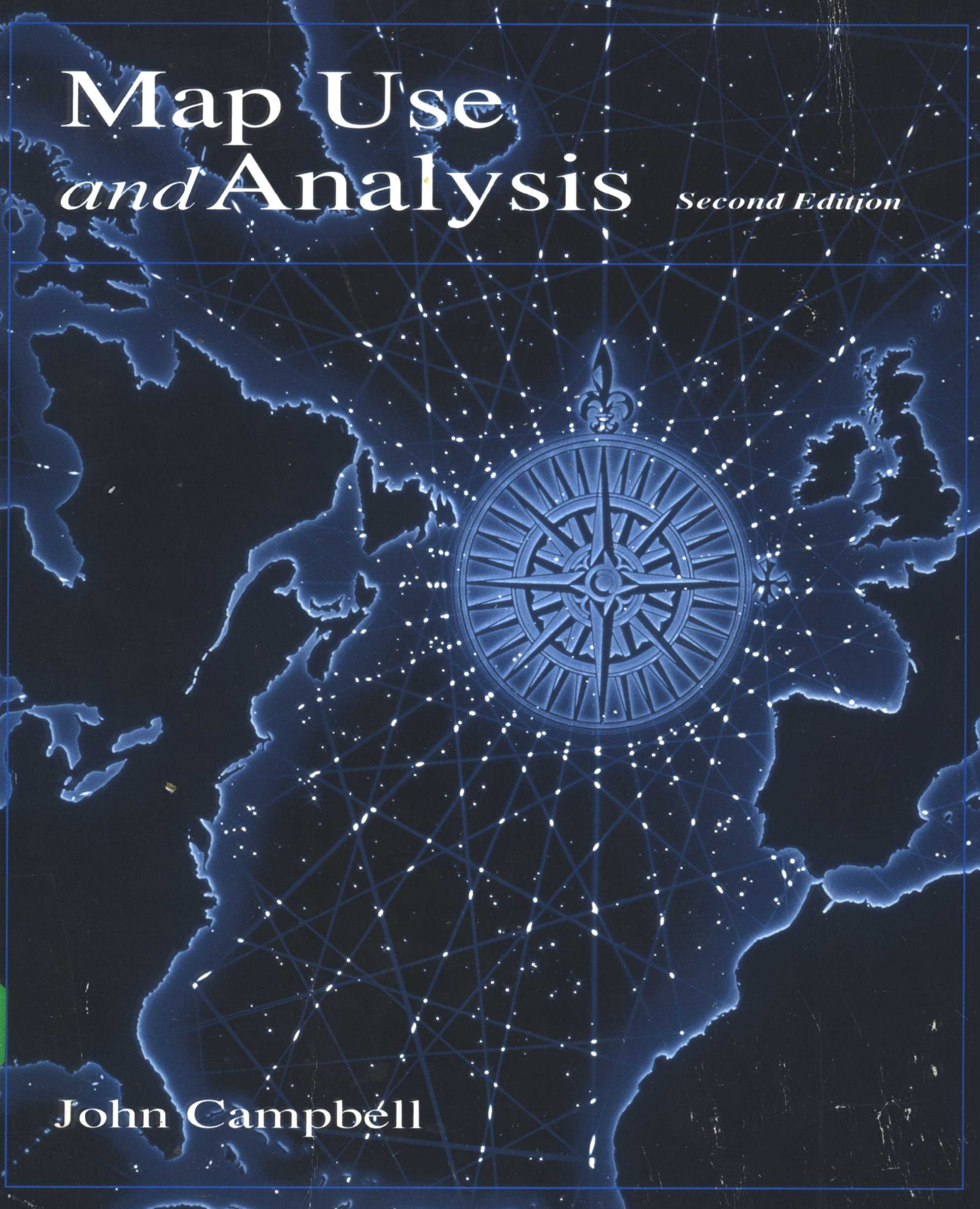
Map Use *and* Analysis

Second Edition



John Campbell

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Second Edition

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University of Wisconsin–Parkside

WCB Wm. C. Brown Publishers
Dubuque, Iowa • Melbourne, Australia • Oxford, England

For Hazel

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Library of Congress Catalog Card Number: 92–75544

ISBN 0–697–13579–9

Printed in the United States of America by Wm. C. Brown Communications, Inc., 2460 Kerper Boulevard, Dubuque, IA 52001

