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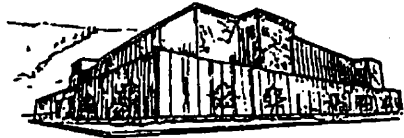
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An Evaluation of Methods for Displaying Time in Cartography

by

Brian W. Collins

B.A. University of Montana, 1998

Presented in partial fulfillment of the requirements

for the degree of

Master of Arts

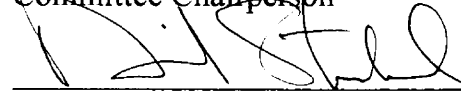
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2002

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Committee Chairperson



Dean, Graduate School

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An Evaluation of Methods for Displaying Time in Cartography

Advisor: Paul B. Wilson

The purpose of this thesis is to compare methods for representing time in cartography. Three map sets, each based on only one map symbol (area, line, point), were developed as a focus for the research. The maps were output in both paper and animated formats. Each map was initially prepared and designed using the ArcView GIS software package. Paper maps were printed directly from ArcView. Animated map information was exported from ArcView in graphic file formats. These files, each representing a unique time interval, were the basis of the animated maps. Macromedia Flash, a graphic animation software package, was used to create the animations. Final animated maps were distributed in CD-ROM format.

Three map tests, one for each map, were designed in accordance with the information displayed on each map. Each test consisted of ten questions with a maximum possible score of ten points. Questions were subdivided into two categories, thematic and marginal. Thematic questions pertained to the map itself and did not require reference to additional information. Marginal questions referred to marginal information included on each map. A questionnaire based on personal characteristics was also included. A purposive sample, consisting of eighty-six map-readers, was randomly assigned to either the paper or animated map group. Participants were given a packet of maps, tests, and questionnaire. Each map-reader was asked to follow written instructions and return the packet upon completion.

Results of the research were based on a quantitative comparison of map test score between the two groups. Overall, there was a significant difference between the performances of each group. No significant difference was identified in the thematic category. The marginal category suggested a high probability of independence between the groups. The paper map group scored higher on almost all accounts. Findings based on these participants suggest that paper maps were the most effective medium for representing time as a cartographic variable.

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CHAPTER 1

INTRODUCTION

As it is seldom possible to inspect the ground on which movements will be carried out, or to remember accurately details of such ground once seen, some representation of the area involved must be prepared. This is called a Map.¹

Representing changes in spatial phenomena over time is an important aspect of geographic communication and map display. Data of all formats is subject to certain time constraints. Some kinds of information are collected at only one point in time. Other data is obtained at some predetermined interval. Other forms of information are gathered continuously. For geographic information where time is a pertinent factor, cartographers are challenged by how they may best represent a given time span. Although cartographers have experimented with map animations for more than forty years, the effectiveness of these maps has been underrepresented in previous research. Traditional paper map formats have been thoroughly tested in order to establish cartographic principles. Animated maps, although increasingly prevalent, have not been sufficiently evaluated according to their ability to convey geographic information. The incomplete understanding of map animation provides an ideal platform for research in cartography.

The History of Time in Cartography

Historically, maps have been limited to mass production upon paper. From the earliest days of cartography, skills have been learned and principles have been tested upon this native medium. By no fault of its own, this medium lacks the ability to easily

¹ *Notes on Map Reading*. 2nd ed., ed. The War Office. Ottawa: Edmond Cloutier: Printer to the King's Most Excellent Majesty, 1940.

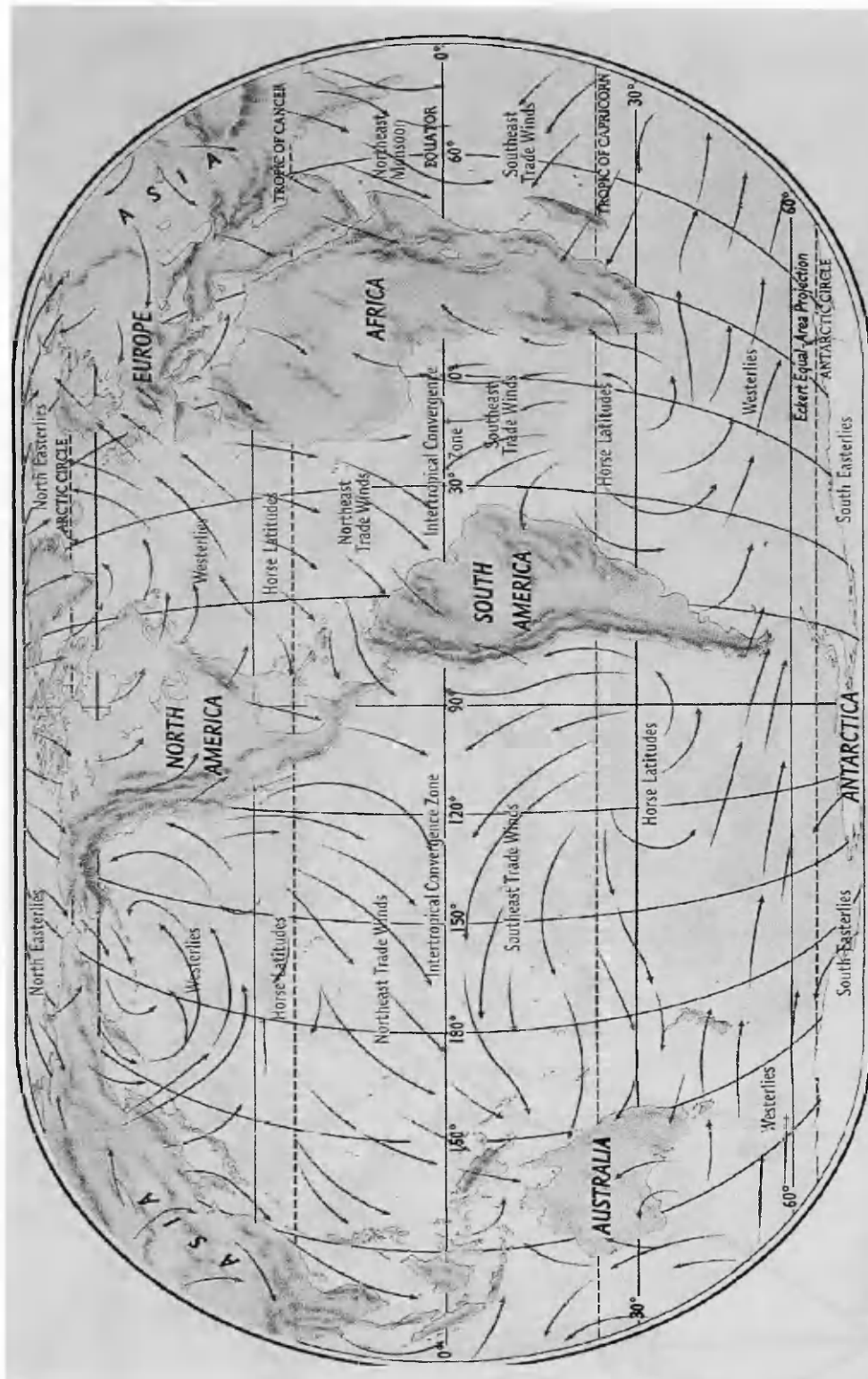
display geographic variables over time. One can certainly compile multi-dated information into one map composition. Or, for simplicity, create a series of maps that display individual instances of the topic at hand. However, both examples seem to be lacking in their potential to adequately convey the information. Campbell and Egbert go so far as to imply that paper maps are only a crude form of representing dynamic events that take place over time.²

Little information exists on the history of incorporating time into maps. That is not to say that cartographers have not made successful attempts; every map incorporates time on some level. Its inclusion is inherent and inseparable from a cartographic product. Navigational charts display wind patterns and their shift with the seasons (Figure 1-1). Road maps indicate the time required to drive from point A to point B (Figure 1-2). Every map, regardless of type or topic, is bound to both the time it was created and the time of the information it represents. This relationship, obvious as it may be, could be one of the reasons that cartographic research and principles have not historically focused upon displaying time. Not until the advent of media such as film and television did cartographers begin to experiment with using time as a cartographic variable.

Norman Thrower was the first to investigate the possibilities of displaying sequences of time in cartography.³ His experiments were based entirely upon individual images filmed briefly with a movie camera. These images were then shown in sequence to produce an animation. Thrower noted some aspects of this cartographic form that differed significantly from the traditional paper map: legends were oftentimes absent;

² Craig S. Campbell, Stephen L. Egbert. "Animated Cartography: Thirty Years of Scratching the Surface." *Cartographica* 27, no. 2 (1990): 24-46.

³ Ibid



WINDS

Figure 1-1 Map displaying prevailing global wind patterns.⁴

⁴ John F. Shupe, et al. *The World – Physical*. The National Geographic Society. Washington, D.C. 1995.

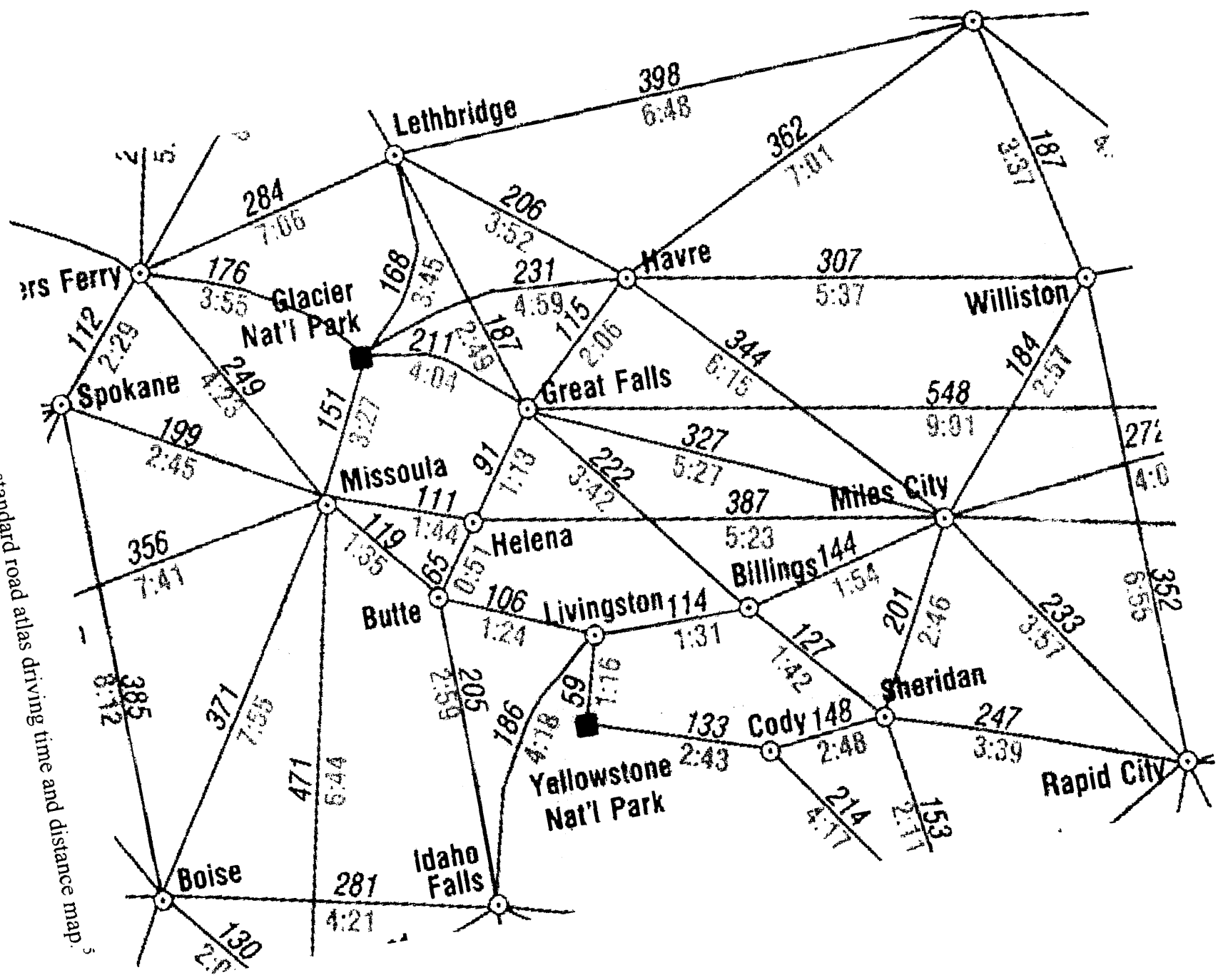


Figure 1-2 Excerpt from a standard road atlas driving time and distance map.⁵

⁵ North American Mileage and Driving Time Map. Rand McNally Easy to Read Travel Atlas, U.S., Canada, and Mexico. 1998.

orientation references, or grids, were not present; and geographic scales were not used to display distance. Thrower's research also suggested that animated maps should not be considered a substitution for traditional maps. However, he did note that cartographers should continue to experiment and develop cartographic animations.

