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Cartographic design and desktop mapping: A historic perspective

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Cartographic Design and Desktop Mapping

A Historic Perspective

by

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Cartographic Design and Desktop Mapping: A Historic Perspective

Advisor: Dr. Paul B. Wilson

The purpose of this study is to examine the developments of cartographic design in manual cartography and to assess if desktop-mapping programs can accommodate established design principles. To answer this question, the author first reviewed historic examples of traditional cartographic design. The review involved observing thirty-five maps from three distinct periods in the history of cartography. From the observed maps, traditional cartographic design elements were established. These traditional aspects were outlined as: the use of different colors to classify, organize, and simplify; the use of background color to discern figure ground relationships; the proper spacing and balancing of graphic elements; the use of neat lines and borders with different colors, patterns, orientation, size, shapes and location to compartmentalize and convey information. Also they included the ability to place, rotate, space, and size different text and typefaces; the ability to place and balance a multitude of different symbols; and the incorporation of marginal information into the map design.

These design principles were then used to examine desktop mapping programs to learn if the software accommodated them. Eight different software packages were observed: ArcView, AutoCAD, IDRISI, Adobe Illustrator, Maptitude, MapViewer, MicroCAM, and MicroStation. The capability of these programs to accommodate traditional methods reveled items that were accomplished effectively and poorly.

Results of the research reveled that computerized cartography allows anyone the freedom to sit at a personal computer, get access to a large amount of data, and produce a map. The problem with this freedom is that the software is designed to accomplish graphic functions -- not to facilitate cartographic design principles. A person trained in cartographic techniques can easily use a desktop mapping program to produce effective and artistic maps. However, the software does not direct untrained users towards proper cartographic design. Help files, templates, and examples need to be developed that discuss, clarify, explain, and demonstrate design unambiguously. Development of these tools will help designers understand, and effectively use map design principles.

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Most of all I wish to dedicate this thesis to my wife, Stephanie. Without her I never would have been able to accomplish my goals.

CHAPTER 1

INTRODUCTION

> Maps break down our inhibitions, stimulate our glands, stir our imagination, loosen our tongues. The map speaks across the barriers of language; it is sometimes claimed as the language of geography.[1]

The opening of the twenty-first century finds cartography in the middle of a historic change, a revolution so to speak.[2] Change, however, is not new to the discipline of cartography. Throughout its history, there have been a number of revolutionary changes. What makes the current historic change different is the disassociation of cartographers from their own trade. Recently, cartographers have not been the instigators of change, in some cases they are not even involved.

The present revolution involves the use of computers to make maps. The introduction of desktop mapping has given anyone the tools to produce a map (desktop mapping refers to the use of stand-alone personal computers for map production). Computer dominance has resulted in cartographers no longer being the sole owners of the mapmaking trade.

During the last six hundred years, cartographers have been the guardians of cartographic design and knowledge. For centuries, they underwent a series of apprenticeships to learn the trade of cartography. These apprenticeships involved not just learning the elements of cartography but also the principles of graphic design. Incorporating graphic design into a map allows for more effective communication. Professor of cartography, Borden Dent says, "The map designer arranges the visual

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[1]Carl Sauer, "The education of a geographer," *Annals of the Association of American Geographers* 46 (1956): 289.

[2]The focus of the research was on the concepts and methods of traditional Western cartographic design. All references to the history of cartography and cartographic design refer to European or American map production.

elements into a functional composition to facilitate communication."[3] If a map is graphically confusing, it is often ineffective at communicating.[4] Basic graphic design principles related to color, shape, orientation, spacing, fonts, etc. help to communicate spatial information and need to be the knowledge of a mapmaker. The understanding and use of the principles of graphic design makes cartography an art as well as a science. The challenge before all mapmakers is to produce an aesthetically pleasing as well as functional product.[5] By following established cartographic design principles, a map becomes a functional product.

The History of Cartographic Design in Traditional Cartography

Traditional Western cartography might be defined as analog cartography or the process of producing a map with other than digital means. In traditional cartography, cartographic design evolved from practices and technologies developed over hundreds of years. A review of the history of cartography revealed three distinct times for study: the Renaissance, the nineteenth, and the twentieth centuries.[6]

The Renaissance

The Renaissance contributed to the development of cartographic design with the re-emergence of Ptolemy's *Geography*, the age of Western Exploration, and the

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[3]Borden D. Dent, *Cartography Thematic Map Design,* 3rd ed. (Dubuque: Wm. C. Brown Communications, Inc., 1990), 247.

[4]The process of communicating with a map involves four stages. First, the mapmaker selects information for mapping. Then, the information is manipulated, generalized, and presented to the user in some type of graphic form. The user then reads the graphic representation. Finally, the user analyzes and interprets the information.

[5]Dent, *Cartography Thematic Map Design*, 247.

[6]J.B. Harley and David Woodward, ed., *The History of Cartography,* vol 1, (Chicago & London: The University of Chicago Press, 1987), xviii.

invention of the printing press.[7]

Before the Renaissance, development in cartography was regressed due to the dominance of culture and thought by the Catholic Church. Church doctrine and dogma stifled the creative processes of math and science. Many of the earlier discoveries about the size and shape of the earth were lost. One of the most important discoveries to be lost was a book written by the Alexandrian Librarian, Ptolemy.

The reintroduction of Ptolemy's *Geography* to the western world established an awakening of the scientific method and possibilities behind cartography. Ptolemy designed and explained a systematic way to represent the features of the earth with a series of parallel and meridian lines. Figure 1-1 shows an example of Ptolemy's conception of a reference grid to find spatial locations using Longitude and Latitude. Figure 1-2 shows a map constructed from Ptolemy's written directions and instructions. With this system, any point on the face of the earth can be accurately located and mapped.

The age of exploration marked an expanded understanding and curiosity about the world beyond European borders and ushered in the age of globalism. Global exploration by fortune hunters, colonists, and missionaries from European nations contributed to the use and production of maps. With increased contact, trade, and travel, geographic knowledge exploded during this time.[8] Mapmakers had to devise new ways of representing the earth. Cartographic design evolved as a process of artistic and scientific method used to represent geographic knowledge.

During the Renaissance, the invention of the printing press became a valuable asset to cartography. Maps became far more accessible with this invention. Copies of a map no longer had to be produced by hand, and multiple identical maps could be

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[7] Arthur H. Robinson and others, *Elements of Cartography, 6th ed.* (New York: John Wiley & Sons, Inc., 1995), 24.

[8] Ibid.

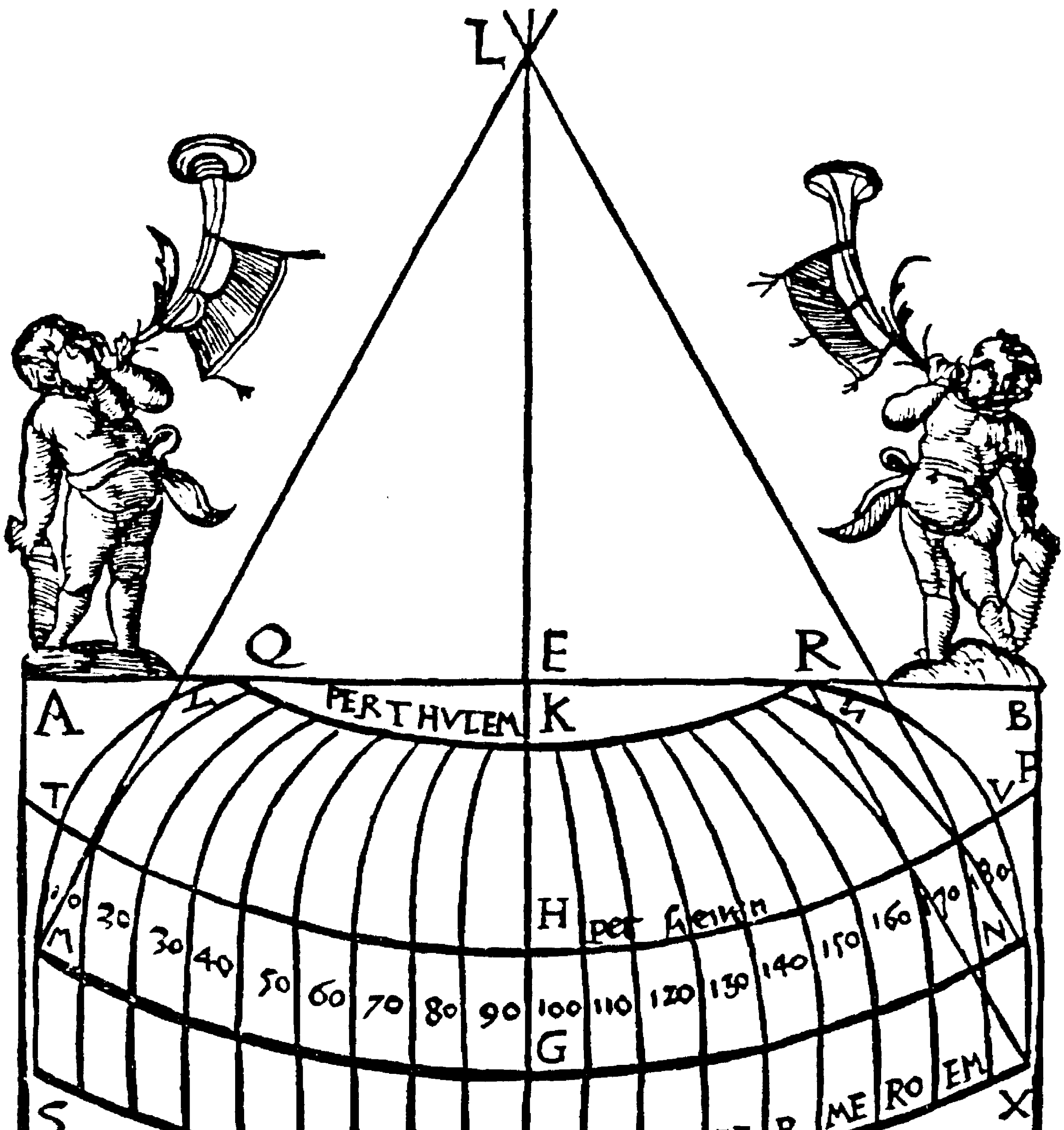

Figure 1-1 Ptolemaic example of Longitude and Latitude[9]

[9]Claudius Ptolemy, *The Geography* (New York: Dover Publications, Inc., 1991), 46.

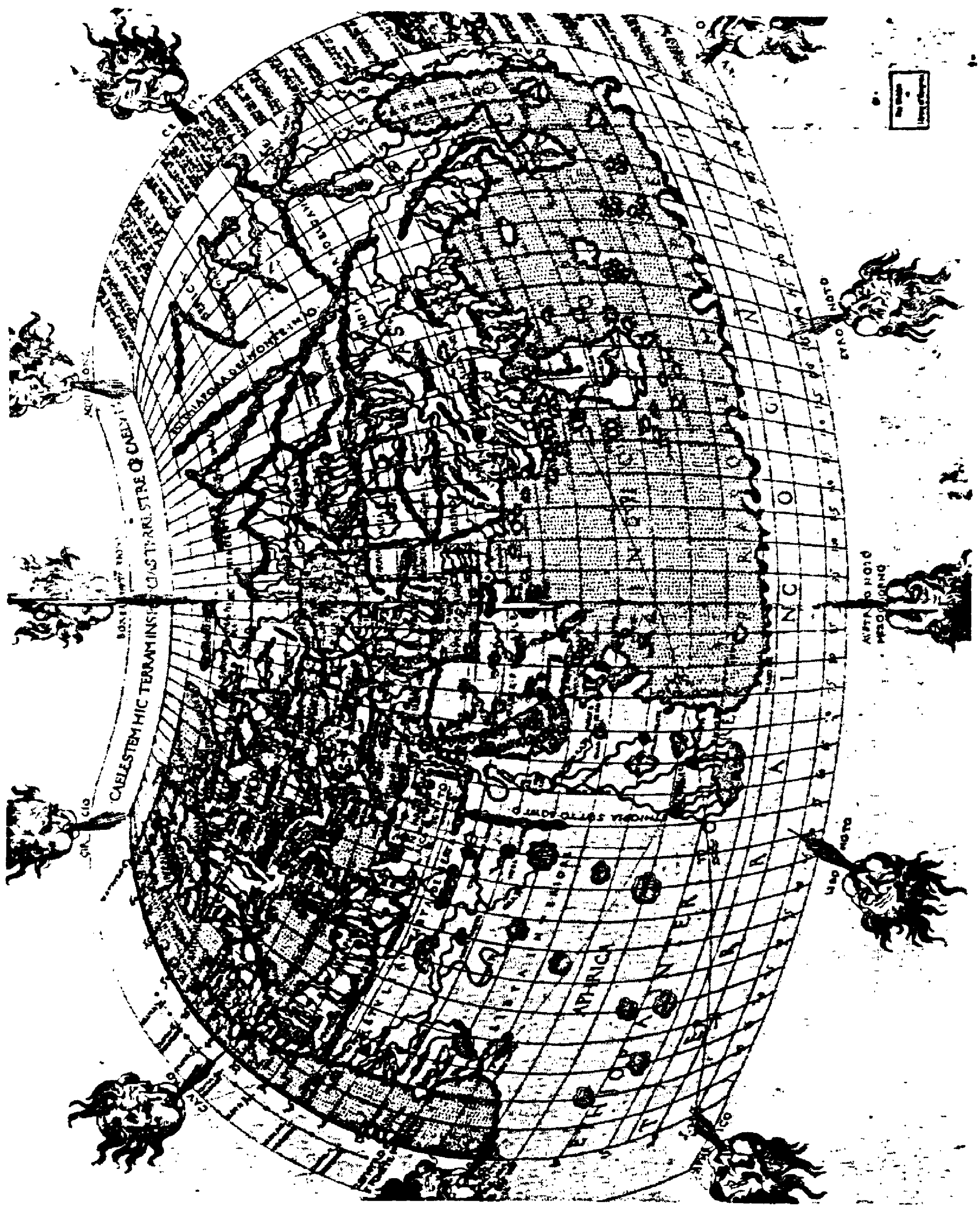

Figure 1-2 An Example of a World Map Draw to Ptolemy's Standards[10]

[10]Robinson and others, *Elements of Cartography,* 24.

produced in large quantities. Figure 1-3 shows a carver preparing a woodcut, and Figure 1-4 shows the early printing process. Increased map printing resulted in advances in production speed and efficiency, allowing for reduced map costs and making maps more available.[11]

The Nineteenth Century

Cartographic changes during the nineteenth century involved the development of lithography and rotary printing and thematic maps. In Germany, Alois Senefelder first introduced lithography printing in 1796, but it was not until the 1800's that the process enjoyed widespread use. This printing method relies on the fact that water and oil do not mix. On the printing plate, the image to be printed receives ink while other areas do not. When paper is pressed to the printing plate, only the inked area will transfer to the paper. In conjunction with lithography, Friedrich Konig developed the first workable cylinder press in 1810, and an American, Richard M. Hoe developed the rotary printing in 1846.[12] Cartographers gradually began to see the advantages of lithography and rotary printing. These printing techniques were faster, cheaper, and more manageable than engraving and eventually led to widespread color printing by mid-century.[13]

The nineteenth century marked a major shift in mapping with the introduction of scientific methods, which try to bring order out of chaos or randomness. Concern for precise measurement and accurate observations gained in importance during this period. This concern with positional accuracy sent mapping professionals into the field to make rigorous measurements of the shape and size of the earth. See Figure 1- 5.

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[11]Ibid., 31.

[12]The rotary press allows paper to pass between two curved surfaces. One of the curved surfaces contains the type covered with ink. Another curved surface presses the paper against the inked type to produce the printed image.

[13]Dent, *Cartography Thematic map design,* 333.

Figure 1-3 A Carver of Woodcuts[14]

[14]Robinson and others, *Elements of Cartography,* 30.

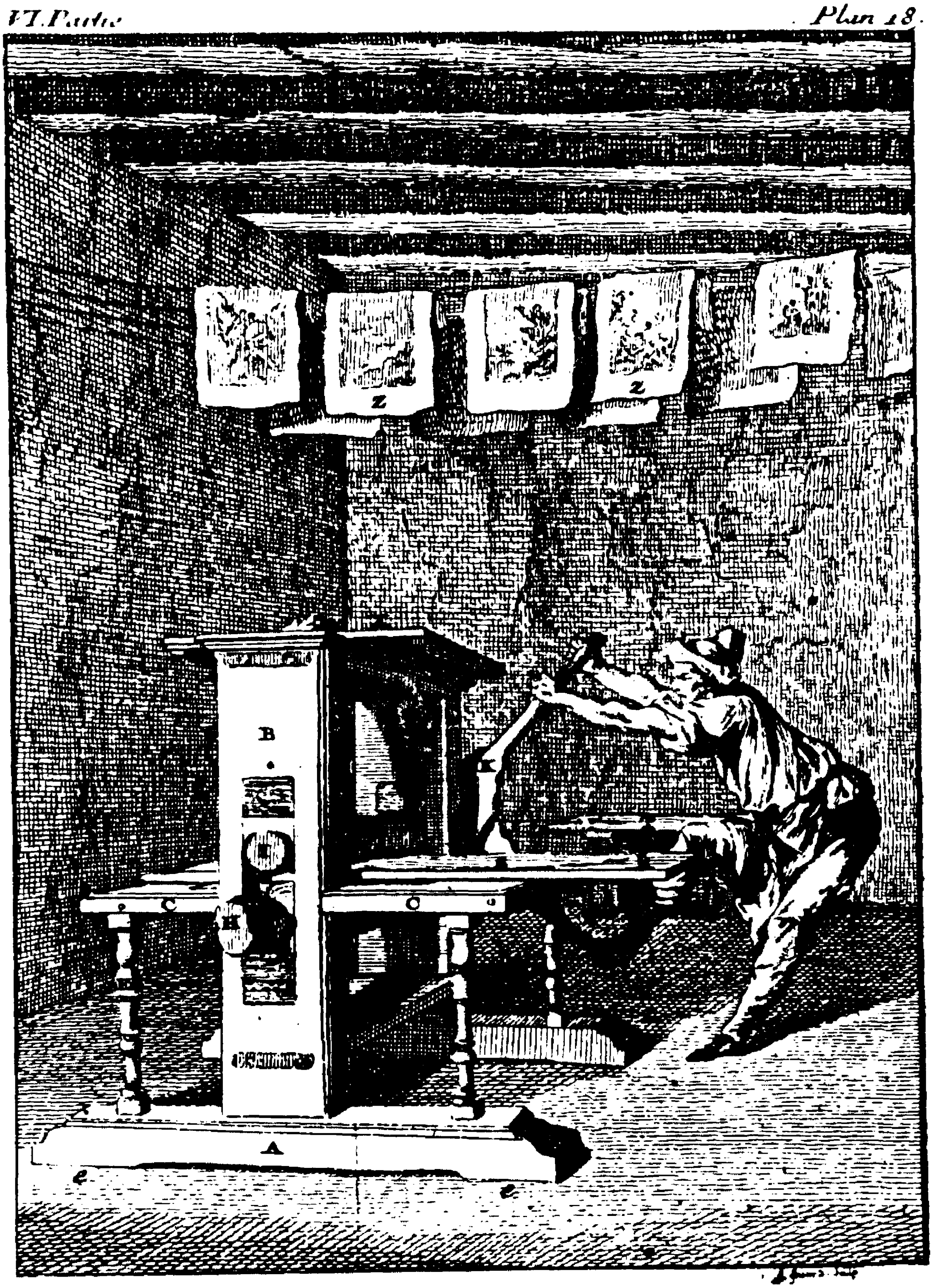

Figure 1-4 Printing from Copper Plate Engraving[15]

[15]Robinson and others, *Elements of Cartography,* 32.

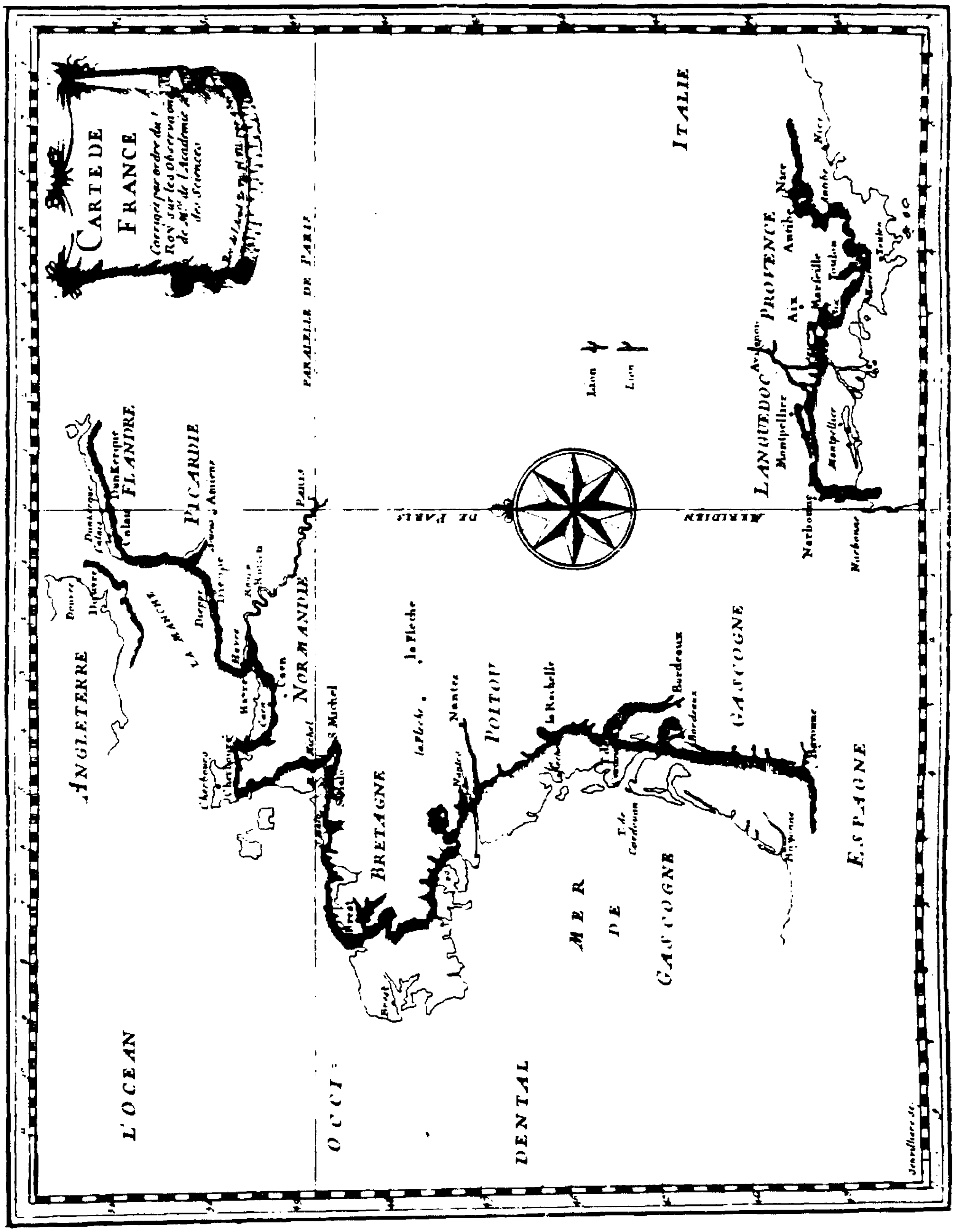

Figure 1-5 Adjusted Coastline of France after Improved Measuring Techniques[16]

[16]Robinson and others, *Elements of Cartography*, 26.

Scientists such as Charles Darwin, Alexander von Humboldt, and Edmond Halley also began to collect and classify specimens of animals, plants, and rocks.[17] As environmental observations grew, the concept of thematic maps was born. A thematic map demonstrates particular features or concepts, which are then presented as a graphic theme. These maps are special purpose, single topic, or statistical maps.[18] Their function is to illustrate the spatial relationships between geographic features. This involves the mapping of physical and cultural patterns or abstract ideas such as population, elevation, temperature, soil types, or ocean currents.

The Twentieth Century

During the twentieth century, two major changes affected the discipline of cartography. The first was the introduction of remote sensing and the second was the emergence of computerized cartography. Remote sensing is defined as the process of collecting, storing, and extracting environmental information from images of the earth taken from devices that are not in direct physical contact with the observed spatial feature.[19] Starting in the 1930's images of environmental features began to be collected with the use of aerial photography, radar, and sonar. Remote sensing has evolved into the use of satellites or highflying aircraft to collect and record data. These satellites record information of different electromagnetic radiation wavelengths. This unique perspective has become critical to monitoring natural and cultural processes. The use of remote sensing technologies has drastically changed the way cartographers map the planet.

Cartographers began to explore making maps with computers during the late nineteen fifties. During the 1960's, computers emerged as valuable tools in map production. The adaptation of cartographers to this new tool occurred very quickly even

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[17]Ibid., 26.

[18]Ibid., 6.

[19]Robinson and others, *Elements of Cartography,* 127.

though early graphic outputs produced crude maps. "Programs such as SYMAP created maps using the typewriter-like characters of the computer line-printer."[20] Cartographers found that the gains made in computer data capture, management, organization, retrieval, memory, and printing, could be extended to cartography. As the dependency on computers increased, programmers and software companies became the leaders behind cartographic change. The emergence of microcomputers in the early nineteen eighties ultimately resulted in the creation of desktop publishing and desktop mapping.

Desktop mapping software allowed for the production of maps with any personal computer. These programs were developed to support individual users as opposed to supplying mapping capacities to an entire organization. With simplified use and falling costs, more and more organizations developed departments for map production. The ever-growing appeal of desktop mapping software led the author to the research problem involved in this thesis.

The Problem with Cartographic Design in Desktop Mapping

Problem Statement

The problem of this thesis is to learn to what degree present desktop computer mapping software has accommodated the traditional concepts and principles of map design.

Research Scope and Questions

In order to examine the connections between traditional cartographic design and desktop applications, the research was organized around the following questions:

- What are the cartographic design elements of manual cartography?