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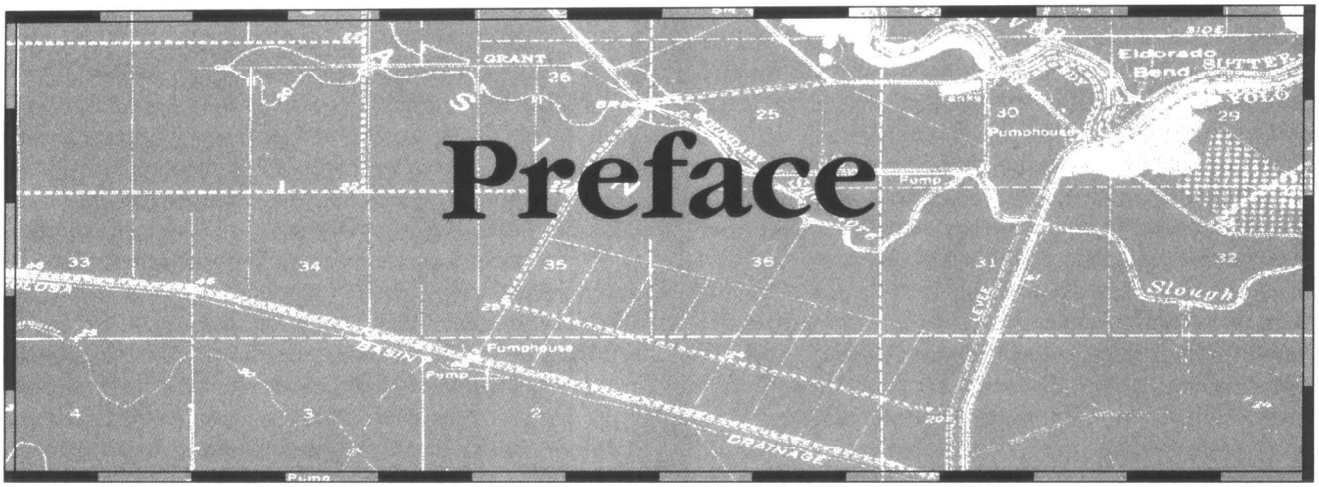


Preface

This book is designed to serve as an introduction to the fascinating world of maps. It explains how to use maps to obtain information about a wide variety of topics. Throughout the book, maps are viewed in a broad framework. Thus, the discussion includes mental maps, aerial photographs, remotely sensed images, computer-assisted cartography, and geographical information systems, in addition to traditional printed maps. The writing style is neither formalistic nor casual, with an emphasis on clarity of explanation. The discussions assume that the reader has no specific prior knowledge of the topic, so that even novice map users can understand and use the information and techniques presented.

Chapter 1 explains why maps are useful and lists the many types of maps available. Then, mapping processes are discussed in Chapter 2 because an understanding of how maps are produced provides a necessary basis for their proper use. For similar reasons, important aspects of the size and shape of the earth are reviewed. Chapter 3 surveys the characteristics of map projections, especially from the standpoint of the appropriateness of certain projections for specific purposes. The link between scale and generalization is discussed in Chapter 4, as are methods of scale determination. Because maps are used for measuring distances and areas, Chapter 5 discusses techniques for carrying out these measurements.

Techniques used in route selection and navigation on land and water and in the air are examined in Chapter 6. Chapter 7 examines how the surface of the terrain is represented on maps. Contour interpretation techniques and techniques for producing profiles and determining slopes are provided in Chapter 8. Chapter 9 follows with extensive illustrations of a variety of landform types. The examples shown are, in large part, selected from the definitive U.S. Geological Survey collection *A Set of 100 Topographic Maps Illustrating Specified Physiographic Features.*

A variety of locational and land ownership systems, which are essential for specifying location and for describing land ownerships, are explained in Chapter 10. These include latitude and longitude, the Universal Transverse Mercator and State Plane Coordinate systems, metes-and-bounds surveys, the U.S. Public Land Survey System, and the similar Canada Land Survey System.

More abstract topics are introduced in the following two chapters. First, Chapter 11 surveys the characteristics of mapped distributions, such as the shape and pattern of point distributions. Second, Chapter 12 analyzes stream patterns and transportation systems through the abstract concepts of networks and trees.