One of the most important advances in displaying time in cartography followed Norman Thrower's work: the development of the computer. Computers revolutionized the ability to treat time as a graphic variable. Like Thrower's experiments with film, computers could display sequential images to produce an animation. In addition to display, computers also permitted the mapmaker the ability to easily manipulate individual images. Unlike filmed animation maps, multiple computer animations could be conveniently designed, created and observed without ever leaving the computer.

By the mid 1960s, many cartographers were experimenting with computer-animated maps. Cornwell and Robinson were the first to publish an article on the potential uses for computers in map animation (Figure 1-3).⁶ They utilized the cathode ray tube (C.R.T.) inside the monitor to produce a moveable beam of light in both point and line form. Their experiments depicted map animations pertinent to many scientific fields including meteorology, physics, and astronomy. Fueled by the quantitative revolution in geography and cartography, the practice and research of map animation continued into the early 1970's. W.R. Tobler produced a three-dimensional representation of population growth in Detroit, Michigan.⁷ Sam Hillard, a historical

⁶ Bruce Cornwell; Arthur H. Robinson. "Possibilities for Computer Animated Films in Cartography." *The Cartographic Journal* 3, no. 2 (1966): 79-82.

⁷ Campbell and Egbert, "Animated Cartography," 24-46.

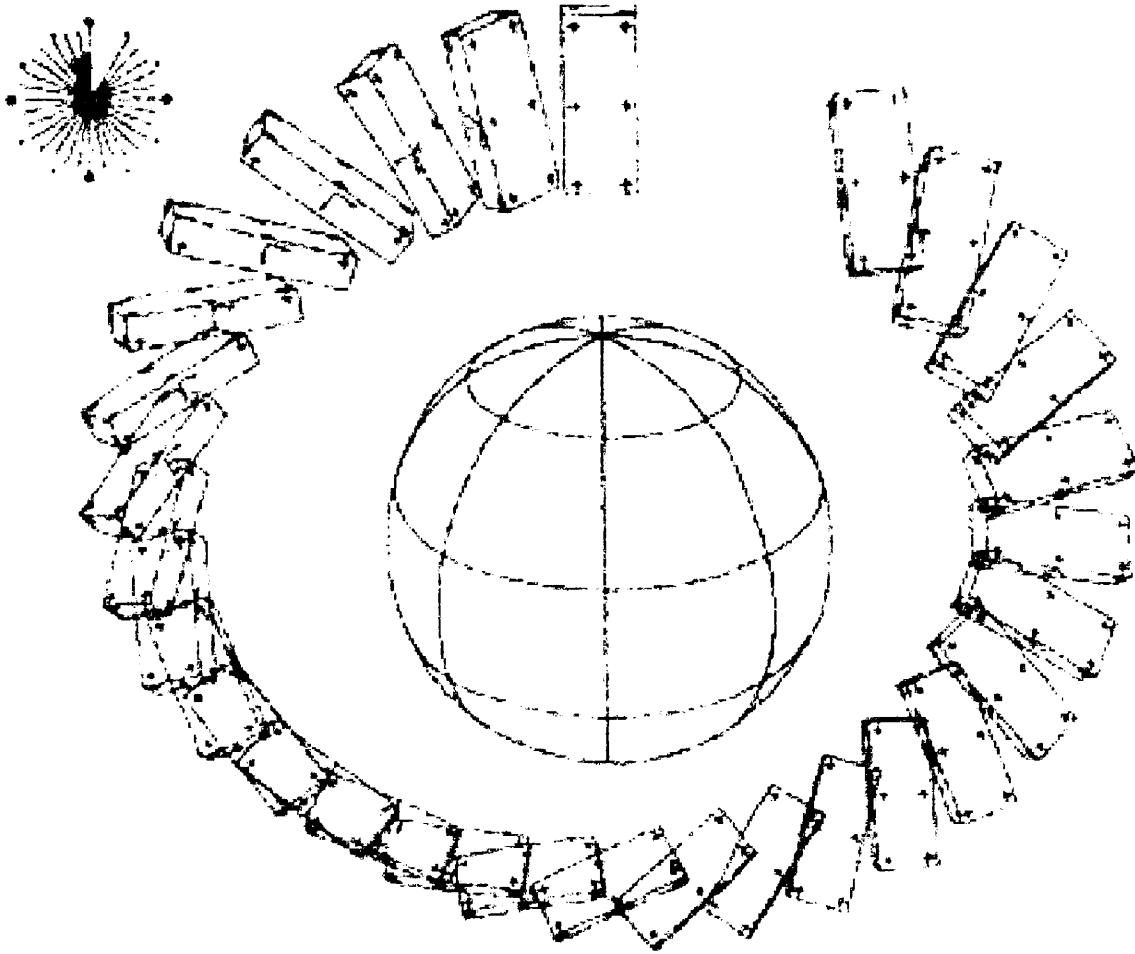


Figure 1-3 Composite drawing from the animated map Attitude Control of a Satellite.⁸

geographer, created animations of land cessions from Native Americans to the United States government.⁹

As various applications of computer animation grew, animation became a field in itself. Computer programming languages were developed to improve animation. Specific techniques were also created to allow for more realistic displays. One of the most important of these techniques is a process known as “tweening.” This term, short for “in betweening”, refers to the creation of a specified number of interpreted frames in

⁸ Cornwell and Robinson. "Possibilities for Computer Animated Films", 81.

⁹ Campbell and Egbert, "Animated Cartography," 44-46.

between two key frames.¹⁰ Stated differently, tweening permits the computer to interpolate intermediate images between two specified images. Depending on a designated number of tweened frames and the overall speed of the animated sequence, the viewer is given the illusion that an image is moving. The process of tweening is much like cartoon flipbooks made for children. Each page displays one static that is slightly different than the images before and after. Individually, these images convey no sense of movement or change. However, when the pages are flipped through in rapid succession, the child sees the image move. Figure 1-4 illustrates the concept of a simple tweened shape created in Macromedia Flash 5, a multimedia animation program. The small circle on the left represents the first specified image or key frame. The large circle on the right is the second designated key frame. Using a tweening function in Flash, the computer interpolates intermediate circles between Key Frame 1 and Key Frame 2. Each

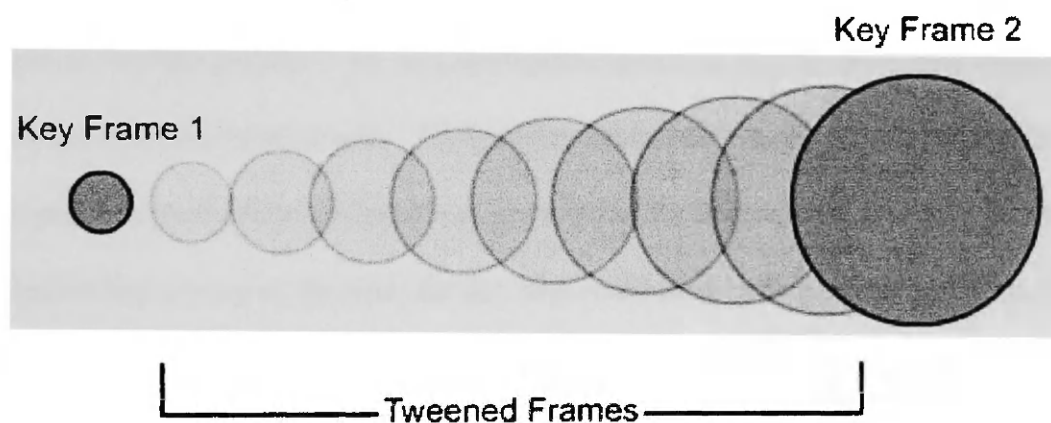


Figure 1-4 Illustration of animation tweening.¹¹

tweened frame shows the circles increasing in diameter to approximate the change in diameter between the key frames. When the sequence is played back, the viewer does

¹⁰ Peterson, Michael P. *Interactive and Animated Cartography*. Englewood Cliffs: Simon & Schuster, 1995.

¹¹ Illustration created by author using Macromedia Flash 5 Animation Software.

not see the individual circles. Instead they see one circle moving from left to right while it grows larger. The importance of this process for cartographers lies in the ability to depict map variables at a known time and place, and allows the computer to interpret the intermediate stages between a series of events. While it is important to remember that tweening is only an approximation, cartographers can use the method to observe temporal patterns in spatial phenomena that may have been otherwise obscured.

Animated maps continued to be created throughout the 1970s and 1980s. Exploiting the continuous developments in computer hardware and software, cartographers such as Harold Moellering and Mark Monmonier began to experiment with three-dimensional map displays.¹² The 1990s saw research in animated map sequences switch from focusing on specific techniques to interpreting how animated maps might better serve the map-reading public. Monmonier led the way by suggesting that map-readers would increasingly require the need to examine both spatial and temporal information simultaneously.¹³ He saw animations as a tool to examine increasingly large amounts of data with relative ease. Time-series charts and graphics associated with spatial phenomena could be included in the animations. In this manner, the quantitative information that served as the basis for the map could now be a dynamic part of it. Users could view entire sequences or stop them at will to investigate individual static relationships. Thus animated maps became part of a more broadly defined field known

¹² Campbell and Egbert, "Animated Cartography," 44-46.

¹³ Mark Monmonier. "Strategies for the Visualization of Geographic Time-Series Data." *Cartographica* 27 (1990): 30-45.

as dynamic mapping that includes animation, interaction, and sound.¹⁴ In 1995, Peterson wrote the first text specifically devoted to dynamic mapping techniques and practices.¹⁵ His book, although technologically outdated, remains the foremost authority on animated and interactive cartography.

At present, animated cartography appears to be both widely practiced and poorly studied. While map animations are very prevalent in our culture today, there is an apparent lack of recent literature focusing on specific techniques and their implications. There are many explanations for this shortcoming in cartographic research.

Technology in the computer industry is progressing by leaps and bounds. Improved storage space and processing speeds allow users to continually improve the efficiency of all computer applications. However, there is an inherent lag between the development of technology and the rate at which that technology is utilized. As a result, we are oftentimes consumed with learning the technology instead of the topic to which it will be applied. In addition to, and in conjunction with, technological advances, there have been increases in the overall size of datasets. As our ability to store vast amounts of data increases, the datasets themselves become so large as to be almost incomprehensible. Consequently, time formerly spent on map design and production is lost in trying to understand the wealth of data that needs to be displayed upon the map.¹⁶

¹⁴ David DiBiase, et al. "Animation and the Role of Map Design in Scientific Visualization." *Cartography and Geographic Information Systems* 19, no. 4 (1992): 201-214.

¹⁵ Peterson, *Interactive and Animated Cartography*, 1995.

¹⁶ Personal communication with Professor Paul Wilson. University of Montana, Department of Geography. March 2002.

The Dilemma of Time in Cartography

The passage of time is perhaps the most important facet of life; it is the cornerstone of existence. Time allows all things to begin and to end. It dictates events of the future and allows for reflections on the past. Time is often referred to as “Father” and is inseparable from “Mother Earth”. It has been praised and scorned, feared and embraced. We are consumed with it. Yet, ironically, time is taken for granted and rightly so. Despite all the uncertainties of this world, time will continue unscathed.

Countless forms of human expression have immortalized time. Music, written words, conversation, and art often focus upon some aspect of time. Historians document events of time passed. Analysts and prophets speculate on the future. What both have in common is the objective of capturing time.

What is the best method for representing time? We are all inherently familiar with it, and yet it can be a struggle to depict or describe. Language is the most common way of describing time or the events that have transpired as a result of its passage.

Different forms of media have also been widely employed. Second to verbal communication is the written word. Paper is the most common medium for writing. Some individuals argue that the continued growth of computer-based applications will eventually override the paper medium; that is, in the future most reading will be done from the screen instead of the page. While this speculation may be valid, a transition of this magnitude is still in its infancy. A counterargument by this author suggests that paper will continue to dominate as the written medium.

Photographic images also describe time. Every family that keeps a photo album can attest to the importance of how photographs records time. Time is effectively

represented on media such as television and film. Like photographs, these methods use time to show events as opposed to simply describing them. Many applications of computers also make use of this dynamic relationship of representing time. Through computer animation, time passage can be easily displayed. The forte of these dynamic methods recalls the old adage “a picture is worth a thousand words.” The dilemma comes in acknowledging that pictures are relatively new in terms of communication while words and writing have been utilized for thousands of years.

Other forms of conveying information, namely graphic communication, predate both the picture and the word. The study of graphic communication, known as semiology, is based upon all forms of visual representation¹⁷. While graphics may include text or photographic images, they are more often thought of as artistic illustrations. Webster’s New World Dictionary defines graphics as “... arts that include any form of visual artistic representation, especially painting, drawing, etching, etc...”. One could extend this definition to include other forms such as statistical diagrams and analytical figures. More important to the topic of this thesis, one must also consider maps as a form of graphic communication.

An obvious omission from Webster’s definition is the failure to include any mention of computer graphics. Technology now allows for the production and display of graphics upon a digital canvas, more commonly known as a monitor. By and large, graphics are losing ground in their analog format and emerging strongly on the digital platform. Where a painter once produced their work with raw materials, their brush is now a mouse and the palette is upon the screen. The same may be said for cartographers.

