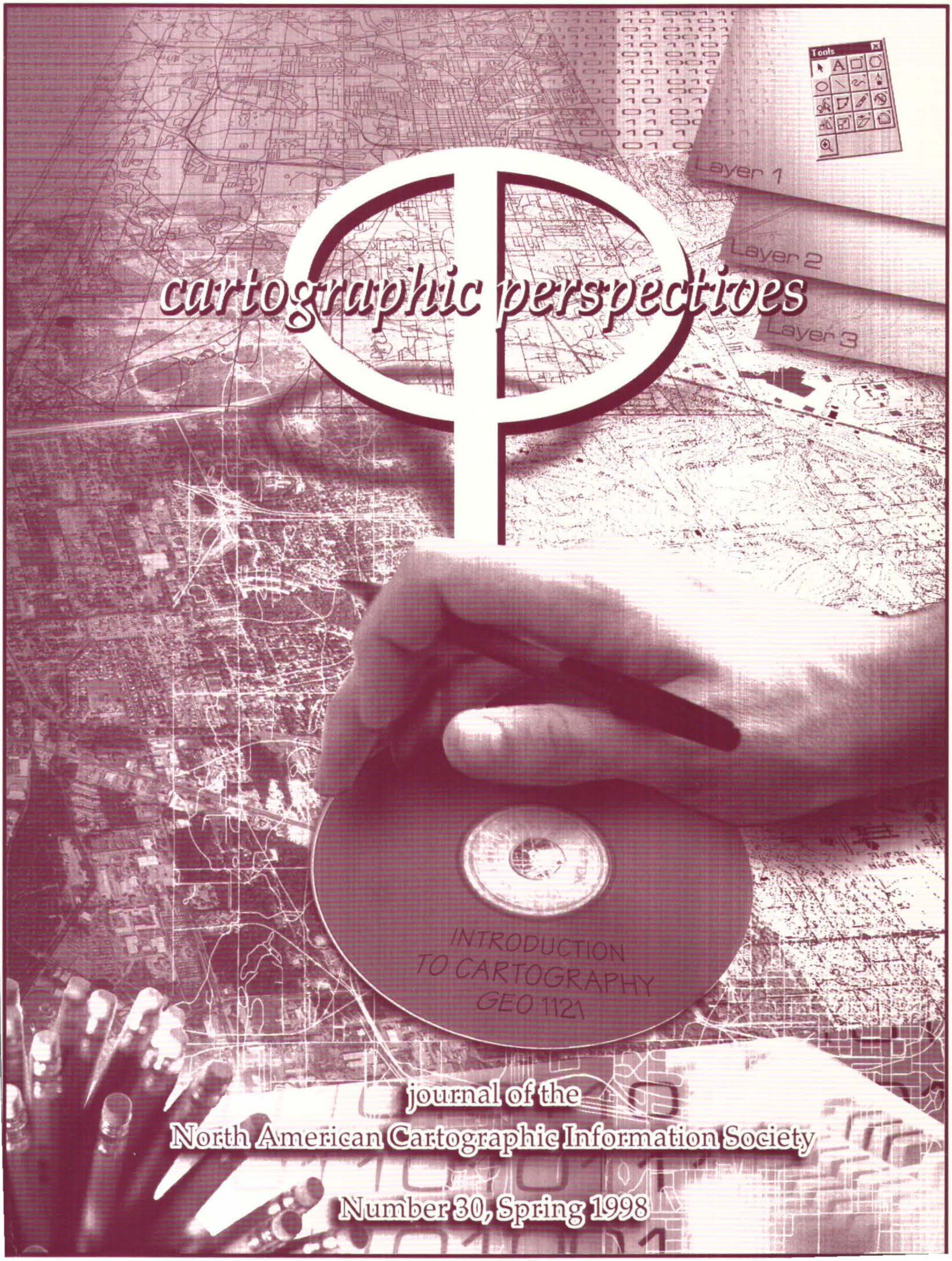

cartographic perspectives

journal of the
North American Cartographic Information Society

Number 30, Spring 1998

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in this issue

messages

LETTER FROM THE EDITOR

Cartographic Perspectives, first published in 1989, will soon celebrate its tenth anniversary. It has been a remarkable decade for cartography and for the journal. The technology of map-making has advanced but, more significantly, new ideas have emerged about the meaning of mapping. This publication has provided a 'perspective,' publishing a number of seminal articles that have been widely cited. The circulation has expanded with subscribers in many foreign countries. In short, *CP* has become a world-class journal.

I am pleased to have assumed the editorship of the journal with issue number 29 (winter 1998). The previous editors - David DiBiase and Dr. Sona Andrews - need to be thanked for all of their work in getting the journal started and established. It has been a

(continued on page 72)

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cartographic perspectives

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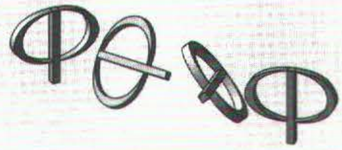
about the cover



The cover design was created by Louis Cross III. Louis is a cartographer and multimedia specialist at the Florida Resources and Environmental Analysis Center at Florida State University. Current research interests include the manipulation of digital raster imagery as foundations for vector linework overlays for high-quality printed educational materials.

Adobe PhotoShop was used to assemble the graphic components extracted from USGS DOQQs, DRGs, DLGs, and other digital sources. Evolutionary techniques addressed in present introductory cartography courses such as GIS, graphic design software, and new methods of presentation and storage of maps inspired the images that were chosen for the digital data collage.

essay

The Convergence of Spatial Technologies

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Here is a map test: Who is the biggest mapmaker in history? The Dutch map houses of Hondius or Mercator certainly published quite a few maps. But probably some government agency has published more–for example, the USGS has over 55,000 maps for the United States alone at the 1:24,000 scale. Or maybe someone more recently? The Defense Mapping Agency (now the National Imagery and Mapping Agency) put out thousands of maps during the Gulf War, working in special 24-hour shifts (Clarke, 1992).