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[20]Michael P. Peterson, *Interactive and Animated Cartography*. (New Jersey: Prentice-Hall, Inc., 1995), 6.

- Have cartographic design elements and principles from manual cartography been incorporated into desktop mapping software?
- What support systems (help files, templates, and samples) exist to explain the elements of cartographic design in different mapping programs?
- Finally, if support systems do not exist or are not adequate, what elements can be introduced to enhance desktop cartographic design?

To answer these questions the author developed a seven-stage plan. First, literature review was conducted, then a research methodology was selected and developed. After developing a research methodology, data was gathered pertaining to cartographic design in traditional maps. Following this collection, the gathered data was analyzed. The author then proceeded to collect data about desktop cartographic design.[21] This collected data was also then analyzed. Finally, the research conclusions were presented.

Literature Review

Literature review was conducted to build a base of knowledge on aspects of cartographic design and research fundamentals. The author reviewed literature to establish the principles of map design, the history of cartography, and the relevance and present status of research regarding the topic.

When designing a map there are several principles to consider. These principles were defined as clarity and legibility, hierarchical structure, color and pattern, visual contrast, figure and ground, balance, and typography.[22]

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[21]The author connected the analyzed data from the observations of traditional cartographic design to the gathering of data about desktop mapping design. This process is outlined and explained in the following sections and chapters of this thesis.

[22]Robinson and others, *Elements of Cartography*, 324.

To achieve clarity and legibility requires a concern for the quality of graphic symbols and text; this ensures that the resulting maps are easy to read and understand.[23] Hierarchical structure is used to separate meaningful characteristics and to portray likenesses, differences, and interrelationships.[24] The use of hierarchical structure helps to achieve a visual layering of mapped features. In association with hierarchical structure, color and pattern allow the viewer to discern differences between map features. Color is used to create an aesthetically pleasing map, to distinguish different features, and to increase legibility. Pattern is used to distinguish the classification and importance of map features.[25] Visual contrast relates to the crispness or sharpness of the distinction between map features and symbols.[26] Figure-ground relationships relate to visual perception and how the human mind organizes visual information. When a map is viewed, the elements are automatically organized into two contrasting perceptual impressions: a figure on which the eye settles, and the ground around it.[27] Balance in cartographic design is the positioning of elements so that they appear logical; nothing seems out of place. "In a well-balanced design, nothing is too light or too dark, too long or too short, too small or too large, in the wrong place, or too close to the edge."[28] The final element of map design is typography. Typography is the art and technique of printing with moveable type and is used on many maps as a primary element in communicating information. The understanding of these map design elements helped to guide the author while conducting research.

In order to establish the traditional elements of map design, the author reviewed

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[23]Jones, *Geographic Information Systems and Computer Cartography,* 258.

[24]Robinson and others, *Elements of Cartography*, 327.

[25]Dent, Cartography Thematic map design, 333.

[26]Jones, *Geographic Information Systems and Computer Cartography,* 258.

[27]Robinson and others, *Elements of Cartography*, 325.

[28]Ibid., 334.

literature associated with the history of cartography. This review was directed to acquire a list of maps and cartographers for observation. Books by Lloyd Brown, Borden Dent, Arthur Robinson, Normon Thrower, and David Woodward were the primary resources in the review of historic cartography.[29] The review revealed many cartographers who were influential in the development of cartography and thus cartographic design. These include cartographers such as: Juan de la Cosa (who traveled with Christopher Columbus), Martin Waldseemuller (who first mapped North America and named America), Sebastian Munster (who mapped information from Magellan's circumnavigation of the earth), Abraham Ortelius (who first produced maps in atlas form), Gerardus Mecator (who first used the name atlas and developed one of the earliest map projections), and the Cassini family (four generations of map makers who where the first to make an accurate map from field surveyed data).[30] These cartographers were but a few influential contributors to cartographic development. Others included: Joan Bleau, William Clark, Capt. James Cook, James Charles Fremont, Edmund Halley, Hendrick Hondius, Alexander von Humboldt, Jan Jansson, Virgil Kauffman, W. Sidney Park, John Wesley Powell, Erwin Raisz, and many more.[31] As the author conducted the research, maps created by these cartographer's were observed if possible.

The author also reviewed literature to establish the relevance and status of the

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[29]Lloyd A. Brown, *The Story of Maps* (New York: Dover Publications, Inc., 1977); Dent, *Cartography Thematic Map Design; Harley, The History of Cartography,* vol 1; Arthur H. Robinson, *Early Thematic Mapping in the History of Cartography* (Chicago: The University of Chicago Press, 1982); Normon J. W. Thrower, Maps *& Man* (New Jersey: Prentice-Hall, Inc., 1972); David Woodward, ed., *Art and Cartography: Six Historical Essays* (Chicago: The University of Chicago Press, 1987).

[30]Brown, *The Story of Maps,* 150-179.

[31]John Noble Wilford, *The MapMakers* (New York: Random House, Inc., 1981), 73-241.

chosen research topic. The need for this research can be summed up in the words of author Christopher Jones who said: "It should be reiterated that little of the knowledge concerning map design has found its way into computer mapping systems."[32] The review of literature allied to research relevance uncovered the following passages taken from *A History of Graphic Design*:

> Since prehistoric times, people have searched for ways to give visual form to ideas and concepts, to store knowledge in graphic form, and to bring order and clarity to information.[33]
>
> The history of graphic design is written in the belief that if we understand the past, we will be better able to continue a culture legacy of beautiful form and effective communication. If we ignore this legacy, we run the risk of becoming buried in a mindless morass of a commercialism whose molelike vision ignores human values and needs as it burrows forward into darkness.[34]

These quotes about the history of graphic design also relate to the relevance of researching the history of cartographic design.

To establish the condition of research covering the chosen topic, literature review focused on comparable articles or books covering the historical aspects of cartographic design in present computer mapping systems. There was a great deal of literature and research into how maps communicate, tell stories, symbolize, etc. There was also a fair amount of research associated to cartographic design, cartography and art, and the history of cartographic design. However, there is a need for research into the

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[32]Christopher Jones, *Geographic Information Systems and Computer Cartography* (England: Addison Wesley Longman Limited, 1996), 259.

[33]Philip B. Meggs, *A History of Graphic Design* (USA: International Thomson Publishing, Inc., 1992), xiii.

[34]Ibid.

connection between the history of cartographic design and its relation to computerized cartography.

Methodology

Content analysis was the method used for researching maps and computerized programs. "Content analysis is a multipurpose research method developed specifically for investigating any problem in which the content of communication serves as the basis of inference."[35] It is used to systematically analyze the message content and message handling (in relation to the research the "message" refers to map content). It is a tool for observing and analyzing the communication behavior of selected communicators (in this case, the maps are the communicators).[36] To paraphrase the initial quote of renowned geographer Carl Sauer, maps can be considered the language of geography.[37] As the language of geography, maps are used to communicate a spatial message. Poor design limits the map's ability to communicate. Research conducted for this thesis examines cartographic design with the idea that well designed maps communicate much more effectively then poorly designed maps. Since the ability of maps to communicate is the underlying theme, content analysis was the chosen research method.

From observations of manual and computerized cartography, elements and principles of cartographic design were observed and encoded. This encoded data was then assessed for frequency, and validity. Since the purpose of the research is

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[35]Ole R. Holsti, *Content Analysis for the Social Sciences and Humanities* (Philippines: Addison-Wesley Publishing Company, Inc., 1969), 2.

[36]Ibid.

[37]Sauer, 289.

descriptive, "content validity" or "face validity" will be the method used for assessing validity. Content validity is established through the informed judgment of the investigator's observations.[38] Observations were conducted through a series of systematic inquiries. Systematic inquiries in content analysis must be able to answer the following questions:

> What is the universe of communication to be described, and what sample is to be drawn therefrom? Do repeated measures with the same categories on a set of documents yield stable and consistent results? That is, can the study be replicated?[39]

Content analysis studies usually involve a number of stages, which the researcher modified to five for the specific research. First, the investigator formulates a research question, theory, problem, or hypothesis. Second, an element of communication is defined and categories developed. Third, content is observed and recorded according to research objectives. Fourth, items are scaled to arrive at scores. And finally, the findings are interpreted according to research theories. For the purpose of the research the stages encompassed: First, the problem of this thesis is to learn to what degree present desktop computer mapping software has accommodated the traditional methods of map design. Second, maps are the elements of communication and categories have been defined related to the elements of map design. Third, Content was recorded on a Traditional Map Observation Form and a Desktop Mapping Form that will be explained in the proceeding sections and chapters. Fourth, items were scaled and scored according to research methodology. Finally, the collected information was organized and analyzed.

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[38]Holsti, 143.

[39]Ibid., 127.

Observations of Traditional Maps

The scope of this research is to assess the connections between traditional cartographic design and map design in desktop mapping software. In order to assess this connection, research must first examine the development of cartographic design in traditional mapping. Most of the information pertaining to traditional cartography was obtained through observations of maps at the Library of Congress in Washington D.C. and the Mansfield Library at the University of Montana.

The map reading room at the Library of Congress was chosen as the primary place to observe traditional maps. The Library of Congress has one of the largest and oldest collections of maps in the world. It was used primarily to observe maps from the first two time periods discussed earlier in the chapter. The library was vital in examining earlier maps because many of these maps no longer exist at other facilities.[40]

Information pertaining to traditional cartographic design was recorded and organized on the Traditional Map Observation Form. See Appendix A, pp. 125. The form was designed to systematic observe and collect information about traditional cartographic design. The author, with the help of professors, course work, and extensive background research and study developed the map observation form. It primarily incorporated cartographic design elements taken from the works of Borden Dent and

[40] The Library of Congress's collection includes over 4.6 million maps. A catalog of the library collection was obtained to form a list of maps and cartographers to observe. In addition, Kathryn Engstrom, who works at the library as a Research Team Leader, was contacted for research assistance. She assisted the author by gathering atlases from the sealed vaults and overseeing and permitting the photographing and recording of map information. The Library at the University of Montana was used to supplement the research and for observations of traditional map details of the last one hundred years.

Arthur Robinson.[41] These design elements were included on the form under subheadings of a graphic element heading. Associated with each subheading was a different spreadsheet table. In the table, was a series of questions pertaining to each element. Answers to these questions were marked as excellent, good, moderate, poor, or not applicable (NA) in different columns, depending on the informed observation of the author. Recorded information assisted in making conclusions about traditional design elements consistently present. In concluding the development of the form, it was pretested on a number of cartographic professionals in order to address its relevance to the topic.[42]

With the use of the Traditional Map Observation Form, information was collected from traditional maps during three periods: 1450 to 1800, 1800 to 1900, and 1900 to 1960. A total of thirty-five maps from each of the three time periods were observed. The number thirty-five was an arbitrary number selected to give representation of cartographic design during these time periods. The selection criterion of a map involved a connected to the literature review of the history of cartography. In all cases, the author tried to review primary works done by important cartographers or cartographic houses.

Data retrieved from the Traditional Map Observation Form was organized and analyzed in SPSS statistical software. Within the analysis function of the software, outcomes were generated that revealed elements of cartographic design that emerged consistently through the ages. Using frequency analysis, SPSS produced tables that displayed the percentage of a graphic element occurring across a given time period.

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[41]Dent, 263-301; Arthur H. Robinson, *Elements of Cartography*, 120-160.

[42]Criteria used to develop, use, and pretest the traditional map observation form are discussed in-depth in Chapter 2, page 37.

Only elements that were recorded as excellent to good above fifty percent of the time across all three-time periods were considered as consistent cartographic elements. Consistent cartographic elements were then used for observations of the mapping software.

Observations of Desktop Mapping

Data pertaining to the computerized programs was obtained from observations of eight different desktop mapping systems (Adobe Illustrator (MAPublisher), ArcView, AutoCAD, IDRISI, Maptitude, MapViewer, MicroCAM, MicroStation,). The selected software packages were available to the author though the Social Science Research Lab at the University of Montana and through work at the Montana Power Company. The author worked extensively for two years to learn the capabilities and functions of the software. These eight programs were not the ultimate in desktop mapping applications, however, they do comprise a significant portion of the mapping capabilities currently available.

In order to observe the capabilities of the mapping software, each program was used to create a map. The map was complied from data or samples that accompany the software. The generated map was observed to assess if the programs could reproduce the elements of traditional cartographic design. Data was acquired and recording on a Desktop Observation Form. See Appendix B, pp. 128. The form was similar to the Traditional Map Observation Form except that it developed after the observations and analysis of traditional maps finished. Design of the form included conclusions about the elements of cartographic design gathered from earlier research. After the form was developed it was pretested on a number of novice computer users and cartographic professionals.[43] Following the pretest, the updated form was used to collect data.

All of the recorded observations were organized into Excel spreadsheets. Excel was used because the author did not intend to do any computer analysis, but the results needed to be organized. The results were organized into different graphic categories containing the questions recorded with "yes" and "no" answers. The development, refinement, and use of the Desktop Observation Form lead to research conclusions that are analyzed and discussed in the final chapters.

Summary

This chapter introduced a general idea of the research by establishing an overview of the historic developments of cartographic design, stating a problem, defining the research scope and questions, addressing literature review, and developing the research methodology. The research scope and questions played a vital part in organizing and conducting the research. They were listed as:

- What are the cartographic design elements of traditional cartography?
- Have cartographic design elements and principles from traditional cartography been incorporated into mapping desktop software?
- What support systems (help files, templates, and samples) exist to sample elements of cartographic design in different mapping programs?
- Finally, if support systems do not exist or are not adequate what elements and samples can be introduced to enhance desktop mapping?

These questions were the focus of the research and lead into Chapter 2.

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[43]A description and explanation of the criteria for developing the observation form and a full discussion of using and pretesting the form are discussed in-depth in Chapter 3, page 72.

CHAPTER 2

CARTOGRAPHIC DESIGN IN TRADITIONAL CARTOGRAPHY

The Art of Traditional Cartographic Design

Five hundred years of traditional cartography has revealed that effective cartographic design is an art. However, cartographic design is not a creative art form such as painting, music, literature, or dance.[1] A map must bear some relation to reality, to a real spatial entity.[2] Cartographic design is used to make a map that is functional. This need for functionality puts constraints on the designer and does not allow for total freedom of expression. From the arts, cartographic design has incorporated the graphic methods of drawing and painting to capture spatial relationships. The integration of art techniques assists in placing a picture of geographic reality into the minds of users.

For the purpose of this research, maps were critically observed to make known the elements of traditional cartographic design. The development of cartographic design did not happen overnight, but was the result of hundreds of years of successes and failures. Traditional cartographic design evolved from these successes and failures in science, astronomy, mathematics, and art. The research was focused to make connections to the artistic aspect of cartographic design, however, and not the scientific, astronomic, or mathematic aspects.

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[1]Robinson and others, *Elements of Cartography*, 317.

[2]The author considered only traditional Western examples of a map, such as atlases, single sheet, thematic, or road maps. Others maps such as dream maps, mental maps, or stick maps were not considered in the research design, questions, or results.

Why should traditional cartographic design be considered as an artistic model? Throughout history, humankind's perceptions of the globe have changed and thus the way cartographers presented that perception has changed. Traditional cartography was more concerned with design than are today's mapping programs. A traditional map had to be hand drawn and then carved on a surface, such as wood, bronze, or aluminum. This time consuming process required additional concern for detail and design. If a mistake was made, it often took a great deal of time to fix that mistake. A mistake would be especially troubling if thousands of maps had already been printed. Because of this cartographers had to be taskmasters with great attention to detail. Extra thought was associated with designing, communicating, and presenting map information. The design elements of traditional cartography are the elements of cartographic design.

The proper use of map design elements labors to evoke in the minds of viewers an environmental image appropriate to the map's purpose.[3] Regardless of the accuracy and precision of the data, if the map is not designed well, it is a poor map. As stated earlier, map design elements include clarity and legibility, hierarchical structure, color and pattern, visual contrast, figure and ground, balance, and typography.[4] A combination of these design elements with graphic variables and map composition helps to produce an aesthetic map. The next section defines and describes the use of graphic variables and map composition in cartographic design.

[3]Ibid., 316.

[4]Ibid., 324 - 330.

Graphic Variables and Map Composition

Graphic variables and map composition are used on a map in various ways to communicate different types of information. There are several graphic variables and elements of map composition that can be identified. Graphic variables can be defined as hue, lightness, size, shape, texture, orientation and location. Figure 2-1 shows examples of the use of these variables in the context of point, line, area, and volume symbols.[5] Items of map composition are explanatory aids such as titles, legends, insets, scales and direction indicators; they are often referred to as marginal information.[6] Figure 2-2 shows the arrangement of various elements of map composition. The use of map composition items provides context to the map data. Their primary purpose is to identify, organize, classify, and balance a map's structure.

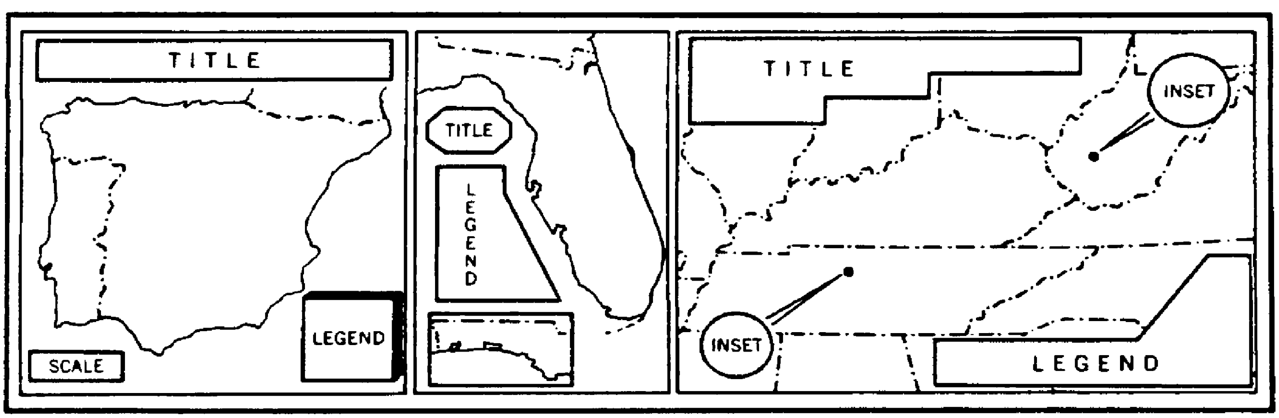

Figure 2-2 The Arrangement of Various Elements of Map Composition[7]

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[5]Jones, Geographic Information Systems and Computer Cartography, 253.

[6]Ibid., 332.

[7]Robinson and others, *Elements of Cartography*, 333.

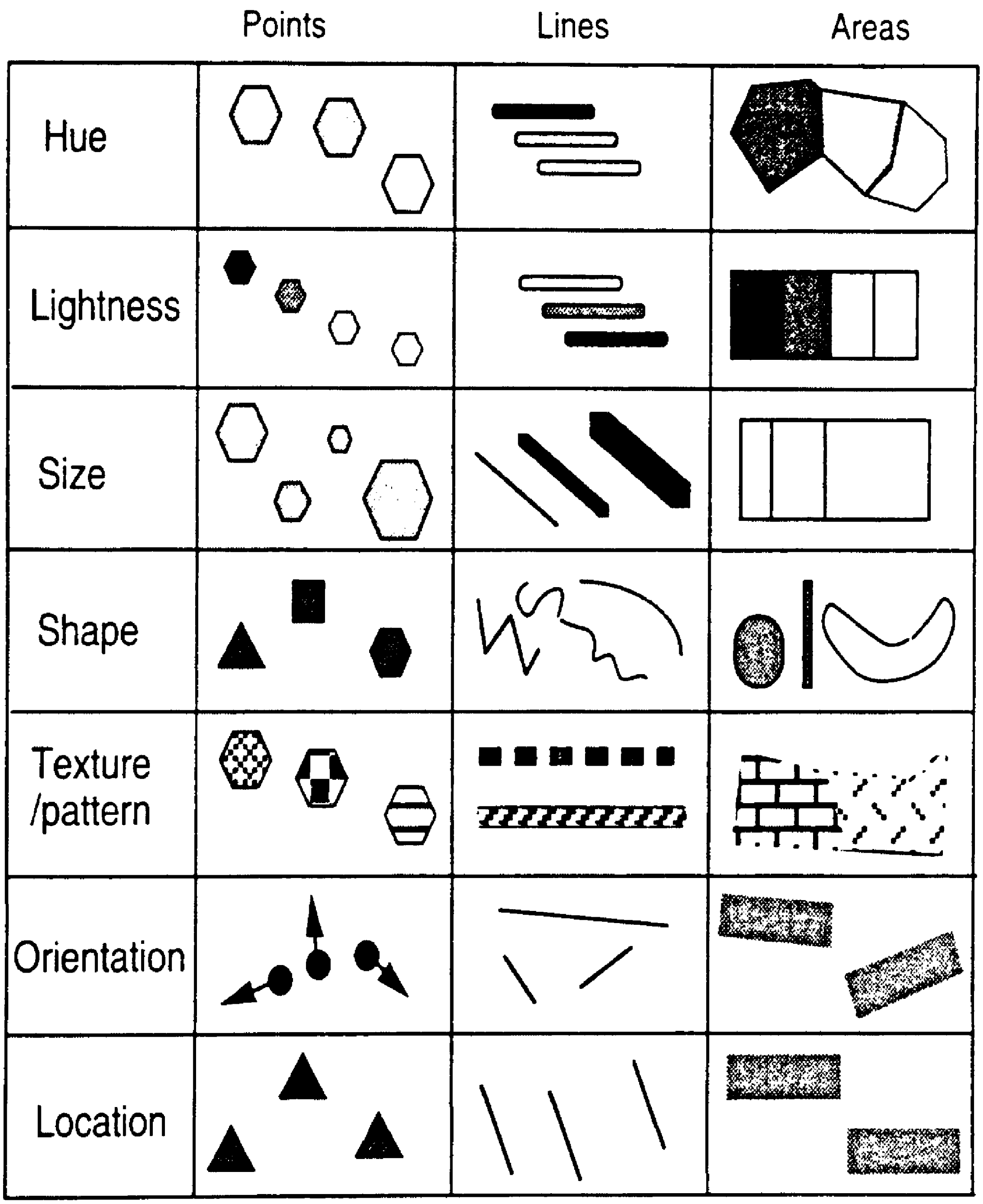

Figure 2-1 Graphic Variables[8]

[8] Ibid.

For the purpose of this research, five items were reviewed as primary graphic variables and map composition elements. They were color, text, line, symbol, and marginal information. The subsequent sections focus on these five elements and their use and combination in traditional cartographic design. A brief discussion of each of these elements follows.

Color

Color is very important in map communication; it allows for greater design freedom. However, the use of color is a complex issue that has resulted in almost no standard rules, except for a few conventions and strategies.[9]

Cartographic designers are concerned with the use of color to simplify and clarify, to enhance legibility, and to elicit reactions to the map.[10] Color can also develop features and allow them to stand out. Effective use of color brings balance to a map design. The functions of color are to attract attention, stimulate interest, identify elements, relate elements, provide emphasis, illustrate, attract the reader's attention, create a mood or atmosphere, and show structure and design.[11] Map designers must employ several strategies to reach the fullest potential of effective color communication. A brief summary of color strategies follows:

- Color can provide contrast between different items. The world is full of different colors that distinguish elements from other elements. Cartographic design should take advantage of visual reality and use different colors to contrast features.

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[9]Dent, *Cartography Thematic Map Design,* 304.

[10]Ibid., 316.

- Grouping of items is better understood when similar colors are used to define areas. Colors that are similar in brightness and hue can be acknowledged as belonging together.
- Colors that are brighter and more powerful have a different effect on how the map communicates. Warmer, earth-tone colors that are subdued are more appealing. Different levels or a hierarchy can be associated with the use of different colors, such as the use of color to show the different aspects of elevation or depth.
- The ability to make features such as lines and text look better and more legible can be accomplished with color.
- Colors placed on different backgrounds can often make the feature appear to be raised from the map, grabbing the reader's attention.
- Color harmony is an important aspect of map design. Color harmony includes these aspects: functionality, conventional use, color selection, relationship of the hues, and quantitative definition of the colors on the map.[12]

Many agencies, companies, and professional societies have established color standards. The use of color standards can make a map easier to understand and also help to make it visually pleasing. The selection and use of color, especially when used in combination with other elements, is an important aspect of cartographic design.

Text

Text is utilized on a map to communicate spatial information. The selection and

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[11]Ibid.

[12]Ibid., 322.

placement of text is one of the most time consuming aspects of map design. It is estimated that text manipulation occupies up to fifty percent of the time involved in map compilation. This estimate reveals that text manipulation is an important element of cartographic design. "The selection of typeface and placement of lettering are the two chief concerns of the designer."[13]

The selection of text clarifies different graphic elements and features on a map.

> It becomes necessary to include text on a map when we need to be able to distinguish between unique members of a class of objects, as in naming individual towns and cities, or when it may be appropriate to remind the map user of a detailed classification, or to remove ambiguity, as in annotating topographic contours or detailed rock and soil classifications.[14]

Text is incorporated into legends, titles and other marginal material to make the map more comprehensible. The selection process involves choosing different text styles, sizes, and spacing. These selections help to set text apart from other features on the map.

Placement is also used to set text apart from other features. A lack of attention to text placement can have a debilitating effect on map communication. Poor text placement can make a map unreadable. The main problem associated with text use is that there is no one position on the map that the text belongs.[15] Hence, text needs to compete for space with other map features. Often text is placed wherever there is room and may be stuffed in between other symbols or graphic objects. Lack of attention to text placement reveals poor planning and design. Figures 2-3 and 2-4 illustrate poor and proper text placement respectively.

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[13]Ibid., 280.

[14]Jones, *Geographic Information Systems and Computer Cartography,* 259.

[15]Ibid.