¹⁷ Jacques Bertin. *Semiology of Graphics*. Translated by William J. Berg. Madison: The University of Wisconsin Press, 1983.

The days of manually drafting maps are gone and we are immersed in digital map production and Geographic Information Systems (GIS). Yet, despite the strengths in production, distribution, and accessibility of digital products, we are often left with one nagging question: Are they better?

Statement of Purpose

The purpose of this thesis is to compare methods for representing time in cartography. The research will focus upon a statistical analysis of test results based on the map-reader's ability to understand identical geographic information presented in paper and animated formats.

Research Relevance and Questions

The juxtaposition of paper versus computer produces fertile ground for research in cartography. Historically, maps have been produced upon paper. Before paper, geographical references were drawn upon stone, animal skins, papyrus, and even the Earth itself. Currently, however, cartography and map production is amidst transition. By and large, the days of tediously preparing paper maps are gone. They have been exchanged for newer and faster methods that are deemed more efficient. Students are no longer given the opportunity to try their hand at drawing their own maps. Instead, they are instructed on the use of computer software as a tool for creating geographical references. Certainly, we have not completely lost touch with creating maps by hand. People still sketch directions on scraps of paper. Occasionally while in the field we draw maps in the sand. But overall, with the passage of time and progression of technology, the methods have changed. Even this author, an aspiring cartographer, has not actually

drawn a map since he was twelve years old. In *Technological Transition in Cartography*, author and cartographer Mark Monmonier suggests:

The paper map might well be one of the casualties of cartography's Electronic Transition. Little more than a decade ago almost every map was conveniently available only on paper. If a user wanted to examine a copy, he viewed a paper copy. If a customer ordered a copy he was sent a paper copy. Except for plastic or glass drafting and production materials, microform copies, globes, instructional exhibits, and cognitive maps in people's minds, all maps existed on paper. In the decades ahead, though, the digital map will displace the paper map from its dominant position. Although a copy on paper or some other permanent graphic reproduction medium should be obtainable for almost all maps, paper will no longer be the principal medium for compiling, storing, distributing, displaying, and viewing geographic data. Moreover, most paper maps will be affected in their design or selection by digital cartography.¹⁸

Given the relevance of this research, there is one primary question upon which the study shall focus:

- Are there noticeable differences in the way a map-reader retains identical information presented in two separate ways?

Secondary research questions are also included within the scope of this thesis in order to address related topics:

- Which method is best suited for displaying time as a cartographic variable?
- Does the map-reader's use of media (television, books, magazines, internet, etc...) correlate with their understanding of an animated or static paper map?

Literature Review

A literature review was conducted in order to obtain information in three basic categories that pertain to this thesis.

¹⁸ Mark Monmonier, *Technological Transition in Cartography*. Madison. The University of Wisconsin Press. 1985. 4.

First, information on the use and history of time as a cartographic variable was sought in order to build a coherent background and research framework. Much of this research focused upon the development and usage of cartographic techniques since the late 1950's.¹⁹ Because computer applications, namely animation, did not emerge in the field of cartography until the mid-twentieth century, cartographic research did not focus on time as a variable. Since the 1950's, significant research has been conducted on many aspects of time-series cartography; however, the majority of this research focuses upon specific cartographic techniques and does not assess map-reader interpretation with time displayed on maps.

The second form of literature concentrated on the complex relationship between the map and the map-reader. This of interaction can be reduced to a psychological term known as cognition. Simply stated, cognition refers to mental activities such as thought, reasoning, problem solving, and the human being's ability to interpret the world around them.²⁰ Applied to cartography, cognition is the basis of how people read maps. Mental maps, according to Muehrcke, are developed in the human mind from infancy and influence our perceptions of the world through the remainder of life.²¹ Although we each develop our own cognitive maps, map perceptions can also be greatly influenced by the maps we observe throughout life. Maps carry with them a connotation of importance, and reality. Because maps are created by a relatively small group of individuals, the population at large oftentimes accepts maps as geographic truth. While most

¹⁹A 1959 article in the *Professional Geographer*, entitled "Animated Cartography", by Norman Thrower, is the first known written work and the usage of animation to display time as a cartographic variable.

²⁰Peterson, *Interactive and Animated Cartography*, 1995, 25.

²¹Phillip C. Muehrcke; Juliana O. Muehrcke; *Map Use: Reading, Analysis, and Interpretation*. Madison: JP Publications. 1995.

cartographers strive to present mapped information correctly, agendas and misconceptions on their part can greatly influence how others perceive the map. Despite our best efforts to overcome, or account for, this subjectivity, we will inevitably trust maps. As a result, it is important for cartographers to continually assess the viability and effectiveness of their product. Figure 1-5 represents a schematic view of how cartographers and map-readers perceive reality based upon the common ground of a map.

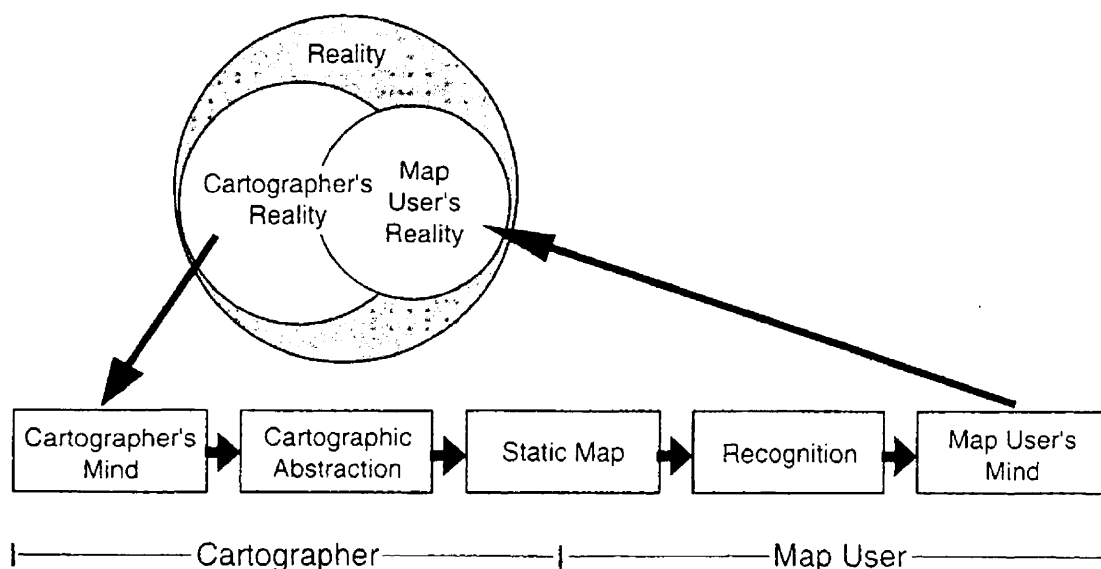


Figure 1-5 Representation of Cartographic Reality for Map Maker and Map-Reader²²

By necessity the core of the third form of literature focused upon statistical analysis and map-reader interpretation. Although human interaction and cognition are subjective by their very nature, these factors may be analyzed according to general traits observed in a population sample. Statistical procedures are oftentimes very useful in quantifying qualitative information.

²² Peterson, *Interactive and Animated Cartography*, 5.

Summary

It is easy to become apprehensive when confronting technological changes such as these; however, one should maintain that change does not imply abandoning the old for the new. Instead, we should think of new methods as extensions of all those previously used. For indeed, any discipline could not be considered empirical if it did not embrace the old while creating the new. Perhaps this understanding would allow us to reshape the question concerning paper versus digital media from, “Are they better,” to “What more will they allow us to do,” and “Are they more effective?” In cartography, this transition is allowing us to display and analyze geographic information like never before. By embracing the traditional methods, we are given the opportunity to test the new ideas against the old.

CHAPTER TWO

METHODOLOGY

Overview

Analyzing map-reader understanding and comprehension is a difficult task. Many cartographic research studies have focused upon this type of assessment; however, results are often prefaced with the understanding that interpretations of the data may be considered inconclusive or highly subjective. Research of this type is often categorized into a field known as Visualization or Scientific Visualization. These studies focus largely upon the cognitive response and/or understanding of graphic information. The popularity of this field has grown in recent years; however, cartographers have always been inherently mindful of visualization while producing their maps. “A map is a specialized form of visualization which contains geographical information and reveals by inference the spatial interdependence among geographical entities.”²³

While the results of Visualization research may be considered uncertain, it is important to review these studies within the context of their research framework. Subjectivity is inseparable from research on human subjects. Attempts to quantify results from human-interpretive studies that are qualitative by definition can be very difficult to obtain. Further complications arise in the field of cartographic visualization because the mapmaker can never truly present unbiased information, just as an author can never truly present unbiased narrative. Digital cartography and GIS add further complexity because data is typically acquired instead of produced. Websites and CD-ROM's now provide complete cartographic datasets that were previously drawn by hand. Attribute

²³Kate Beard and William Mackaness, "Visual Access to Data Quality in Geographic Information Systems," *Cartographica* 30 (1993): 37.

information describing each cartographic layer often accompanies this data in the form of large databases. Although these digital methods are incomparable in their presentation and analysis of spatial data, they also serve to remove the geographer from the geography. The pitfall of the digital method is man's nature to simply accept it. Without question, cartographic products are subjective. They are models based upon the cartographer's interpretation of what the map should be. Despite standards developed for the graphic design and content of maps, the end product can unarguably be reduced to human inference. Though we cannot overcome this fact, it does pose an important reminder that, oftentimes, "maps fail because of the mapmakers ignorance or oversight."²⁴ The responsibility of the cartographer, now more than ever, is to understand the map information before it is presented to others. Estimating the intended audience for a given map is crucial for the most effective and unambiguous representation. Most importantly, the cartographer should be ever mindful of the methods and format by which a map is produced.

Three map sets were produced: 1.) The Blodgett Canyon Fire, 2.) Corps of Discovery, 3.) Montana Quakes. Each set included a paper version and an animated version of the same geographic information. The theme of each map was limited to display only one cartographic symbol (point, line, or polygon/area). This limitation was twofold in its intent: First, past research has largely focused upon one symbol type per study, and neglected to compare interpretations of various symbols by the same map reader(s). Second, by focusing upon only one symbol per map, the overall complexity of the map was significantly reduced. The maps were based on their ability to convey

²⁴ Mark Monmonier, *How to Lie with Maps*. Chicago and London: University of Chicago Press, 1996, 43.

information that displayed a spatial change over time; therefore, a time-series, or temporal, theme was the intended focus. Each map topic was chosen according to its perceived appeal to an audience residing in western Montana. By doing so, the author hoped that individuals who participated in the study would not be instantly intimidated by the subject matter. Furthermore, because all participants knew they would be completing a test after viewing the maps, the map themes were chosen to ease any preconceived apprehensions.

A purposive sample, consisting of voluntary test subjects, was used to conduct the research. This sampling method, sometimes known as haphazard or fortuitous sampling, was chosen as a means of achieving a relatively large sample size (n).²⁵ Approximately half of the participants consisted of family members, friends, and coworkers. These individuals made up the first tier of the purposive sample. The second tier was made up of individuals referred by the first tier. The second tier participants were not directly acquainted with the author. Research guidelines, discussed in the preceding paragraph, mandated that all participants be eighteen years of age or older. All test subjects (a.k.a. map-readers) were randomly assigned into one of two groups: paper or animation. Each individual was presented with a map packet and asked to review the maps until they felt comfortable with the content.²⁶ Tests based on the content of each map were used as a tool to quantitatively assess the comprehension and retention of information displayed on each map. Upon completion of the map tests, a questionnaire was employed to solicit

²⁵ Leslie Kish, *Survey Sampling*, (New York: John Wiley and Sons, Inc., 1965), 19.

²⁶ Each individual was tested in the same order; in other words, participants in both groups were asked to first view the area map, then the line map, and finally the point map.

information used to make comparisons between personal characteristics and the overall understanding of the maps.²⁷

In accordance with the University of Montana guidelines for testing upon human subjects, provisions for this research were submitted to the Institutional Review Board (IRB). This organization serves to protect human research subjects participating in the academic research of any discipline. Although the invasiveness of research upon human subjects varies greatly between departments, all researchers are required to complete a short course and submit research proposals. The research framework of this thesis provided minimal physical, psychological, and social vulnerability to participants; therefore, the IRB granted a full administrative waiver.²⁸

Data Acquisition

The data used to create each map was obtained over the course of approximately one year (June 2001 – April 2002). This information was obtained from various sources that provide digital cartographic and/or spatial data. All data was downloaded from the Internet with the exception of some state and national boundaries that are bundled with the GIS software used to make the maps.²⁹ Each of the three maps presented in this research required different skills and techniques based upon the thematic content of each map. Various processes were required to manipulate the original data so that it would display properly with other layers. These tasks included, but were not limited to, uncompressing, reprojecting, and editing of both spatial and attribute data. While most of

²⁷ Map tests and questionnaires can be found in Appendix A.

²⁸ All documentation in accordance of IRB guidelines can be found in Appendix D.