Actually it is none of these. The biggest mapmaker in history, putting out more maps than anyone else, is undoubtedly MapQuest, an as yet little known unit of GeoSystems Global. According to the trade press, MapQuest produces over 1.5 million individual maps per day (*Internet World*, April 6, 1998). It is one of the reasons why CP Editor Mike Peterson claims that the Internet sees the publication of as many as 10 million maps per day and leads him to say that the impact of Internet mapping "will likely be greater than that of the printing press" (Peterson, 1997a, p. 2).

Despite this productivity, MapQuest does not carry the *"weight"* of more traditional cartography. Undoubtedly, one of the reasons for this is that its maps are mostly basic street maps automatically generated from databases, are fairly poorly designed, and are at low resolutions. MapQuest is very new, starting only on Feb. 3, 1996 (Peterson, 1997b). The cartographic community does not yet know what to make of these maps, so they must be put in some context.

"The web, and GIS . . . are each other's next most logical growth area."

Online mapping, which produces what may be called *"user-defined, on-demand maps,"* is part of a convergence of spatial technologies (digital cartography, GIS and the web) that have been rapidly developing over the last few years. The web, and GIS in particular, are each other's next most logical growth area. The web offers GIS users the opportunity to distribute their capabilities more widely, including the analytical capabilities of GIS - not just finished maps. The Internet may be able to deliver *"public participation"* GIS (PPGIS), or GIS *"for the rest of us."* On the other hand, GIS offers the web something it mostly lacks, that is good content, especially of an analytic nature. Online maps can be called up on-demand, and reflect the data the user wants to analyze; they are user-defined. This is very different from choosing a map from a map archive of finished maps where the cartographer has tried to anticipate the user's needs.

The convergence of spatial technologies is leading to a wider adoption of an exciting type of map use called *"visualization or geographic visualization"* (GVis). To some extent, visualization is what cartographers have always been doing in that they make aspects of the world visible, but there are important differences. Visualization, in this sense, also refers to the added capabilities of interactive mapping software such as rotating the data in three dimensions, adding or stripping away data layers during data exploration, or querying the map interactively. The map information changes in response to user input. But as Alan MacEachren, the Chairman of the ICA Commission on Visualization points out, "visualization is foremost an act of cognition, a human ability to develop mental representations that allow geographers to identify patterns and to create or impose order" (MacEachren, 1992, p. 101). There is, therefore, a sense that GVis allows *different* kinds of questions to be asked. The differences between visualization and traditional cartography can be captured using MacEachren's concept of *"cartography cubed."*

Cartography cubed is a method of understanding the different kinds of map uses. The *"cube"* contains three dimensions; private–public, high interactivity–low interactivity, and revealing knowns–exploring unknowns. Traditional cartography has emphasized public use, low interactivity and revealing knowns, while visualization emphasizes private use, high interactivity, and exploring unknowns (though perhaps without ignoring presentation of information). The ICA Commission is especially interested in full-blown visualization, map uses that meet all three of the latter criteria. But, it is suggested here that using maps in highly interactive, exploration of unknowns in a public setting is a more critical and far-reaching component of visualization. That is, of course, delivering mapping capabilities via the world wide web.

Mapping and the web has so far received less attention than other kinds of visualization. It is important, however, for a number of reasons because doing and thinking about geography (the goal, it can be argued, of all cartography and GVis) increasingly requires a virtual component; a feature that has elsewhere been labeled the "virtuality of geography" (Crampton, forthcoming). Web-based mapping is a part of this increasing virtuality and has obvious benefits (e.g., increased accessibility to data by the public in community GISs) and costs (e.g., increased merging of databases containing personal information for marketing and surveillance).

"What happens to map quality if this widespread access to online mapping means that anyone can now be a cartographer?"

What happens to map quality if this widespread access to online mapping means that anyone can now be a cartographer? The fear is that online maps and GIS capabilities will permit only low-quality maps and superficial renditions of data (i.e., data poor) due to low Internet bandwidths. This is a technical problem which will probably be alleviated to some extent, though it may never entirely go away (the Internet's First Law: information expands to fill the bandwidth available). Indeed it could be argued from this perspective that online maps of lower graphic quality are a trade-off for higher levels of interactivity.

Is that an acceptable tradeoff? There is a danger in online mapping that the user's experience with that spatial data, be it for exploration (GVis) or communication (traditional cartography/GIS) will be superficial, or just plain incorrect. This danger (or map misuse) has two components: low data dimensionality and misunderstanding of cartographic/geographic spatial data principles by online map users.

Visualization was initially proposed as a way of dealing with the huge quantities of data available to the modern scientist from remote sensors such as The Mission to Planet Earth satellite AM-1, due to launch later in 1998. If the dimensionality of that data in online mapping/GIS (data–poor maps) is now reduced, the full potential of GVis will not be realized. We will have an immensely powerful tool but no data to put in it.

Misuse may occur by misunderstanding basic geographic requirements such as reprojecting the data for minimum error when the user moves from a world map to a regional map (online mapping capabilities typically do not reproject data on zoom–ins), ignoring the effects of scale, being unable to select appropriate data classification categories and so on. Misuse is especially likely among users with little or no familiarity with principles of spatial data analysis. This danger is separate from the lack of familiarity users may have with the capabilities of the software.

Both of these dangers are implications of the convergence of spatial technologies and suggest that anyone can now be a cartographer. As cartographers, therefore, it is our responsibility (though not ours alone) to ensure well–designed, data–rich maps are part of any online geographic visualization system, and to be *"Internet activists"* in developing good content. It is now, while the web is relatively young that we have the most opportunity to shape it.

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Anatomy of the Introductory Cartography Course Revisited

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This paper reports the results of a survey sent to instructors of cartography in the United States and Canada during the fall of 1995. The intent of the survey was to determine if there was a common consensus among cartography instructors on the content and structure of the introductory course. In addition, the survey was designed to determine the impact of computer technology on the structure of the course. In an effort to identify changes and trends, results of this survey were compared to a similar survey conducted in 1989.