Chapter 13 discusses methods by which thematic maps are used to convey a variety of qualitative and quantitative information. Cartograms, map misuse, and the use of maps as powerful propaganda tools are examined in Chapter 14. Chapter 15 surveys a variety of special-purpose maps, including highway and street maps, weather and climate maps, geologic maps, maps of the past, maps of the moon and the planets, and maps in journalism and on television. Chapter 16 is devoted to the interpretation of graphs. Graphs are important in their own right, but they are also extensively used as map symbols and as map supplements.

Remote-sensing techniques are becoming increasingly important and accessible to map users. Therefore, aerial photography, as well as remote sensing from space, are explained in Chapters 17

and 18. Chapter 19 describes modern techniques of computer-assisted cartography, and Chapter 20 examines geographic information systems. Both of these approaches are increasingly used to produce unique products and analyses of interest to map users.

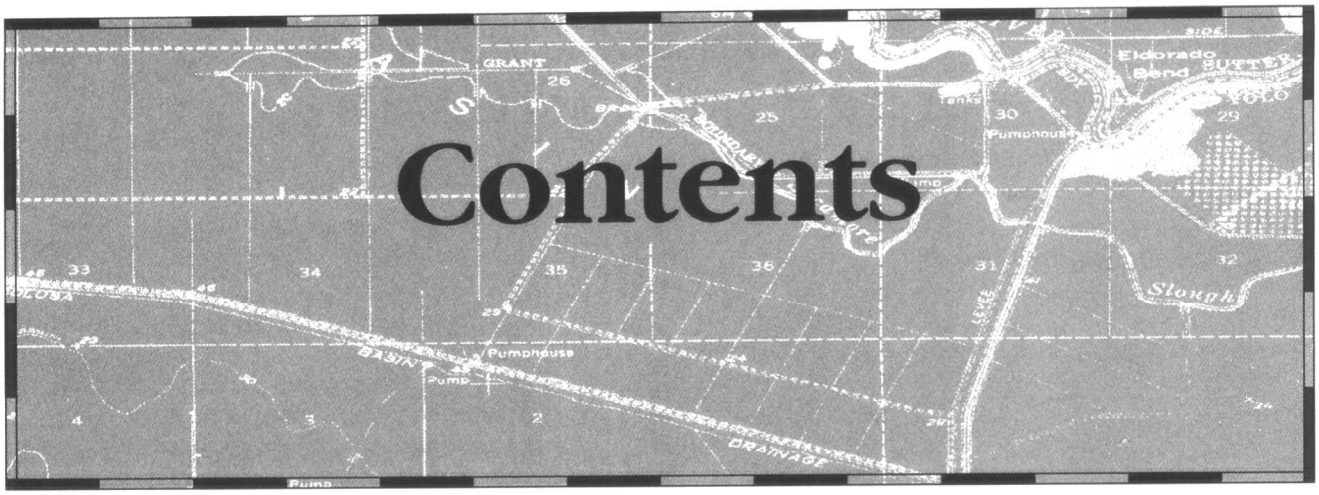
A survey of U.S. and Canadian map producers and map sources is provided in Chapter 21. This chapter also includes comments on major map collections that map users will want to visit when their travels permit. The final chapter, Chapter 22, briefly discusses the special problems often encountered when dealing with foreign maps.

At appropriate points in the text, supplementary treatments of a variety of topics are provided, including discussions of the analemma, dates and time zones, units of measurement and map scales, the National Map Accuracy Standards, and levels of measurement. Finally, appendixes discuss a variety of background topics, including copyright protection, the use of the magnetic compass in the field, sources of mapping programs and databases for microcomputers, the International Map of the World, the locations of Earth Science Information Network Offices, map storage and cataloging systems, and the British National Grid.

While working on this second edition, I have been conscious of my continuing indebtedness to the many people who assisted in the production of the first. I have also appreciated and benefitted from the comments in published reviews, as well as from those submitted during the revision process. Particularly appreciated have been the less formal comments offered at meetings, and in letters and telephone calls. The following reviewers provided numerous useful suggestions: Daniel E. Turbeville, Eastern Washington University; Linda M. Marston, University of Wyoming; Kenneth W. Engelbrecht, Central Missouri State University; and Joseph W. Weidel, University of Maryland. All comments have been considered carefully and many have been incorporated into the text. However, not every suggestion has been heeded. This is not because of stubbornness but because (as always) it is impossible to please everyone. A plea for more detail on a particular topic from one reviewer, for example, has frequently been directly countered by a suggestion from another that the topic be eliminated altogether. Thus, in the end, I have had to follow my own view of what is needed. I hope that many of these decisions will prove correct.