²⁹ ESRI, Inc. provides digital cartographic data with their ArcView GIS 3.2 software package. These layers include national and state boundaries, city locations, hydrography, and latitude/longitude grids, as well as tabular attribute information.

the acquired data was high quality, some tailoring was required for the most effective cartographic display.

Each map was produced independently of the others; that is, one map project was finalized prior to beginning the next. In this way, there was no overlap in map production. This decision was made in order to focus solely upon one map topic and not to become overwhelmed by simultaneous projects.

Area Map

The area map, entitled The Blodgett Canyon Fire, focused on the 2000 Blodgett Canyon Fire in western Montana. This forest fire, one of almost twenty fires in Montana during the summer of 2000, burned within close proximity to the town of Hamilton. Residents of Missoula, Hamilton and much of western Montana were plagued by the constant smoke and ash produced by the blaze. The community of Pinesdale, on the eastern flank of the Bitterroot Mountains, had to be temporarily evacuated because of the impending threat. Between August 8th and September 9th, the duration of the forest fire, one home and numerous outbuildings were destroyed. When all was said and done, the Blodgett Canyon Fire burned nearly 11,500 acres and was fought by more than 250 personnel.³⁰

The U.S. Forest Service, Northern Region, provided the data for the Blodgett Canyon Fire map.³¹ Fire perimeter polygons were downloaded from the Internet, uncompressed, and imported into ArcView GIS. Other data acquired for this map

³⁰Michael Moore. Montana on Fire! Summer of 2000. Montana Magazine. Helena. 2000.

³¹Fire GIS data for the 2000 Blodgett Canyon Fire can be accessed and downloaded from <http://www.fs.fed.us/r1/ecology/fire2000/index.html>

included a 30-meter Digital Elevation Model provided by the U.S. Geological Survey and the U.S. Census Bureau 2000 Tiger Line Files.

Line Map

The route of the Lewis and Clark Expedition of 1804 – 1806 was selected for the line map topic. This theme was chosen primarily because of the regional appeal associated with Lewis and Clark. The expedition, which sought a geographic passage between the Missouri River drainage and the Pacific Ocean, spent considerable time exploring Montana and the northwestern U.S. The history of this journey was extremely well documented by the expedition party and has since been retold by countless authors. As the bicentennial of the Lewis and Clark Expedition approaches, the map topic is ideal for instilling interest in a wide variety of map-readers.

The cartographic information for this map was primarily digitized according to historically based reference maps. Data production, instead of acquisition, was required due to a lack of readily available sources via the Internet or other digital media. National boundaries, state boundaries, and hydrographic features were selected from the data distributed with the ArcView GIS software package.

Point Map

The point map used in this study detailed the date, location, and magnitude of the five largest earthquakes in Montana's recorded history. Because western Montana lies in an earthquake-prone zone known as the Inter-Mountain Seismic Belt and because earthquakes are an inherent danger to human beings, this map provided an ideal topic for a point symbol display.

The earthquake data was accessed from the University of Utah Seismograph Stations website.³² The information was provided according to the latitude and longitude of each earthquake epicenter. These points were saved as an attribute table and added to the basemap data in ArcView GIS. Other map layers shown in the point map include a 1 Kilometer Digital Elevation Model, major transportation routes, and hydrographic features that were provided by the State of Montana Natural Resource Information System.

Map Design and Production

Each map was produced using ArcView GIS 3.2 software. Like many other digital cartography and GIS software packages, ArcView maps are based upon a series of layers or “themes.” Figure 2-1 depicts the standard ArcView work environment. The boxes on the left-hand side of the figure, entitled “Roads.shp” and “States.shp”, indicate the themes for this view. In ArcView the cartographer is given complete control over the graphic qualities (color, shape, size, etc...) and sequence of each layer in the map design. Additionally, each layer may be turned on or off depending upon the display needs at any given time during map production.³³

Once the graphic design and textual labeling of each layer was completed, a map layout was created. ArcView provides a separate window, called “*Layout*”, in which the overall design of the map is produced. This window allows the cartographer to add

³²Earthquake data for the western United States can be accessed from the University of Utah Seismograph Stations at <http://www.seis.utah.edu>.

³³A complete description of ArcView GIS functionality can be found in *Getting to Know ArcView GIS: The Geographic Information System (GIS) for Everyone*. 1 vols. Cambridge: GeoInformation International, 1997.

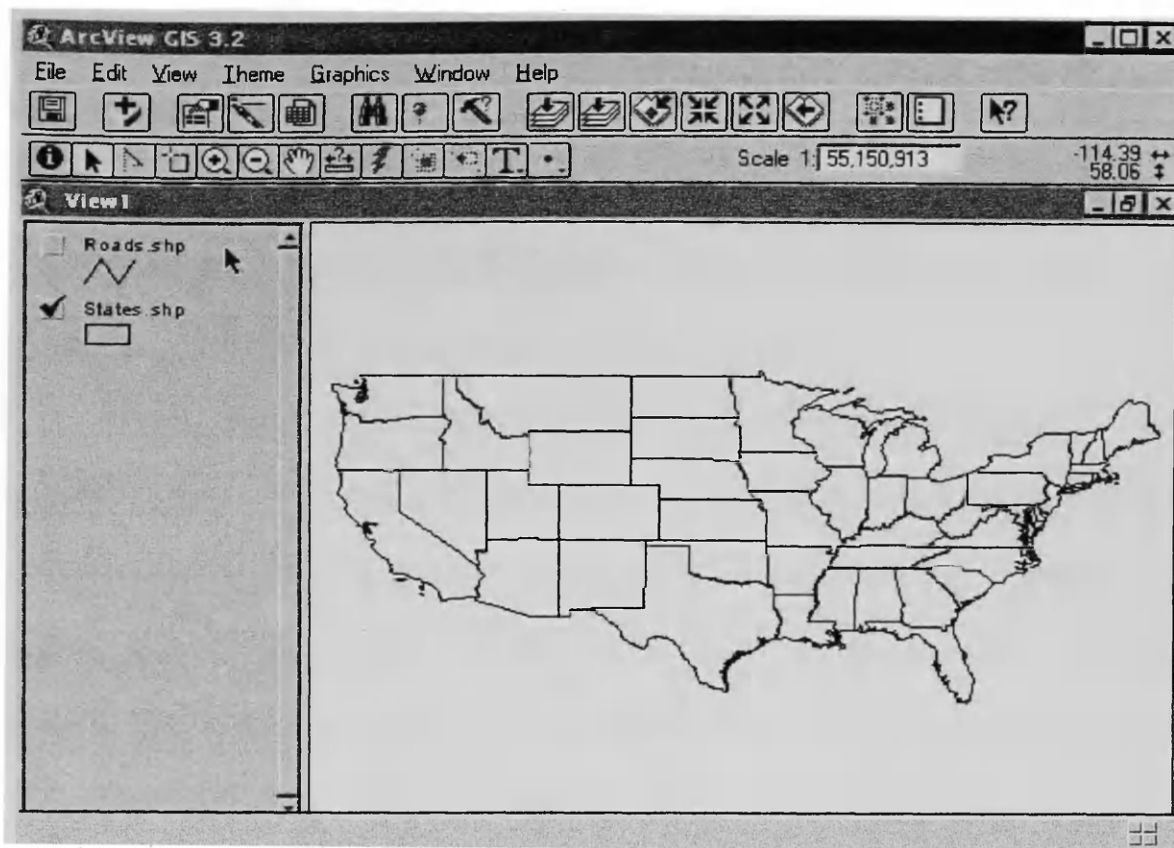


Figure 2-1 ArcView GIS 3.2³⁴

marginal information to the map. Such information may include the title, legend, scale bar, north arrow, author citation, and data references associated with the map. Layouts for each paper and animated map within the same set varied slightly. Paper map layouts were produced on an 11" x 17" page. This paper size allows for the production of a large map that is easily read, and efficiently displays the necessary information. Layout dimensions for the animated maps were restricted by computer monitor size. Therefore, animated versions made use of special tools in order display or access the same information presented on the paper map. Although the methods used to display the

³⁴ Screen capture of ArcView GIS 3.2, ESRI, Inc. Image depicts the View screen where map layers can be graphically manipulated or turned on / off for display purposes.

geographic information varied, the data included on both paper and animated maps within the same set was identical.

After completing the map design process, the paper maps were printed. No further modifications were made to these maps. The animated map layouts were exported as graphic images for use in the animation software.

Animated maps were developed with the Macromedia Flash 5.0 software package. Flash is a multimedia design and web-authoring software package that allows for the creation of animated computer graphics. Figure 2-2 represents the standard working environment for Flash. The timeline, which controls the animation, is located at the top of the screen shot. Individual layers, called “Scale,” “Title” and “Basemap” are indicated on this timeline. The basemap of the conterminous United States was exported from ArcView and imported into Flash. In general, graphic images are added as layers to the application. Flash allows each image to be displayed according to a designated location on a time line. In this way, image layers are only visible for a specified duration. The animation is created by displaying a series of individual graphics for a discrete time interval; that is, each image is briefly shown before the next appears. In this fashion, the audience perceives a change in the appearance of the graphic.

For each animated map, a control panel was provided allowing the map-reader to play, stop, rewind, and forward the animation. An interactive link that initialized a secondary page with any metadata information contained on the paper map version was also provided in the control panel.

The final animated maps were distributed on CD-ROM, for display on personal home computers.³⁵

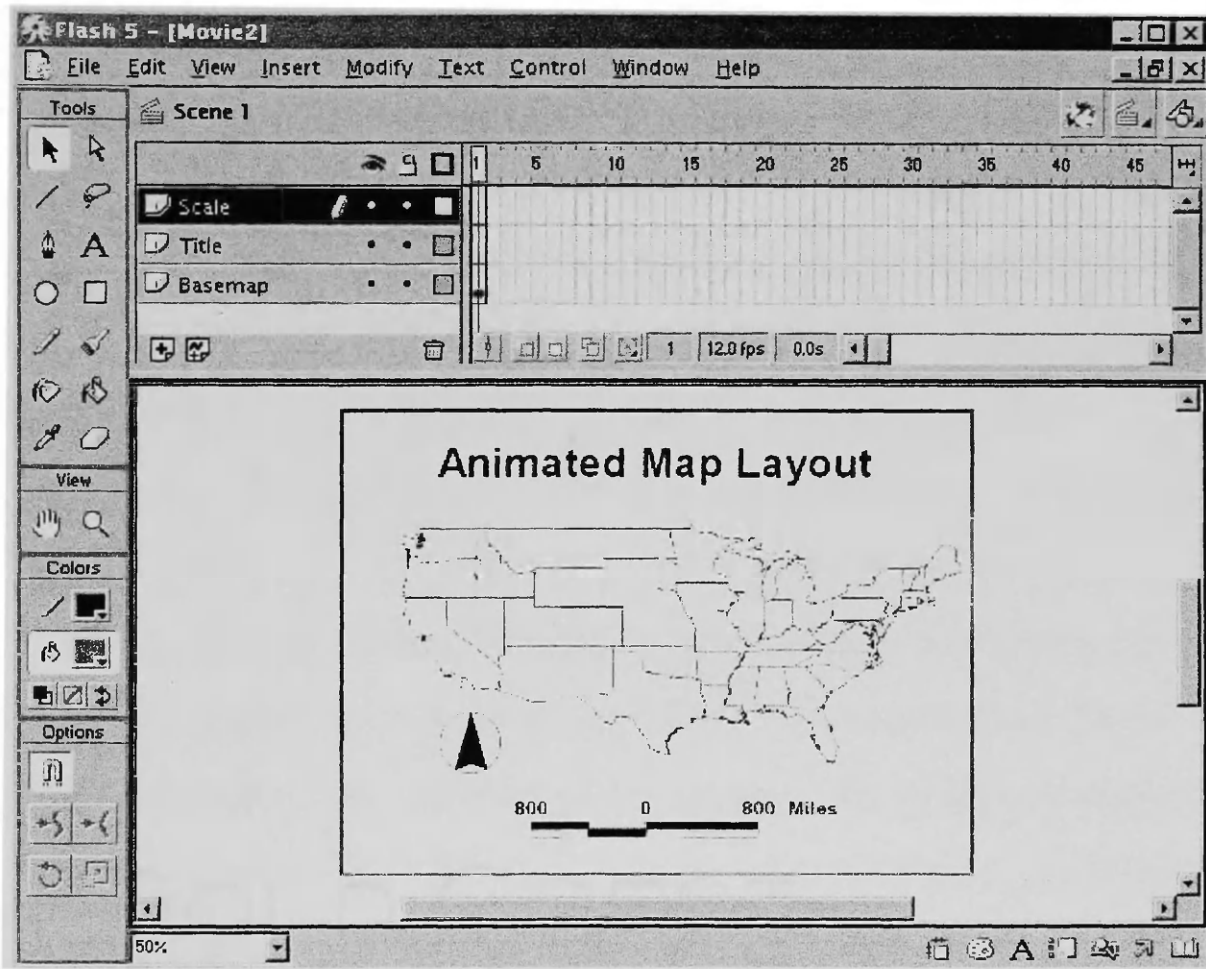


Figure 2-2 Macromedia Flash 5.0³⁶

³⁵ Both PC and Macintosh versions of the animated maps were produced, so as to remove bias from the computer operating system that each map-reader was comfortable using.