Keywords: cartographic education, map design, cartographic technology

INTRODUCTION

"The purpose of this paper is to provide a cross-sectional view of academic cartography through the examination of the introductory cartography course in the United States and Canada."

Cartography is a profession that has experienced considerable change over the past several decades. Many of the shifts in emphasis and methods of producing maps have been linked to advancements in technology and more specifically to the universality of the computer. Academic cartographers charged with training the next generation of professional cartographers often question their knowledge of current technological changes within the discipline. In addition, they often wonder how other academic cartographers approach the teaching of cartographic concepts and techniques.

The purpose of this paper is to provide a cross-sectional view of academic cartography through the examination of the introductory cartography course in the United States and Canada. The introductory course was chosen because it is the first, and perhaps only exposure students may have to actual map production. In addition, past research has indicated that the introductory cartography course accounts for approximately one-half of all cartography courses offered (Dahlberg and Jensen, 1986).

This cross-sectional view was obtained through a questionnaire designed to probe the current structure, content and level of computer technology found in the introductory cartography course. The questionnaire results were compared with a similar survey conducted in 1989. The comparison of responses over a six-year time period was used in order to identify changes in course structure and content.

BACKGROUND

The use of a survey to gain insight into the workings of the introductory cartography course specifically, and academic cartography in general, is not novel. As early as 1965, B. Moriarty used a survey to investigate the focus of cartography at academic institutions. He found that some schools exclusively stressed either drafting, or concepts of graphic communication. However, the majority of institutions achieved a balance between these extremes (Moriarty, 1965).

In 1978, a group of twelve Canadian cartography instructors were part of a session of the Canadian Cartography Association meeting that examined the introductory cartography course at Canadian universities. The published proceedings of this session revealed an emphasis on the practical components of mapping and very little attention to computer mapping (Coulson, 1981).

Andrew's 1985 survey of cartographic textbook usage included cartography textbooks at all academic levels. The dominant textbook used in the introductory cartography course in the mid-1980's was *Elements of Cartography* (Robinson and associates, 1984).

The state of professional training for cartographers, and cartographic educators are topics covered in several articles by Dahlberg (Dahlberg; 1977, 1983, 1984). Much of his research was based on a comprehensive survey of departments offering cartography. The *Mapping Sciences Education Data Base* supplied information on cartography courses in 1978 and 1983. He found that the majority of cartographic training was taking place in a limited number of universities and that the thematic map dominated the course content in introductory cartography courses. Fryman and Sines (1990) used a questionnaire to survey cartography instructors in the United States and Canada in order to assess the structure and content of the introductory cartography course. Survey results found a prevalent use of thematic maps for exercises, little computer use and a predominant use of Robinson and associates textbook.

THE SURVEY

The 1995 questionnaire was designed to replicate the 1989 survey previously conducted by the authors. Questions were added that were overlooked in 1989 or that have become relevant since then. The 1989 survey served as a benchmark in determining changes in the content and structure of the introductory cartography course. Both surveys focused on the introductory cartography course, defined as the class in which students actually begin producing maps. Courses designed primarily for map use, interpretation or advanced courses in specific cartographic areas, such as reproduction, color and design were excluded from the survey. Both surveys targeted only geography departments in four-year colleges and universities. Past studies have indicated that cartography courses are taught primarily in geography departments (Dahlberg and Jensen, 1986).

". . . focused on the introductory cartography course, defined as the class in which students actually begin producing maps."

The current survey was intended to examine four major aspects of the introductory cartography course: (1) the characteristics of the individual instructors, their department and institution, (2) the context and structure of the course, (3) the introductory cartography course content, and (4) the use of the computer in teaching and laboratory exercises.

Two publicly accessible documents were used to identify potential survey recipients; the Association of American Geographers' *Guide to Departments of Geography in the United States and Canada* (AAG Guide, 1995-1996) and Schwendeman's *Directory of College Geography of the United States* (Schwendeman, 1995). All departments listed in the *Guide* that indicated cartography as a specialty or had a faculty member with a cartographic specialty were included in the survey. In addition, any departments that did not appear in the *Guide*, but were listed as departments reporting actual cartography enrollment in Schwendemen's *Directory* also were included in the survey.

Questionnaires were mailed to the chairs/heads of 311 departments of geography believed to offer cartography. They were asked to give the survey to the instructor offering the introductory cartography course. Approximately 47 percent (145) of the surveys were returned. Of these, six departments indicated that they did not offer courses in cartography at that time. Thus, the actual number of surveys used in the analysis was 138.

In 1989, 378 surveys were sent to 285 institutions with a return rate of 51 percent (190 surveys). The greater response rate of the previous survey was attributed to the fact that in 1989, surveys were sent to specific individuals who indicated expertise in cartography, rather than to institutions offering cartography. This resulted in several instructors at the same institution returning surveys. It should be noted that 86 geography departments were common to both the 1989 and 1995 surveys.

THE RESULTS

Characteristics of the School, Department and Instructor

The 138 completed surveys used in the study represented institutions ranging in enrollment size from 800 to 31,000 students. Most universities were on the semester system (83 percent) and publicly controlled (90 percent). One hundred and twenty-eight institutions were located in the United States (92.7 percent), the remaining were located in Canada (7.3 percent).

The Geography departments in the survey represented institutions at all three degree levels; 32 granted Ph.D., 38 offered Master's degrees and 68 departments offered only Bachelor's degrees. Departments ranged from two to eighteen faculty members with an average of eleven.

"The average instructor had been teaching cartography for twelve years, with the number of teaching years ranging from two to thirty-five."