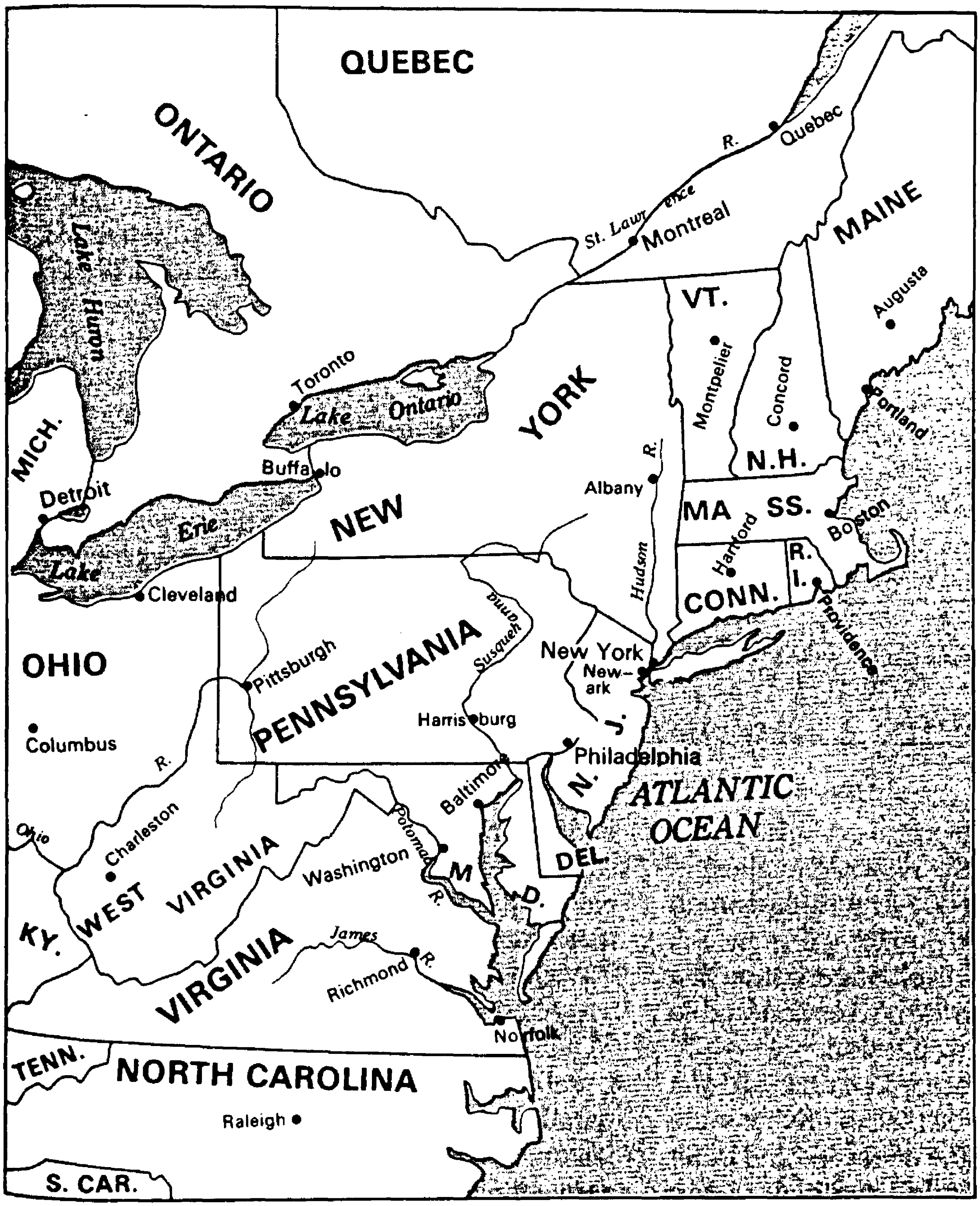

Figure 2-3 Illustration of Poor Text Positioning[16]

[16]Robinson and others, *Elements of Cartography,* 417.

Figure 2-4 Illustration of Proper Text Positioning[17]

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[17]Ibid., 418.

Lines

The use of line styles and line weights is another important element of cartographic design. Lines can be put to a variety of uses, including, labels, borders, neat lines, political boundaries, quantitative or qualitative symbols, special symbols to divide areas, or graphic devices to achieve other goals.[18] Line style refers to how the line is constructed, whether it is made of a series of dashes or designed as a solid line, or if it includes other line symbols. The style of one line should contrast other lines, symbols, and features that make up the map design. Line style should also include the use of different colors to represent different lines. A good rule of thumb is to use at least two different attributes, such as color and pattern, when distinguishing lines. Figure 2-5 illustrates the use of different line styles and patterns.

Along with line style, line weight also plays an important role in cartographic design. Line weight is the thickness associated with the line symbol. Figure 2-6 illustrates different line weights. The contrast between line weights introduces visual stimulation to a map. "A map having lines of all one weight is boring and lacks potential for figure formation."[19] Maps that have a variety of line weights and line styles are vivid and attract attention, drawing the reader into the map content. Effective use of line styles and weights compartmentalizes and focuses user attention and increases map communication.

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[18]Dent, *Cartography Thematic Map Design,* 256.

[19]Ibid.

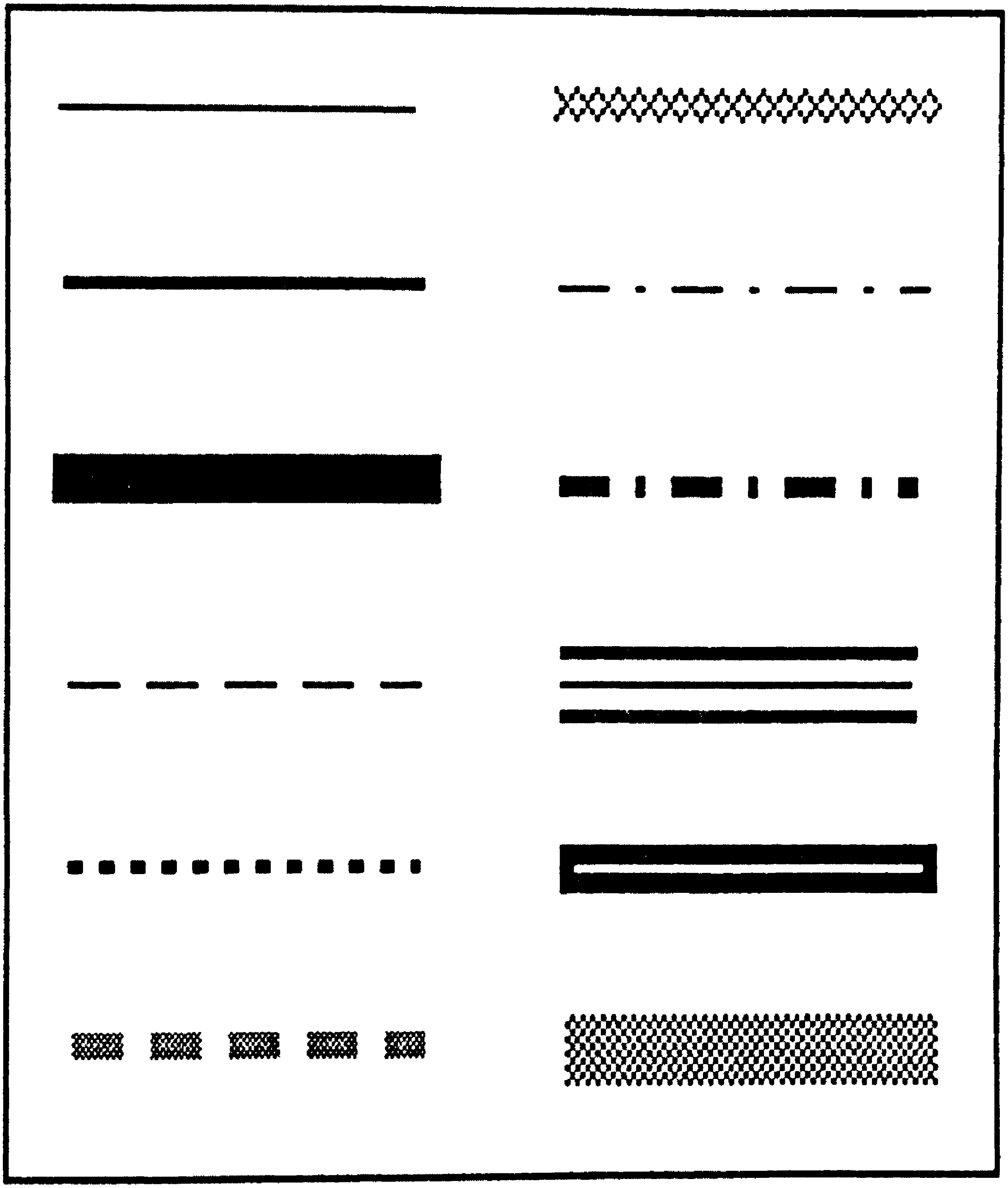

Figure 2-5 The Use of Different Line Styles and Patterns[20]

[20]Jones, *Geographic Information Systems and Computer Cartography*, 259.

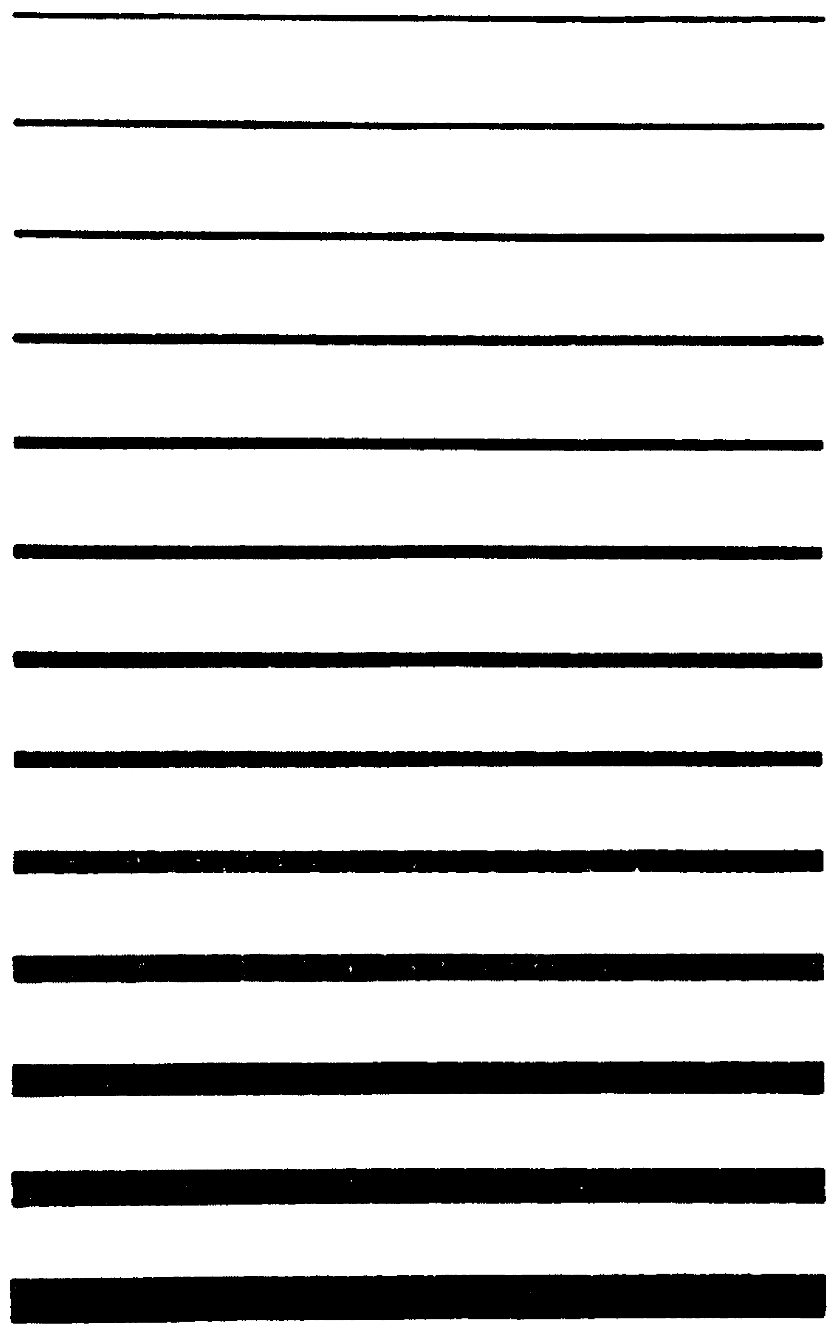

Figure 2-6 Different Line Weights[21]

[21]Dent, *Cartography Thematic Map Design*, 256.

Symbols

Cartography is a visual medium and as a visual medium it is based on the principles of graphic communication.[22] Symbols are used to represent spatial Information. Maps present information about geographic features using symbols. Cartographers use symbols to present information that would be impossible to fit on a map in words.

Symbols are classified by their spatial emphasis. This spatial emphasis approach yields point, line, area, and volume symbols.[23] Figure 2-7 illustrates examples of the four classes of symbols. Points can represent spatial features with abstract symbols such as circles, crosses, squares, etc. They can also represent features with a pictorial symbol, where the shape of the symbol is intended to suggest the phenomena being mapped. Points are also used to represent a position or a location of a feature. They define map objects whose boundary or shape is too small to be shown as a line or area. Line symbols represent geographic phenomena that are linear.[24] They may be used to represent elongated features that are too small to be shown on the map as areas, such as roads or rivers; or they may be used to represent objects that have no width, such as contour lines or administrative boundaries. Area symbols indicate enclosed regions that share common attributes, such as water bodies, states and counties, or some other measurable characteristic.[25]

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[22]Robinson and others, *Elements of Cartography*, 322.

[23]Robinson and others, *Elements of Cartography*, 322.

[24]Ibid.

[25]Ibid.

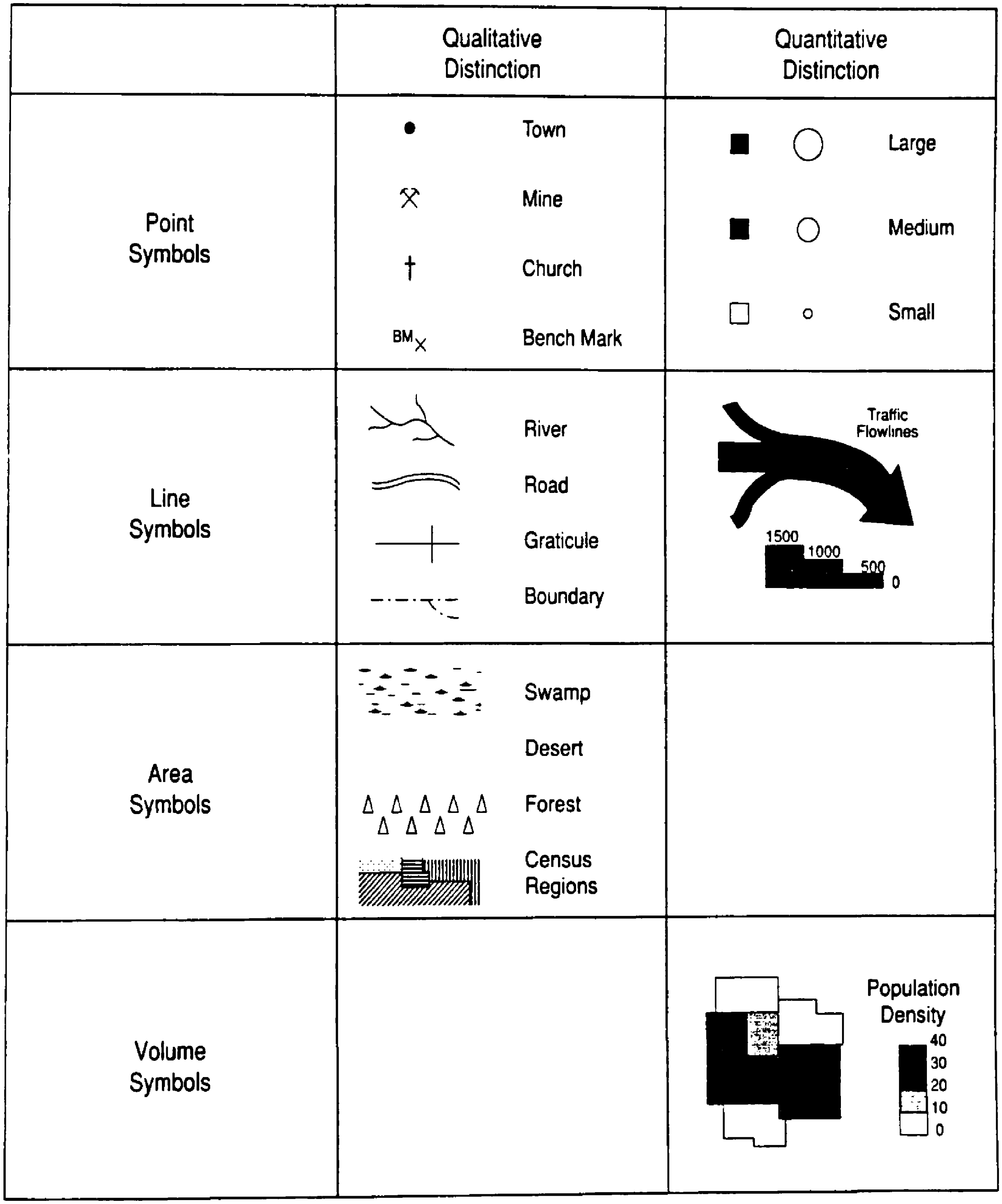

Figure 2-7 Examples of the Four Classes of Symbols[26]

[26]Ibid., 323.

The fourth and final classified symbol is the volume symbol. "Volume symbols represent the vertical or intensity dimension of a spatial phenomenon through space."[27]

It is important for the map user to understand the symbols. Understanding the symbols allows for obtaining all of the important information the map is trying to convey. Symbols need to be placed so that they are legible and clear. They must be associated and relevant to the map; they must also be of an adequate size to ensure that they can be seen. Consideration of size should not just be limited to the symbol size but also to the spacing between symbols. Often symbols need to be associated with a legend that provides their definitions.

Marginal Information

In traditional cartographic design, the marginal information is the information that is present in the margins of the map. This information can be classified by the acronym developed by educator Jeremy Anderson, TODAL-SIGS[28]. The acronym stands for title, orientation, date, author, legend, scale, index, grid or graticule, and surrounding places. The first part of the acronym, TODAL, can be considered required map information, while the SIGS part can be considered optional information. A brief explanation of the nine elements follows:

Title is a basic definition of the subject of the map. The title also should contain information about the location of the map area and the topic of the map. It should catch the attention and the interest of the viewer. It should be spaced and balanced with other

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[27]Ibid.

[28]The National Geographic Society, *Desk Reference* (USA: National Geographic Society, 1999), 32.

graphic elements in the map design. The title is a graphic element that helps to describe the geographic data of the map.

Every map is a representation of a geographic feature, **orientation** tells the user which direction the geographic feature is facing. Orientation can be represented with graphic elements such as north arrows or declination diagrams. With the use of a north arrow, the user can determine directions on the map.

The **date** tells the user when the map was created. This is important for future use of the map. If the map is outdated, the user may wish to use another map. If the map contains information that may become significant to history, the date is doubly important.

The **author** is the agency, the cartographer, or the company that developed, researched, and drew the map.[29]

The **legend** is the key to the map symbols. It contains the representative symbols, and their definitions. Any map symbol that is not self-explanatory should be explained in the legend.[30] The legend may also articulate the classification system used for symbols of related types such as those used to represent soils or vegetation.

Maps are drawn to some type of **scale**. Scales can be broken down into three different types, graphic, verbal, and representative fraction. The graphic scale is a line that resembles a ruler and shows the length of a certain distance. The verbal scale expresses the relationship between a map distance and an actual distance as an oral expression. The representative fraction indicates a ratio, or fraction that expresses the mathematical relationship between the map and the actual area on the earth that it

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[29]Ibid.

[30]Robinson and others, *Elements of Cartography,* 336.

represents.[31]

The **index** is an alphabetic listing of the map features and place names, cross-referenced to their grid location on the map. In atlases, it may refer to the map page number.[32] Indexes in atlases, which refer to place and feature names by their longitude and latitude, are called gazetteers.

A **grid** is used to provide a frame of reference for locating points on a map. The grid is superimposed onto the map with lettered rows and numbered columns to form a matrix of squares. On a map the lines of latitude and longitude produce another type of grid, called a **graticule**.[33]

The final S in TODAL-SIGS stands for **surrounding places** that border the mapped area, such as states, countries, mountains, oceans or neighboring map sheets.[34] The author believes that this final S could also stand for **source**. Where the data came from to make the map is a relevant aspect that needs to be included in the design.

Traditional Map Observation Form: Description and Explanation

The use and combination of graphic variables and map composition items were recorded for each observed map on the Traditional Map Observation Form. An overview of the observation form was outlined in Chapter One (Observation of Traditional Maps, page 17). The following subheadings describe the development, and use of the form to collect data. See the observation form in the Appendix A, pp. 125. In those instances

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[31]The National Geographic Society, 33.

[32]Ibid., 32.

[33]Ibid., 35.

[34]Ibid., 32.

where questions about the form might arise, the author has added additional information about the questions. The subheadings of the form were listed as: general information, graphic elements, color, map design, neatlines, text, insets, symbols, and marginal information. After the description and explanation of the manner in which the form was developed, the process of pretesting is discussed.

General Information

The form was used to collected certain general map information which included: name of the map cartographer, date the map was produced or published, type of map, map source, geographic area of the cartographer, and library call number. The following provides the rationale for collecting this information.

- The map cartographer was important because certain cartographers or cartographic houses were renowned for their map production. It was important to observe many different cartographers to gather information relevant to different styles and elements.
- Date was relevant because it organized the observations into the three distinct time periods that have been noted earlier as important. Since the author was trying to examine thirty-five maps from these three different time periods, it was important to keep track of the dates.
- "Type of map," refers to single sheet, atlas, map in a series, or maps from a book. For the purpose of observation and research, the primary types of maps that were observed were atlases. There were many reasons to choose atlases as the primary research choice, the most important being that a series of atlases could be observed through different time periods. In addition, the first real collections of maps were in

atlas form. One of the problems associated with doing research at the Library of Congress was that the maps were not organized. It was hard to get single sheet maps because they have not been effectively cataloged. It was much easier to select, view, and observe atlases because they were effectively cataloged.

- The map source was also recorded if it was known. Map source referred to how the map was compiled: where, who and how the data was collected. If the map was collected from observations, explorations, field surveys, or notes, this was recorded. The author was interested in the question: with the emergence of scientific technique what changes took place with regard to cartographic design?
- Geographic area was important because many areas of the world are known for the styles of maps created there as is the case today with Swiss maps. The researcher was trying to observe if different cartographic design styles had emerged from different cartographic regions. Establishing the geographic area of the cartographer was often difficult and required further research.

Graphic Elements

The observation form summarizes important graphic elements in which the researcher was interested. Again, the elements that were focused on were those considered to be vital to cartographic design. Elements observed were: color, map design, neat lines, text, map insets, and symbols. The form was developed with five categories for ranking the observations. It should be kept in mind that the observations relating to cartographic design were subjective. The five categories included one column for excellent, one for good, one for moderate, and one for poor, as well as a column for not present (if an item was not observed on a particular map). The categories were the same for all six elements of cartographic design. A check was entered in the appropriate column as determined from observations. The following is an explanation of the criteria associated with observed cartographic design elements.

Color

The use of color has been stated as being very important in map design. In the color category two characteristics of color were looked into - hue and value. Hue was considered one category and value as another. Other categories included: did the colors simplify, did the colors clarify, and the use of background color. Each one of these elements will be discussed to clarify the research content.

- The use of different hue refers to the colors that made up a majority of the map. Hue is the color we normally see as red, orange, yellow, green, blue, indigo, and violet. Did the cartographer use different hues or were they all the same? Even the use of black and white was considered a color element if they were used to organize the map.
- Were different color values used? A different color value refers the amount of lightness or darkness in different hues. As an example, if red was used were there different shades of reds? On the other hand, were just primary colors used? Also, under this element was the observed quality of the selection of vibrant colors or subdued colors.
- Did the use of color on the map help to simplify? Simplification refers to the incorporation of color to make the map less complicated or cluttered.

- Did the use of color clarify different elements or features on the map? Color clarifies by making an object different from surrounding objects.
- The final element for this category was the use of background colors. Observations were conducted to see if background colors were present and if the color added or distract from the overall design of the map. If gaudy or contradictory colors were observed then the map received a lower score.

Map Design

Under the category of map design, elements were addressed with questions regarding: how did the graphics look together, what was the focus of attention, were the graphics spaced well, how was blank space used, were the graphics well balanced, was the orientation appropriate?

- How the graphics looked together was the first reaction when looking at the map. Did things seem to flow together or were items confusing and cluttered?
- The focus of attention was the first thing that caught the eye when seeing the map. The focus of attention has much to do with the placement of graphics in the map area. Just above the center of the map is the primary focus of attention.
- The next element was the spacing of the map objects. Were items spaced with enough area or did everything appear to be crowded?
- Did the cartographic design allow for blank space or was there a feature to fill every area?
- The balance of graphics refers to if the graphics were balanced throughout the map or were features grouped in an unproportionate area of the map?

- The final element of the category was the orientation of the graphics. Were the graphics parallel to other objects or were they rotated at different angles?

Neat lines

The next category was the use of neat lines. This subheading included these six elements: use of a border, other neat lines, line weights, different line symbols, and different colors.

- Was there a border present? Was the border a simple line style or was it an artistic line style?
- Were other neat lines used? The use of other neat lines referred to if other lines were used to compartmentalize the map design and to group items or to break up the flow of the map.
- What were the line weights of the neat lines? Did the cartographer use different line weights to distinguish the different features of the map?
- Were there different line symbols employed? Did the cartographer use solid lines and dashed lines or were there artistically draw line symbols?
- In conclusion, did the cartographer make use of different colors for neat lines? Did the use of color clarify the lines and allow them to stand out from other lines?

Text

The fourth category was the use of text on the map. This category was made up of the following elements: placements of the text, rotation of the text, spacing of the text, text legibility, size of lettering, and typeface (fonts).