³⁶ Screen capture of Macromedia Flash 5.0. Image depicts a map exported from ArcView GIS and imported into Flash. At the top of the screen is the time line where individual layers can be added and set to display for specific intervals during the animation.

Area Map

The Blodgett Canyon Fire map was based upon individual polygons representing the fire perimeter for selected days between August 8th and September 9th, 2000. Only five days with corresponding perimeters were chosen for display on the map. These days reflected the greatest changes in the spatial distribution of the forest fire during its duration. The selected days were August 8th, 15th, 21st, 30th, and September 9th. Focusing upon only these perimeters emphasized the spatial and temporal change of the fire while minimizing the overall complexity of the map. In addition to the fire perimeter layers, the map displays hillshade topography, transportation routes, rural towns and communities, and hydrographic features.³⁷ Marginal map information includes the title, author, production date, map legend, north arrow, data source citation, and scale bar.

The paper map version presents each fire perimeter day as individual polygons colored by date (Map 2-1). This cartographic technique presents a contoured effect in which each polygon is easily distinguished from the others. The animated map displays the entire sequence by first displaying a red polygon which fades to gray as a subsequent red polygon appears. The second red polygon then fades to gray, as the third appears, and so on until the entire sequence has been played out. In this manner, the map-reader sees a moving progression of the forest fire from beginning to end.³⁸

³⁷After final production and distribution of the Blodgett Canyon Fire maps, a flaw was detected in the animated map design. The right-hand margin of the animated map is slightly truncated when compared to the paper map. This oversight partially obscures Willow Creek on the eastern edge of the map.

³⁸The animated version of the Blodgett Canyon Fire map can be found at the end of this thesis on the CD-ROM entitled "Animated Maps." Follow the instructions printed on the outside of the pocket in order to view the map.

Line Map

The Corps of Discovery map is a simple line map portraying the route of the Lewis and Clark Expedition between 1804 and 1806. Six points of interest that specify important events during the journey are indicated at various locations on the map. The present-day continental United States serves as the basemap with Canada and Mexico subtly shown in the background. The line illustrating the expedition route is color-coded based on the westward journey (red) and the return journey (green). This line appears dashed where the expedition separated into two contingents. Land designations from 1804, including existing states, the Louisiana Purchase, and various territories and possessions, were included for historical representation of North America during this time period. Current state boundaries are superimposed under the historical boundaries as a means of reference for the map-reader. Major hydrographic features are shown as many of them directly pertain to the Lewis and Clark Expedition. For general reference, as well as aesthetic purposes, a graticule displaying latitude and longitude was also included. In addition to title, legend, and scale bar, marginal map information includes images of Merriwether Lewis and William Clark. A graticule displaying latitude and longitude was also included for general reference and aesthetic qualities.

The design between the paper and animated maps varies only slightly due to the computer monitor size restriction for the animated map. Six points of interest are designated on both maps. The paper map contains numbers at each location that correspond to a full-length text description in the map legend. The same description is displayed on the animated map. However, as the animation runs, the text briefly appears

next to the point of interest and disappears as the expedition route continues. All other elements of map layout and design were identical between paper and animation.³⁹

Point Map

The point map, *Montana Quakes*, displays the five largest earthquakes in the recorded history of Montana. The use of earthquake data was ideal for creating both a standard proportional-circle map and presenting a topic of great interest to a wide variety of map-readers. In addition to representing proportional circles, the five earthquakes, all in west-southwest Montana, are different colors. A topographic hillshade of western Montana serves as the basemap for *Montana Quakes*. Large towns, along with interstate highways, are indicated as a means of reference for the map-reader. Hydrographic features such as lakes and major rivers are also displayed on the map. Marginal map information includes title, legend, scale bar, author, and data source citation.

The layout and design of the paper and animated *Montana Quakes* maps only differed in one respect. Both maps display dates for each earthquake. These dates are displayed in the legend of the paper maps, along with the corresponding map symbol, quake name and magnitude. The animated map also contains these dates but the dates are revealed in conjunction with the corresponding earthquake as the animation progresses. This difference in design, like the line map, was dictated by limitations in the monitor size and effective workspace on the animated map.

³⁹After final production and distribution of the Corps of Discovery maps, a minor flaw was noticed between the two formats: the paper map displays graphics of Merriwether Lewis in the upper left corner, and William Clark in the upper right corner. The animated map displays William Clark in the upper left corner and Merriwether Lewis in the upper right corner.

Map Comparison and Evaluation

The paper and animated maps in each category (area, line, point) were designed with the intent of statistically analyzing map-reader interpretation and retention. Since both paper and animated maps in each category conveyed the same information, they were used as a tool to assess differences between the two cartographic methods. A purposive sample of map-readers was randomly assigned to either the paper or animated map category. Questionnaires based on the content of each map served as an evaluation instrument between paper map-readers and animated map-readers.⁴⁰

Map Test and Questionnaire Design

Individual tests were designed according to the content of each map. These map tests solicited responses from map-readers based upon the information shown on each map. A multiple-choice design was used in order to compensate for map-reader apprehensions of being tested.⁴¹ Because the same information was presented on both paper and animated maps, map-readers in each category received identical tests. Each map test consisted of ten questions. The questions were divided into two separate categories, Thematic or Marginal, with five questions in each category.⁴² Thematic questions specifically focused on the mapped information. The questions included, but were not limited to, the time-series features portrayed on each map. Other thematic questions referred to specific locations of mapped features, whether or not features were present or how the time-series data interacted with other features. Thematic questions did

⁴⁰ See Appendix A for questionnaire design and format

⁴¹ Patricia J. Labaw, *Advanced Questionnaire Design*, (Cambridge: Abt Books, 1982.)

⁴² Each question on the questionnaires in Appendix A has been coded with a superscript “T” or “M” that indicates its Thematic or Marginal designation.

not require the map-reader to refer to the map legend or any other marginal map information in order to correctly answer the question. Marginal questions focused on auxiliary information contained in each map. This information, commonly referred to as marginalia, includes such things as the title, legend, author, date, scale bar, and data source citations. Marginal map components can be reduced to anything that isn't physically mapped but is used to describe the map or enhance the overall cartographic design.⁴³

A fourth questionnaire was employed to gather information based on the personal characteristics of each map-reader. In addition to age and gender, participants were asked to provide information that could be used in a correlation analysis with map questionnaire scores. Space was also provided for additional comments or questions that each participant may have had.

Pretest

A pretest was conducted in order to ensure the feasibility of conducting this research on a large intended sample size. Ten individuals were asked to observe the maps and complete the associated questionnaires. Participants in the pretest group were not randomly assigned to either group. Instead they were assigned to a group in order to achieve a stratified representation of map-reading abilities.⁴⁴ In addition to the questionnaires, a form requesting additional comments, questions, or concerns was included with the project. The author also encouraged verbal communication at the time

⁴³ Alan M. MacEachren, *Some Truth with Maps: A Primer on Symbolization and Design*. Washington, D.C.: Association of American Geographers. 1994. 98.

⁴⁴ The group assignment of pretest participants was based upon their map-reading level as perceived by the author. The intent was to include an even distribution of map-readers in both categories.

the project was returned. Changes were made to both questionnaire and map design based upon the pretest outcome.

After collecting the results for all pretest participants, the questionnaires were scored and evaluated. A variety of statistical procedures were conducted to guarantee that quantitative analyses could be applied.

Comparing Animated and Paper Maps

The primary results of this research shall focus upon a quantitative analysis of map-test results between paper and animated map-readers. The questionnaires were designed with the intent of utilizing specific statistical techniques to compare the paper and animated test results. As stated by the principal research question, the goal is to assess any differences between map interpretations of paper and animated maps. The majority of the research results and analysis will focus upon answering that question.

Secondary analyses will be conducted as a means evaluating other questions pertaining to this research. These measurements will be based upon relationships between personal characteristics of participants and results from the three map questionnaires.

CHAPTER 3

RESULTS AND ANALYSIS

Questionnaire Results

Descriptive statistics based upon results from the General Information Questionnaire will serve as the initial focus of this section. This information was collected as a means of assessing some general characteristics of participants in the animated and paper map groups. Although the sample of map-readers in either group was not randomly selected, every individual was randomly assigned to their respective map group.⁴⁵

Table 3-1 displays the results for both groups according to participant age and time to complete the project. Although slight variations exist in the distribution of participant age between the paper and animated map categories, the difference is minimal.⁴⁶ More interesting is the distribution of total time spent completing the project

Table 3-1 Age of Participants and Time to Complete Project

	Mean	Median	Std. Dev.	Minimum	Maximum
Paper Group (n = 43)					
Age	41.3	38	14.7	18	77
Time (minutes)	25.7	25	9.3	15	50
Animation Group (n = 43)					
Age	40.2	41	10.1	22	62
Time (minutes)	22.6	20	6.7	10	38

⁴⁵ A purposive, or convenience, sample of map-readers was used to collect all data for this research; therefore, results cannot be applied to the population at large. Instead, they only serve to describe and quantify the data obtained from research participants.

⁴⁶ The IRB administrative waiver required a minimum participant age of eighteen; therefore, minors could not be included in this research.

for the paper map-readers versus the animated map-readers. On average, the paper map group spent three minutes more completing the map reading and associated tests. Both distributions show a positive skew, however this measurement is noticeably higher for the animated map group.⁴⁷ The standard deviation for the animated group is much lower, as compared to results from the paper map group. The minimum and maximum values for time spent also represent a noticeable difference between the groups. By comparing the values it is interesting to note that the minimum value of 15 minutes for the paper group is five minutes more than the minimum value for the animated group. In addition the maximum time of 50 minutes for the paper group is twelve minutes more than the maximum time for the animated group. These measurements strongly suggest that map-readers observed the paper maps and animations in two distinct ways.

The descriptive statistics in Table 3-1 suggest that the values for time spent by the paper map group is normally distributed. The animated group distribution is more tightly centered about the mean, suggesting a less normal distribution. The distributions for both animated and paper map groups may represent a clear difference between the amount of time each group deemed necessary to complete the project.

The gender of each participant was included as a question in the General Information Questionnaire. The measurement was incorporated for two reasons. First, it was intended to describe the distribution of participants based on gender. Secondly, it was included for possible use as a correlation variable with other test scores. Table 3-2 includes the results for participants in both categories based on gender. The paper map

⁴⁷ This measurement was assessed according to the difference between the mean and median scores for the time to complete the project.

Table 3-2 Gender of Participants

	Female	Male	Total
Paper Group	21	22	43
Animation Group	27	16	43

group was evenly distributed with respect to the number of female and male participants. The animated map group, however, was not evenly divided but had overwhelming number of female participants. Although this outcome may or may not have effects on the outcome of other research results, participants were not stratified according to gender before placement in their group. Instead every individual was randomly assigned to observe either paper or animated maps.⁴⁸ Further statistical results may indicate whether these gender distributions had any effect on map interpretation.

Variables assessing general usage of media were included as potential correlation variables with map-test scores. These variables asked readers to indicate the number of hours each day spent each day using computers and reading paper materials. The goal was to evaluate whether a general increase in media habits was reflected in test scores. More specifically, the author was curious if paper map scores increased in conjunction with the number of hours spent reading each day. The same information was sought for the relationship between animated map scores and use of a computer each day. Table 3-3 indicates the number of hours each group spends reading and computing.

Due to the categorical nature of these variables it is difficult to assess the quantitative distribution of results.⁴⁹ In general, the variable that assessed the number

⁴⁸ Random assignment was chosen in order to remove any preconceived notions or bias based on previously known characteristics of participants.

⁴⁹ Participants were asked to circle the category which best represented their personal media usage. Although these results are based on an ordinal scale, they can be used to analyze any potential association with map-test scores.

Table 3-3 Usage of Specific Media

	Hours per Day					Total
	0-1	1-2	2-3	3-5	5+	
Paper Group						
Reading	18	20	4	1	0	43
Computer	8	10	4	8	13	43
Animation Group						
Reading	14	21	8	0	0	43
Computer	8	10	3	15	7	43

of hours spent reading per day was consistent for both paper and animated groups.

According to the results, most participants spend between one and two hours per day reading. Very few participants spend up to three hours reading. Only one participant, in the paper map group, indicated they spend up to five hours per day with reading materials. With respect to the computer use variable, there appears to be two specific categories within both groups. Generally speaking, the majority of participants either use computers two hours per day or less, or more than three hours per day. Only four individuals in both groups reported computer use between two and three hours per day. This natural break in the results may reflect the difference between people who use computers as part of their daily work and people who are strictly home users. The distribution certainly suggests that participants in both groups can be divided into low computer usage or high computer usage category. Further testing may indicate specific relationships between these categories and the map-test results.

Participants were also asked to indicate, on a rank-ordered scale, two variables that could be used to assess personal interaction with maps. The first question solicited a response estimating the general amount of time each participant uses and/or refers to maps. Scores were based on an interval from one to five, where one indicated a response

of “never” and five indicated a response of “frequently”.⁵⁰ The second map assessment question asked participants to rate their own map reading abilities. These scores were also collected on an ordinal scale between one and five. A response of one indicated “poor” map reading ability, while a score of five indicated “excellent” map reading ability.⁵¹ Table 3-4 reflects the results of these two questions.