The average instructor had been teaching cartography for twelve years, with the number of teaching years ranging from two to thirty-five. The graduate schools attended by cartography instructors in the study are indicted in Table 1. The table includes only those institutions that had been attended by two or more instructors. The leading graduate institutions in 1989 were the University of Kansas (eighteen graduates or 9.5 percent), University of Wisconsin-Madison (thirteen graduates or 6.8 percent) and the University of Washington (thirteen graduates or 6.8 percent). These three universities have been the leading producers of cartographers for several decades. However, the 1995 survey indicated a more even distribution of cartography graduates.

Rank	GRADUATE INSTITUTIONS	1989	1995
1	University of Kansas	9.3%	9.6%
2	Michigan State University	2.1%	5.9%
3	University of Oklahoma	1.0%	4.4%
4	University of NC - Chapel Hill	2.6%	3.7%
5	University of Washington	6.7%	3.7%
6	University of South Carolina	0.5%	3.7%
7	University of Wisconsin-Madison	6.7%	3.0%
8	University of Illinois - Urbana	2.6%	3.0%
9	State University of New York - Buffalo	1.0%	3.0%
10	The Penn State University	3.1%	3.0%
11	University of Georgia	2.6%	3.0%
12	Arizona State University	0.5%	2.2%
13	University of Iowa	2.6%	2.2%
14	Oregon State University	1.6%	2.2%
15	University of Tennessee	1.0%	2.2%
16	University of California-Los Angeles	1.0%	2.2%
17	University of Minnesota	1.6%	2.2%
18	University of Michigan	2.6%	2.2%
19	University of Kentucky	1.0%	2.2%
20	University of Northern Colorado	0.5%	1.5%
21	University of Utah	1.0%	1.5%
22	University of Oregon	1.0%	1.5%
23	University of Pittsburgh	2.1%	1.5%
24	University of Victoria	0.5%	1.5%
25	University of Florida	1.0%	1.5%
26	Clark University	4.1%	1.5%
27	Ohio State University	1.0%	1.5%
28	University of Colorado	2.1%	1.5%

Table 1. Graduate Institutions of Survey Respondents

COURSE CONTENT AND STRUCTURE

Questions regarding course context and structure refer to the design of the introductory cartography course, and the administration and sequence of the course relative to the general cartography program at each university. Those questions and survey responses are given below.

(1) How many cartography courses are offered by your Department?

The number of cartography courses offered by geography departments ranged from one to twelve courses, with an average of 3.3, a median of 3 and a mode of 2. Figure 1 shows the number of courses per department for 1995 and compares these results with those of the 1989 survey. Because the number of cartography courses offered should correspond to the size of faculty and student body, a statistical correlation was calculated between the three variables. Results indicated a slight statistical association between the number of courses and the number of faculty ($r2=0.184$) and institutional enrollment ($r2=0.165$).

"The number of cartography courses offered by geography departments ranged from one to twelve courses . . ."

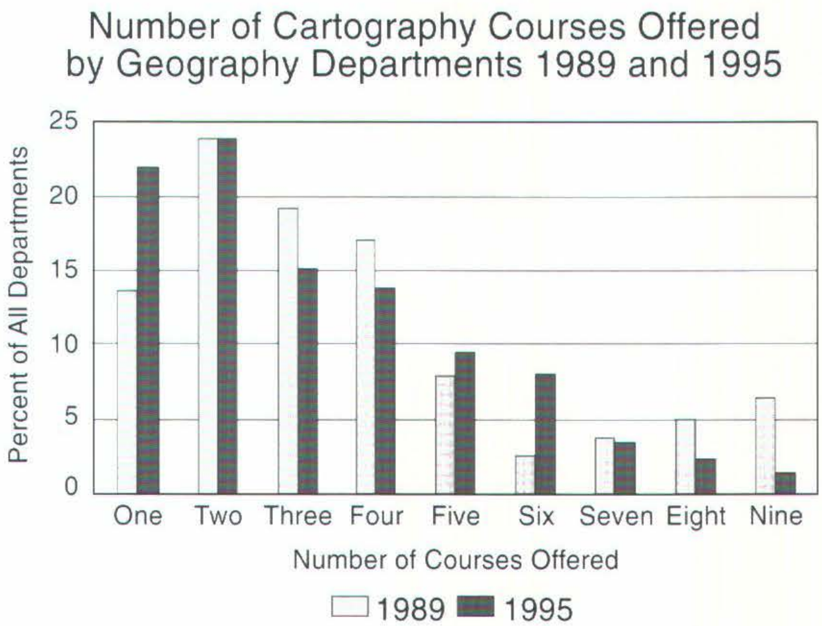

Figure 1. Number of Cartography Courses Offered in 1989 and 1995

(2) Does your Department offer a Cartography Certificate?

Approximately 14 percent of the surveyed institutions indicated that they offered a certificate program in cartography. Most of the certificate programs required a combination of cartography, remote sensing and geographic information systems courses.

(3) What is the course name?

The most common course name, representing 43 percent of all responses was *Cartography*. *Introduction to Cartography* accounted for another 18 percent. Other titles included the word *Computer, Principles, Thematic* and *Design* with *Cartography*. These combinations accounted for another 12 percent.

(4) What is the class size of the introductory cartography course?

Figure 2 compares the size of classes between 1995 and 1989. In both, 10 to 15 students is the most predominant class size. Small classes appear to be the mode. Class size traditionally was limited by the availability of drafting tables and now, perhaps, by the number of computers.

"Class size traditionally was limited by the availability of drafting tables, and now, perhaps, by the number of computers."