- The placement of the text focused on how the text was placed about the map. Were areas crowded with text?
- Text rotation addressed whether the text followed the features they were meant to annotate, such as text following a river.
- The spacing of the text referred to the spacing of letters in relation to other letters in a word. Were the spaces too wide, too narrow or were they visually appropriate?
- An overall assessment was made to whether the text was legible. Could the text be read and understood? Was the sizing of the text appropriate or was in out of co9ntext with other text and surrounding graphic items?
- Did the cartographer use different typefaces or fonts? There are two important aspects of typeface and font classification, type style and type form. Type style includes such elements as serifs—smaller lines used to finish off a main stoke of a letter—and line thickness.[35] Type form refers to whether the type is upper or lower case, roman or italics, upright or slanted, and combinations of these and other elements.[36]

Insets

The fifth category was the use of map insets. The map insets category was made up of the following items: size of the insets, informative aspects, relevancy to the map, the spacing of insets, and, again the use of color.

- Did the size of the insets distracted from the overall appearance of the map?
- Were map insets informative or filled with map clutter used to fill blank space?

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[35]Robinson and other, *Elements of Cartography,* 407.

- Were the insets relevant to the content of the map? Did they add additional information about the mapped area?
- Were map insets well spaced? Did they appear to be well balanced with other map features?

Symbols

The sixth category was symbols, involving: placement of symbols, representation of symbols, spacing of symbols, orientation of symbols, symbol legibility, and color.

- Was the symbol placed appropriate to the feature it was trying to represent? Was the symbol representative of the feature or did a legend exist that defined the symbol?
- Were the symbols spaced well or were they cluttered with other features and symbols?
- Were the symbols oriented in a logical fashion?
- Were the symbols legible and clear? Could the user understand the symbols?
- Were different colors used to make the symbols more readable?

Marginal Information

The final category included information related to TODAL-SIGS. These additional questions addressed the incorporation of a scale, north arrow, data source, title, date, cartographer, and graticule or grid.

- Was a scale included in the map?
- Did the map have a north arrow or some type of feature that shows map orientation?

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[36]Ibid., 409.

- Was a data source represented on the map?
- Did the map have a title?
- Was the date of production included on the map?
- Was the name of the cartographer or map-compiling agency present on the map?
- Did the map have a graticule or grid?

Pretesting

The map observation form was compiled with a number of detailed questions regarding the elements of cartographic design. In order to address the effectiveness of the observation form, the author sent it to five cartographic/graphic design teachers and professionals along with a cover letter of what the research was trying to accomplish. The professionals were asked to conduct observations on three different atlases. They were asked if they could observe original atlases from the three time-periods or facsimiles if originals were not available. The author suggested that the recipients add information that they felt was necessary in cartographic design and elements that they often incorporate into their maps.

The pretesting was a valuable experience in the sense that the author received a large amount of support and items to consider when thinking about cartographic design. The number of respondents who addressed interest in the research outcomes highlighted its relevance. Pretesting helped the author to refine the map observation form and to focus in on questions associated with research goals. With the results of pretesting incorporated into the updated observation form, the form was pretested by the author on ten maps in the Mansfield Library before undertaking the trip to Washington. Any conflicts the author had were resolved and the observation form was used to collect data about the traditional elements of cartographic design.

The preceding subsections defined the criteria, description, and explanation of the traditional observation form. This preceding overview was intended to give an idea of what was observed and why the researcher chose to observe these elements. The remaining parts of this chapter will focus on tabulating the results and selecting the consistent elements of traditional cartographic design.

Tabulation and Analysis of Traditional Map Observations

Results from the observations of all three time periods were combined to produce tables that were used to determine consistent elements of traditional cartographic design. In the following discussion and analysis, the combined time periods were displayed in a single table. The five different graphic variables and map composition items of color, map design, neat lines, text, and marginal information are displayed. Each one of the tables presents the results of observations for each of the graphic elements. To reiterate the methodology of the research, only items that were observed as excellent to good fifty-percent or higher across all three periods were considered consistent cartographic design elements.

Color

The tabulation of the observations of color was organized into four categories: hue, clarification, background color, and value. Observations on the subject of color use produced the following results:

Hue. The first element that was observed was the use of different colors to distinguish features and map components (See Table 2-1). Maps from the 1400's to 1880's displayed excellent to good observations 68.5 percent of the time. Moderate to poor observations occurred 17.1 percent of the time. During the 1800's to 1900's excellent to good observations occurred 94.2 percent of the time. Observations that fell into the moderate to poor categories occurred 5.8 percent of the time. Maps from 1990's to 1960's were viewed as being excellent to good 68.6 percent of the time. Moderate observations occurred 31.4 percent with no observations in the poor category.

Different hues can relay a powerful message when used properly. Color can contrast, organize, and clarify information and elements. Results of observations demonstrated that elements were observed as excellent or good above fifty percent of the time across all three periods.

Table 2-1 Hue

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	2	5.7	1	2.9	0	0
Moderate	4	11.4	1	2.9	11	31.4
Good	13	37.1	6	17.1	15	42.9
Excellent	11	31.4	27	77.1	9	25.7
Not Present	5	14.3	0	0	0	0
Total	35	100	35	100	35	100

Clarification. The next graphic variable of cartographic design was the use of color to clarify the maps and make elements easier to understand (See Table 2-2). During the 1400's to 1800's, color was observed to clarify at the good to excellent level 62.8

percent of the time. Under the categories of moderate to poor, observations were present with a recorded outcome of 22.8 percent. During the 1880's to 1900's color was observed as being excellent to good at 88.5 percent. With moderate observation at 11.4 percent and no recorded observations in the poor category. The 1900's to 1960's observations displayed excellent to good observations at 60 percent. Observations at the moderate to poor level occurred 40 percent of the time.

Table 2-2 Clarification

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	2	5.7	0	0	4	11.4
Moderate	6	17.1	4	11.4	10	28.6
Good	11	31.4	6	17.1	12	34.3
Excellent	11	31.4	25	71.4	9	25.7
Not Present	5	14.3	0	0	0	0
Total	35	100	35	100	35	100

Color is used to visually make certain elements appear different from surrounding elements. Color, even black and white, clarifies information on a map. The use of color to clarify was recorded above fifty percent during all three time-periods. It was therefore, included as an element that should be accommodated by the desktop software.

Background Color. The use of background color was the next element of cartographic design (See Table 2-3). During the 1400's to 1800's, color was observed at the good to excellent level 60.0 percent of the time. A total of 40 percent was recorded at the moderate to poor levels. Between 1800 to 1900, background color was observed to be excellent or good 77.2 percent of the time. Observations of maps within the moderate to poor categories were recorded at 14.3 percent. The 1900's to 1960's displayed excellent to good observation 62.9 percent of the time. Combined scores for moderate to poor observations totaled 34.3 percent.

Background color operates to set features apart from surrounding features. It can often enhance the figure and ground relationship. Results revealed that the ability to create background colors appeared above 50 percent of the time and would be considered a consistent design element

Table 2-3 Background Color

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	7	20	2	5.7	1	2.9
Moderate	7	20	3	8.6	11	31.4
Good	8	22.9	3	8.6	15	42.9
Excellent	13	37.1	24	68.6	7	20
Not Present	0	0	3	8.6	1	2.9
Total	35	100	35	100	35	100

Value. The last element under the subheading of color was the use of color value (See Table 2-4). During the 1400's to 1800's, the use of different color value was observed 65.7 percent of the time in the excellent to good categories. Moderate to poor observations occurred at 34.3 percent. During the 1880's to 1900's results demonstrated excellent or good observations at 82.8 percent. Moderate to poor observation occurred 17.2 percent of the time. Observations in the 1900's to 1960's period had a percentage of excellent to good of 65.7 percent of the time. The moderate to poor grouping contained 34.2 percent of the observations.

Color value is the amount of lightness or darkness in a color. It can be used to discern different classifications of data. The recorded observations of color value did reach the criteria of higher then 50 percent across all three periods. According to the criteria of the research methodology, it was included in consideration when observing desktop mapping.

Table 2-4 Use of Color Value

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	5	14.3	1	2.9	6	17.1
Moderate	7	20	5	14.3	6	17.1
Good	5	14.3	4	11.4	10	28.6
Excellent	17	51.4	25	71.4	13	37.1
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

Conclusions regarding the graphic variable of color revealed a disqualification of none of the four observed elements. All four of the elements discussed: ability to create different colors, use color to simplify, create background color, and use different color values will be considered consistent elements of cartographic design. Concluding the observation of color, the research addressed the observation of map design.

Map Design

Map design was defined as the over all organization of the map. It included the subheadings: look of graphics, focus of attention, spacing, blank space, and orientations of graphics. When using a map to communicating information, effective map design is as important as the use of graphic variables and the incorporation of map composition items. Observations of map design revealed the subsequent results:

Look of Graphics. The first element of map design was how the graphics looked together (See Table 2-5). During the 1400's to 1800's excellent or good observations occurred 82.8 percent of the time. There were 17.1 percent of the observations at the moderate level and none recorded at the poor level. The 1800's to 1900's displayed an excellent to good recording of 91.4 percent. There were 8.6 percent of the observations at the moderate level and none at the poor level. During the time-period of 1900 to 1960, excellent to good classifications were recorded at 77.1 percent of the observations. The moderate class amounted to 22.9 percent, and the poor class recorded no observations.

Table 2-5 Look of Graphics

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	0	0	0	0	0	0
Moderate	6	17.1	3	8.6	8	22.9
Good	11	31.4	9	25.7	20	57.1
Excellent	18	51.4	23	65.7	7	20
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

Elements of a map need to be organized in such a way that they look good together. Components need to be spaced, oriented, balanced, and sized to establish effective cartographic design. Observation revealed that the look of graphics appeared excellent to good above fifty percent of the time.

Focus of Attention. Focus of attention was the second category observed under the graphic elements of map design (See Table 2-6). In the observations made of maps drawn between the 1400's and 1800's, the focus of attention was recorded as excellent to good 77.2 percent of the time. Moderate or poor observations occurred 22.9 percent of the time. During the 1880's to 1900's, recorded observations equaled excellent to good 65.7 percent of the time. Conversely, within the grouping of moderate to poor, there was 34.3 percent. The 1900's to 1960's observations totaled excellent to good 74.2 percent and moderate to poor 25.7 percent of time.

Table 2-6 Focus of Attention

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	3	8.6	2	5.7	5	14.3
Moderate	5	14.3	10	28.6	4	11.4
Good	10	28.6	7	20	13	37.1
Excellent	17	48.6	16	45.7	13	37.1
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

As noted earlier, focus of attention refers to the optical center of the map. The optical center is a point slightly higher then the physical center of the map; effective cartographic design balances elements around this point. Observations demonstrated that focus of attention was an important aspect of cartographic design recorded above 50 percent over all three time periods, thus it was included as one of the categories to be studied.

Spacing. Spacing, was the next observed element (See Table 2-7). During the 1400's to 1800's, spacing was recorded as excellent to good 68.6 percent of the time. Moderate use of graphics spacing was recorded 28.6 percent of the time with no recorded observations in the poor category. During the 1880's to 1900's spacing was observed as being excellent to good at 80 percent. Only 20 percent fell into the moderate category, and none fell into the poor. The 1900's to 1960's observations totaled 48.5 percent in the excellent to good category. The moderate to poor grouping had 51.4 percent of the observations.

The element of spacing was recorded as moderate to poor above 50 percent of the time for observations during 1900 to 1960. Thus it was removed from consideration as an element to be accommodated by desktop mapping.

Table 2-7 Spacing

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	0	0	0	0	5	14.3
Moderate	10	28.6	7	20	13	37.1
Good	12	34.3	6	17.1	13	37.1
Excellent	12	34.3	22	62.9	4	11.4
Not Present	1	2.9	0	0	0	0
Total	35	100	35	100	35	100

Blank Space. Use of blank space was the next observed element (See Table 2-8). Within the period from the 1400's to 1800's, the use of blank space was recorded excellent to good 34.3 percent of the time. Moderate to poor observations were recorded at 62.9 percent. Observations from the 1800's to 1900's revealed excellent to good use of blank space 71.4 percent of the time, while moderate to poor was recorded at 28.5 percent of the total. The last time period of 1900 to 1960, recorded excellent to good results at 65.7 percent. In addition, moderate to poor results occurred 28.6 percent of the time.

Analysis of the observation of Table 2-8 revealed that effective use of blank space was not present above 50 percent of the time during the time-period of 1400 to 1800. Consequently, this element of cartographic design was removed from observations of the mapping programs.

Table 2-8 Blank Space

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Poor	5	14.3	4	11.4	5	14.3
Moderate	14	48.6	6	17.1	5	14.3
Good	4	11.4	5	14.3	11	31.4
Excellent	8	22.9	20	57.1	12	34.3
Not Present	1	2.9	0	0	2	5.7
Total	32	100	35	100	35	100

Orientations of Graphics. The final element observed under the subheading of map design was the orientation of graphics (See Table 2-9). Within the years of 1400 to 1800, the recorded observations produced a rating of excellent to good 74.3 percent of the time. The recorded results displayed a moderate score occurring at 25.7 percent of the observations. There were no observations in the poor category. The period of 1880's to 1900's generated an observed score of excellent or good at 89.6 percent. Moderate to poor observations were recorded 11.4 percent of the time. Within 1900 to 1960 observations, excellent to good equaled 71.4 percent of the total maps; moderate to poor observations occurred at 28.5 percent of the total.

Table 2-9 Orientations of Graphics

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	0	0	1	2.9	6	17.1
Moderate	9	25.7	3	8.6	4	11.4
Good	22	62.9	8	22.9	13	37.1
Excellent	4	11.4	23	65.7	12	34.3
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

As noted earlier, orientation refers to the directional arrangement of the graphic elements within the map design. The proper use of orientation was viewed as excellent to good above 50 percent of the time during all three periods.

Under the subheading of map design, three of the five observed elements were included as elements of cartographic design: how graphics looked together, focus of attention, and orientation of graphics. Two elements were removed because they did not equal a rating of excellent to good above 50 percent across all three time-periods. Spacing between graphic objects was removed because it scored above 50 percent in the moderate to poor category during the years of 1900 to 1960. The use of blank space was removed because observations did not reach the established threshold during the 1400 to 1800 time-period.

Neat Lines

Tabulations on the subject of neat lines involved the subheadings: border, line weights, other neat lines, and color. Observations of neat lines produced the following results:

Border. The use of a border was the first element under the category of Neat Lines (See Table 2-10). During the 1400's to 1800's, the use of a border was recorded as excellent to good 85.7 percent of the time, while moderate to poor were recorded at a percentage of 24.3 percent. Contained in the time-period 1800 to 1900, observations showed an excellent to good ranking 85.7 percent of the time. Moderate use of a border was recorded at 11.4 percent with none of the observations falling in the poor category. Relating to observations during 1900 to 1960, excellent to good scores were recorded 77.2 percent of the time and moderate rankings occurred at 22.9 percent with no scores in the poor category.

Table 2-10 Border

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	1	2.9	0	0	0	0
Moderate	4	11.4	4	11.4	8	22.9
Good	18	51.4	10	28.6	22	62.9
Excellent	12	34.3	18	51.4	5	14.3
Not Present	0	0	3	8.6	0	0
Total	35	100	35	100	35	100

A border contains, organizes, and structures elements of map design. Observations of the three time-periods revealed that the use of a border appeared excellent to good above fifty percent of the time in all three time periods. Therefore, the use of a border was added as a consistent cartographic element.

Line Weights. The second element was the use of line weights (See table 2-11). Connected to the observations for 1400's to 1800's, the use of line weight was recorded as excellent to good 88.6 percent of the time. Observations in the moderate to poor classes occurred at 11.5 percent. During the 1800's to 1900's, observations within the excellent to good category occurred 91.4 percent of the time. Scores in the moderate class were recorded 8.6 percent of the time with none of the scores in the poor category. Observations from the 1900's to 1960's displayed rankings of excellent to good 71.4 percent and moderate to poor 28.6 percent of the time.

Table 2-11 Line Weights

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	1	2.9	0	0	2	5.7
Moderate	3	8.6	3	8.6	8	22.9
Good	26	74.3	16	45.7	21	60
Excellent	5	14.3	16	45.7	4	11.4
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

Different line weights are used to contrast features and organize information. Results demonstrate a presence of excellent to good observations above fifty percent of the time. The effective use of line weight qualified as an element of cartographic design that desktop mapping software should be able to recreate.

Other Neat Lines. The use of other neat lines was the next observed element of cartographic design (See Table 2-12). Within the observations from 1400's to 1800's, other neat lines were used in an excellent to good fashion 65.7 percent of the time. Ranks in the moderate to poor categories occurred 34.3 percent of the time. In the 1800 to 1900 category, excellent to good was represented 74.3 percent of the observations. In combination, 8.6 of the observations occurred in the moderate to poor category. Contained in the years between 1900 to 1960, observations revealed excellent to good observations at 62.8 percent and observations recorded at 20 percent in the moderate to poor grouping.

Table 2-12 Other Neat Lines

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	1	2.9	1	2.9	2	5.7
Moderate	11	31.4	2	5.7	5	14.3
Good	12	34.3	7	20	11	31.4
Excellent	11	31.4	19	54.3	11	31.4
Not Present	0	0	6	17.1	6	17.1
Total	35	100	35	100	35	100

Neat lines act similar to a border; they are used to compartmentalize and organize map information. The use of other neat lines was observed more then 50 percent of the time and was added with the other elements of consistent cartographic design.

Color. The fourth element of line design was the use of color (See Table 2-13). During the 1400's to 1800's, use of line color was observed as excellent or good 54.3 percent of the time. Moderate to poor observation occurred 20 percent of the time.

Relating to observations of maps during the 1800's to 1990's, excellent to good occurred 80 percent of the time. In the category of moderate, observations occurred only 11.4 percent of the time, and there were no observations in the poor category. Observations of maps from the 1900's to 1960's displayed excellent to good observations 54.3 percent of the time. From observation at the moderate level a results of 28.6 percent occurred. None of the observations were recorded in the poor category.

The use of color is a vital aspect of cartographic design. Whether it is differences in hue, saturation, or value, color can be a powerful tool at displaying and organizing information. The use of color to characterize a line was present more then 50 percent of the time and was added as a graphic element to be considered.

Table 2-13 Color

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	3	8.6	0	0	0	0
Moderate	4	11.4	4	11.4	10	28.6
Good	11	31.4	8	22.9	16	45.7
Excellent	8	22.9	20	57.1	3	8.6
Not Present	9	25.7	3	8.6	6	17.1
Total	35	100	35	100	35	100

The four elements that made up the graphic variable of neat line were: use of a border, different line weights, other neat lines, and the use of color. Of the four observed elements, all were observed as excellent or good above 50 percent of the time. Therefore, they were all considered as cartographic elements to be considered when evaluating desktop mapping systems.

Text

The next observed graphic variable of cartographic design was text use. This category was divided into five subheadings: text placement, text rotation, text spacing, text legibility, and text size. Observations of this category disclosed the following results.

Text Placement. The first category under the text subheading was text placement (See Table 2-14). Between 1400 and 1800, the combination of excellent and good observations for text placement totaled 80 percent. There were 17.1 percent of the recorded observations in the moderate class and only 2.9 percent in the poor class. The second period, the 1880's to 1900's, demonstrated the importance of text placement. The combined scores of excellent and good observation totaled 100 percent. There were no observations in the moderate or poor categories. Of the observed maps, many had highly stylized text or fonts that were artistically decorative but also informative. During the observations of 1900's to 1960's, there were 65.7 percent of the observations in the excellent to good classification. In the moderate category, 28.6 percent of the observations fell and none in the poor category.

Table 2-14 Text Placement

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	1	2.9	0	0	2	5.7
Moderate	6	17.1	0	0	10	28.6
Good	19	54.3	14	40	12	34.3
Excellent	9	25.7	21	60	11	31.4
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

The positioning of text can seriously effect map communication. Correct positioning of text has as much to do will effective design, as does any other graphic variable. Observations revealed that text placement materialized at the excellent to good level over 50 percent of the time across all three periods.

<u>Text Rotation.</u> The second category under the text subheading was the use of text rotation (See table 2-15). Text rotation for observed maps of the 1400's to 1800's demonstrated an excellent to good classification 82.8 percent of the time. Maps observed in the moderate to poor classification occurred at 17.0 percent. Text rotation was observed to be excellent or good 88.6 percent of the time during the 1880's to 1900's. There were a small number of observations in the moderate category, recording 11.4 percent of the total, and none observed in the poor category. Between 1900 to 1960, 58.4 percent of the observations landed in the excellent to good categories. Only 28.6 percent of the observations were recorded at the moderate or poor level.

Table 2-15 Text Rotation

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	1	2.9	0	0	1	2.9
Moderate	5	14.3	4	11.4	9	25.7
Good	20	57.1	9	25.7	18	51.4
Excellent	9	25.7	22	62.9	7	20
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

Text rotation guidelines should accomplish the following: be able to rotate along the axes of spatial features, be placed within and across the borders of areas, and be positioned so as not to be crowded along borders and edges. From the tabulated results, it was revealed that the incorporation of text rotation appeared above 50 percent of the time across all three periods.

Text Spacing. The third element of the text variable was the use of text spacing (See Table 2-16). In the 1400's to 1800's, text spacing was observed as excellent to good 60 percent of the time and moderate to poor 40 percent of the time. The observations from 1880's to 1900's demonstrated the use of text spacing as being excellent to good at 74.3 percent of the time. While there were 9-recorded observations (25.7 percent) in the moderate category and none in the poor category. Contained in the observations of the 1900's to 1960's period were the results of excellent to good equaling 71.4 percent. Moderate to poor recorded observations totaled 28.5 percent.

Table 2-16 Text Spacing

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	3	8.6	0	0	4	11.4
Moderate	11	31.4	9	25.7	6	17.1
Good	15	42.9	9	25.7	21	60
Excellent	6	17.1	17	48.6	4	11.4
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

When spacing text, there should not be wide spaces left between the letters in a word. Text should not be curved unless it is meant to follow a feature. The observations of text spacing revealed excellent to good observations above fifty percent of the time. Therefore, this element was selected to be incorporated into the observation of desktop software.

Text Legibility. The next element was text legibility (See Table 2-17). During the 1400's to 1800's text was observed as legible 71.4 percent of the time in the excellent and good categories and 28.6 percent in the group of moderate to poor. Within the observations of the 1880's to 1900's time frame the grouped observations of excellent to good were recorded at 77.1 percent. Moderate recorded observations equaled 22.9 percent with none recorded in the poor category. The 1900's to 1960's period demonstrated excellent to good observations 71.5 percent of the time. Within the grouping of moderate to poor a total of 28.6 percent of the observation fell.

Table 2-17 Text Legibility

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	3	8.6	0	0	5	14.3
Moderate	7	20	8	22.9	5	14.3
Good	16	45.7	9	25.7	17	48.6
Excellent	9	25.7	18	51.4	8	22.9
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

Text must be legible, and easy to read and understand. The recorded observations demonstrated that text legibility was recorded as excellent to good above fifty percent of the time and should be represented as a cartographic element for the purpose of the research.

Text Size. The fifth element recorded was the use of text size (See Table 2-18). During the 1400's to 1800's observations were recorded as excellent to good 65.7 percent of the time. While moderate use of text size was recorded 34.3 percent of the time and no observations recorded in the poor category. Related to the observations of 1880's to 1900's maps, 71.4 percent fell within the excellent to good grouping. In conjunction, 28.6 percent landed in the moderate to poor category. Observations from the 1900's to 1960's equaled 62.8 in the excellent to good classes. Meanwhile observations in the moderate to poor group equaled 37.2 percent.

Table 2-18 Text Size

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	0	0	1	2.9	3	8.6
Moderate	12	34.3	9	25.7	10	28.6
Good	17	48.6	11	31.4	18	51.4
Excellent	6	17.1	14	40	4	11.4
Not Present	0	0	0	0	0	0
Total	35	100	35	100	35	100

Perhaps the most important decision a map designer will make relating to text is the selection of text size. Text size should be chosen based on the size of the object being named and the space being filled. However, text should also be sized in respect to the total map design. Observations demonstrated that the use of text size was excellent to good above 50 percent of the time across all three times.

Under the graphic variable of text, five different elements were selected for observation: text placement, rotation, spacing, legible, and size. Of the five elements all were observed as excellent to good above 50 percent of the time. Consequently, these five elements were included into the observations of desktop mapping software.

Map Inset

When observing the tabulated results of the observations regarding map insets, the research revealed that there were not enough observations to meet the selection criteria. By looking at the tables, it can be seen that map insets were not present 54 percent of the time during 1400's to 1800's, 52.4 percent of the time during 1800'so 1900's, and 45.7 percent of the time during 1900's to 1960 (See Tables 2-19 – 2-22). Though the author believes that map insets are an important aspect of cartographic design, they did not appear in enough of the observations. Therefore, the entire category has been removed from consideration. The four tables have been presented to reveal the observations that were found while conducting the research.

Table 2-19 Map Inset Size

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	1	2.9	0	0	0	0
Moderate	3	8.6	4	11.4	5	14.3
Good	6	17.1	8	22.9	10	28.6
Excellent	6	17.1	5	14.3	4	11.4
Not Present	19	54.3	18	51.4	16	45.7
Total	35	100	35	100	35	100

Table 2-20 Map Inset Informative

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	0	0	2	5.7	0	0
Moderate	5	14.3	7	20	7	20
Good	2	5.7	4	11.4	8	22.9
Excellent	9	25.7	4	11.4	4	11.4
Not Present	19	54.3	18	51.4	16	45.7
Total	35	100	35	100	35	100

Table 2-21 Map Inset Relevant

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	1	2.9	2	5.7	0	0
Moderate	4	11.4	6	17.1	10	28.6
Good	1	2.9	5	14.3	9	25.7
Excellent	10	28.6	4	11.4	0	0
Not Present	19	54.3	18	51.4	16	45.7
Total	35	100	35	100	35	100

Table 2-22 Map Inset Spacing

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	1	2.9	1	2.9	0	0
Moderate	1	2.9	5	14.3	9	25.7
Good	6	17.1	11	31.4	8	22.9
Excellent	8	22.9	18	51.4	2	5.7
Not Present	19	54.3	0	0	16	45.7
Total	35	100	35	100	35	100

Symbols

The final category of observations involved the use of symbols. This category included the subheadings of: symbol placement, symbol representation, symbol spacing, and symbol orientation. The observed results revealed the following:

Symbol Placement. Symbol placement was the first element observed under the subheading of symbols (See Table 2-23). The observations of maps from the 1400's to 1800's recorded excellent to good use of text placement 57.1 percent of the time. Within the categories of moderate to poor, 17.1 percent of the observations were recorded. During the including the 1800's and 1900's, 51.4 percent of the observations occurred in the excellent to good group, and 21 percent of the observations occurred fell in the moderate to poor group. Within the observations of 1900's to 1960's maps, symbol placement was observed as excellent to good 65.7 percent of the time and moderate to poor, 20 percent of the time.