I remain indebted to my colleagues in the Geography Department at the University of Wisconsin–Parkside for their active support and encouragement. It is hard to visualize a more congenial group of long-term colleagues. Finally, as always, I thank my wife, Hazel, for her continued loyalty and her companionship on the hiking and kayaking expeditions that have put our map use skills to the test.

John Campbell
Racine, Wisconsin



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1 Introduction

WHY USE A MAP?

Maps are an ancient invention, probably having existed for over four thousand years. Remnants of clay-tablet maps dating to about 2500 B.C. have been found (figure 1.1). In addition, primitive, maplike scratchings in the sand, as well as maps in other forms, likely existed for many millennia before that.

These early maps performed useful functions for their creators, functions that maps still perform for us today. For example, maps are especially effective devices for recording and communicating information about the environment. Most importantly, they clearly preserve the locational attributes of that information; that is, they show the relationships between one feature and another. Not only do they show that there is a forest outside of town, but they also indicate the extent and limits of both forest and town. This is something that other forms of recording and communicating information, such as written descriptions, tables, and graphs, generally do not do as effectively or efficiently. Furthermore, maps can also indicate distances and directions between locations, or the areas occupied by different types of land uses or features.

In more recent times, maps have acquired additional applications. For example, they are useful for determining the patterns formed by many types of distributions on the earth's surface. The arrangements of cultural features, such as the spacing between towns or the patterns of roads and other transportation facilities, can be analyzed using maps.

FIGURE 1.1 Clay-tablet map, circa 2500 B.C. Oldest known map, discovered in the ruins of Nuzi in northern Mesopotamia by the American School in Baghdad and Harvard University. Mountain ranges are shown on the left and right. Two rivers join near the bottom of the map and flow toward the upper-left corner. Localities of special interest are designated by circles, within which the names are written. (Size of the original: 7.6 by 6.5 centimeters.) SMN 4172. Photograph courtesy of the Harvard Semitic Museum.

Similarly, the alignments of physical features, such as streams and lakes, and the crests of hills and the floors of valleys, can be determined. The arrangements of such features can be explored, organized, and analyzed by visual and statistical methods, using maps as the database. These techniques have aided investigators in the generation of hypotheses about why the patterns are as they are. These investigations have suggested, for example, that certain economic relationships underlie the locational pattern of settlement and that the pattern of some physical features affects the location of specific human activities. Similarly, regular physical relationships underlie the patterns of stream erosion, the arrangement of drumlins in glaciated regions, and the alignment of river tributaries, to name just a few of the vast multitude of possible examples.

Maps are not limited only to showing information about physical and cultural features found on the earth's surface. They are also used to show distributions of more abstract features, such as the flow of trade, the use of communications, the extent of political influence, or the areas occupied by peoples of various races, languages, or religions. They provide a major source of historical documentation and are used for regional planning and property-assessment purposes. In addition, features found on the surface of extraterrestrial bodies, such as the moon and the planets, have been mapped, as have imaginary environments used as the settings for works of fiction.

Regardless of the topic or the locale maps frequently play a role in providing information and explanations regarding topics of interest. The rest of this introductory chapter examines just what constitutes a map.

WHAT IS A MAP?

The answer to the question, What is a map? may seem rather obvious to someone who is interested enough in maps to read this book. Maps, after all, are neatly drawn, bird's-eye views of the earth's surface. They show where places and things are located and help us find our way from one place to another. We are all familiar with many kinds of maps—from those confusingly folded, multicolored road maps that are stuffed into the glove compartments of our automobiles; to the beautifully drawn illustrations in books and atlases that provide information about the distribution of climates, vegetation types, languages, income, political patterns, and myriad other topics; to the topographic sheets whose intricate contours and drainage patterns serve as guides for our hiking or fishing expeditions. A visit to the map collection of your community or university library will convince you that a tremendous variety of maps is available.