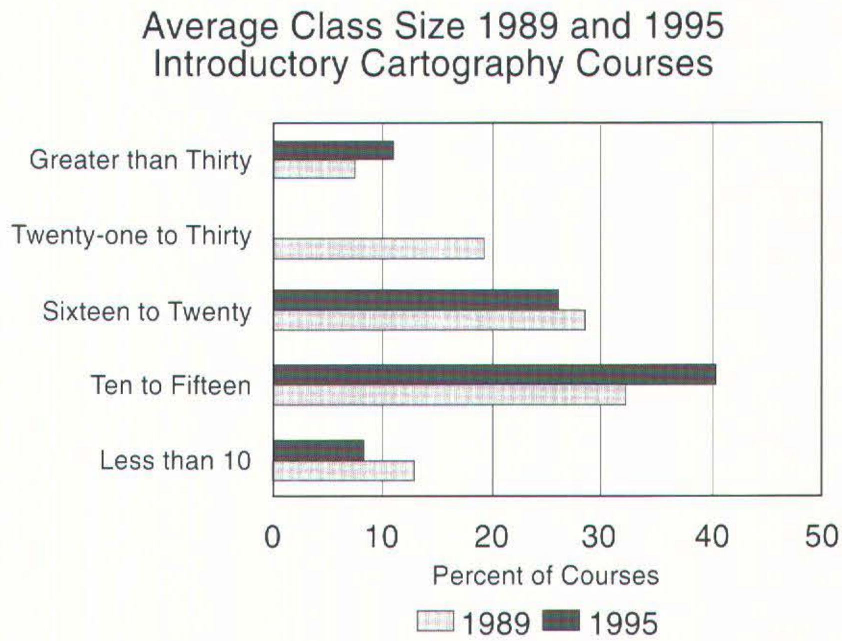

Figure 2. Average Class Size Compared Between 1989 and 1995

(5) How frequently is the introductory cartography course offered?

Approximately half of the departments surveyed offered the introductory cartography course one time each year (Figure 3). This represents very little change from 1989 to 1995.

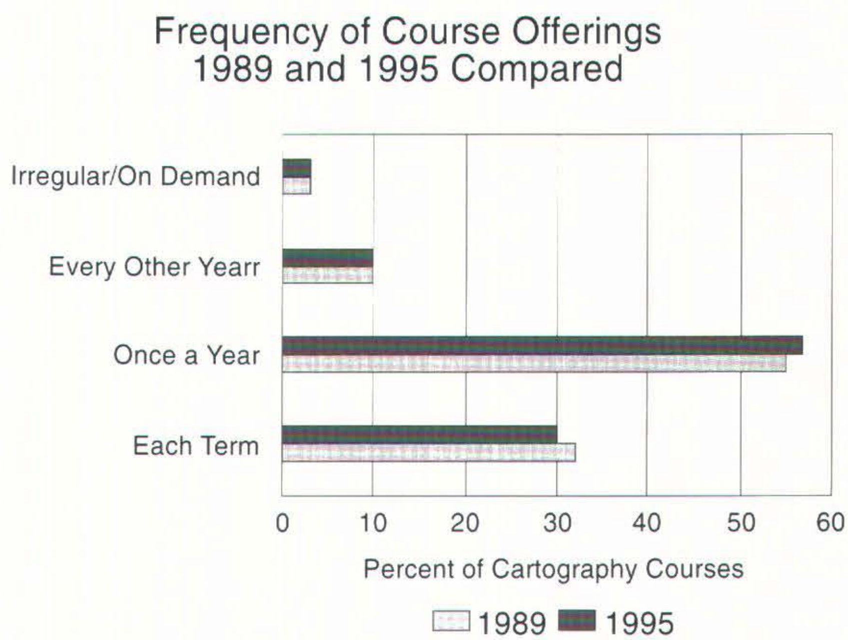

Figure 3. Comparison of 1989 and 1995 Frequency of Course Offerings

(6) Does the introductory cartography course have a prerequisite? If yes, what is it?

Forty-five percent of the departments surveyed in both 1989 and 1995 indicated that their introductory cartography course had a prerequisite. The most frequently cited prerequisites in 1995 were: (1) the student must have had a geography course (42 percent); (2) a student must have had a course in map interpretation (30 percent); (3) the student must have taken a course in computer science or mathematics (16 percent); and (4) students must have a specific class standing (sophomore or junior) or have declared geography as a major (13 percent).

(7) What are the average number of class hours devoted to lecture and laboratory each week?

The average time spent in lecture was two hours per week, with an average of three hours devoted to lab exercises. These averages are almost identical to those of 1989.

"It would appear that laboratory assistance is a function of program size and the availabilty of graduate students."

(8) Does the introductory cartography course have a laboratory assistant?

Thirty-eight percent of the departments surveyed indicated that the introductory cartography course did have a lab assistant. When departments were compared by degree level, the percentage of courses with a lab assistant was as follows: Ph.D. granting departments (79 percent), Master's programs (42 percent) and Bachelor Degree only programs (20 percent). It would appear that laboratory assistance is a function of program size and the availability of graduate students.

(9) Are field trips a part of the introductory cartography course? If yes, what type of field trips?

Field trips were part of the curriculum for one-third of the introductory cartography courses. Few were identical because of the diversity of opportunities at individual locations, but those most often mentioned were private mapping firms (28 percent), governmental mapping offices (25 percent), and GIS centers (13 percent).

"Many . . . indicated that their enrollment would increase if classroom capacity were expanded."

(10) Over the past five years, how would you classify enrollment in the introductory cartography course?

Three response options were available on the survey: increasing, decreasing and stable. Only three percent of the respondents indicated a decrease in enrollment over the past five years, while thirty-four percent indicated an increase. Sixty-three percent of those surveyed indicated stable enrollment. Many of those indicated that their enrollment would increase if classroom capacity were expanded.

COURSE CONTENT

(1) Is a textbook required? If yes, which textbook is used?

Eighty-six percent of those surveyed indicated a textbook requirement. Two instructors required two textbooks. The most commonly used textbooks, each accounting for approximately one-third of the total text notations, were Dent's *Principles of Thematic Map Design* (1985) and *Elements of Cartography* (1984,1995) by Robinson et al.

Table 2 lists all textbooks cited by two or more instructors and indicates the change in textbook usage between 1989 and 1995. Texts that were not included were map reading, computer cartography or specialized texts. Several textbooks, including Cuff's *Thematic Maps* (1982), were out of print in 1995.

(2) How many lab exercises are required for the course?