Table 2-23 Symbol Placement

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	2	5.7	3	8.6	2	5.7
Moderate	4	11.4	4	11.4	5	14.3
Good	13	37.1	9	25.7	20	57.1
Excellent	7	20	9	25.7	3	8.6
Not Present	9	25.7	10	28.6	5	14.3
Total	35	100	35	100	35	100

Symbol placement is another important aspect of cartographic design. Proper symbol placement helps a map to relay important geographic information. Observations revealed that symbol placement was excellent to good above 50 percent of the time across al three periods.

Symbol Representation. The next element was the use of symbol representation (See Table 2-24). The 1400's to 1800's map observations recorded a total of 51.4 in the excellent to good grouping and 22.9 in the moderate to poor group. During the period of 1800's to 1900's observations were excellent to good at 48.6 percent. Observations in the moderate category occurred 22.9 percent of the time. The category of poor recorded no observations for this time period. The time-period of 1900's to 1960 recorded excellent to good observations 48.6 percent of the time with moderate to poor occurring 37.2 percent of the time.

Table 2-24 Symbol Representation

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	3	8.6	0	0	5	14.3
Moderate	5	14.3	8	22.9	8	22.9
Good	12	34.3	5	14.3	7	20
Excellent	6	17.1	12	34.3	10	28.6
Not Present	9	25.7	10	28.6	5	14.3
Total	35	100	35	100	35	100

According to the criteria, the element of symbol representation was removed because observations revealed two time periods, 1800's to 1900's and 1900's to 1960's, where excellent to good observations did not occur more then 50 percent of the time.

Symbol Spacing. The next element of cartographic design was symbol spacing (See Table 2-25). Between the time-period of 1400's to 1800's 54.2 percent of the observations were recorded as excellent to good. Moderate to poor observations was recorded 20 percent of the time. In the time period of 1800's to 1900's, excellent to good observations produced a figure of 65.7 percent, with a total of 5.7 percent in the moderate category and no observations in the poor category. Within observations of the 1900's to 1960's, excellent to good observations occurred at 45.7 percent. Tabulations of the moderate to poor category produced scores of 40 percent.

Table 2-25 Symbol Spacing

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	3	8.6	0	0	6	17.1
Moderate	4	11.4	2	5.7	8	22.9
Good	13	37.1	14	40	12	34.3
Excellent	6	17.1	9	25.7	4	11.4
Not Present	9	25.7	10	28.6	5	14.3
Total	35	100	35	100	35	100

The use of symbol spacing was another element that did not reach 50 percent across all three time-periods and was eliminated from future study.

Symbol Orientation. The final element of the symbol subheading was the use of symbol orientation (See Table 2-26). For the period of 1400's to 1800's, observations in the categories of excellent to good occurred 51.4 percent of the time, and observations of the moderate to poor group revealed 22.9 percent. During the time-period of 1800's to 1900's, excellent to good observations occurred 65.5 percent of the time. While, moderate observations were displayed 5.7 percent of the time and poor observation had no recorded observations. The observations of 1900 to 1960 displayed excellent to good observations of 51.4 percent. Observations of moderate to poor occurred 34.3 percent of the time.

It has been stated that orientation is an important graphic variable of cartographic design. The results of observations displayed that symbol orientation was present above 50 percent of the time in all three time-periods.

Table 2-26 Symbol Orientation

	1400's to 1800's		1800's to 1900's		1900's to 1960's	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Poor	5	14.3	0	0	4	11.4
Moderate	3	8.6	2	5.7	8	22.9
Good	12	34.3	15	42.6	11	31.4
Excellent	6	17.1	8	22.9	7	20
Not Present	9	25.7	10	28.6	5	14.3
Total	35	100	35	100	35	100

Under the subheading of symbols four elements were observed. They included: symbol placement, representation, spacing, and orientation. Of the observed elements, two had to be removed for not reaching the criteria of 50 percent-- symbol representation and symbol spacing.

Marginal Information

The observing and recording of marginal information was handled differently then the other four categories. If the element was present then it was recorded as true, if it was not present then it was recorded as false. Under this category, if the element was not present above fifty percent of the time then it was not removed from consideration. The change in methodology was because map composition is a fundamental aspect of map design. Content in the margins of the map are used to disseminate important information about the map. However, earlier maps often did not incorporate these elements because their use had not yet been developed. All of the components of map composition are summed in the acronym TODAL-SIGS, which is historically a fairly new aspect of cartographic design.

The process of observing traditional maps was accomplished to develop the elements of traditional cartographic design. According to the research methodology, items that were not observed above fifty percent of the time across all three time-periods were eliminated. Elements that were consistent across all three times were used as a litmus test to see if they could be recreated by the observed desktop mapping programs. The remaining two sections of the chapter discuss the elements that were removed and the elements that were kept.

Elements Removed From Observations of Desktop Software

Many of the observed graphic elements of traditional cartography appeared more than fifty percent of the time. However, a number of elements were eliminated because they did not attain the research criteria. The following is a list of the elements that were removed from observations of desktop mapping:

Map Design

- Spacing between graphic elements
- Use of blank space

Map Insets

- Map inset size
- Whether the map inset was informative.
- Whether the map inset was relevant.
- The spacing between map insets.

Symbols

- Symbol representation
- Symbol spacing

These elements were removed from further consideration; this does not mean that they are not important to cartographic design. Spacing between graphics, the use of map blank space, as well as, incorporating map insets, and efficient symbol representations and spacing are important aspects of cartographic design. The observations were designed to focus in on elements that have consistently been used successfully and effectively. The only conclusion the author makes about these elements is that they did not appear consistently, according to the established methodology.

Elements of Traditional Cartographic Design

Elements that were observed and recorded more then 50 percent of the time across all three time-periods were considered consistent cartographic design principles. These observed design elements included:

Color

- Map designer's use of different colors to classify and organize map content.
- A cartographer's use of color to simplify and clarify map information.

- Designer's use of background colors to discern the figure ground relationship.
- Using different color values.

Map Design

- The proper balance and spacing of graphics and text.
- The placement of graphic components within the focus of attention of the user.
- Orientation of graphic elements with context to other features on the map.

Neat Lines

- Designing a map with a border to compartmentalize and structure information.
- Designing a map with different line weights to classify and organize information.
- Creating other neat lines to compartmentalize content.
- Using lines of different color to contrast them with surrounding lines and features.

Text

- The ability for the designer to place text anywhere on the map.
- Design freedom to rotate text so it can follow features.
- The freedom to space text differently from one letter to the next.
- Selecting text and typefaces that are legible.
- Using the proper text size when annotating a feature.

Symbols

- Designing a map that has symbols placed appropriately.
- Orientating symbols according to visual balance and clarity.
- The incorporation of marginal information into a map composition.

The author believes that the preceding elements are the root elements of effective cartographic design. The efficient use of these elements with a sense of purpose and design foresight will help to produce aesthetic maps. That is why software programs need to be able to accommodate these elements.

The process of designing a map is a complex undertaking that involves creativity and aesthetics, organization and planning, and specifications and generalizations. Effective cartographic design combines colors, lines, text, symbols, and marginal information with design principles, graphic variables, and map composition. Observations of traditional maps were accomplished to format an idea about the process and elements involved in map design. Conclusions about traditional design elements were used to structure the research and develop questions to learn to what degree these elements have been accommodated by desktop mapping programs. Chapter Three incorporates these conclusions into an overview of desktop mapping design and software.

CHAPTER 3

CARTOGRAPHIC DESIGN IN DESKTOP CARTOGRAPHY

An Overview

The use of desktop software has prompted a major change in the way maps are designed and produced. Desktop mapping programs require a minimal amount of training, thereby bringing the technology to a wider audience. Computers are used as tools to make the creation of maps easier for the cartographer and the noncartogapher. With a little amount of time just about anyone can make a map. Map makers no longer have to be (professionally trained) cartographers. This major change is the catalyst for the present cartographic revolution.

This revolution involves the loss of professional control by cartographers. They no longer exercise the power over map production that they did in the past. In the past, the printed map was the sole product, and cartographers controlled every bit of information. The user could only extract information that the cartographer chose to include. With computer cartography, the situation is entirely different. Users can now select the information that they want to include on a map.[1]

The wide spread use of computer technology, coupled with the lack of training, has had an effect on cartographic design. Basically, design lags behind the technological potential. This is because design elements of the technology are not associated with traditional cartography. The future reveals that the skills and expertise of cartographers will be less defined. "To a large extent the expertise of cartographers will be codified in the mapping software and data structures available to nonprofessionals."[2]

It seems that the primary designers of the mapping software are programmers, not

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[1]Robinson and others, *Elements of Cartography,* 6.

[2]Ibid.

cartographers. Because of this, the elements of cartographic design are not inherently visible or available to the untrained user. Since untrained mapmakers increasingly use the software, it is important that design elements be easily communicated. Software programmers are more concerned with being able to accomplish a certain function than with asking and explaining why that function is being accomplished.

The goal of the research is to examine current mapping programs and to assess the ability of each to reproduce established design elements. In order to record and gauge the extents of traditional cartographic design in desktop mapping, a Desktop Mapping Observation Form was created.

Description and Explanation of the Desktop Mapping Observation Form

The Desktop Observation Form was used to systematically collect, organize, and store information intended to summarize the software's ability to accommodate traditional methods of map design (See the observation form in Appendix B, pp). A series of tasks and questions involving graphic elements, help files, and templates and samples were put forth to the software. These questions were intended to concentrate on the elements stated by the author at the end of Chapter 2. The ability of the software to accomplish and address these tasks and questions were recorded as yes or no answers. Tabulated results of these observations were used to delineate the traditional elements of cartographic design present within the software.

Pretesting

Prior to using the form to collect data, it was pretested by the author. The pretest of the observation form involved three individuals who were novices to the world of computer mapping. The researcher gave the participants an observation form and asked them to use the form on ArcView software. They were asked to open a sample map and to answer the questions associated with the software. The author polled the participants for input as to how the form worked and if anything seemed unclear or ambiguous. The author also sent the observation form to two cartographic professionals and asked them to use the form in the same manner. The suggestions from the participating professionals and novices were used to update the form. The form was then used to observe and record elements of cartographic design evident in the eight selected desktop mapping programs.

Graphic Elements

The software's ability to reproduce the graphic elements of traditional cartographic design with programmed graphic functions was observed. The graphic elements to be examined in each software packages included: color, map design, neat lines, text, symbols, and marginal information.

- Color: Subclassed into the following elements: the use of different colors, the use of different color values, and the creation of background color.
- Map Design: Subclassed into the following elements: the look of graphic elements, spacing of graphic elements, resizing of graphic elements, introduction of illustrations (non-spatial features), changing the orientation and angles of graphic elements.
- Neat Lines: Subclassed into the following elements: the creation of borders, creation of other neat lines, creation of different line symbols, creation of different sized lines, creation of different colored lines.
- Text: Subclassed into the following elements: placement of text anywhere, free manipulation of text, different text sizes, different text typefaces, the creation of different colored text.
- Symbols: Subclassed into the following elements: rotation of symbols, use of different symbols, and different colors.
- Marginal Information: Subclassed into the following elements: automatic creation of a scale, a north arrow, a title, and a graticule or grid.

The objective of the research, and the intention of the observation form, was not only to distinguish if the graphic elements of cartographic design were accommodated but to also evaluate other aspects of the software, namely, help files, and templates and samples.

Help Files

All desktop mapping programs contain help files. The research questioned whether the help files contain information about cartographic design. The author reviewed the files by indexing twenty-four key words associated to design. The key words were recorded as either present or absent (yes/no). If a close association to the word was located or if the meaning of another word was close in content, then it was recorded as present (yes). Help files were queried for the following words: background, balance, border, cartographic design, color, value, hue, data source, focus of attention, graphics, graticule, grid, map design, neat lines, north arrow, orientation, parts of a map, rotation, scale, spacing, symbols, text, title, and typeface.

Templates and Samples

The final category of the desktop observation form was an evaluation of templates and samples. If the software had templates, they were examined to see if they led the user towards proper map design. See Figure 3-1 for an example of an ArcView template. If templates existed, they were reviewed for the following elements: introduction of text, graphics, legends, titles and other cartographic design elements. The software was also reviewed to see if sample maps existed. If sample maps existed, they were reviewed to see if they showed a full map layout.[3] The results of this category were also recorded with yes and no answers.

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[3]A full map layout included: title, legend, scale, author, date, grid, orientation.

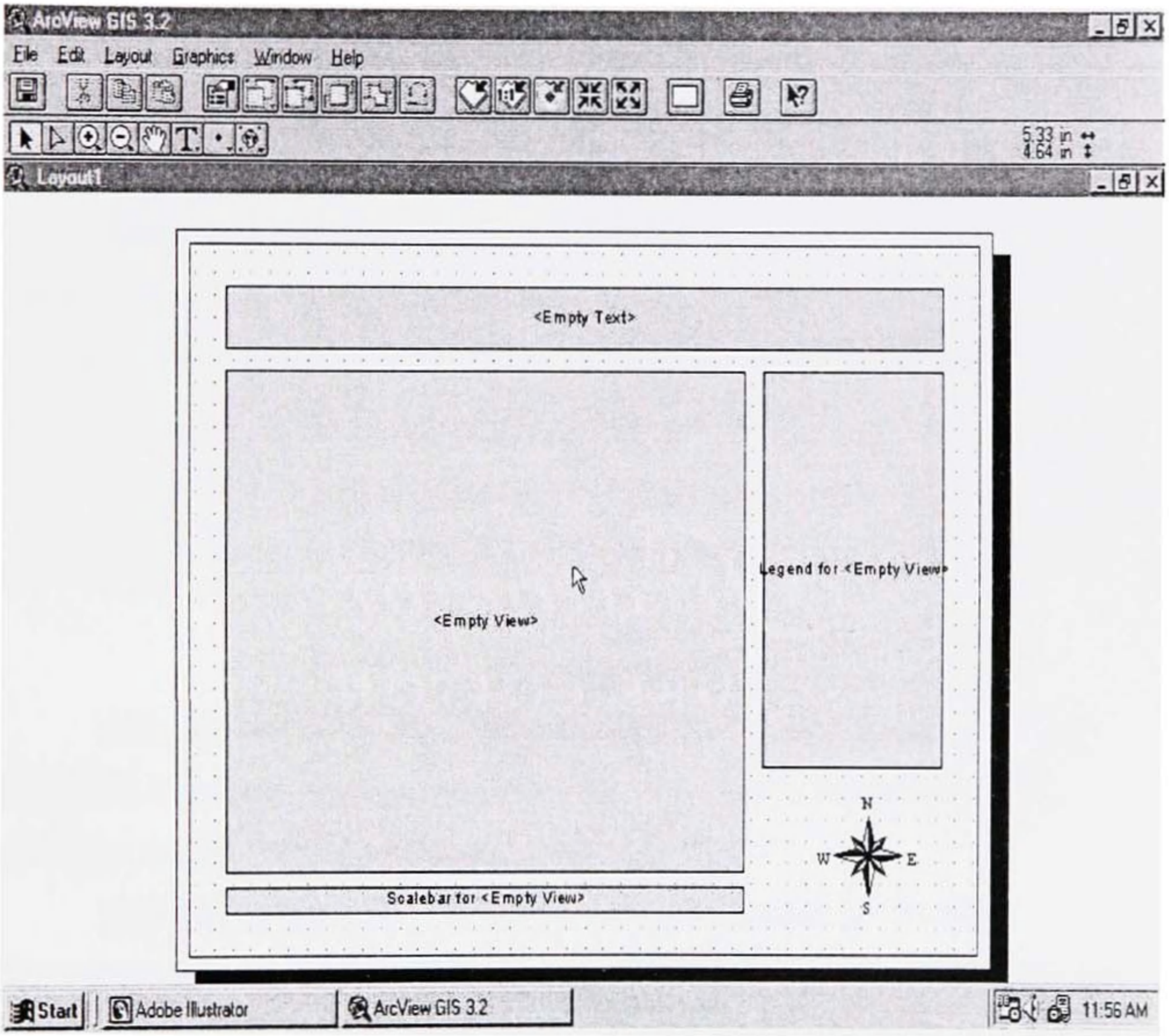

Figure 3-1 Capture of ArcView Template[4]

[4]The image was captured with a program called Snag-It (advanced screen capture) designed by the software company Techsmith Corporation (copyright 1995-1999). All the figures displayed in this chapter were captured with Snag-It. This particular capture was taken from ArcView software, designed by Environmental Systems Research Institute of Redlands, CA. 92373-8100.

Selected Desktop Mapping Software

Criteria for Software Selection

The popularity and capabilities of desktop mapping programs has increased during the last ten years. These programs are designed to be used on personal computers that have limited data storage capacity. Their primary purpose is to produce maps; they are not designed to support large cartographic organizations. These programs do not handle complicated data management, analysis, and large format map production.[5]

There is an ever-increasing amount of desktop mapping programs currently on the market. It would be a Herculean task to review and analyze all of these desktop programs. For the purpose of this research, an arbitrary selection of desktop mapping programs was selected based on availability. All of the observed programs were designed to be used on personal computers. The programs allow for maps to be compiled and produced with very little knowledge of, or training in, how they worked.

The Software

Available software used for the study included; ArcView, AutoCAD, IDRISI, Illustrator, Maptitude, MapViewer, MicroCAM, MicroStation. Table 3-1 lists the software programs, the company name, address, and email.

ArcView (Version 3.2). ArcView is a software program developed by Environmental Systems Research Institute of Redlands, California. See Figure 3-2 for a screen capture of the ArcView Graphic User Interface (GUI). ArcView is a desktop mapping program that allows the user to select and display different combinations of data.[6]

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[5]George B. Korte, *The GIS Book* (Santa Fe: OnWord Press, 1997), 94.

[6]Ibid., 173.

Table 3-1

Software	Companies Names & Addresses	http: Addresses
ArcView	Environmental Systems Research Institute 380 New York Street Redlands, CA. 92373-8100	www.esri.com
AutoCAD	AutoDesk, Inc. 111 McInnis Parkway San Rafael, CA. 94903	www.autodesk.com
IDRISI	Clark Labs/Clark University 950 Main St. Worcester, MA. 01610-1477	www.clarklabs.org
Adobe Illustrator With MAPublisher	Adobe Systems Incorporated 345 Parl Avenue San Jose, CA. 95110-2704	www.adobe.com
Maptitude	Caliper Corporation 1172 Beacon Street Newton, MA. 02458	www.caliper.com
MapViewer	Golden Software, Inc. 809 14th Street Golden, CO. 80401-1866	www.golden.com
MicroCAM	Dept of Geography and Environmental Engineering United States Military Academy West Point, New York	ftp.usma.edu
MicroStation	Bentley Systems Incorporated 685 Stockton Drive Exton, PA. 19341-0678	www.bentley.com

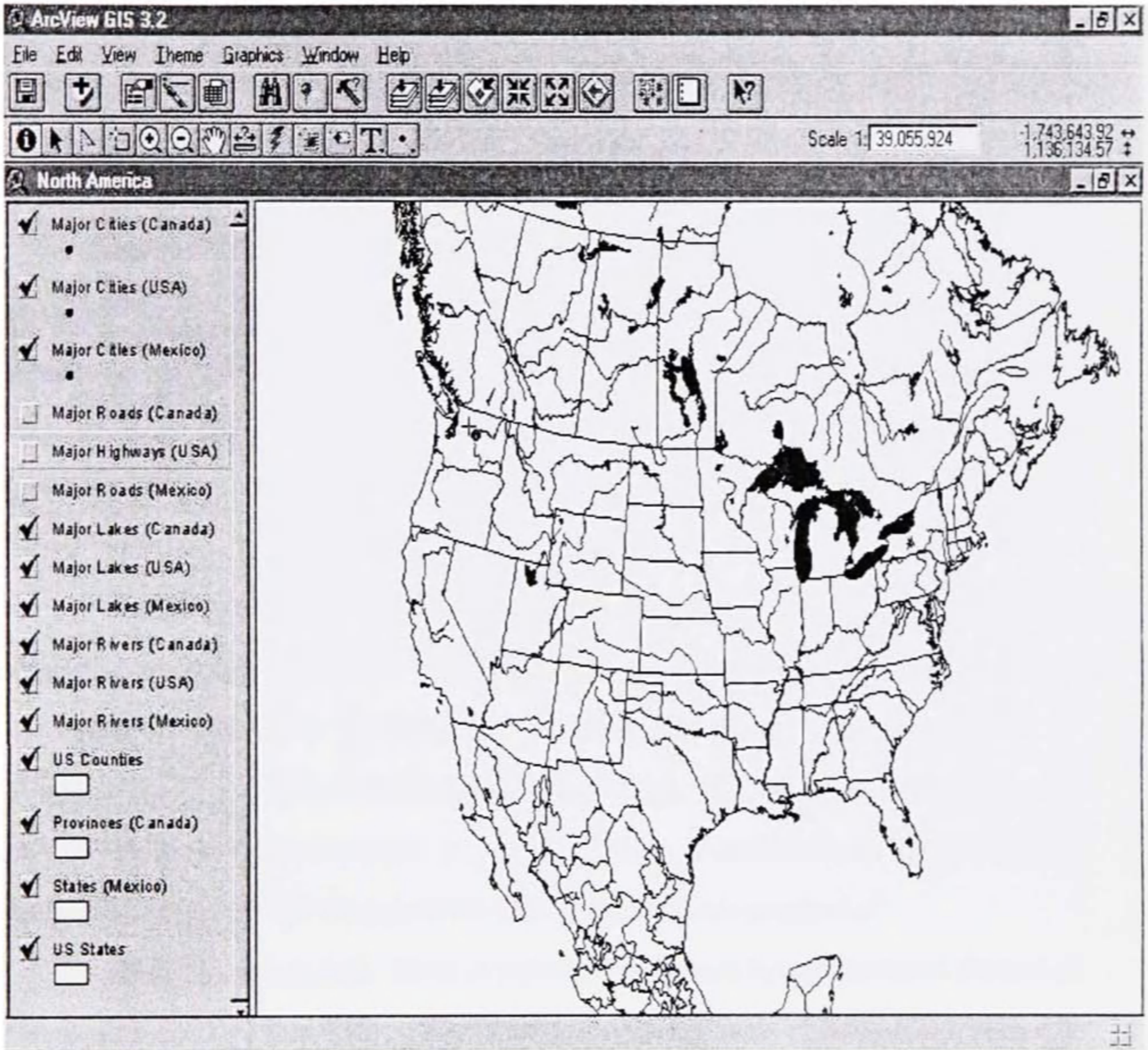

Figure 3-2 ArcView GUI[7]

[7] This capture was taken from ArcView software, designed by Environmental Systems Research Institute of Redlands, CA. 92373-8100.

> ArcView is integrated with other applications, creating an environment for analysis and desktop publishing, spreadsheets, database, word processing, publication graphics, and other software applications that extend the functionality of ArcView."[8]

ArcView has strong table functions that allow for the importation of different database formats (dbase, excel, txt.). The program allows for the creation of vector data files as well as Raster and TIN representations of the geographic surface.

AutoCAD (Version 14). AutoCAD is the leading Computer Added Design (CAD) program on the market. AutoDesk of San Rafael, California developed the program. See Figure 3-3 for a screen capture of AutoCAD GUI. The program was designed to produce engineering drawings and incorporates a large amount of graphic precision. AutoCAD was not originally designed for desktop mapping, but during the years it has been used extensively for that purpose.

AutoCAD is designed with drawing tools that automate the tasks of drawing lines, symbols, and graphic elements. The software creates presentation quality drawings that can be used to plot maps. Data is stored in .dxf file format and can be transported throughout a great number of other software products. The program can also import a number of other file formats such as .gif, .jpeg, .bmp. A series of xref enhancements make sharing AutoCAD files possible with other software programs.[9]

IDRISI (Version 2.0). Idrisi is software developed by the Graduate School of Geography at Clark University. The Clark Laboratories is an education and research facility located in Worcester, Massachusetts. The laboratories develop, distribute, and support the geographic analysis and image software named IDRISI. See Figure 3-4 for a screen capture of the IDRISI GUI. It is primarily used for surface analysis and

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[8]Ibid.

[9]xref, is an across platform reference system that allows other software applications the capability to view and manipulate AutoCAD files.