In recent years, new methods of gathering, analyzing, and presenting information about the earth have been introduced, including aerial photography and satellite-based remote sensing, as well as computer methods. These developments have made it necessary to recognize that the conventional maps mentioned previously are only part of the contemporary map picture and that the definition of maps must include an extremely broad range of "products." Some of these products show topics that are physical (such as road maps), some show more social or cultural topics (such as language maps), and some show even more abstract subjects (such as maps of income levels). In addition, many products, such as aerial photographs or satellite images, qualify as maps even though they do not resemble conventional maps. It also has been suggested that some "maps" are not even visible. Invisible maps may exist only as bits of electronic information stored in the memory of a computer, or, even more abstractly, only in our minds. Finally, maps are not limited to representing information about the earth. They are equally useful, for example, for showing features found on the moon or the other planets, and they can present patterns that exist on the ground (topographic maps), under the ground (geologic maps), or above the ground (weather maps).

Given the variety of possible maps, this text uses a broad, flexible definition: A map is any concrete or abstract image of the distributions and features that occur on or near the surface of the earth or other celestial bodies. The great variety of map concepts that fall within this definition can be classified as either (1) real maps or (2) virtual maps.[1]

[1]The classes used here are simplified from those proposed by Harold Moellering in "Real Maps, Virtual Maps, and Interactive Cartography," in *Spatial Statistics and Models*, ed. Gary L. Gaile and Cort J. Willmott (Dordrecht, Holland: D. Reidel Publishing, 1984), 109–32.

FIGURE 1.2 Map image on the screen of a cathode-ray tube (CRT).
Courtesy of Intergraph Corporation.

A **real map** is any tangible map product that has a permanent form and that can be directly viewed (often referred to as "hard copy"). Conventional drawn or printed products (traditionally called maps) fit into this category, as do maplike aerial photographic products or the end product of some other type of remote sensing, maps produced using devices controlled by computers, block diagrams and similar drawings, and relief models and globes constructed to represent some part or all of the earth's surface.

Virtual maps are related to real maps in one way or another and have qualities that allow them to be converted into real maps. They are divided into three types.

One type of virtual map consists of images that can be directly viewed but are not permanent. A map image projected onto the screen of a **cathode-ray tube (CRT)** is an example (figure 1.2). Such an image is real while the device is turned on, and the information that it presents is similar or identical to that of a real map of the same topic. The difference is that as soon as the CRT is turned off, the image vanishes.

A second type of virtual map consists simply of mental images that are in many ways the conceptual equivalent of a conventional printed map.

The third type of virtual map consists of information gathered by researchers in the field or obtained by remote-sensing methods about such topics as surface elevations, rock types, soils, ethnic types, income levels of inhabitants, types of crops, and names and locations of geographic features. Such geographic data are traditionally stored in written notes, books, or computer printouts, all of which can be directly viewed. Increasingly, however, they are stored in digital form in a computer memory or storage device, such as a magnetic disk. This form of map is common for remotely sensed information, which is often gathered and stored directly in digital form, but also frequently includes information converted from printed or written sources. Computer software and hardware systems permit this type of information to be seen in tabular form, or in the form of a visual image.

All three types of virtual maps can be converted into visible, "real" map products.

While there is not complete agreement on the use of the term *virtual map,* the label does convey the idea that a map is simply a special format for the storage of geographic data. Whether the information is called "map data" or "virtual maps," there is no doubt that it is an integral element of the mapping process. Virtual maps are discussed frequently in this book, beginning with the next section.

VIRTUAL MAPS

Mental Maps

As already noted, the current concept of maps must encompass much more than the artifacts traditionally called maps. Indeed, the most familiar but, at the same time, most unusual forms of maps are the virtual maps called cognitive maps, or mental maps.

Mental maps are images we have in our minds. These images provide us with an awareness of the location of places in the world, the relationships between places in terms of direction and distance, the size and characteristics of regions, and so on. Mental maps have been called "the environmental image, the generalized mental picture of the exterior physical world that is held by an individual."[2] Some mental

[2]Kevin Lynch, *The Image of the City* (Cambridge, Mass.: M.I.T. Press, 1960), 4. Much of the discussion that follows is based on this book.

