perversions of reality are inherent in mapping that the result is best viewed as an intricate, controlled representation. Maps are like statistics—people can use them to show whatever they want, and maps reflect the capabilities of their maker. Once a map is made, it may last hundreds of years, although the world keeps changing. For all these reasons, a map's credibility is open to debate.

Also, be careful not to confuse maps' visual impact with proof or explanation. Just because a map leaves a powerful visual impression doesn't make it meaningful or insightful. A map is a snapshot of a portion of the environment at a point in time. From this single view, it is sometimes difficult or impossible to understand the processes that caused the patterns we can see on maps. For explanations, you must look beyond maps and confront the real world (as discussed in chapters 19 to 22).

## FUNCTIONS OF MAPS

Maps function as media for the communication of geographic information, and it is instructive to draw parallels between maps and other communication media. You can first think of maps as a reference library of geographic information. Maps that serve this function, called **reference maps**, are more efficient as geographic references of the locations of different features than are maps with a certain theme. They catalog feature types and record their geographic locations. Reference maps allow you to instantly see the relative position of features and estimate directions and distances between them. Explaining these spatial relationships among features in writing could take hundreds of pages.

Maps can also function as an essay on a topic. Like a well-written theme, a map can focus on a specific subject and be organized to make the subject stand out above the geographic setting. We call maps that function as geographic essays **thematic maps**. Some thematic maps are presented as online **story maps** that combine interactive maps and multimedia content to lead a reader through a story.

Maps are tools for navigation, equal in utility to a compass, GPS receiver, or mobile app. When you get into your car and drive across the city, you are navigating the roads. When you find your route on a subway or bus system, you are navigating a transit system. When you hike along a trail, you are navigating through a trail network. In the first case, you use a **road map**; in the second case, you use a **transit map**; and in the last case, you use a **trail map**.

When you step into an airplane and fly to a distant city, you must use air navigation (assuming you are the pilot). And when you motor or sail between two destinations on a body of water, you are marine navigating. In these two cases, you use **navigational charts** to plan your route in advance and guide you on your trip.

Maps are instruments of persuasion. Like a written advertisement or television endorsement, some maps persuade you to buy a particular product, make a certain

business decision, or take a targeted political action. These maps are often more sales hype or propaganda than a graphic representation of the environment, and you should view such maps with caution. Although all maps incorporate elements of graphic design, these maps are often more artistic in nature, employing art for visual influence. Graphic embellishments are also placed on maps for pure visual entertainment. And, finally, maps can be used as media in the creation of fine art.

Now we will take a closer look at maps with each of these different functions.

## Reference maps

The earliest known maps, dating back several thousand years, are the reference type. On reference maps, symbols are used to locate and identify prominent landmarks and other pertinent features. An attempt is made to be as detailed and spatially truthful as possible so that the information on the map can be used with confidence. These maps have a basic "Here is found ..." characteristic and are useful for looking up the location of specific geographic features. On reference maps, no particular feature is emphasized over the others. All features are given equal visual prominence as much as possible.

The topographic map and remote sensor images (orthophotomaps, orthophotos, and aerial photographs, discussed in chapter 10) in figure I.3 are excellent examples of reference maps because they show a variety of phenomena, with about the same emphasis given to each one. Reference maps are often produced in national mapping series, such as the US Geological Survey **topographic map series**. The topographic map segment in figure I.3 is from such a series.

Topographic maps show and label **natural features** that are found in the physical environment, including mountains, valleys, plains, lakes, rivers, and vegetation. They also show **cultural features** that are created by humans, such as roads, boundaries, transmission lines, and buildings.

The geographic information on reference maps makes them useful to professional and recreational map users alike. These maps are used in engineering, energy exploration, natural resource conservation, environmental management, public works design, and commercial and residential planning. Maps for outdoor activities such as biking, camping, and fishing are often variations of reference maps, in which additional features, such as bike trails, campsites, and fishing spots, are added.

Globes and atlases are reference maps that show natural and cultural features in more generalized form than topographic maps. School wall maps are another form of reference map, as are the road maps and recreation guides that are produced for different states (figure I.5).


**Figure I.5. Reference map examples include (A) a world globe, (B) the northwest section of a US road and recreation atlas map, (C) an Esri basemap on a handheld mobile device, and (D) a section of the Oregon State Highway map.** (B) Courtesy of Benchmark Maps, (C) courtesy of the Map Shop and Esri, and (D) courtesy of the Oregon Department of Transportation.