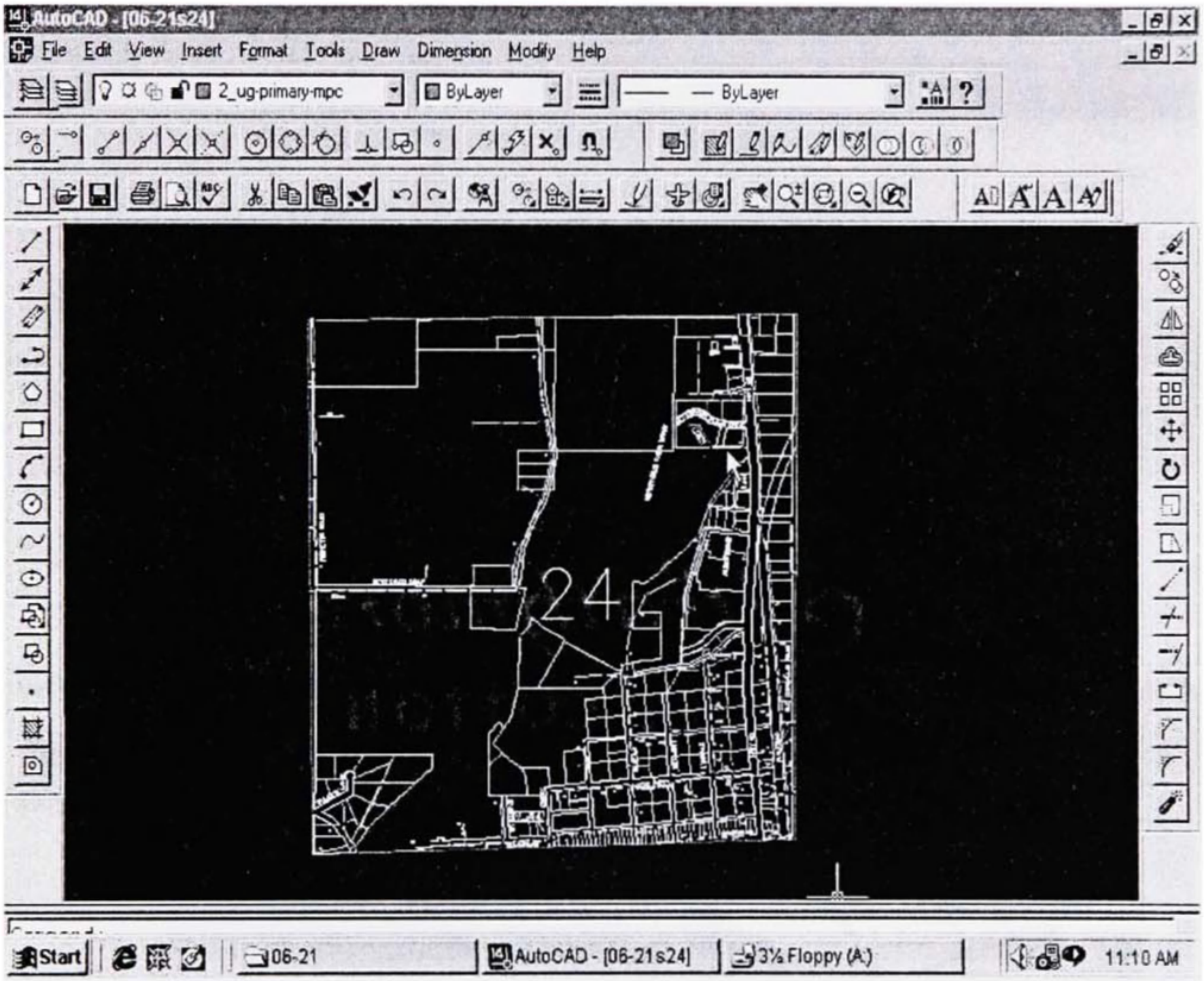

Figure 3-3 AutoCAD GUI[10]

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[10]This particular screen capture was taken from AutoCAD software, designed by AutoDesk, Inc. San Rafael, CA. 94903.

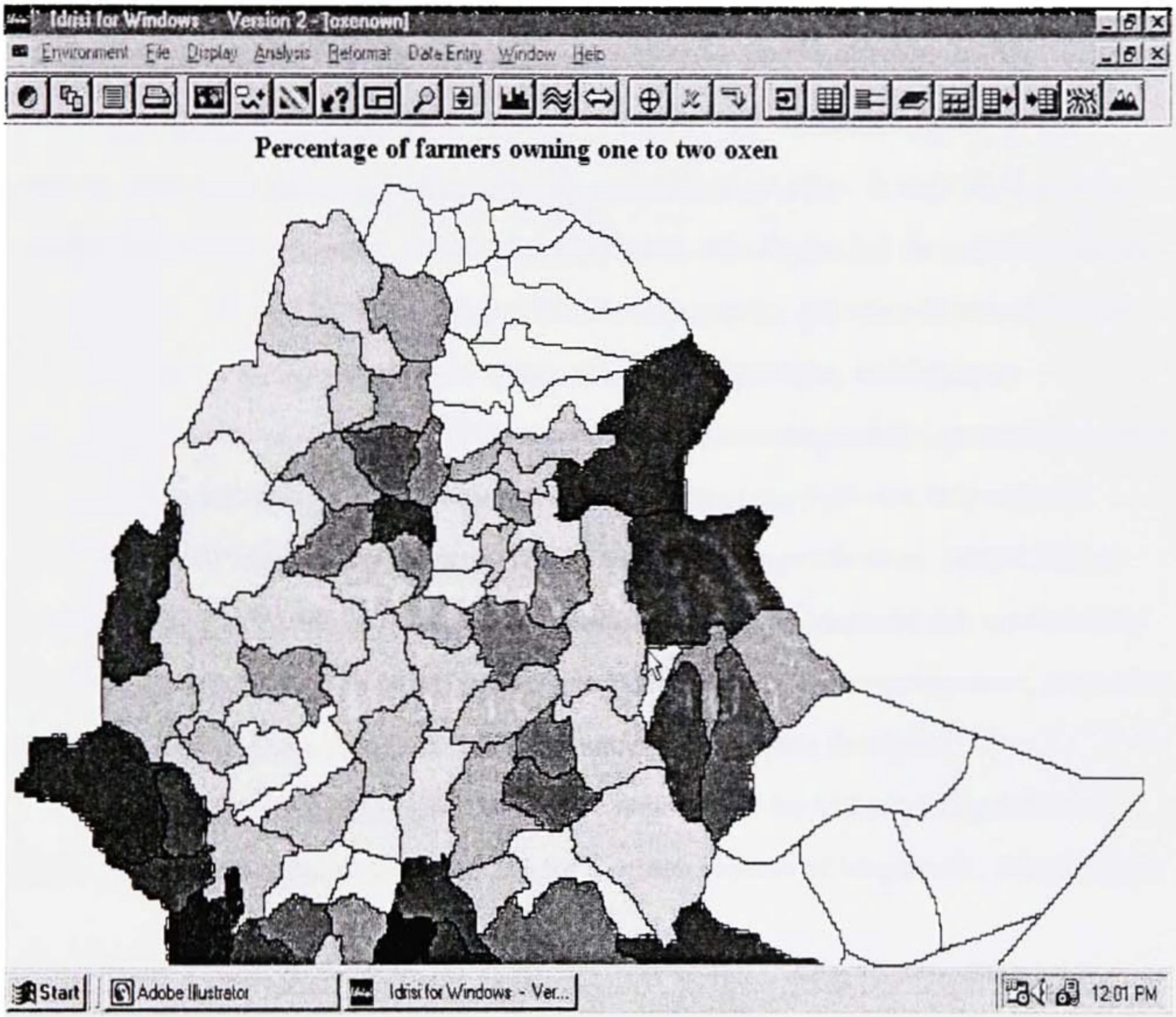

Figure 3-4 IDRISI GUI[11]

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[11]This screen capture was taken from IDRISI software, designed by Clark Lab/Clark University of Worcester, MA 01610-1477.

monitoring of environmental issues.[12] It is well suited to handling images from aerial photographs, mulitspectral satellite imagery, and manipulating Digital Elevation Models (DEM's). IDRISI is designed to be easy to use while providing professional level mapping capabilities on Windows-based personal computers.[13] Just about all major data formats can be imported into IDRISI software.

Adobe Illustrator with MAPublisher (Version 7.0). Illustrator is one of the leading illustration software produced in the United States today. It was developed by Adobe Systems Incorporated in San Jose, California. See Figure 3-5 for a screen capture of Illustrator. Adobe Illustrator along with other illustration software (Freehand, Corel Draw) is used by designers, graphic artists, technical illustrators, and business professionals the world over.[14] The program offers advanced graphics, presentation, print and image capabilities. It is not considered desktop mapping software, but with the addition of MAPublisher the software can be used for map production. MAPublisher allows for the production of cartographic quality maps in the graphics rich environment of Illustrator software. The MAPublisher plug-in allows for data management, projection conversion, three dimensional analysis, and other cartographic functions.[15]

Maptitude (Version 4.0.3). Maptitude is produced by Caliper Corporation of Newton, Massachusetts. See Figure 3-6 for a screen capture of Maptitude. Maptitude is

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[12] *Overview,* on the Clark Labs web page, par 2 [cited 29 February 2000]; available from World Wide Web http://www.clarklabs.org/03prod/overview.htm

[13] Ibid., par3.

[14] *Adobe Illustrator,* on the Adobe Illustrator web page, par 1 [cited 29 February 2000]; available from World Wide Web http://www.adobe.com/products/illustrator/main.html

[15] *Plug-ins for Adobe Illustrator,* on the Adobe Illustrator web page, par 1 [cited 29 February 2000]; available from World Wide Web http://www.golive.de/products/plugins/illustrator/mapublisher.html

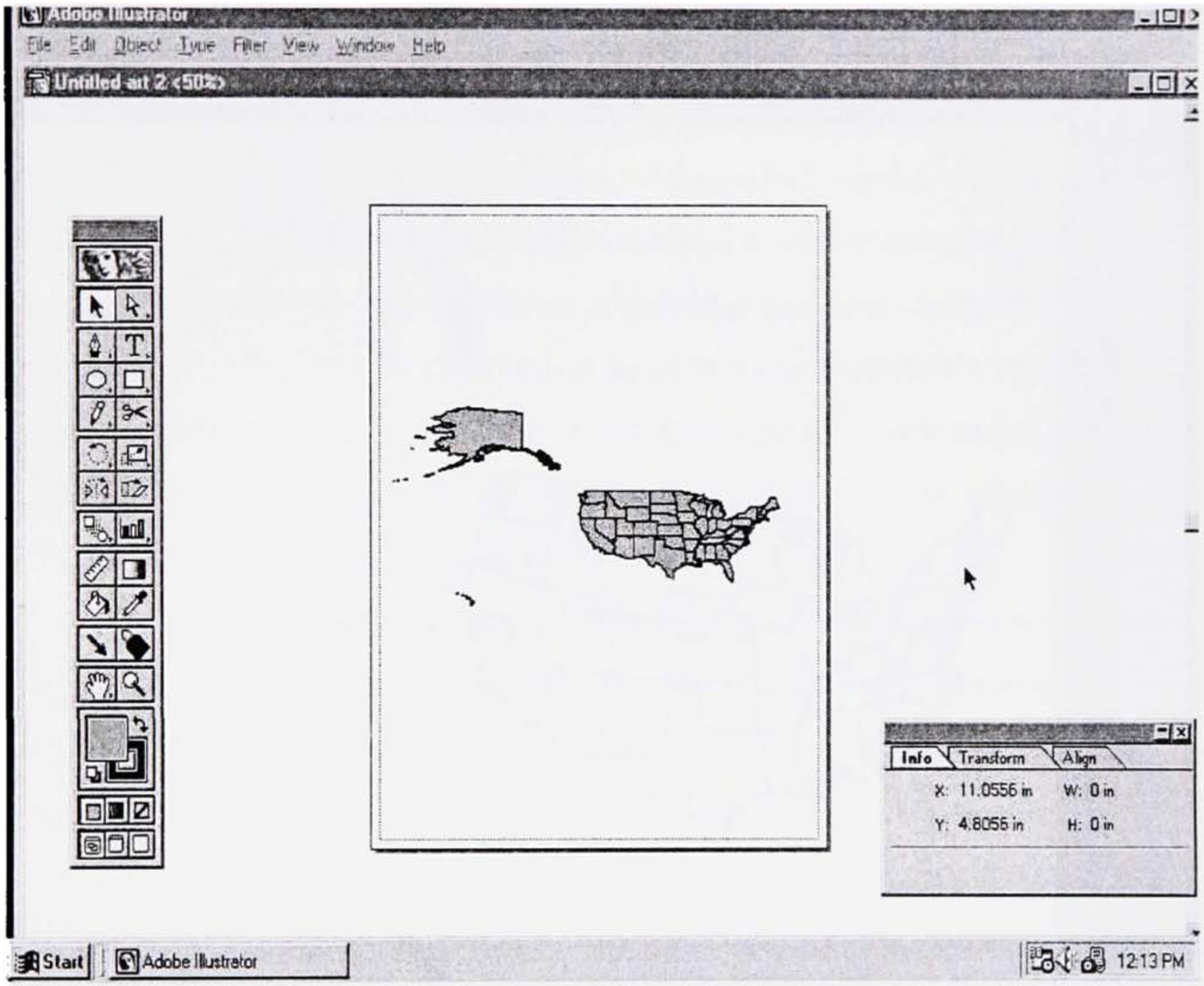

Figure 3-5 Illustrator GUI[16]

[16]This screen capture was taken from Illustrator software, designed by Adobe Systems Incorporated San Jose, CA. 95110-2704.

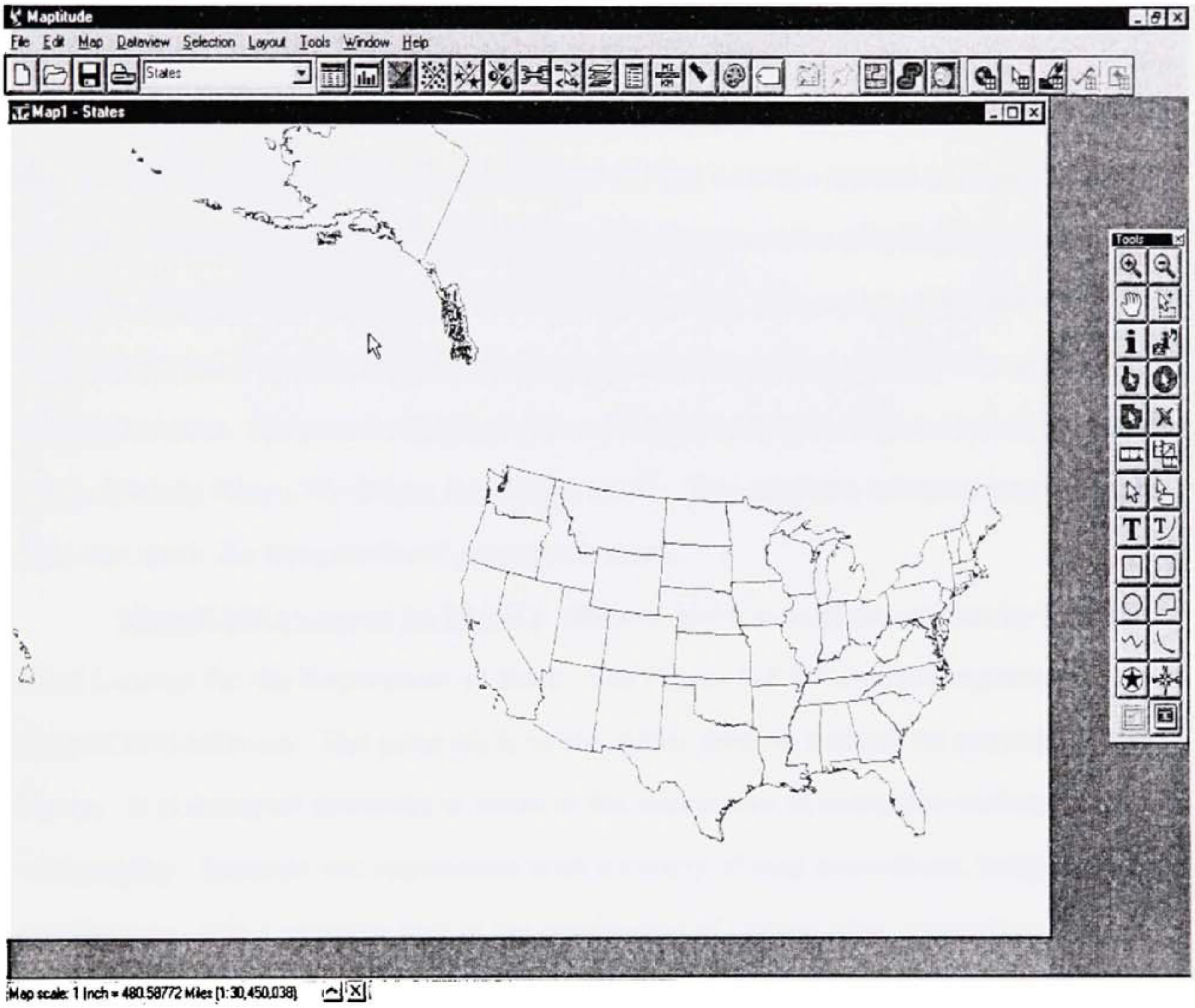

Figure 3-6 Maptitude Capture[17]

[17]This screen capture was taken from Maptitude software, designed by Caliper Corporation Newton, MA. 02458.

a capable, accessible, and affordable mapping package for Windows Operating Systems.[18] The software is designed for data visualization and geographic analysis. It incorporates expanded functionality, technology and ease of use to produce quality maps. Maptitude comes with a comprehensive library of worldwide and nationwide maps that include, streets, census, ZIP codes and demographic data.[19]

MapViewer (Version 3.0). MapViewer has been developed by Golden Software Inc. located in Golden Colorado. See Figure 3-7 for a screen capture of MapViewer software. Golden Software has grown to be a leading provider of scientific graphics software that serves researchers in mining, engineering, geography, and medicine.[20] MapViewer is a thematic mapping program that is designed to produce a map from geographic data. Data can be displayed in a series of thematic formats including, Hatch Maps, Density Maps, Pie Maps, Bar Maps, etc.[21] The software includes many sample files that show the boundaries of geographic areas.

MicroCAM (Version 95/98/NT). MicroCAM is a program written by Colonel Scott Loomer for the Department of State. See Figure 3-8 for a screen capture of MicroCAM software. The program is in the public domain and can be acquired free of charge. It is designed primarily to assist in the instruction of computer-assisted cartography. Students can experiment with a variety of map projections, mapping tools, and formats. It is a valuable tool in the conducting of cartographic instruction and evaluating student work.[22]

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[18] *About Caliper,* on the Caliper Corporation web page, par 5 [cited 29 February 2000]; available from World Wide Web http://www.caliper.com/ovuabout.htm

[19] Ibid.

[20] *About Golden Software,* on the Golden Software web page, par 3 [cited 29 February 2000]; available from World Wide Web http://www.golden.com/learn.htm

[21] Ibid., par4.

[22] *Introduction*, par 4 [cited 29 February 2000]; available from World Wide Web http://wolf.its.ilstu.edu/MicroCAM/intro.htm

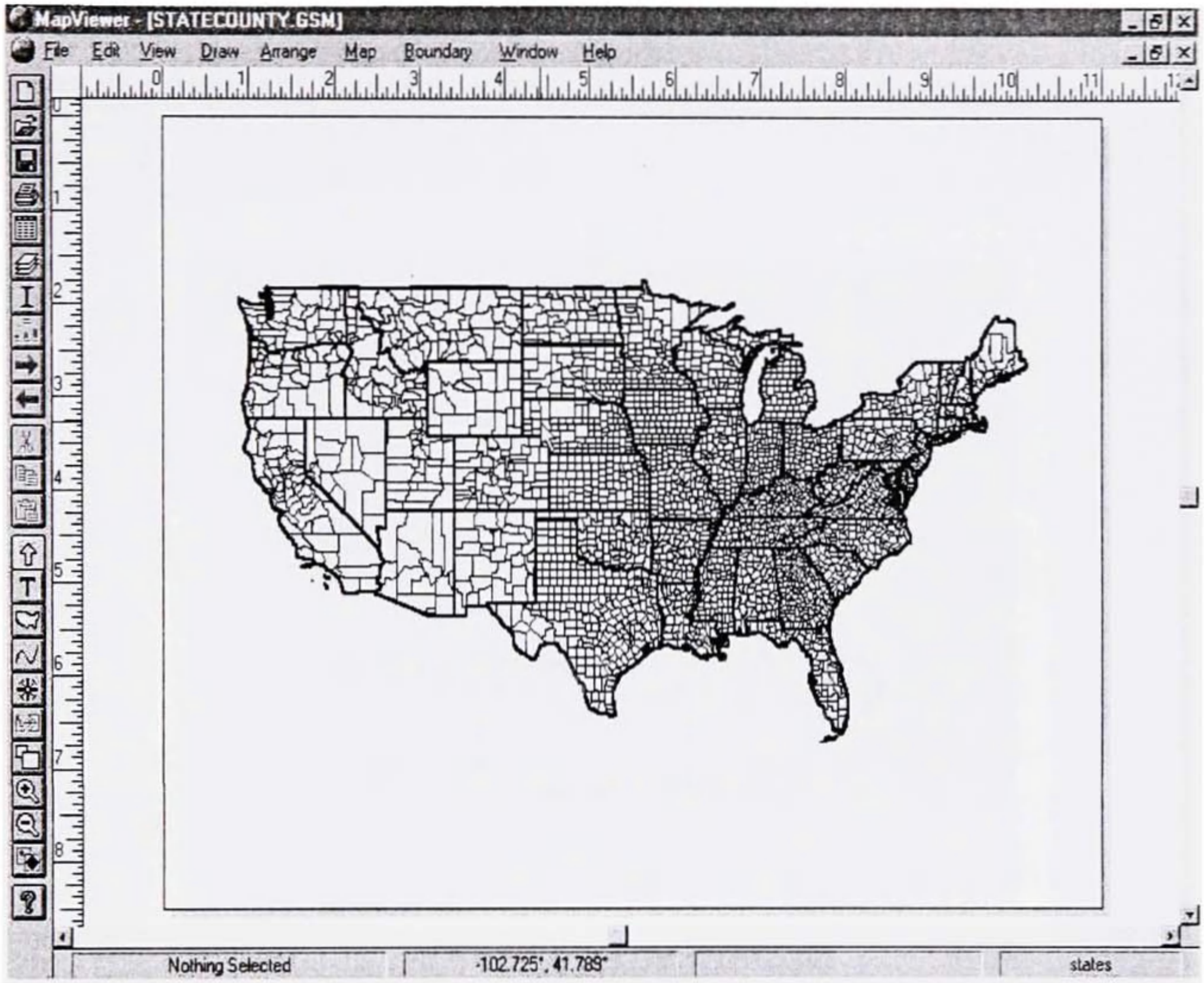

Figure 3-7 MapViewer GUI[23]

[23]This Screen capture was taken from MapViewer software, designed by Golden Software Inc. Golden, CO 80401-1866.

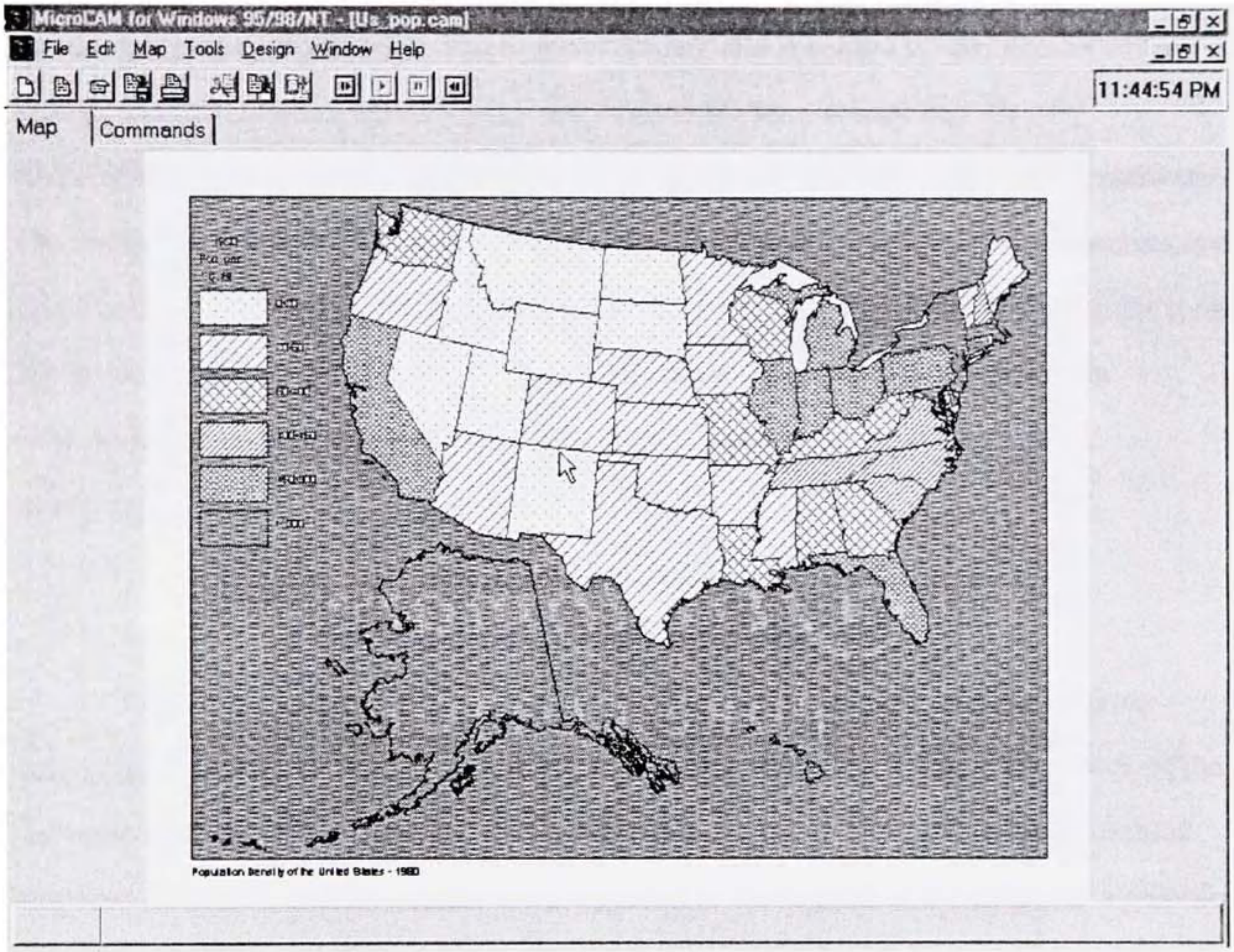

Figure 3-8 MicroCAM GUI[24]

[24]This screen capture was taken from MicroCAM software, designed by Dept of Geography and Environmental Engineering, United States Military Academy West Point, New York.