The number of exercises required ranged from three to sixteen exercises, with a mean, mode and median of eight exercises. This is slightly higher than the average of 7.5 in the 1989 survey.

(3) What types of exercises are required?

The exercises required in the introductory cartography classes in 1995

REQUIRED TEXTBOOKS
Introductory Cartography Courses

AUTHOR	TEXT	1989	1995
A. Robinson, et al.	Elements of Cartography	50%	33%
B. Dent	Principles of Thematic Map Design	19%	32%
J. Campbell	Introductory Cartography	4%	11%
J. Tyner	Intro to Thematic Cartography	0%	5%
P. Muehrcke	Map Use	5%	3%
T. Rabinhorst	Applied Cartography	2%	2%
J. Campbell	Map Use and Analysis	0%	2%
J. Keates	Cartographic Design and Production	0%	1%
G. Brannon	Practical Cartography	0%	1%
D. Cuff, M. Mattson	Thematic Maps	12%	0%
D. Greenhood	Mapping	2%	0%
Others		6%	10%

Table 2. Required Textbooks

are ranked in Table 3. They are compared with required exercises from the 1989 survey. Because the actual number of responses was not the same between time periods, figures were converted to percentages for comparison purposes. Only those 1995 exercises noted by four percent or more of the instructors are included in the table. The popularity of the choropleth map reflects the fact that choropleth maps are not only seen more often in the media, but that they are often available in computer mapping programs. The increase in the frequency of graph construction exercises may be attributed to the availability of programs and spreadsheets such as Excel, Quattro Pro and Lotus 1-2-3 that produce graphs and charts. The decline in the frequency of the dot map exercises could also be related to software availability. Because the algorithm in computer dot map programs generally places dots randomly, realistic patterns are not created.

"The popularity of the choropleth map reflects the fact . . . that they are often available in computer mapping programs."

(4) What percentage of exercises are computer-aided?

Sixty percent of the laboratory exercises in the introductory cartography courses were computer-aided. Because each instructor indicated the percentage of lab exercises completed with the assistance of a computer, it was possible to examine the extremes in the range of computer usage. Overall, the use of computers for lab exercises ranged from 23 instructors who indicated that the computer was not used at all in their lab exercises, to 30 instructors who stated that all of their lab exercises were computer-aided.

(5) What topics are discussed in the introductory cartography course?

Each respondent was asked to check those topics covered in the lecture component of their introductory cartography course. An extensive list of topics was included in the survey as well as instructions to add any topics not covered in the survey list. All topics ranked by percentage of response greater than 20 percent are shown in Table 4. Comparison with the 1989 survey was not possible because this question was not asked in that survey.

Instructors were asked two questions regarding equipment used in the cartography lab: **(6) What equipment is required to be purchased by the student?** And **(7) What equipment is supplied by the department?**

These questions were included in order to determine whether the cost of purchasing equipment as well as a textbook had the effect of lowering

	EXERCISE	PERCENT 1989	PERCENT 1995
1	Choropleth	82.1%	88.5%
2	Graduated / Proportional Circle	77.4%	65.4%
3	Isarithmic	60.0%	54.6%
4	Map Projection	55.8%	53.8%
5	Dot	60.5%	48.5%
6	Redesigned Published Maps	29.5%	35.4%
7	Maps to accompany an article	32.6%	32.3%
8	Cartogram	33.7%	28.5%
9	Land Use	30.0%	22.3%
10	Smooth Statistical Surface	26.8%	21.5%
11	Maps from Aerial Photos	16.3%	20.0%
12	Flow	4.2%	18.5%
13	Large Scale Survey	15.3%	17.7%
14	Situation	19.5%	14.6%
15	Graphs	0.5%	10.0%
16	Dasymetric	14.7%	7.7%
17	Scale	3.2%	6.2%
18	Topographic	3.2%	6.2%
19	Drafting / Equipment Familiarization	3.7%	6.2%
20	Lettering	2.6%	5.4%
21	Data Capture / Digitizing	1.1%	5.4%
22	Generalization	1.1%	4.6%
23	Data Classification	1.1%	4.6%

Table 3. Laboratory Exercises Used in the Introductory Cartography Course

student enrollment. In addition, the question was to determine the degree to which departments were willing to allocate money for manual drafting. Table 5 compares the 1995 and 1989 survey results. In both, expendable items were usually required to be purchased by the student, while the more costly equipment was provided by the departments. Fewer departments were requiring students to purchase equipment in 1995 than in 1989.

"... expendable items were usually required to be purchased by the student, while more costly equipment was provided by the departments."

COMPUTER AIDED DRAFTING

(1) Are computers used in the Introductory Cartography course?

A major interest of this survey was the change in computer usage over time. The findings in 1989 indicated that computers were being used infrequently in the introductory cartography classes. Indeed, only 53 percent of those surveyed indicated that they used a computer in their introductory cartography courses. Of those using computers, only 16.2 percent of the laboratory exercises were executed with a computer. The results of the 1995 survey found that 82 percent of the respondents used a computer in their cartography course. Instructors also indicated that 60 percent of their laboratory exercises were completed using a computer.

"A major interest of this survey was the change in computer usage over time."

(2) What type of computer is used in the Introductory Cartography course?