Table 3-4 Personal Map Interactions

	Never		Occasionally		Daily Basis	Total
Frequency of Map Use	1	2	3	4	5	
Paper Group	5	25	9	1	3	43
Animation Group	8	19	9	3	4	43
	Poor		Average		Excellent	
Map Reading Ability	1	2	3	4	5	
Paper Group	4	6	20	11	2	43
Animation Group	7	5	24	6	4	43

Like the results for favored use of media, the scores in Table 3-4 can also be broken into some general categories. For the variable estimating map use, the majority of participants in both groups indicated a value of two. An equal number of nine individuals reported occasional use of maps. Very few participants responded at levels four and five. This distribution indicates that participants are most often relatively infrequent map users.⁵² Although this outcome may not prove beneficial to this research, it may reflect a general map-reader trend. Because maps are often viewed as specialized forms of communication, many individuals lack the skills or desire to use them.

⁵⁰ A response of three on this scale indicated a general map use of “occasionally.”

⁵¹ A response of three on this scale indicated a general map reading level of “average.”

⁵² It is important to note that this variable is difficult to quantify. Ordinal categories such as these are subject to the interpretation of each participant. An individual who refers to maps on a daily basis may truly be an occasional map user; therefore, results from this statistic do not imply true population parameters.

Results from the second question, which assessed map-reading ability, is much more insightful in terms of potential categorization. An overwhelming majority of respondents in the paper and animated groups rated themselves as average map-readers. An approximately equal number of responses for both groups exist above and below the average score of three.⁵³ General categorization can again be applied to suggest three levels of map-reading ability: low, medium, and high. It is interesting to note that, while most participants indicated infrequent use of maps, the majority consider themselves average map-readers. Although only general speculations can be made, this juxtaposition may reflect unintentional human bias. This bias could be explained as an inability to accurately rate ourselves as map-readers despite the amount we use maps. It may also mean that individuals are confident in their map-reading abilities, but are rarely required to refer to maps. In both cases one could resolve the relationship by stating that maps mean different things to different people. Results such as these are subjective by nature; however, the general trends in the data provide an enlightening description of the participant interaction with maps.

At this juncture it is appropriate to restate the implications of results associated with the research. Because map-readers in each group comprise an overall purposive sample, both quantitative measurements and qualitative inferences only apply to research participants. The variables included in Table 3-4 would undoubtedly differ for the population at large. As previously stated, quantifying these results in the form they were collected is difficult due to inherent subjectivity. However, these statistics do provide noticeable trends that help describe characteristics of participating map-readers.

⁵³ While most participants indicated a value of three, similar distributions for both groups are clustered about values of one and two and values of three and four.

The final variable included on the General Information Questionnaire simply asked participants to indicate which of the three maps they most favored.⁵⁴ The question was included as a means potentially estimating map-test scores based on a singular favored map. If test scores were abnormally high for one map, and the majority of participants selected that map, the relationship could be used identify some bias. The results for this question are included in Table 3-5.

Table 3-5 Favored Map

	Area Map	Line Map	Point Map	Total
Favored Map				
Paper Group	8	31	4	43
Animation Group	16	26	1	43

More than half of the participants in each group chose the line map as their favored map in the series. The area map was the second choice over all. Only one individual in the animated group, and four individuals in the paper group, chose the point map.

Map Test Results

Before discussing specific results from the map tests it is necessary to describe the method by which scores were calculated. One test was distributed for each map, which equates to three map tests. Individual scores were calculated for each map test. The individual scores were then combined to reflect the overall map test performance. The following discussion describes the nature of variables calculated for both individual tests and all map tests combined.

⁵⁴ This question asked participants to indicate which map conveyed the most information. Numerous responses were included on questionnaires stating that a specific map was not necessarily chosen for information content, but overall aesthetic appeal. In either case, results are intended to assess one favored map in the series.

As stated in Chapter 2, map-test results have been divided into three categories based upon the specific question types. First, total scores for each map test were calculated. Each test was worth a maximum of ten points. A combined total score for all map tests was then calculated by summing the three individual scores. Because there were three tests to complete, the maximum combined total score was thirty points. These calculations will hereafter be referred to as Total Scores.

The second category, based upon thematic-related map questions, was calculated in the same fashion as the Total Scores. Each of the three map tests included five thematic questions. The maximum allowed for thematic scores on each test was five points. A total of fifteen points was the maximum achievable for all map tests combined. These calculations will be referred to as T Scores.⁵⁵

The third category of map-test scores will be known as M Scores. These calculations focus upon questions that pertain to marginal map information. Like the Total Score and T Score, the M Score will be calculated for individual maps, as well as a combined total for all three maps. The maximum M Score for each map was five points, with a combined total of fifteen points for all map tests.

The Total Score, T Score and M Score categories were used to statistically compare the results of map-test scores between the paper and animated map groups. The Total Score category was designated as a means of identifying general differences between map interpretation and retention for both groups. T Score and M Score results were used to subdivide these differences based on types of information unique to maps.

⁵⁵ The nomenclature of “T Score” should not be confused with a value calculated using a t-test, which statistically compares distributions about a mean. A t-test will be employed in comparing the map-test results between paper and animated groups.

Paper Map Group

Table 3-6 contains the map-test results of participants who observed paper maps. Overall these data can be considered normally distributed. Very little difference exists between mean and median test scores for each category. Of all three maps the point map received the highest Total Score. The line map placed second in the Total Score calculation. T Scores were highest for the line map, followed by the point map. Results from the M Score calculation were highest for the point map and then area map. Alone these results are not conclusive. After the description of these variables for the animated map group, the results will be compared to one another. Analysis will focus upon distinguishing the probability that the paper map-readers and animated map-readers represent two statistically unique populations.

Table 3-6 Paper Map Test Results

	N	Mean	Median	Std. Dev.	Minimum	Maximum
Combined Map Scores						
Total Score (30pts)	43	22.56	23	3.70	14	29
T Score (15pts)	43	11.53	12	2.09	5	15
M Score (15pts)	43	11.02	11	2.26	5	15
Area Map Scores						
Total Score (10pts)	43	6.98	8	1.91	3	10
T Score (5pts)	43	3.09	3	1.19	0	5
M Score (5pts)	43	3.88	4	1.18	1	5
Line Map Scores						
Total Score (10pts)	43	7.51	7	1.33	5	10
T Score (5pts)	43	4.72	5	0.59	3	5
M Score (5pts)	43	2.79	3	1.17	1	5
Point Map Scores						
Total Score (10pts)	43	8.07	8	1.45	4	10
T Score (5pts)	43	3.72	4	0.98	2	5
M Score (5pts)	43	4.35	5	0.84	2	5

Animated Map Group

Table 3-7 displays the results of all map-test scores from participants in the animated map group. Like the results from the paper map group, these scores can be considered parametric, or normally distributed. Unlike the paper map group, the area map test produced the highest total mean score. The second highest total mean score was for the point map. The highest T Score occurred in the line map results, which also produced the lowest M Score in all map tests. The point map results provided the highest mean M Score although it only differed from the area map M Score by two hundredths. Like the results from the paper map group, these findings are not particularly insightful by themselves. The next section will focus upon a quantitative comparison of results between the paper and animated map groups.

Table 3-7 Animated Map Test Results

	N	Mean	Median	Std. Dev.	Minimum	Maximum
Combined Map Scores						
Total Score (30pts)	43	20.49	20	2.91	13	26
T Score (15pts)	43	10.81	11	1.99	6	15
M Score (15pts)	43	9.67	10	1.73	7	13
Area Map Scores						
Total Score (10pts)	43	6.90	7	1.31	4	10
T Score (5pts)	43	3.42	3	0.93	2	5
M Score (5pts)	43	3.49	4	0.96	2	5
Line Map Scores						
Total Score (10pts)	43	6.70	7	1.60	3	9
T Score (5pts)	43	4.02	4	0.89	2	5
M Score (5pts)	43	2.67	3	1.23	0	5
Point Map Scores						
Total Score (10pts)	43	6.88	7	1.37	3	9
T Score (5pts)	43	3.37	3	1.18	0	5
M Score (5pts)	43	3.51	4	0.70	2	5

Comparing Map Test Scores

Table 3-9 displays a side-by-side representation of the map test scores detailed in the preceding sections. This table is an essential precursor for the statistical analysis described in the proceeding section. Computational statistics in the next section will focus upon a comparison of the mean and standard deviation of the Total Score, T Score and M Score; therefore, only the mean and standard deviation calculations are included in Table 3-8.

Table 3-8 Comparisons of Paper and Animated Map Test Scores

	Mean		Std. Deviation	
	Paper Map	Animated Map	Paper Map	Animated Map
Combined Map Scores				
Total Score (30pts)	22.56	20.49	3.70	2.91
T Score (15pts)	11.53	10.81	2.09	1.99
M Score (15pts)	11.02	9.67	2.26	1.73
Area Map Scores				
Total Score (10pts)	6.98	6.90	1.91	1.31
T Score (5pts)	3.09	3.42	1.19	0.93
M Score (5pts)	3.88	3.49	1.18	0.96
Line Map Scores				
Total Score (10pts)	7.51	6.70	1.33	1.60
T Score (5pts)	4.72	4.02	0.59	0.89
M Score (5pts)	2.79	2.67	1.17	1.23
Point Map Scores				
Total Score (10pts)	8.07	6.88	1.45	1.37
T Score (5pts)	3.72	3.37	0.98	1.18
M Score (5pts)	4.35	3.51	0.84	0.70

In all instances except one the mean paper map scores exceed the animated map scores. Only the Area Map T Score reflects a higher mean in the animated group than the paper group. Overall this comparison suggests that the paper map group performed better than the animated map group. Although the statistical analysis that follows will not focus

upon identifying which group actually scored higher, it is noteworthy to mention the differences here.

Significance of Map Test Scores

The primary goal of this thesis, as stated in Chapter 1, is to objectively compare methods for representing geographic time-series phenomena. This comparison will now focus upon the quantitative results collected from the paper and animated map-test scores. The analysis will be based upon the framework of standard statistical hypothesis testing.⁵⁶ The format that follows has been derived from a number of texts focusing upon statistical analysis. Five commonly accepted steps for this quantitative technique have been utilized for this procedure. They are as follows:

1. Construct the Research Hypothesis (H_1) for the sample
2. Indicate the Null Hypothesis (H_0) for the population
3. Designate the Statistical Test for Analysis
4. Compare the Sample Statistic Distributions
5. Reject H_0 or Fail to Reject H_0 Depending Upon a Given Probability

As previously stated, the primary intent of this research focuses upon the comparison of methods for displaying time as a cartographic variable. The research hypothesis, hereafter called H_1 , shall state that there is a noticeable difference of mean test scores between the paper and animated map groups. In general, H_1 holds that a noticeable discrepancy exists between how individuals interpret identical information displayed in two separate formats, paper and animation. The quantitative results will not focus upon which method is more apt at conveying the geographic information. Instead

⁵⁶ David C. Howell, *Statistical Methods for Psychology*, (Pacific Grove: Duxbury, 2002), 97.

the analysis will identify any significant differences between the methods.⁵⁷ Given H_1 as stated, the null hypothesis (H_0) states that the mean test scores for all people who read paper and animated groups are the same. That is, at a given probability level, there will be no difference between the mean scores of paper map readers compared to the same scores for animated map readers for the entire population. Because of the constraints of H_1 and H_0 , a known statistical test must be chosen based upon the sampling distribution. Because participants were randomly assigned to one of two separate groups, and the analysis focuses specifically on comparing these groups, an independent samples t-test is the most ideal statistical evaluation.⁵⁸

The formula for the independent samples t-test is as follows,

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S_{x1-x2}}$$

where: \bar{x}_1 and \bar{x}_2 are the mean scores for paper and animated groups, respectively
 S_{x1-x2} is the difference in standard error between the paper and animated groups

The independent samples t-test is based upon calculating a ratio between the difference in mean scores to the difference in standard deviation of each mean. This ratio is then compared to a critical value of t, for a given probability, to determine whether the

⁵⁷ The statistical test employed for this comparison will be two-tailed, or non-directional. As stated in H_1 the goal is identify a general difference in how map-readers interpret the same information displayed in two distinct formats.

⁵⁸ An independent samples t-test was chosen for this analysis because the sampling distribution focuses upon only two independent groups. If more groups had been included in the research framework other tests, such as ANOVA, would have been more appropriate.

groups are truly independent of one another or represent the same population. If the calculated t values lie outside the critical t value, then we are able to reject H_0 for the specified probability level. Step four in the hypothesis-testing framework (Compare the Sample Statistic Distributions) was conducted using SPSS statistics software. Table 3-9 gives the results of the independent samples t-test between paper and animated groups.