MicroCAM is designed to generate reference maps of any region of the world. The software allows for interaction with the maps and displays the results in high resolution that can then be printed. Produced maps can be exported as Windows bitmaps or in several other industry standard exchange formats.

MicroStation (Version 7.01). MicroStation is developed by Bentley Systems Incorporated of Exton, Pennsylvania. See Figure 3-9 for a screen capture of MicroStation GUI. Bentley Systems is a worldwide distributor of engineering software. The company serves professionals in building and plant engineering, geoengineering and construction.[25] The software encompasses aspects of geoengineering, and provides tools that design, build, and operate cartographic features. MicroStation software has incorporated powerful client/server, Web, mobile devices, and spatial database technologies. [26]

Conducting the Software Observations

The author proceeded to conduct observations on the eight selected desktop mapping programs. According to the methodology outlined in Chapter One, each of the software systems was used to produce a map from available date sets. The assembled map was observed, and the results were recorded to distinguish if the software's graphic functions, help files, and templates and samples accommodated elements of traditional cartographic design. The recorded results of each observation were combined in Excel spreadsheets. The spreadsheets were organized by software, and by answers to the questions and tasks put forth. The results of the observations can be viewed as the tables generated in Chapter Four.

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[25]*Bentley Corporate Background,* on the Bentley web page, par 2 [cited 29 February 2000]; available from World Wide Web http://www.bentley.com/bently/ backgrnd.htm

[26]Ibid.

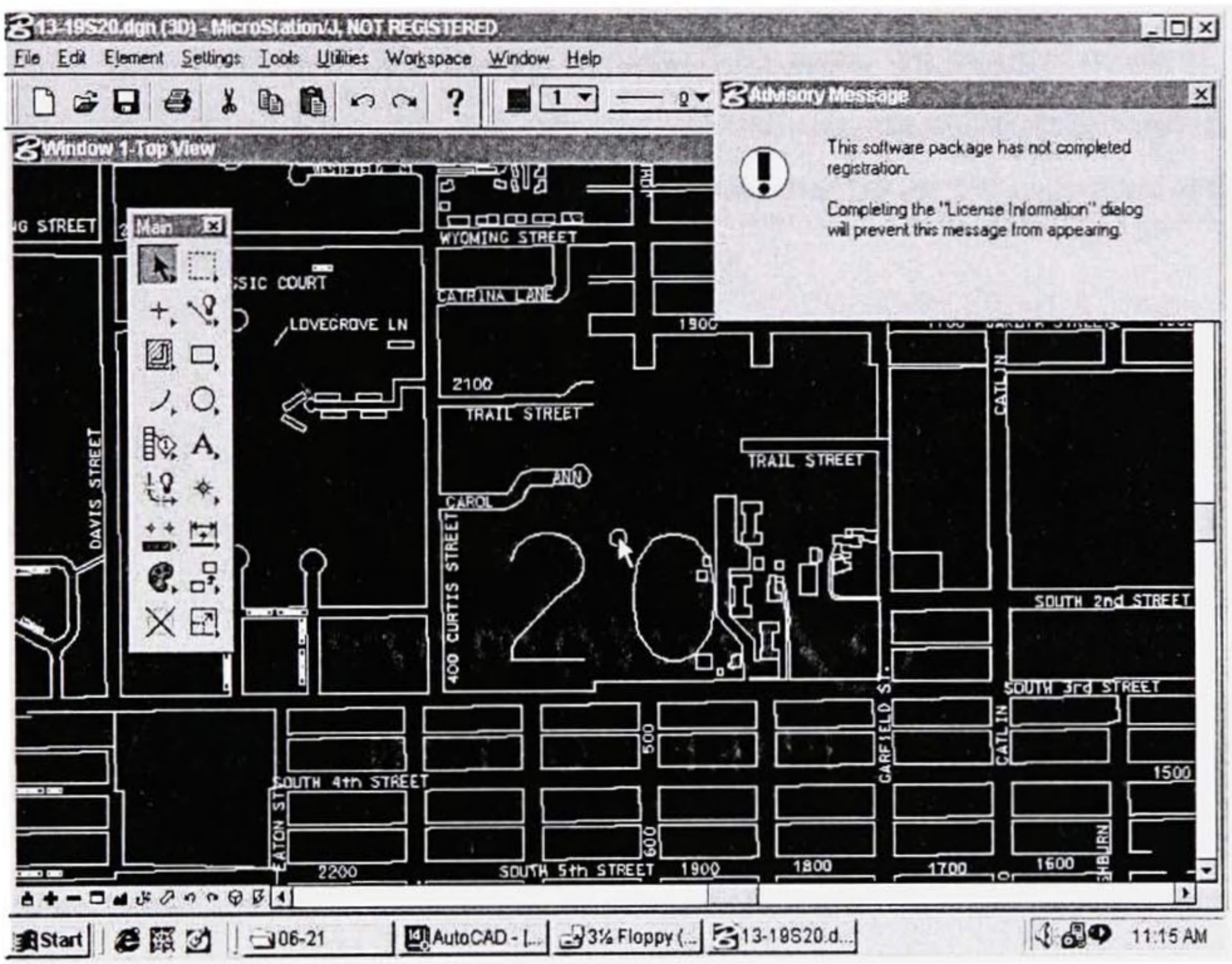

Figure 3-9 MicroStation GUI[27]

[27]This screen capture was taken from MicroStation software, designed by Bentley Systems Incorporated Exton, PA. 19341-0678.

Conclusion

Traditional design elements established in Chapter Two were used to develop a desktop observation form. The forms function was to record to what degree these elements have been accommodated by desktop mapping programs. Eight different mapping programs were selected and observed with the form. The tabulated results of these observations were used to delineate the traditional elements of cartographic design at hand within the software. A presentation of the tabulated results and an analysis of the software capabilities were addressed in Chapter Four.

CHAPTER 4

RESULTS AND ANALYSIS

Examining the Results

In order for a computer-generated map to communicate effectively, elements of traditional cartography need to be part of the software's design and function. As stated earlier, the purpose of this study is to examine the developments of cartographic design in manual cartography and to assess if present desktop mapping programs can accommodate these design elements. In conducting the research, traditional elements of cartographic design were established from observations of historic maps. Then, eight software systems were observed to evaluate their ability to accommodate traditional cartographic design elements.

Results from the observations of the mapping software are presented in this chapter. The following is a discussion and analysis of the different selected elements of cartographic design. The elements included: color, map design, text, neatlines, symbols, marginal information, help files, and templates and examples. Each of these elements, along with the selected questions, is discussed in detail. After the results were presented, conclusions connected to the research were presented in Chapter 5.

As mention earlier, Tables were generated in Excel to illustrate the results of the observations. All the recorded observations of graphic elements, help files, and templates and samples were recorded with yes or no answers. The tables visually demonstrate how the eight software packages compared to one another. The goal was not to pick the best software package but to develop an overview of the current design capabilities of desktop mapping; each has its own plusses and minuses. The connections between traditional and desktop mapping centered on the software's abilities to recreate the elements of traditional design. How the two relate addresses the problem statement.

Connections between Traditional and Desktop Mapping

Color

Selecting color can be one of the hardest and most challenging aspects of map design. In traditional cartographic design, from the 15^{th} century on, the use of color within maps became a common practice. Entire trades were developed that involved the hand coloring of maps. With the growth of lithography printing, techniques for printing with color were developed. The development and employment of color theories has extended from the Renaissance to current map production. Therefore, it is important that the software have a variety of color options available to map designers.

The first question put to the software was whether different colors could be added to the map design. Observations revealed that all eight of the software programs allowed for the use of different colors or hues (See Table 4-1).[1] Most of the software programs had a large variety of color palettes and offered plenty of color choices. Colors could be picked from a symbol window or created directly from red, green, and blue values. Default color schemes were also available for many of the primary colors.

Did the software allow for the use of different color values? As stated earlier, color value is the quality of lightness or darkness that can be represented in different hues. The ability to create different color values or shades was also fairly consistent in

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[1]Hue is the various colors recognized as: reds, greens, browns, blues, etc.

all the software. Only MicroCAM would not allow for the use of different shades. Adobe Illustrator was by far the best software, even allowing for different percentages of a color value.

Table 4-1 Color Observations

COLOR	ArcView		AutoCad		Idrisi		Illustrator		Maptitude		MapViewer		MicroCam		MicroStation		Total	
Does the software allow:	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
Different colors?	✓		✓		✓		✓		✓		✓		✓		✓		8	0
Different color values?	✓		✓		✓		✓		✓		✓			✓	✓		7	1
Background colors?	✓		✓		✓		✓		✓		✓			✓	✓		7	1
Total	3	0	3	0	3	0	3	0	3	0	3	0	1	2	3	0	22	2

Could the software create background colors? All the observed programs except for MicroCAM allowed for the changing of the background color. Each program had a color palette that controlled the fill color of the background. Clicking the desired color with the mouse changed the background. Most of the software permitted a user to switch between the foreground and background colors.

The capability of the software to generate different color, different color value, and background color is an important aspect of computerized cartographic design. In general, all of the software programs, except MicroCAM, created and employed a variety of color capabilities, allowing for the fullest potential in map communication. A total of 24 questions were put to the software. The ability to create these elements was answered in the affirmative 22 times.

Map Design

Map design focused on the manipulation of elements and the software's ability to arrange and organize these elements. Map design related to the map's total look. How the graphic variables, and map composition items represented important shapes, features, names, and relationships.

The programs were first tasked with the question; does the software allow for changing the look of the graphics (See Table 4-2). Changing the look of the graphics meant that a feature could be edited or deleted. Could graphic elements be separated and rearranged? All the software packages except for Maptitude and MicroCAM allowed for graphic elements to be altered and moved.

Table 4-2 Map Design

MAP DESIGN	ArcView		AutoCad		Idrisi		Illustrator		Maptitude		MapViewer		MicroCam		MicroStation		Total	
Does the software allow:	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
Changing the look of graphic elements?	✓		✓		✓		✓			✓	✓			✓	✓		6	2
Different spacing of graphic elements?	✓		✓		✓		✓			✓	✓			✓	✓		6	2
Resizing graphic elements?	✓		✓		✓		✓		✓		✓			✓	✓		7	1
Introduction of Illustrations?		✓	✓		✓		✓		✓		✓			✓	✓		6	2
Changing the orientation and angles of graphic elements?		✓	✓			✓	✓			✓	✓		✓		✓		5	3
Total	3	2	5	0	4	1	5	0	2	3	5	0	1	4	5	0	30	10

Could graphic elements be spaced differently? It is important to be able to place and move graphics anywhere on the map. The designer should be able to arrange elements so that they are visually balanced. Of the observed software, only Maptitude and MicroCAM did not allow for the free manipulation of graphics.

Did the software give the user the ability to resize the graphic elements? Larger objects attract more attention and can be visually contrasting to smaller objects. The ability to resize graphic objects allows for design segregation and impact. MicroCAM was the only software program that did not allow for the resizing of graphic elements.

Did the software allow for the introduction of illustrations? Illustrations are items that were scanned or drawn and then imported as a generic digital format such as jpegs, gifs, or bitmaps. The ability to import illustrations adds clarity, relevance, and artistic expressionism to computer designed maps. Many of the mapping programs allowed for the importation of one or many of the generic forms of illustrations. ArcView and MiroCam were the only two programs that did not allow for the importation of illustrations.

The final question under the category of map design was if the software allowed for the changing of orientation and angles of graphic elements. By changing the angles and rotation the designer can attract attention to the objects, thus stressing the importance or uniqueness of the element. ArcView, IDRISI, and Maptitude did not allow the free rotation of objects in any direction. The other programs did allow the rotation of angles and direction imposing a visual contradiction to surrounding subject matter.

Map design relates to the map's total expression. Effective design articulates important information with diverse spacing, sizes, symbols, shapes, and orientations. In addition, design should involve crisp, clean, and sharp contrasts that balance and clarify the map content. The observations revealed that in general the software did a good job at allowing for the manipulation of graphic elements. Of the 40 total questions put to the eight programs, 30 were answered in the affirmative. Only the ability to orient the graphic could not be accomplished by more then two of the programs.

Neat Lines

Recorded observations concerning the use of borders and neat lines are addressed in this section. Lines offer a variety of choices and uses on a map. They can function as different graphic devices to organize and communicate information. Along with color, lines can contrast each other in two ways: line style and line weight. Line style refers to the way the line is drawn. It can be solid, dashed, dotted, doubled, etc. to mention only a few. Line weight refers to the thickness of the line to other lines and elements.

The software was examined to see if it allowed for the creation of a border (See Table 4-3). The use of a border helps to contain, compartmentalize, organize, and structure spatial information. All of the eight observed software programs allowed for the creation and resizing of a border and neat lines.

Were other neat lines able to be created? Neat lines work in the same fashion as a border to compartmentalize and clarify map information. Of the observed software, all eight were able to create and adjust different neat lines.

Did the software allow for the creation of different line symbols? The use of different line symbols constructs a visual classification and hierarchical structure. Line symbols used to portray spatial features are easy to find on most maps. Such symbols include roads, coastlines, and contour lines. It is important to have a variety of line symbols available so that contrast and disparity can be established. All eight of the observed software programs allowed for a creation of different line symbols.

Were different sized lines able to be created? It is important for different sized lines to be created because dissimilar lines can be used to denote importance and order. Map clarity and communication can be enhanced with the use of dissimilar line weights.

Regarding this task, seven of the eight mapping programs were able to create different sized lines. Only MicroCAM could not manipulate the line weight.

Table 4-3 Neat lines

NEAT LINES	ArcView		AutoCad		Idrisi		Illustrator		Maptitude		MapViewer		MicroCam		MicroStation		Total	
Does the software allow:	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
The creation of Borders?	✓		✓		✓		✓		✓		✓		✓		✓		8	0
The creation of other neat lines?	✓		✓		✓		✓		✓		✓		✓		✓		8	0
The creation different line symbols?	✓		✓		✓		✓		✓		✓		✓		✓		8	0
The creation of different sized lines?	✓		✓		✓		✓		✓		✓			✓	✓		7	1
The creation of different colored lines?	✓		✓		✓		✓		✓		✓		✓		✓		8	0
Total	5	0	5	0	5	0	5	0	5	0	5	0	4	1	5	0	39	1

The last question and task put to the software involved the creation of different colored lines. As has been mentioned before, color is a primary graphic variable and can be an effective aid in communicating spatial information. Observations revealed that all eight of the software programs allowed for the manufacture of different colors.

The creation of a border, neat lines, different line symbols, different sized lines, and colored lines allows the user to distinguish between line classifications. If a line has contrast to other lines, it is easier to understand, classify, and to retrieve the desired information. Lines are often used to represent a spatial feature (such as a road); visual contrasts enhance the effectiveness of communicating information with lines. Of the eight programs, all were very adept at accomplishing the desired tasks. All of the programs permitted the creation of different line symbols, sized lines (MicroCAM did not allow for the creation different sized lines), and the use of different colored lines. Of the 40 total questions asked of the software 39 responses were in the affirmative.

Text

Until the mid nineteenth century, freehand stenciling, carving on woodblocks, or engraving on copperplates was used to produce text on maps. The introduction of mechanical type in the 1930's reduced the costs of lettering and increased the speed of map production. Today, computer programs incorporate the principles of mechanical type to produce a new flexibility in lettering. The category of text use encompassed five questions. The first question approached the placement of text anywhere on the map.

Did the software allow for the placement of text anywhere on the map (See Table 4-4)? Text placement is important to the user and appearance of the map. It should be permitted to exist on any area of the map. Through observations it was revealed that seven of the eight programs authorized the user to place text freely. Only MicroCAM did not allow for the placement of text.

Did the software give the user the ability to manipulate text? Text often needs to be manipulated so it can adequately label desired features. Manipulation involves changing the orientation and spacing of the letters. In general, all of the mapping software allowed for manipulating the text as desired, only MicroCAM did not. Of the seven that did allow text manipulation, Adobe Illustrator was by far the most impressive because it permitted text to be manipulated along a curved line.

Could different sized text be created? The size of text refers to the height of the letters on the printed screen or page. Using different text sizes enhances legibility and understanding of ambiguous map features. Involving text sizing, seven of the eight programs permitted the resizing of text up to 72 points high.[2] Again, only MicroCAM was not able to resize text.

Table 4-4 Text

TEXT	ArcView		AutoCad		Idrisi		Illustrator		Maptitude		MapViewer		MicroCam		MicroStation		Total	
Does the software allow:	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
The placement of text anywhere?	✓		✓		✓		✓		✓		✓			✓	✓		7	1
The free manipulation of text?	✓			✓	✓		✓		✓		✓			✓	✓		6	2
The use of different text sizes?	✓		✓		✓		✓		✓		✓		✓		✓		7	1
The use of different typefaces?	✓		✓		✓		✓		✓		✓			✓	✓		7	1
The creation of different colored text?	✓		✓		✓		✓		✓		✓		✓		✓		8	0
Total	5	0	4	1	5	0	5	0	5	0	5	0	2	3	5	0	35	5

Did the software allow for the use of different typefaces? A different typeface refers to the characteristics of the type including such elements as serifs and line thickness.[3] The use of these elements allows the text to stand out from surrounding text and map features. Seven of the programs had a large variety of typefaces; only MicroCAM did not. There were many of the generic typefaces that come with most software such as Times New Roman, Ariel, Lucida, and Courier. But there were also a large variety of special cartographic typefaces that came as part of the specialized mapping software.

[2]One point is about 0.35 mm or 1/72 of an inch high.

[3]A serif is the small line used to finish off the main stroke of a letter.

To conclude the section on text, the software was tasked to observe if different colored text could be created. Text legibility can be improved by integrating visual contrast with the surrounding ground. The use of color significantly enhances the quality of contrast between the text and surrounding elements. All eight of the observed programs authorized the changing of text color.

Text is designed to be seen and read. When text is properly used, it clearly names or describes the feature it is trying to identify. Consequently, the software should be able to accomplish a variety of tasks when dealing with text. Text must be able to be placed anywhere on the map. It must be permitted to be adjusted and manipulated in unlimited manifestations. Different text sizes, typefaces, and colors must also be allowed to be created. Most of the mapping programs were very flexible when dealing with the use of text. Only MicroCAM and AutoCAD did not allow for its free manipulation. MicroCAM was also the only program that did not permit the placement of text anywhere, the use of different text sizes, and the use of different text typefaces. All of the other programs were able to accomplish the desired text functions. Of the tasks and questions put forth to the software 35 of the 40 responses were in the affirmative, with MicroCAM accounting for 4 of the 5 negative responses.

Symbols

All the graphic features on a map are symbols. The designer can use these symbols to represent an idea, a series of facts, or the distribution of geographic phenomena. Symbolization is critical to a map's ability to communicate effectively. Symbols that simplify, classify, and clarify map information enhance the map's effectiveness.

Did the software have a large variety of symbols (See Table 4-5)? Symbols are used to convey a multiplicity of environmental features and distributions. Therefore, it is important that the software have a large variety of symbols. Five of the eight programs had a large variety of symbols with IDRISI, MicroCAM, and MicroStation being the three that did not.

Was the importation of different symbols allowed? Many time symbols are pictographic representations of a geographic feature. It would be a great benefit to the designer if a symbol could be created or if a scanned image could be imported into the map design. The software was queried to see if symbols created could be imported as .gif's or .jpeg's, or some other image format. Results revealed that six of the eight programs permitted the importation of image formats. The two programs that did not where AutoCAD and MicroCAM.

Table 4-5 Symbols

SYMBOLS	ArcView		AutoCad		Idrisi		Illustrator		Maptitude		MapViewer		MicroCam		MicroStation		Total	
Does the software allow/have:	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
A large variety of symbols?	✓		✓			✓	✓		✓		✓			✓		✓	5	3
The importation of different symbols?		✓		✓	✓		✓		✓		✓			✓	✓		5	3
The rotation and manipulation of symbols?	✓		✓		✓		✓		✓		✓		✓		✓		8	0
The use of different symbol color?	✓		✓		✓		✓		✓		✓		✓		✓		8	0
Total	3	1	3	1	3	1	4	0	4	0	4	0	2	2	3	1	26	6

Could the observed software accomplish the rotation and manipulation of symbols? As has been stated before, the rotation and manipulation of graphic elements allows for contrast and distinction. It is also important that symbols be able to fit in spaces on the map that best enhance their ability to represent and communicate. All eight of the observed programs let the user manipulate and rotate symbols.

In concluding the section on symbols, the software was queried to whether different symbol colors could be generated. Color combinations of hue and value effectively communicate large amounts of information and can reinforce the other graphic variables of size, shape, pattern, orientation, and location. In regards to use of different color, all eight of the programs permitted diverse color changes to symbols.

Good design and implementation of symbols will enhance a map. Conversely, poor symbol design and placement can distract and render a map useless. To be effective tools in map design, computer-mapping programs have to have a large variety of symbols. They also need to be able to import, to freely rotate and manipulate, and to change the color of the symbols. Of the observed programs, only five had a large variety of symbols and permitted the importation of different symbols. All the programs did allow for the rotation and manipulation of symbols and the use of different colors. The software was addressed with a total of 32 questions and tasks, 26 were answered totally in the affirmative. Observation revealed that symbol creation, importation, and representation was an area where desktop mapping programs need improvements in order to reach the proficiency of traditional cartography.

Marginal Information

In traditional cartographic design, the marginal information refers to the information that is present in the margins of the map. The acronym outlined in Chapter 2 describes the elements that should be included within the margins.[4] Computer software that automatically facilitates the creation of marginal information increases production speed and demonstrates effective cartographic design. Four questions addressing the automatic creation of marginal information were put to the different software programs: does the software allow for the automatic creation of a scale, a north arrow, a title, and a grid or graticule?

Did the software allow for the automatic creation of a scale (See Table4-6)? All geographic maps are reduced images of the real world. Each map has a defined mathematical relationship between this reality and the map; the relationship is the map scale. The automatic creation of a scale increases the maps ability to express information about the geographic feature. By allowing the automatic creation of a scale, the software is accommodating elements of traditional cartography. Only, four of the observed programs automatically created a scale; AutoCAD, Adobe Illustrator, MicroCAM, and MicroStation did not. The observations revealed that the programs that did not allow for the creation of a scale were the programs that were not originally designed for map production.

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[4] This information can be classified by the acronym TODAL-SIGS. The acronym stands for title, orientation, date, author, legend, scale, index, grid or graticule, and surrounding places. The first part of the acronym that stands for TODAL can be considered required map information while the SIGS part of the acronym can be considered optional information.

Table 4-6 Marginal Information

MARGINAL INFORMATION	ArcView		AutoCad		Idrisi		Illustrator		Maptitude		MapViewer		MicroCam		MicroStation		Total	
Does the software allow:	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
The automatic creation of a scale?	✓			✓	✓		✓		✓		✓			✓		✓	4	4
The automatic creation of a north arrow?	✓		✓		✓		✓		✓		✓			✓		✓	6	2
The automatic creation of a title?	✓		✓		✓			✓	✓		✓		✓		✓		7	1
The automatic creation of a graticule or grid?	✓			✓	✓		✓		✓		✓		✓			✓	6	2
Total	4	0	2	2	4	0	2	2	4	0	4	0	2	2	1	3	23	9

Could a north arrow be automatically created with the software? A north arrow is used as a directional indicator. It allows the user to orient the map in relation to a known reference point. As with the automatic creation of a scale, the automatic creation of a north arrow facilitates proper cartographic design principles and increases speed and productivity of map design. Observations revealed six of the eight programs automatically created a north arrow. MicroCAM and MicroStation did not allow for the automatic creation of a north arrow. It was very surprising that the program MicroCAM, which is developed to teach cartography principles, did not allow for the automatic creation of a north arrow.

Did the software allow for the automatic creation of a title? As was stated earlier, the title is a basic definition of the subject of the map. It contains information about the location of the map and the topic of the map. Seven of the observed eight programs automatically created a title or title box, with Adobe Illustrator being the only exception.

The final question under the subheading of marginal information was the automatic creation of a graticule or grid. A graticule or grid provides a frame of reference, and permits locating different points within a map. Six of the observed programs automatically created a grid or graticule; only AutoCAD and MicroStation did not. Again, these two programs were not created for map production, but are currently used for this function by a number of individuals.

In general, the mapping software did a good job at automatically creating marginal information. Simplifying the process of designing a map and automatically incorporating design elements helps to create aesthetically pleasing maps that communicate effectively. The author has asserted that marginal information is a required aspect of cartographic design. This argument is not necessarily the opinion of all cartographic professionals. Many believe that marginal information is only required when it is vital to map content and communication. There is not a consensus on what should be required in the margins. However, the author believes that the acronym created by educator Jeremy Anderson is a valuable tool and should be included in all map design.

Help Files

All desktop mapping programs contain help files. The research questioned whether the help files contain information relating to the elements of cartographic design. The author reviewed the files by examining the indexes of the help files to learn if they contained an entry for twenty-four key words associated to design. The twenty-four key words were broken up into two groups; words associated with graphic elements and words associated with cartographic design. Each software program was evaluated at how well they addressed these two groupings.

The first groupings of indexed words were associated with graphic elements (See Table 4-7). The group included the words: background, border, color, color value, color hue, graphics, graticule, grid, symbols, text, and typeface. MapViewer had the largest number of indexed words associated with graphic elements, 8 of the 11 words were present in the software; ArcView and AutoCAD had 7 of the 11; Maptitude had 6; Adobe Illustrator and MicroStation had 5; MicroCAM had 3; and IDRISI had 2. In all, the majority of the programs did not do a very effective job at indexing words associated with graphic elements.

The second grouping was words associated with cartographic design. This group included the words: balance, cartographic design, data source, focus of attention, map design, neat lines, north arrow, orientation, parts of a map, rotation, scale, spacing, and title. ArcView did the best job at incorporating indexed words about cartographic design, 8 of the 13 indexed words were present; AutoCAD and Maptitude had 4 of the 13; IDRISI, MapViewer, and MicroCAM each had 3; and Adobe Illustrator and MicroStation both had 2. While the software's help files did a poor job at referencing word about graphic elements, they did a pitiful job at indexing words about cartographic design. Only ArcView adequately represented cartographic design principles in their help files.