In 1989, approximately 71 percent of the departments using computers indicated that the personal computer was used in their classroom exercises. In the 1995 survey, the percentage of personal computer users had risen to 94 percent. This could reflect the greater availability of software for use on a personal computer and a trend reflecting decreasing costs and

LECTURE TOPIC	1995 PERCENT
Scale	96.2%
Choropleth maps	94.7%
Map design	91.7%
Thematic mapping	91.7%
Generalization	89.4%
Symbolization	88.6%
Dot maps	86.4%
Base map compilation	86.4%
Map projections	83.3%
Classification	82.6%
Proportional symbol maps	82.6%
Computer maps	80.3%
Data sources	79.5%
Data analysis	79.5%
Coordinate systems	78.0%
Isarithmic maps	71.2%
Figure-ground	71.2%
Color	70.5%
Measurement scales	69.7%
Visual hierarchy	69.7%
Cartographic analysis	67.4%
Cartograms	65.2%
Map reproduction	62.9%
Flow maps	60.6%
Communications	58.3%
Linework	58.3%
Topographic maps	57.6%
Typographics	56.1%
Reference maps	53.8%
Manual cartography / drafting	53.8%
Ethics in cartography	50.8%
History of cartography	50.0%
Relief maps	44.7%
Aerial photos	43.9%
Graphs	36.4%
Historical maps	26.5%
Scribing	23.5%

Table 4. Most Frequently Cited Lecture Topics

EQUIPMENT AND SUPPLIES	1989	1995
Computer disk	26.1%	46.2%
Pencil and ink eraser	55.3%	28.5%
Drafting pens	60.0%	26.9%
Gum eraser	58.4%	26.9%
Drafting paper	44.7%	26.2%
Drafting pencils	51.1%	25.4%
Hand calculator	30.5%	24.6%
Masking tape	56.3%	23.8%
Exacto knife set	54.2%	20.0%
Scale	11.1%	16.2%
Triangle, 45 degrees	33.2%	14.6%
Scale, engineers, 10ths	37.9%	14.6%
Triangle, 30-60 degrees	32.6%	13.1%
Protractor	23.7%	10.8%
Screen patterns	31.1%	9.2%
Curve, irregular	15.3%	8.5%
T-square	17.9%	7.7%
Rub-on letters	31.1%	6.9%
Compass set	11.1%	4.6%
Flexible curve	9.5%	3.8%
Map distance measure	2.6%	1.5%
Ship's curves	6.8%	1.5%
Planimeter	1.6%	0.0%
Beam compass	1.6%	0.0%

Table 5. Percent of Equipment/Supplies Required to be Purchased by Students

increased power and capacity of computers between 1989 and 1995. Of those using personal computers, 28.8 percent indicated they were Macintosh users in 1995. This is in contrast to 20.2 percent using the Macintosh in 1989.

(3) What software programs are employed in the Introductory Cartography course?

Another question of importance to the cartography instructor is the availability of software to produce the variety of maps necessary for a well-rounded laboratory experience. The 105 instructors who responded that they used a computer indicated 71 different software applications, ranging from word processing to Geographic Information Systems programs. While this represented a wide variety of software being used, it should be noted that the top ten most cited software packages accounted for 60 percent of the total software usage. The most used software packages are indicated in Table 7.

". . . it should be noted that the top ten most cited software packages accounted for 60 percent of the total software usage."

Written comments often accompanied the returned survey forms, particularly in reference to computers and software. A common comment was that *"software is but a tool to the overall mission of teaching cartography."* Several instructors remarked on the problems associated with the use of computers in the classroom, such as inadequate budgets for computer equipment and software, the lack of multiple computers for laboratory use, and the reluctance of some instructors to use computers because of inadequate computer training.

(4) Additional questions attempted to determine the importance instructors placed on the student experience making maps using pen and ink or with the aid of the computer. The two questions were stated as follows: **Do you feel that it is imperative for students to have pen and ink drafting experience as a part of your introductory cartography course?** and **Do you feel that it is imperative for students to have hands-on computer experience as a part of your introductory cartography course?** Each question was followed by a secondary question, **If yes, to what extent?** A one to ten ranking system, with one indicating little importance to the student and ten being very important, was used.

Forty-five percent of the respondents indicated that they believe pen and ink drafting is an essential part of the introductory cartography course. When asked to rate how important this experience is on a one to ten scale, responses averaged 6.9.

Response to the second question on the importance of having computer experience was overwhelmingly (84 percent), yes, that computer experience is essential. When asked to determine how important this experience was, they gave an 8.6 rating out of a possible 10.

Eight respondents indicated that both pen and ink and computers were essential elements of the introductory cartography course. Overall, instructors placed more value on the computer experience in teaching cartography. However, many still support the premise that students should be exposed to both manual and computer-aided drafting.

EQUIPMENT AND SUPPLIES	NUMBER	1995
T-square	59	44.7%
Protractor	48	36.4%
Compass set	44	33.3%
Triangle, 45 degree	44	33.3%
Masking tape	42	31.8%
Drafting paper	40	30.3%
Triangle, 30-60 degree	40	30.3%
Scale	39	29.5%
Drafting pens	35	26.5%
Beam compass	34	25.8%
Scale, engineers, 10ths	33	25.0%
Curve, irregular	33	25.0%
Flexible curve	32	24.2%
Rub-on letters	31	23.5%
Ship's curves	30	22.7%
Exacto knife set	24	18.2%
Screen paftems	24	18.2%
Computer disk	22	16.7%
Planimeter	22	16.7%
Map distance measure	21	15.9%
Drafting pencils	18	13.6%
Gum eraser	18	13.6%
Pencil and ink eraser	15	11.4%
Hand calculator	10	7.6%

Table 6. Percent of Equipment and Supplies Provided by Geography Departments

SUMMARY AND CONCLUSIONS

This research identifies the characteristics, content and structure of the introductory cartography course. Results are based on a 1995 survey of instructors responsible for teaching the introductory cartography courses, and compares these results with the results from a similar survey conducted in 1989. The latest survey was sent to 311 academic cartographers, with 138 completed forms (44.4 percent) being returned. Specific subjects examined in the survey included the background of the cartography instructor, required textbooks, types and quantity of laboratory exercises, lecture topics, and extent of computer usage in the introductory course.

A comparison of characteristics of the cartography instructor between 1989 and 1995 revealed very similar statistics. The only significant difference was in the graduate institution of the instructors. Although most academic cartographers come from only a few graduate schools, a more varied list of schools was represented in 1995. .

"Comparison of characteristics of the cartography instructor between 1989 and 1995 revealed very similar statistics."