Table 3-9 Independent Samples t-test Results

	d.f.	t	Level of Significance (2-tailed)		
			0.10	0.05	0.01
Combined Map Scores					
Total Score	84	2.885	Reject H_0	Reject H_0	Reject H_0
T Score	84	1.639	F.T.R. H_0	F.T.R. H_0	F.T.R. H_0
M Score	84	3.107	Reject H_0	Reject H_0	Reject H_0
Area Map Scores					
Total Score	84	0.198	F.T.R. H_0	F.T.R. H_0	F.T.R. H_0
T Score	84	-1.411	F.T.R. H_0	F.T.R. H_0	F.T.R. H_0
M Score	84	1.704	Reject H_0	F.T.R. H_0	F.T.R. H_0
Line Map Scores					
Total Score	84	2.565	Reject H_0	Reject H_0	F.T.R. H_0
T Score	84	4.296	Reject H_0	Reject H_0	Reject H_0
M Score	84	0.450	F.T.R. H_0	F.T.R. H_0	F.T.R. H_0
Point Map Scores					
Total Score	84	3.898	Reject H_0	Reject H_0	Reject H_0
T Score	84	1.492	F.T.R. H_0	F.T.R. H_0	F.T.R. H_0
M Score	84	5.006	Reject H_0	Reject H_0	Reject H_0

Note: The nomenclature F.T.R. H_0 indicates a failure to reject the null hypothesis. Bolded results indicate a rejection of H_0 for the given significance level.

Results for step five of hypothesis testing (Reject or Fail to Reject H_0) are included in the last three columns of the table.

Discussion of Map Test Scores

The analysis of the map-test scores, employing an independent samples t-test, has proven very insightful. The most noteworthy result of this exercise is the outcome of the Total Score in the Combined Map Scores category. This comparison of mean test scores

between the paper and animated groups allows for a rejection of H_0 with a confidence interval greater than 99%. The result is important because it answers the primary research question and problem statement of this thesis: there are noticeable differences in the way a map-reader retains information presented in two separate ways.

With respect to the participants included in this study, there was a very significant difference between the map interpretations of paper and animated map groups. Although mean test score distributions for both groups were considerably normal, the Combined Map Total Score for the paper map group was notably higher. This outcome has two implications. First, from a quantitative standpoint, participants in this study appear to reflect two independent samples of map-readers. Furthermore, these independent samples suggest that map-reader interpretation of the same information in paper and animated formats varies considerably. The second, more qualitative, implication suggests that the paper maps conveyed more information than their animated counterparts.⁵⁹ While this conclusion must remain speculative as a sample statistic, it is firmly grounded in the results from the two sample groups.

The results for the Combined Map T Score and M Score are as equally interesting as the Total Score results. The end product of combined T Scores from each map resulted in a failure to reject H_0 with any acceptable significance. This outcome suggests, with respect to combined map scores, that the difference between interpretations of animated and paper thematic data was negligible. It also indicates that, despite minor

⁵⁹ This conclusion can only be drawn on a qualitative basis. All statistical testing was two-tailed, and did not imply a directional result. However, general comparison of the mean test scores reflects higher performance in the paper map group. This effect may indicate higher levels of map interpretation and retention for participants who viewed paper maps.

discrepancies in the cartographic presentation of thematic data, paper and animated map-readers interpreted and retained the same information. A qualitative explanation might suggest that neither paper nor animated maps were more effective at displaying time as a variable.

The combined M Scores provided opposite results to their thematic counterparts. For each significance level listed in Table 3-9, H_0 was rejected. This outcome indicates two independent map-reader samples with respect to the marginal map information. Although this conclusion is extremely insightful, it may be a byproduct of the difference in map layout and design. Regardless of the cause, these results identify a very specific, and significant, difference between how people interpreted paper versus animated maps.

The results of the Combined Map T Score and M Score are perhaps the most important findings of this research. These quantitative measurements emphasize a true distinction between paper and animated maps. Furthermore, they may help cartographers determine appropriate methods for displaying time-related variables upon a map.

Correlating Map Test Scores with Questionnaire Results

The third, and final, question addressed in this research sought to identify relationships between map test scores and questionnaire results for both paper and animated map groups. More specifically, the intent of this question focused upon possible correlations between the time per day spent reading and using a computer and overall performance on the map tests. The research hypothesis (H_1) of this test suggests that a positive correlation exists between the amount of time spent with reading materials and the map test results from the paper group. Similarly, the map test results from the animated group will increase with the amount of time spent using a computer each day.

The null hypothesis (H_0) for this correlations states that no significant correlation exists between any of these variables; that is, animated map test scores are not related to time spent using computers and paper map test scores are not related to time spent reading.

Table 3-10 and Table 3-11 indicate the results of two statistical correlation procedures used to answer this research question.⁶⁰ Values listed under both the Parametric and Nonparametric headings indicate the correlation coefficient between each variable.

Table 3-10 Correlation of Combined Paper Map Scores and Questionnaire Results

	Parametric Correlation	Nonparametric Correlation
	Hours per day spent reading	Hours per day spent reading
Total Score	-0.406**	-0.389**
T Score	-0.258	-0.320*
M Score	-0.426**	-0.391**

Note: *Indicates significance at the 0.05 Level. **Indicates significance at the 0.01 Level

Table 3-11 Correlation of Combined Animated Map Scores and Questionnaire Results

	Parametric Correlation	Nonparametric Correlation
	Hours per day spent on computer	Hours per day spent on computer
Total Score	0.009	0.013
T Score	0.114	0.119
M Score	-0.117	-0.094

A correlation value of one (1) indicates a perfect positive correlation. A positive correlation simply means that as values for an independent variable increase, the values for a dependent variable also increase (Figure 3-1). Conversely, a value of negative one (-1) represents an inverse correlation where values from dependent variable increase as

⁶⁰ Both Pearson's (r) and Spearman's (ρ) were calculated for this test. The inclusion of both a parametric and nonparametric test was required because of the categorical nature of the questionnaire results.

the independent variable decreases (Figure 3-2). A value of zero (0) indicates neutrality, or no correlation.

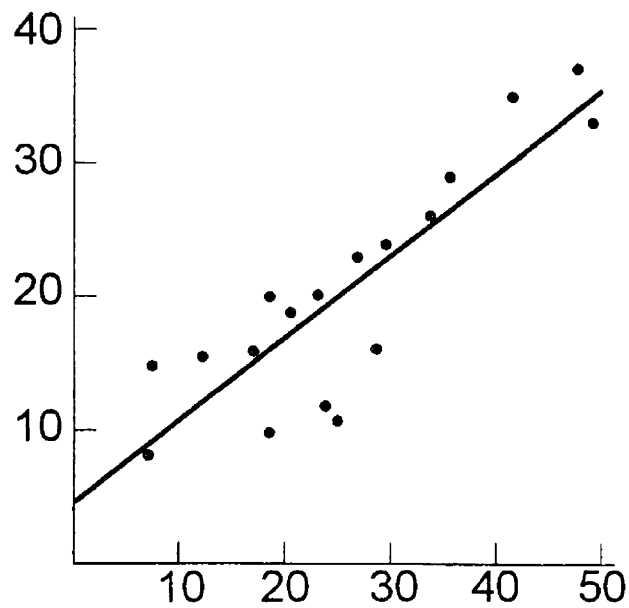


Figure 3-1 Scatter Diagram of a Positive Correlation⁶¹

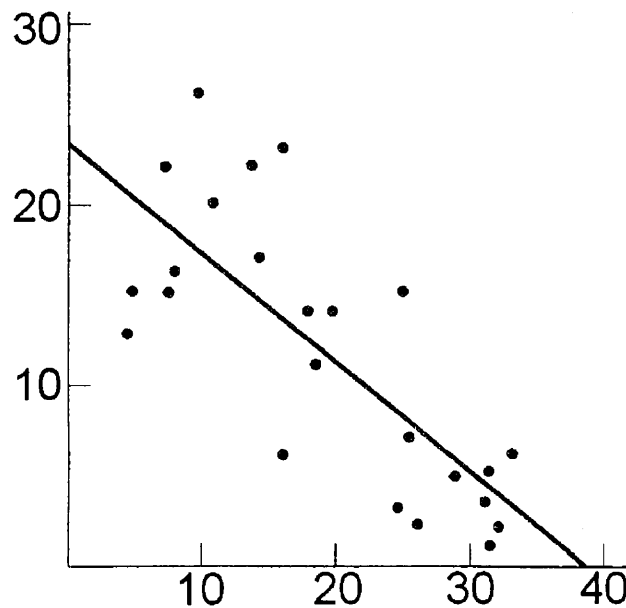


Figure 3-2 Scatter Diagram of a Negative Correlation⁶²

⁶¹ Adapted from David C. Howell, *Statistical Methods for Psychology*, (Pacific Grove: Duxbury, 2002), 246.

⁶² Ibid.

Results from Table 3-10 disprove the research hypothesis for the paper map group. Statistically we fail to reject the null hypothesis because there is no significant positive correlation between any of the variables. Ironically, correlation values that are bolded reflect a significant inverse correlation. As a literal interpretation, these values suggest that as the amount of reading per day increased the performance on the paper map tests decreased. Although this outcome is significant for the paper group participants, it in no way reflects an overall population parameter. The result is likely due to the non-random nature of the purposive sample.

Correlation values in Table 3-11 do not allow for rejection of the null hypothesis. This result suggests that no significant relationship exists between the amount of time spent using computers each day and animated map test scores. As stated for the results of Table 3-11, this conclusion does not indicate a population parameter. Instead it is only applicable to the individuals in the animated map group.

Summary

The results from tests conducted in this chapter have provided answers to each of the research questions stated in Chapter 1. The following discussion will restate the primary and secondary research questions, following each with an appropriate answer derived from the analysis.

Answering the Primary Research Question

The focus of this thesis was based upon answering one primary research question:

- Are there noticeable differences in the way a map-reader retains identical information presented in two separate ways?

Table 3-9, Independent Samples t-test Results, clearly indicates that significant differences were observed between the scores from the paper and animated map tests. These results imply that, for the two groups who participated, each group was independent from the other. These independent samples can then be used to suggest that map-readers do retain identical information, presented in two separate ways, very differently. Furthermore, paper and animated maps are two very distinctive, and independent, cartographic forms.

Answering the Secondary Research Questions

Two secondary research questions were also included within the parameters of this research. These questions will now be stated, as they were in Chapter 1, and directly followed with answers derived from the analysis.

- Which method is best suited for displaying time as a cartographic variable?

Table 3-8, Comparison of Paper and Animated Map Test Scores, suggests that participants in the paper map group performed at a higher level than those in the animated map group. Although the statistical tests in this analysis do not focus upon defining a true winner, a general comparison of the data from Table 3-8 does indicate higher achievement from paper map-readers. With respect to this research, the paper maps appear to have been best suited for displaying time as a cartographic variable. Once again, it is important to remember that this determination is only applicable to the maps and research participants in this thesis, and not necessarily the population at large.

The correlation analysis detailed in Table 3-10 and Table 3-11 was based upon answering the final secondary research question:

- Does the map-reader's use of media (television, books, magazines, internet, etc...) correlate with their understanding of an animated or static paper map?

As previously stated, the results indicate no significant positive relationship between the variables indicated in the question. Participants in the paper map group did not perform better on the map tests based on the amount of time they typically read each day; in fact, the more they read the worse their map test scores. The animated map group did not score higher on map test scores in relation to the amount they use computers each day.

Many factors may have influenced these outcomes. Most likely the use of a non-random, purposive sample had a large impact on the nature of these results, especially for the paper map group. However, the results do provide insight based upon those who participated in this research.

CHAPTER 4

CONCLUSION

Summary of Research

Results derived from this research shed some valuable light on the display of time as a cartographic variable. The paper maps demonstrated the best results for map-reader interpretation and retention. This outcome may be influenced by countless variables; however, the medium of the map seems to make the most significant difference. Both groups performed equally with regard to the thematic map information. Despite slight differences in color, symbology, and overall display, both groups shared an equal understanding of the map theme. In contrast, a striking difference was measured between the interpretation and retention of marginal map information. This difference, as described in Chapter 3, suggests that the effective display of map marginalia is very important in animated cartography. The primary concern, with regard to the marginal map information on animated maps, is that it can be easily overlooked.

Recent research by Morrison and others suggests that human interpretations of animated graphics, such as animated maps, are dependent upon two distinct principles: Apprehension and Expression.⁶³ These categories were formed after the researchers failed to find significant benefits of animation in displaying a temporal change as compared to static graphics. Their conclusions state that animations must adhere to the principles previously mentioned, if they are to be effective. First, the perception and comprehension of the animation must be attained by the observer (Apprehension).

⁶³ Julie Bauer Morrison, Barbara Tversky, and Mireille Betrancourt, "Animation: Does it Facilitate Learning?," AAI Spring Symposium on Smart Graphics, Stanford, California, (2000): 53-59.

Second, the conceptual knowledge conveyed by the animation must be apparent to the observer (Expression). However, even if both conditions are successfully achieved, they conclude the animation may still be inferior to a static graphic.