The author found the observation of help files to be very relevant to the research problem. Many of the elements associated with traditional cartographic design were not accommodated or referenced in the help files. Several of the program's help files addressed the creation of graphic items such as lines, colors, background, text, etc.

However, elements related to cartographic design and effective map communication were not addressed in any of the mapping programs. Aspects of design such as orientation, visual balance, focus of attention, map design, spacing, were not present. Explaining the integration and application of traditional map design principles does not seem to be a high priority of the mapping programs help files.

Table 4-7 Help Files

"HELP" FILES	ArcView		AutoCad		Idrisi		Illustrator		Maptitude		MapViewer		MicroCam		MicroStation		Total	
Does the software address:	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
Background	✓		✓			✓		✓	✓		✓			✓	✓		5	3
Balance		✓		✓		✓		✓		✓		✓		✓		✓	0	8
Border		✓	✓			✓		✓	✓		✓			✓		✓	3	5
Cartographic Design		✓		✓		✓		✓		✓		✓	✓			✓	1	7
Color	✓		✓			✓	✓		✓		✓			✓	✓		6	2
Color Value		✓		✓		✓	✓			✓		✓		✓		✓	1	7
Color Hue		✓		✓		✓	✓			✓		✓		✓		✓	1	7
Data Source	✓			✓		✓		✓		✓		✓		✓		✓	1	7
Focus of Attention		✓		✓		✓		✓		✓		✓		✓		✓	0	8
Graphics	✓		✓			✓		✓		✓		✓	✓		✓		4	4
Graticule	✓			✓		✓		✓		✓	✓			✓		✓	2	6
Grid	✓			✓	✓		✓		✓		✓			✓	✓		6	2
Map Design	✓			✓		✓		✓		✓	✓			✓		✓	2	6
Neat Lines	✓			✓		✓		✓		✓		✓		✓		✓	1	7
North Arrow	✓			✓	✓			✓	✓			✓		✓		✓	2	6
Orientation	✓		✓			✓		✓		✓		✓		✓		✓	2	6
Parts of a Map		✓		✓		✓		✓		✓		✓		✓		✓	0	8
Rotation	✓		✓			✓	✓		✓		✓		✓		✓		7	1
Scale	✓		✓		✓		✓		✓		✓		✓			✓	7	1
Spacing		✓		✓		✓		✓		✓		✓		✓		✓	0	8
Symbols	✓		✓		✓			✓	✓		✓		✓			✓	3	5
Text	✓		✓			✓	✓		✓		✓		✓		✓		7	1
Title	✓		✓		✓			✓	✓			✓		✓	✓		5	3
Typeface		✓	✓			✓		✓		✓	✓			✓		✓	2	6
Total	15	9	11	13	5	19	7	17	10	14	11	13	6	18	7	17	68	124

Templates and Examples

The final observed element of cartographic design was the ability of the software to create templates or map examples. Templates are valuable because they give the designer an idea of where graphics should be placed on the map. Templates can communicate effective map design to novice users. Examples and samples also facilitate the teaching and understanding of proper cartographic design.

Each of the software systems was observed to see if templates existed (See Table 4-8). Only two of the programs (ArcView and IDRISI) offered templates to help with cartographic design. Of the two, only ArcView offered a variety of templates that displayed different map layouts and structures. Figure 3-1 on page 75 shows an ArcView template. These ArcView templates allow for the automatic introduction of a title, legend, graphic (map), scale bar, and north arrow. The templates also organize elements in a logical fashion that produces balance, and visual contrast in the map design.

Table 4-8 Templates and Examples

TEMPLATES AND EXAMPLES	ArcView		AutoCad		Idrisi		Illustrator		Maptitude		MapViewer		MicroCam		MicroStation		Total	
Does the software have:	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
Templates	✓			✓	✓			✓		✓		✓		✓		✓	2	6
Examples	✓		✓		✓			✓		✓	✓		✓			✓	5	3
Total	2	0	1	1	2	0	0	2	0	2	1	1	1	1	0	2	7	9

Did the software have examples? Five of the observed software programs allowed for the creation of examples or samples of a map. However, many of the map samples were just boundary maps of a geographic entity, such as the outline of the United States. They did not show a map that was fully designed and ready for production.

Observations revealed that the software did not adequately use templates and examples to accommodate the traditional methods of cartographic design. Templates were just about non-existent, and examples were limited in their ability to facilitate knowledge about cartographic design. There should be more emphasis at explaining design principles rather then just designing the software to accomplish graphic functions.

Synopsis

The capability of the software to accommodate traditional methods of map design reveled some items that were accomplished effectively and others that were not. The software was effective at generating different color, different color value, and background color. Observations discovered that in general the software did a good job at allowing for the manipulation of graphic elements. Many of the programs also permitted the creation of different line symbols, sized lines, and colored lines. Most of the mapping programs were very flexible when dealing with the use of text; just about all the programs permitted the placement of text anywhere, and the use of different text sizes and typefaces. Also, several of the programs did a first-rate job at automatically creating marginal information.

In contrast, the software did not effectively accommodate other methods of traditional map design. A number of the programs could not freely orient and rotate produced map graphics. Also, observations revealed that symbol creation, importation, and representation were an area where desktop-mapping programs needed improvements.

The software did not adequately use help files, and templates and examples to accommodate and explain the traditional methods of cartographic design.

Overall, the observations of desktop mapping programs revealed that many of the graphic functions that were once done by traditional cartography could now be accomplished with computers. Most of the software programs were able to manipulate, resize, change, and move the graphic elements of text, symbols, map design, neatlines, and color. Nevertheless, the mapping software did not accommodate several of the methods of traditional cartographic design. Nor, did they use the tools of help files, and templates and examples effectively. These elements are expanded on in Chapter 5.

CHAPTER 5

CONCLUSIONS

Summary

The primary objective of a map is to communicate spatial information. A well-designed map communicates more effectively and allows users to organize, retrieve, and visualize geographic images. In order to communicate effectively in a graphic medium, a mapmaker needs to understand the principles of cartographic design. These principles speak more to the traditions of the arts than the sciences. The art of cartography involves the designer's ability to organize different types of information into an effective whole that communicates spatial ideas. Conversely, the science of cartography involves the process of collecting, locating, and recording geographic information precisely and accurately.

Effective map design labors to recreate a picture of the earth. There are many ways to graphically develop this picture. It does, however, have basic elements that can be taught and learned. These elements are hue, value, size, shape, pattern, orientation, location, and TODAL-SIGS (incorporated in the research as: color, text, map design, neat lines, symbols, and marginal information). When designing a map layout, the proper use and combination of these elements allows for effective map communication.

The emergence of computerized desktop mapping has drastically changed cartographic design. Computers can now accomplish all the cartographic tasks that were once done by hand. Today, the designers of maps are not necessarily professionally trained cartographers. They can be novices who rely on the software to help them to produce effective maps. The software implicitly contains the coded expertise and knowledge of the cartographer.

However, does desktop mapping software accommodate the traditional elements of map design? To answer this question, the author first reviewed historic examples of traditional cartographic design. The review involved observing thirty-five maps from three distinct periods in the history of cartography. From the observed maps, traditional cartographic design elements were established. These established traditional aspects were outlined as: the use of different colors to classify, organize, and simplify; the use of background color to discern figure ground relationships; the proper spacing and balancing of graphic elements; the use of neat lines and borders with different colors, patterns, orientation, size, shapes and location to compartmentalize and convey information. Also they included the ability to place, rotate, space, and size different text and typefaces; the ability to place and balance a multitude of different symbols; and the incorporation of marginal information into the map design. These design elements were then used to examine desktop mapping programs to learn if the software accommodated them.

Eight different software packages were observed: ArcView, AutoCAD, IDRISI, Adobe Illustrator, Maptitude, MapViewer, MicroCAM, and MicroStation. The capability of these programs to accommodate traditional methods of map design reveled items that were accomplished effectively. The software packages were successfully able to generate different hue, different color value, and background color. They also did a respectable job at allowing for the manipulation of graphic elements. The packages permitted the creation of different line symbols, sized lines, and colored lines. They were very flexible when dealing with the use of text; allowing the placement of text anywhere, and the use of different text sizes and typefaces. Also, several of the programs did a superlative job at automatically creating marginal information. Many of the aspects of traditional cartography can now be accomplished with computers. Software packages have been able to automate the graphic tasks of traditional map design. Most of the mapping programs offered the designer the ability to defining the size, shape, orientation, and color of text, lines, graphics, and symbols.

On the contrary, the software packages were not effective at allowing a user to freely orient and rotate produced map graphics. Also, observations revealed that symbol creation, importation, and representation were an area where desktop-mapping programs needed improvements. Furthermore, the software did not adequately use help files, and templates and examples to accommodate and explain the traditional methods of cartographic design.

The ability to freely orient and rotate elements needs to be better addressed by software programmers and designers. The software should give the designer the freedom to space elements in small increments with the use of the keyboard arrows. Graphics should be able to lie over the top of other graphics, with the ability to adjust the opacity so a user can see through an element to the ground behind. Tools also need to be present that allow for small and large rotations of objects.

Many of the observed programs had a large variety of symbols. However, the symbols were generic, and functions did not exist to allow for the creation of unique symbols. Nor, did they allow for the importation of other symbols that were designed in auxiliary programs. Mapping software also needs to incorporate the capacity to automatically and accurately place a symbol. To sum up, the aptitude to accomplish more tasks with the creation and importation of symbols would be of value to map designers.

The help files of most programs deal with the creation of graphic elements such as lines and text and the selection of different color. However, they do not deal with cartographic design and the elements that make up a map. Observations revealed that help files really were not much help. The observed software covered few of the elements of cartographic design. Help files are easy to program and incorporate into software. It however, appears that the software designers do not consider the importance of articulating the principles of cartographic design. They need to realize that the users of their software are no longer just trained professionals but also novices. Topics such as focus of attention, balance of graphics, use of blank space could all be referenced. Help files could also index design elements of map insets, neat lines and the incorporation of data source. There should at least be indexed words that address the elements of TODAL-SIGS.

Templates were nonexistent in just about all of the software programs; only two programs offered templates. They can effectively show a user how to design a map. They make map production faster by allowing the insertion of data into an organized structure. Many different templates can be designed that illustrate the proper use of alternate paper size layouts, and the alternative orientation and spacing of graphic elements. They can also be used to properly place and incorporate marginal information. Therefore, they need to be integrated into desktop mapping programs.

Examples were present in many of the desktop mapping programs. However, the observed mapping software did not properly develop this tool. Examples fell far short of effectively communicating cartographic design. They should give untrained users illustrations and ideas for their own map production. For instance, they ought to visually show cartographic design elements such as spacing and balance. Examples can be great teachers of the different elements, theories, and principles of map design. The researcher suggests the development of samples that work also as templates. They would act as a hybrid combination that included a graphic interface that allows for sample data to be replaced with personal data.

Computerized cartography allows anyone the freedom to sit at a personal computer, get access to a large amount of data, and produce a map. The problem with this freedom is that the software is designed to accomplish graphic functions -- not to facilitate cartographic design principles. A person trained in cartographic techniques can easily use a desktop mapping program to produce effective and artistic maps. Nevertheless, what of the person who has no training? The mapping software should direct untrained users towards proper cartographic design. Help files, templates, and examples need to be developed that discuss, clarify, explain, and demonstrate design unambiguously. The designer of a map needs to understand and be able to use graphic variables, map composition, and map design principles. Including such elements as the use of a scale, a north arrow, the concept of visual balance, focus of attention, and the use of color.

It is true that just about anyone can create a map. This also means that just about anyone can create a cluttered, confusing, inartistic map. Geographers and cartographers need to be players in the design of desktop mapping software. The history of cartographic design has a legacy of beauty, style, clarity, and artistic expressionism. Cartographically, (contradicting an age old axiom) if you do not know your history how can you repeat it?

Desktop Mapping Software's Advantages and Major Limitations

Computer cartography offers a lot of advantages over traditional map production. It allows maps to be made more quickly and at cheaper costs. It allows for specific user needs; makes map production possible when skilled staff are unavailable; permits experimentation with different graphical representation of data; smoothes the process of updating; facilitates analysis of data; and creates map that are difficult to create by hand, e.g. 3D maps or stereoscopic maps.[1]

Maps can be seen in a large variety of printed media. They can be seen in newspapers, magazines, and books. With simplified use and falling costs more and more organizations have established departments for map production. The use of desktop software has prompted a major change in the way maps are designed and produced. Today Western industrialized map design is done with the aid of high-quality computer hardware and specialized mapping programs. The use of computers has eliminated many of the problems associated with making maps. Nevertheless, they have also introduced new problems.

The author perceives one major problem associated with computer map design is the selection of the specialized programs that produce the maps. There are three distinct

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[1]Peter A Burrough and Rachael A. McDonnell, *Principles of Geographical Information Systems* (New York: Oxford University Press, 1998), 7.

types of software programs used in the desktop environment: Computer Aided Drafting and Design (CADD) software, Illustration Software, and Mapping Software. All of these software types were observed while conducting the research. Each of the different software types has advantages and disadvantages.

Computer aided design software, such as AutoCAD and MicroStation, can often recreate many of the tasks that were once done by hand in traditional cartography. The software is designed to be used for mechanical drafting and is very precise in representing line features. CADD programs are often used when the primary application is to map roads, boundaries, and utilities. The disadvantage of CADD programs is that they are not topologically structured and lack the ability to perform spatial analysis. CADD systems usually lack the graphic capabilities of illustration and mapping programs. Since CADD systems are not designed specifically for the creation of maps they do not incorporate the elements of cartographic design. This is unfortunate because many organizations still use CADD software to produce maps.

Illustration software, such as Adobe Illustrator, provides the greatest amount of design flexibility. The software is designed to meet the needs of graphic design professionals. Because of this, a user can create just about any graphic element that was once accomplished on manual maps. Illustration software also allows for greater freedom in the creation and use of colors, patterns, line styles, line width, and text. The software produces a better quality graphic product then CADD or mapping programs. The main disadvantage to cartographic design is that the programs are not designed to produce maps. The software is very adroit at creating graphic images but very limited in its ability to facilitate cartographic design elements. As with CADD programs, the elements of traditional cartographic design are not incorporated into the software. It does not address items like the creation of a scale, legend and other map features.

Mapping software, such as ArcView, IDRISI, Maptitude, MapViewer, and MicroCAM, provide the greatest potential for communicating traditional cartographic design principles. Many of the mapping programs give some type of references to the use of text, a legend, and other items of cartographic design. These programs offer the hope of being able to facilitating an overt explanation of design principles. Still, they have yet to incorporated enough information into their programming. The limitation of mapping software is that they do not have the graphic capabilities of Illustration software. As an example, none of the mapping programs allowed for the creation of curves or the ability to attach text to a curved line.

In conclusion, the author believes that there is a desire for one software system that incorporates the precision of CADD programs, the graphic capabilities of illustration programs, and the cartographic dexterity of mapping programs.

Suggestions for Future Study

The research gave a broad assessment of how the elements of cartographic design are represented in desktop mapping. Further research could take any single element of traditional cartographic design and do an in-depth examination of that element's ability to be recreated and communicated.

Only eight software programs were selected as representations. There are, however, numerous other packages that are available and could be assessed. An interesting comparison would be between desktop mapping programs and computer atlases or between computer atlases and traditional atlases.

In addition, only two libraries were visited while conducting the research. There are many libraries that have incredible collections of historic maps. Developing research that involves these collections keeps the past connected to the future. Any historic research is worthwhile and relevant to the further development of the subject. There are a number of on going research projects through out the country that focus just on the historic developments of cartography. Continued research in this field will help to expand the topic and lead to more questions.

The artistic aspect of computer mapping and thematic representation is another subject that needs continued research. Computerized production of choropleth, dot, isarithmic, flow, and dasymetric maps have yet to come close to reaching their fullest potential. Frequently, the map is not an artistic representation of geographic data, nor are they proficient at communicated clearly or displaying data accurately.

Researchers interested in graphic design and programming could explore the developments and coding of these elements in computer mapping. Programming software that is more efficient increases map productivity and helps to produce better quality maps. A programming task that could be addressed is the effective automatic placement of text and symbols. Cartographers in connection with programmers must conduct research in this area. They have to be able to explain exactly how and why elements need to be accomplished. The expertise and knowledge of the cartographer has to be explicitly coded into the mapping programs.

APPENDIX A

Library Call# Date

Map Observation Form

Map Cartographer:

Date:

Type of Map:

Map Source:

Geographic Area of Cartographer:

Graphic Elements of Map:

Colors:

Graphic Element	Excellent	Good	Moderate	Poor	NA
Use of Different Color					
Does Color Simplify & Clarify					
Use of Color Values					
Use of Background Color					

Map Design:

Graphic Element	Excellent	Good	Moderate	Poor	NA
How do graphics look together					
Focus of Attention					
Spacing					
Use of Blank Space					
Balance of Graphics					
Orientation of Graphics					

Neat Lines

Graphic Element	Excellent	Good	Moderate	Poor	NA
Use of Border					
Use of Neat Lines					
Line Weights					
Line Symbols					
Use of Color					

Text:

Graphic Element	Excellent	Good	Moderate	Poor	NA
Placement					
Rotation					
Spacing					
Legible					
Size					
Use of Different Typeface					

Map Inset:

Graphic Element	Excellent	Good	Moderate	Poor	NA
Size of Insets					
Informative					
Relevant to Map					
Spacing					

Symbols:

Graphic Element	Excellent	Good	Moderate	Poor	NA
Placement					
Representation					
Spacing					
Orientation					
Legible					
Color					

Marginal Information:

Scale

North Arrow

Data Source

Title

Date

Cartographer

Graticule

Notes:

APPENDIX B

Desktop Observation Form

Software Name:

Software Design Company:

Version of software:

Graphic elements of map design with-in the software:

Colors:

1. Does the software allow for the use of different colors?
2. Does the software allow for the use of different color values?
3. Does the software allow for the creation of background colors?

Map Design:

1. Does the software allow for changing the look of graphic elements?
2. Does the software allow for different spacing of graphic elements?
3. Does the software allow for the resizing of graphic elements?
4. Does the software allow for the introduction of illustrations (non-spatial features)?
5. Does the software allow for changing the orientation and angles of graphic elements?

NeatLines:

1. Does the software allow for the creation of borders?
2. Does the software allow for the creation of neatlines?
3. Does the software allow for the creation of different line symbols?
4. Does the software allow for the creation of different sized lines?
5. Does the software allow for the creation of different colored lines?

Text:

1. Does the software allow for the placement of text anywhere?
2. Does the software allow for the free rotation of text?

3. Does the software allow for different text sizes?
4. Does the software allow for the use of different text typefaces?
5. Does the software allow for the creation of different colored text?

Symbols:

1. Does the software have a large variety of symbols?
2. Does the software allow for the importation of different symbols?
3. Does the software allow for the rotation of symbols?
4. Does the software allow for the use of different symbol color?

Marginal Information:

Does the software allow for the automatic creation of a scale?

Does the software allow for the automatic creation of a north arrow?

Does the software allow for the automatic creation of a title?

Does the software allow for the automatic creation of a graticule or reference grid?

Help Files: (Do help files address the following key words associated with cartographic design?)

Background

Balance

Border:

Cartographic Design:

Color:

Value:

Hue:

Data Source:

Focus of attention:

Graphics

Graticule:

Grid:

Map Design:

Neatlines:

North Arrow

Orientation:

Parts of a Map:

Rotation:

Scale:

Spacing:

Symbols:

Text:

Title:

Typeface:

Templates and Examples:

Do templates and map examples exist that help to explain or demonstrate cartographic design?

Notes:

References

About Caliper. on the Caliper Corporation web page. [cited 29 February 2000]: available from World Wide Web http://www.caliper.com/ovuabout.htm

About Golden Software. on the Golden Software web page. [cited 29 February 2000]: available from World Wide Web http://www.golden.com/learn.htm

Adobe Illustrator. on the Adobe Illustrator web page. [cited 29 February 2000]: available from World Wide Web http://www.adobe.com/products/illustrator/main.html

Bentley Corporate Background. on the Bentley web page. [cited 29 February 2000]: available from World Wide Web http://www.bentley.com/bently/backgrnd.htm

Brown, Lloyd A. *The Story of Maps.* New York: Dover Publications, Inc., 1977.

Burrough, Peter A., and Racheal A. McDonnell. *Principles of Geographical Information Systems.* New York: Oxford University Press, 1998.

Dent, Borden D. *Cartography Thematic Map Design,* 3rd ed. Dubuque: Wm. C. Brown Communications, Inc., 1990.

Harley, J. B. and David Woodward, ed. *The History of Cartography,* vol 1. Chicago & London: The University of Chicago Press, 1987.

Holsti, Ole R. *Content Analysis for the Social Sciences and Humanities.* Philippines: Addison-Wesley Publishing Company, Inc., 1969.

Introduction. [cited 29 February 2000]: available from World Wide Web http://wolf.its.ilstu.edu/microcam/intro.htm

Jones, Christopher. *Geographical Information Systems and Computer Cartography.* England: Addison Wesley Longman Limited, 1999.

Korte, George B. *The GIS Book.* Santa Fe: OnWord Press, 1997.

Meggs, Philip B. *A History of Graphics Design.* USA: International Thomson Publishing, Inc., 1992.

Overview. on the Clark Labs web page.[cited 29 February 2000]: available from World Wide Web http://www.clarklabs.org/03prod/overview.htm

Plug-ins for Adobe Illustrator. on the Adobe Illustrator web page. [cited 29 February 2000]: available from World Wide Web http://www.golive.de/products/plugins/illustrator/mapublisher.html

Peterson, Michael P. *Interactive and Animated Cartography.* New Jersey: Prentice-Hall, Inc., 1995.

Ptolemy, Cladius. *The Geography.* New York: Dover Publications, Inc., 1991.

Robinson Arthur H., Joel L. Morrison, Phillip C. Muehrcke, A. Jon Kimerling, and Stephen C. Guptill. *Elements of Cartography, 6th ed.*. New York: John Wiley and Sons, Inc., 1995.

--------. *Early Thematic Mapping in the History of Cartography.* Chicago: University of Chicago Press, 1982.

Sauer, Carl. "The education of a geographer." *Annals of the Association of American Geographers* 46 (1956): 287-299.

The National Geographic Society. *Desk Reference.* USA: National Geographic Society, 1999.

Thrower, Normon J. W. *Maps & Man.* New Jersey: Prentice-Hall, Inc., 1972

Wilford, John Noble. *The Mapmakers.* New York: Random House, Inc., 1981.

Woodward, David. *Art and Cartography: Six Historical Essays.* Chicago: The University of Chicago Press, 1987.

Selected Bibliography

Atlas of Exploration. NewYork: Oxford University Press, Inc., 1997.

Bruno, Michael H, ed. *Pocket Pal: A Graphic Arts Production Handbook.* Memphis: International Paper Company, 1997.

Chen, Wan. *The Usage of Map Symbolism in Commonly-Used Computer Mapping Software Packages.* M.A. thesis., University of Montana, 1995.

Creswell, John W. *Research Design.* California: SAGE Publications, Inc., 1994.

Getis, Arthur, Judith Getis, and Jerome Fellman. *Introduction to Geography.* USA: Wm. C. Brown Publishers, 1991.

Gould, Peter. *The Geographer at Work.* Boston: Routledge & Kegan Paul plc, 1985.

Haring, Lloyd L., John F. Lounsbury, and John W. Frazier. *Introduction to Scientific Geographic Research.* USA: Wm. C. Brown Publishers, 1992.

Hearn, Donald., and M. Pauline Baker. *Computer Graphics.* New Jersey: Prentice-Hall, Inc., 1986.

Hutchinson, Scott, and Larry Daniel. *Inside Arcview GIS.* Sante Fe: OnWord Press, 1997.

Keates, J. S. *Understanding Maps.* England: Addison Wesley Longman Limited, 1996.

Leonard, Dennis R. *Symbols and Landscape: The History of Physiographic Diagramming.* M.A. thesis., University of Montana, 1992.

Margolis, Philip E. *Computer & Internet Dictionary.* New York: Random House Webster's, 1999.

Monmonier, Mark. *Computer-Assisted Cartography: Principles and Prospects.* Englewood Cliffs, NJ: Prentice-Hall, 1982.

--------. *Drawing The Line.* New York: Henry Holt and Company, Inc., 1995.

--------. *How to Lie with Maps.* 2d ed. Chicago: The University of Chicago Press, 1996.

Muehrcke, Phillip C., and Juliana O. Muehrcke. *Map Use.* Wisconsin: JP Publications, 1998.

Taylor, D. R. Fraser. *The Computer in Contemporary Cartography.* Canada: John Wiley & Sons, 1980.

--------, ed. *Geographic Information Systems: The Microcomputer and Modern Cartography.* Oxford: Pergamon Press, 1991.

Tufte, Edward R. *Envisioning Information.* Cheshire, Connecticut: Graphics Press, 1990

Turabien, Kate L. *A Manual for Writers of Term Papers, Theses, and Dissertations*, 6th ed., Chicago: The University of Chicago Press, 1996.

Tooley, R. V. *Maps and Map-Makers.* New York: Crown Publishers, Inc., 1949.

Weiss, Richard. "Cultural Boundaries and the Ethnographic Map." In Philip L. Wagner and Marvin W. Mikesell, eds. *Readings in Cultural Geography.* Chicago: The University of Chicago Press, 1962.

White, Ron. *How Computers Work.* California: Ziff-Davis Press, 1997.

Wiggins, Lyna L., and Steven P. French. "Desktop Mapping and GIS." *APA Journal,* (1990): 370-376.

Wood, Denis. *The Power OF Maps.* New York: Guilford Publications, Inc., 1992.

Zeiler, Michael. *Modeling our World: The ESRI Guide to Geodatabase Design.* USA: Environmental Systems Research Institute, Inc. 1999.