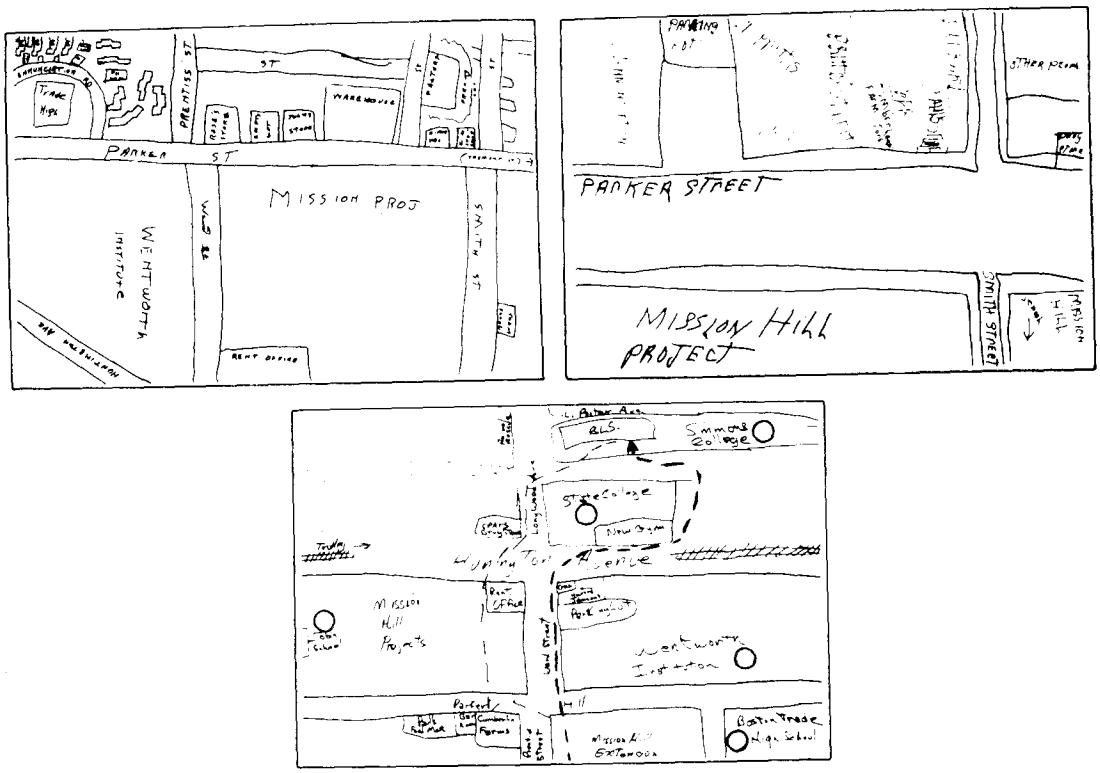

FIGURE 1.3 Mental map images of the same neighborhood, drawn by three different boys: Dave, Ernest, and Ralph.

From Peter Gould and Rodney White, *Mental Maps* (Pelican Books, 1974). Reprinted by permission.

maps are a kind of miniature map in the mind, sometimes rather vague and ill-formed, but sometimes complete with accurate details. Other mental maps are more subtle and difficult to define because they are somewhat more abstract and are tailored to one's individual conceptions, experiences, and needs, even to the point of distortion. Indeed, it has been suggested that mental maps "are quite unlike [real] maps . . . because they are personal, fragmentary, incomplete, and presumably, frequently erroneous."[3]

One aspect of the mental map concept is easily illustrated. Simply visualize the route that you usually follow from your home to the shopping center, or recall the general outline of the United States and the locations of its cities and states. Consider how easily you move about in different environments with the help of your mental images. The framework that mental maps provide allows you to tell others about the route that you follow, and they may be able to visualize it as well. Furthermore, such a mental image provides a frame of reference to which you can add information on the basis of your new experiences. A mental map can be converted into a more conventional real map by sketching its image on a piece of paper (figure 1.3). We all do this when we want to guide our friends to our new house or to indicate to a stranger the best route to follow to see the local tourist attractions.

Another aspect of mental maps is illustrated by considering where in the country you would prefer to live if you were given a choice. You are almost sure

[3]John S. Keates, *Understanding Maps* (New York: John Wiley and Sons, A Halsted Press Book, 1982), 53.