The Apprehension and Expression principles can be used as a tool to further assess the results of this research. Because the analysis of map test scores focused upon two specific forms of cartographic information, thematic and marginal, the principles must be applied to each. Results from the comparison of thematic map information did not yield a discernable difference between the paper and animated groups. Although the mean test score for the paper map group was higher than the animation group, the difference was great enough to reject the null hypothesis. This outcome benefits the animated map by indicating that it did at least as well as the paper map for conveying thematic information. However, the outcome does not imply the animation was more effective at representing time.

The comparison of marginal map information, which permitted rejection of the null hypothesis, may indicate a failure of the animated maps to comply with the Apprehension and Expression principles. Results of the independent samples t-test for the M Scores suggest that the paper and map groups were truly autonomous. Furthermore, the side-by-side comparison of mean map test scores clearly shows higher performance from the paper map group. These results show that the paper maps were undeniably more effective at conveying the marginal map information.

Overall the results from this thesis may provide additional insight into the principles stated by Morrison and others. By subdividing the map information and

analyzing based on Total Scores, T Scores, and M Scores, it is clear that the Apprehension and Expression principles have unique implications for each category.

Cartographers who wish to display time as a variable should be mindful of the complexities involved in designing an effective map. Inevitably the medium upon which the map is produced will be subject to the needs of an intended audience. It is hoped that the research contained herein will both aid in the design of time-based maps and facilitate selection of the most effective medium.

Suggestions for Future Research

Numerous topics within this thesis could serve as the focus for additional research. Overall, the inclusion of numerous additional maps is vital in future research of this sort. Because maps are interpreted differently by every reader, an increase in the number of maps would help to objectify and otherwise subjective form of geographic communication.

Some ambiguity was present in the use of three different map symbology types (area, line, point) to assess human-map interaction. Specific focus could be given to one symbol type, and interpretations of that symbol as a static or animated graphic.

Continued assessment of individual traits within the population, and how those traits influence a map-reader's interpretation of cartographic time, would be beneficial. Despite results in this research, levels of computer usage seem to be an obvious corollary for understanding animated map information.

Although this research utilized only one software package for map animation, different products could be compared and contrasted in terms of their applicability to animated cartographic design. As technology progresses, these multi-media programs

will likely become more commonplace. The exponential growth of the Internet, and human interaction with that medium, will certainly fuel their continued development.

APPENDIX A

QUESTIONNAIRE: Blodgett Canyon Fire

How many towns were labeled on the map?

- a.) 4
- b.) 2
- c.) 6
- d.) 3

Was there a neatline (border) around the map? _____ Yes _____ No

How many miles across (east – west) would you estimate the map to be?

- a.) 5
- b.) 25
- c.) 15
- d.) 10

What was the time span of the Blodgett Canyon Fire?

- a.) August 8th – September 9th
- b.) August 21st – August 30th
- c.) August 15th – September 9th
- d.) August 8th – August 21st

Was the author of the map cited? _____ Yes _____ No

Which water feature (lake, creek, or river) was located furthest to the east?

- a.) Sawtooth Creek
- b.) Fred Burr Creek
- c.) Tag Alder Lake
- d.) Willow Creek

Does the map indicate that a campground burned? _____ Yes _____ No

Which drainage contained the majority of the fire?

- a.) Blodgett Creek
- b.) Mill Creek
- c.) Sheafman Creek
- d.) Canyon Creek

Did the map make use of hillshading (could you see the mountains)? _____ Yes _____
No

What was the map projection?

- a.) Lambert Conformal Conic
- b.) Plate Carree
- c.) Albers Equal Area Conic
- d.) Transverse Mercator

QUESTIONNAIRE: Corps of Discovery

Was there a north arrow on the map? _____ Yes _____ No

What day was the map created?

- | | |
|---------------------|--------------------|
| a.) May 2, 2002 | c.) August 2, 2001 |
| b.) January 3, 2002 | d.) March 24, 2002 |

Where was the picture of William Clark located?

- | | |
|-----------------------------|-----------------------------|
| a.) Lower right-hand corner | c.) Upper right-hand corner |
| b.) Upper left-hand corner | d.) Bottom center |

Was there a graticule (lines displaying latitude and longitude) on the map? _____ Yes
_____ No

How many points on the map displayed specific information about the expedition?

- | | |
|-------|-------|
| a.) 6 | c.) 2 |
| b.) 9 | d.) 4 |

What was the subtitle of the map?

- | | |
|--------------------------------------|------------------------------------|
| a.) Search for the Northwest Passage | c.) Discovering the West |
| b.) The Journey of Lewis and Clark | d.) The Lewis and Clark Expedition |

Were different line colors used to display the expedition route? _____ Yes _____ No

Which area was not included on the map?

- | | |
|------------------------|-------------------------|
| a.) Montana Territory | c.) Spanish Possessions |
| b.) Louisiana Purchase | d.) Oregon Territory |

Were Canada and/or Mexico displayed on this map? _____ Yes _____ No

Besides Lewis and Clark, who else was mentioned on the map?

- | | |
|----------------------|-----------------------|
| a.) Thomas Jefferson | c.) Charboneau |
| b.) Sacajawea | d.) None of the above |

QUESTIONNAIRE: Montana Quakes

How many earthquakes were displayed on this map?

- a.) 3 c.) 7
b.) 5 d.) 4

Were the data sources for the map included? _____ Yes _____ No

Which town was not indicated on this map?

- a.) Helena c.) Kalispell
b.) Missoula d.) Billings

What was the magnitude of the smallest earthquake?

- a.) 5.6 c.) 4.75
b.) 6.25 d.) 5.0

Where was the earthquake data obtained?

- a.) U.S. Geologic Survey c.) University of Utah
b.) University of Montana d.) Montana Bureau of Mines and Geology

When was the most recent earthquake?

- a.) August 17, 1959 c.) July 18, 1962
b.) October 3, 1974 d.) November 23, 1947

Were any roads displayed on the map? _____ Yes _____ No

How would you best describe the earthquakes displayed on the map?

- a.) Color depending on location c.) Color depending on magnitude
b.) Circle size depending on magnitude d.) Circle size depending on date

Was there a scalebar (to measure distance) on this map? _____ Yes _____ No

What color was the earthquake furthest to the north?

- a.) Green c.) Blue
b.) Yellow d.) Red

APPENDIX B

Instructions for Paper Maps

Note* - Please do not review the questionnaires before observing the maps.

- 1.) Remove all materials from the packet.
- 2.) Open the map entitled “Blodgett Canyon Fire”
- 3.) Examine the map for approximately 10 minutes, or until you feel comfortable with the content.
- 4.) Fold map and return to packet.

Note* - Please do not refer to the maps when completing the questionnaires.

- 5.) Open and complete questionnaire entitled “Blodgett Canyon Fire”
- 6.) Repeat steps 2 – 5 for the “Corps of Discovery” and “Montana Quakes” maps.
- 7.) Open and complete the questionnaire entitled “General Information”
- 8.) Place all materials inside the packet to be returned.

APPENDIX C

Instructions for Animated Maps

Note* - Please do not review the questionnaires before observing the maps

- 1.) Remove all materials from the packet.
- 2.) Insert the CD-ROM into the Compact Disc drive on your PC (**Note*** – this CD-ROM requires Windows 95, 98, or 2000 and will not operate on a Macintosh Platform).
- 3.) From the Start Button on your PC, navigate as follows:

Start:

Run:

Browse: (navigate to your CD Drive, usually drive D: or E:)

Select “Blodgett Fire” and press Open

Press OK

Note* – you may have to maximize the window for display on the entire screen.

- 4.) Using the “Play”, “Stop”, “Next”, and “Back” buttons, located in the “Control Panel,” examine the map (approximately 10 min., or until you are comfortable with the content.)
- 5.) Close the map window: File
Exit

Note* - Please do not refer to the maps when completing the questionnaires.

- 6.) Open and complete questionnaire entitled “Blodgett Canyon Fire”
- 7.) Repeat steps 3 – 6 for the “Corps of Discovery” and “Montana Quakes” maps.
- 8.) Open and complete the questionnaire entitled “General Information”
- 9.) Place all materials inside the packet to be returned.

APPENDIX D

Brian W. Collins
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11 Point IRB Summary

- 1.) The purpose of this research is to compare methods of representing geographic phenomena that change over time. The research objective seeks to statistically analyze questionnaire results based upon the map-readers ability to understand identical geographic information presented in paper and animated format. Literature necessary for this study focuses upon the history of cartography, cartographic design principles, map interpretation, and human cognition. The importance of this research lies in its assessment of animated maps, a relatively recent development, as compared to the traditional paper format. Increasing technological capabilities have allowed cartographers to create animated maps with ease; however, few studies have been conducted which focus on the effectiveness of this new format
- 2.) The subjects included in this study will largely be derived from a convenience sample; that is, most individuals will be known by the researcher (ie. friends, family, etc...). An attempt will also be made to include snowball sampling by which original test subjects will recommend other individuals who may participate in the study. No minors (under age 18) will be included in this study. No physical, psychological or social vulnerability exists within this research framework.
- 3.) As stated in point 2, the subjects included in this study will consist of a convenience sample. Although the researcher will know a majority of the participants, an attempt will be made to include individuals recommended by these subjects. This method of sampling, often referred to as snowball sampling, should help to reduce bias within the research results.
- 4.) The study will take place at any location, which is convenient to the subject. Participants will be able to take the materials packet and complete the components without direct supervision of the researcher. No facilities permissions are necessary for this study.
- 5.) Subjects will be divided into two groups. One group will be asked to view a series of paper maps and complete questionnaires related to the content of each map in the series. The second, or experimental, group will be asked to complete the same questionnaires based on a series of animated maps provided to them on

CD-ROM. Both groups will be asked a minimal amount of information pertaining to their gender, age, and personal habits (television watching, internet use, reading, etc...). This data will be used to draw correlations between population characteristics and map interpretation.

- 6.) This research may not benefit the human subjects, per se; however, it will provide useful information concerning map interpretation and map design.
- 7.) Subjects will not be exposed to any risks or discomforts in this study.
- 8.) The study has been designed to allow research subjects to participate at their leisure. The nature of this research is not intrusive, and will not lead to deleterious effects or violation.
- 9.) The data derived from this research will not include any information that would personally link an individual to the study. Furthermore, the researcher will not divulge or distribute the names of any subjects included in the study.
- 10.) A written consent form will not be included in this study.
- 11.) A waiver of written informed consent is requested because this study does not pose any physical, psychological, social threat to the participants. Furthermore, the research will not include any individual under the age of 18 years.

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University of Montana

Questionnaire Summary

Questionnaires included within this study will focus upon information necessary to quantitatively assess map interpretation. Each packet distributed to participants will include three individual maps. Each map will have an associated questionnaire that solicits information from the map-readers according to the map design, layout, and content. In addition to the three map-specific questionnaires, a fourth will be included to solicit other general information. Questions on this general questionnaire may include:

- What is your gender?
- What is your age?
- On average, how many hours of television do you watch per week?
- On average, how many hours do you use the internet each day?
- How often do you read printed materials (i.e. books, newspaper, magazines, etc...)?

The responses to these questions will be used for correlation of population characteristics and map interpretation scores.

The questionnaires will be concise in their design. Each map questionnaire will include no more than ten questions. It is hoped that this simplistic approach will remove bias by producing an atmosphere that is not intimidating or overwhelming to participants.

Brian W. Collins
M.A. Candidate
Department of Geography
University of Montana

Explanation of Research (for Subjects)

The explanation of research will be provided after each subject has completed the questionnaires. Subjects will be verbally informed, by way of general conversation, about the research intent and use of questionnaire results to assess map interpretation. Participants will also be informed of the tentative thesis defense date and location, and be encouraged to attend.

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The University of Montana
INSTITUTIONAL REVIEW BOARD (IRB)
CHECKLIST

#65-02

RECEIVED
(REV. 7/01)

MAY 06 2002

UNIVERSITY OF MONTANA
VICE PRESIDENT FOR RESEARCH

Submit one completed copy of this Checklist, including any required attachments, for each course involving human subjects. The IRB meets monthly to evaluate proposals, and approval is granted for one academic year. See IRB Guidelines and Procedures for details.

Project Director: BRIAN W. COLLINS Dept.: GEOGRAPHY Phone: _____

Signature: [Signature] Date: 5/1/02

Co-Director(s): _____ Dept.: _____ Phone: _____

Project Title: MAPPING TIME: An Evaluation of Geographic Time Series Cartograph

Project Description: Project goal is to statistically analyze map-reader (in nontechnical language) interpretations based upon questionnaire results.

All investigators on this project must complete the NIH self-study course on protection of human research subjects. Certification: I/We have completed the course - (Use additional page if necessary)

Signature	Date	Signature	Date
<u>[Signature]</u>	<u>MAY 2001</u>	_____	_____
<u>[Signature]</u>	<u>MAY 2002</u>	_____	_____

Students Only:

Faculty Supervisor: PAUL WILSON Dept.: GEOGRAPHY Phone: 243-4401

Signature: [Signature]

(My signature confirms that I have read the IRB Checklist and attachments and agree that it accurately represents the planned research and that I will supervise this research project.)

For IRB Use Only

IRB Determination:

Approved Exemption from Review #2

Approved by Administrative Review

Full IRB Determination:

[Signature]

MAY 6, 2002

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