The questions designed to probe changes in course context and structure also revealed similar patterns over the six-year span of time. However, the question regarding cartography enrollment identified a stable to increasing pattern of enrollment.

A number of changes appear to have taken place in the content of the cartography course. Dent's *Thematic Mapping* textbook (1985) now has an equal share of the introductory cartography textbook market with Robinson and associates' *Elements of Cartography*. This could have been due to *Elements of Cartography* being a decade old and needing revision. A new edition was released in 1995 (Robinson, et. al., 1995), while Dent has also updated his book (1996).

SOFTWARE PROGRAMS	IMPORTANCE TO COURSE	PERCENT WHO USE
Atlas*GIS	11	21.5%
Corel Draw	14	19.2%
ArcView	5	15.4%
Macromedia Freehand	15	14.6%
CAD programs	8	13.8%
MicroCAM	0	12.3%
Adobe Illustrator	4	11.5%
Surfer	1	10.8%
ArcInfo	2	9.2%
Atlas*Draw	0	7.7%
MapMaker	3	6.9%
Atlas*Pro	4	6.9%
Atlas*Graphics	1	6.9%
Map Info	3	6.2%
Map Viewer	2	5.4%
Superpaint	3	4.6%
Word Perfect / MS Word / PageMaker	1	4.6%
Idrisi	1	4.6%
MS Excel / Quattro Pro / Lotus 123	1	3.8%
GeoCart	0	3.1%
PCPaintbrush	1	3.1%
PCMap	1	3.1%
Claris Draw / Mac Draw	2	3.1%
Erdas Imagine	0	2.3%
Designer	1	2.3%
Canvas	1	2.3%
Classy	0	1.5%
SPSS Graphics	0	1.5%
Harvard GeoGraphics	0	1.5%
Roots	1	1.5%
MacAtlas	0	1.5%
Adobe PhotoShop	0	1.5%

Table 7. Computer Software Used in the Introductory Cartography Course

The amount of equipment that students were required to purchase has declined significantly between 1989 and 1995. The percentage of laboratory exercises produced by computers has increased substantially. However, the number and type of exercises, and the major topics covered in lecture have remained similar over the six-year period of time.

"The most notable changes identified in the introductory cartography course were in the realm of computer usage."

The most notable changes identified in the introductory cartography course were in the realm of computer usage. At the beginning of this article, the technological revolution in cartography was addressed and a goal was set to measure technological changes in the introductory cartography course over a six-year period of time. The most significant changes identified were the shift from mainframe computers to the personal computer, greater use of computers in producing maps, and changes in the types of software used to produce maps. This is mirrored by the survey response that over eighty percent felt that computer experience in cartography was essential. Nevertheless, a significant number of instructors felt that manual drafting techniques still have a place in the introductory cartography course.

ACKNOWLEDGMENT

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Uses, Users, and Use Environments of Television Maps

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Weather maps have been part of our television environment for more than half a century and, as such, have become part of our culture. Weather maps are seen in a unique environment where users know when and where to tune in to see maps that they have become comfortable viewing. It is argued that these weather maps are good examples of animated cartography and complementarity in cartography. Weather programming on U.S. television is grouped into four types: local, national, all-news, and all-weather. Although it can be argued that more people see weather maps on television than any other type of map, these weather presentations are designed and produced by a community which includes few if any cartographers. The weather maps are used in many different ways, including a general education of the public and entertainment comparable to watching a sporting event. A typology of weather map users is developed based on what users want to get from the maps.

INTRODUCTION

Weather maps presented on television in the United States are arguably the maps seen by the greatest number of people. The weathercasters with their maps are portrayed in jokes and cartoons and are written into television programs and movies. Television weather presentations with the accompanying maps are part of American culture, as well as a business. Like other aspects of American culture, the television weather culture seems to be spreading around the world. In 1997, Scharfe organized and hosted the first international conference on *Mass Media Maps* in Berlin. A significant part of the program was devoted to *Weather Presentations in Mass Media* with most attention given to weather maps on television. Papers in the proceedings of that conference reported on television weather maps and mapping in the Czech Republic, France, Germany, and the United States (Scharfe, 1997). It was surprising to find The Weather Channel (Der Wetter Canal) on Berlin television. The channel is available in many countries, as are other commercial weather presentations. The nature of television weather programming around the world is not dissimilar to that found on commercial television in the U.S.

"Television weather presentations with the accompanying maps are part of American culture, as well as a business."

In the recent volume *Ten Geographic Ideas That Changed the World*, Monmonier (1997) argues that the weather map is one such idea because it has done much to shape our lives, although it is taken for granted. "Snapshot views of the state of weather are so readily available, we easily forget they are one of the great inventions of modern geography." (Monmonier 1997, 40) While Monmonier gives recognition to the contributions of the many weather maps in our midst, Muehrcke (1996) asserts that "...less than half of the adult population in the United States can perform even the most basic tasks related to using maps." If Muehrcke is right, then many television viewers get little from the weather maps. Yet, television weather rates very high in viewership among all of the news programs. Does this mean that all of the dynamic and colorful maps mean little to the public, or that weather maps fall outside the purview of maps considered by Muehrcke? This paper does not answer these questions specifically, but it attempts to provide some structure for determining how weather maps on television are used.

". . . we easily forget [weather maps] are one of the great inventions of modern geography."

There are many dimensions to the study of map use. One dimension focuses on the users who bring varied experiences, skill levels, interests and motivations to the task of viewing the maps. Non-users should be recognized in this mix because they are people who for one reason or another choose not to make use of the weather maps that are displayed all around them. Another dimension in the study of map use is the viewing environment; the ways in which viewers can and will interact with the maps. In the case of television maps, that environment is quite constrained. Still another dimension of map use is the community that produces and presents the maps, thereby setting de facto standards as to what is shown and thereby determining or limiting how the maps can be used. And finally, there are the many different ways maps are used by all of the people operating within this constrained environment. These many dimensions of map use apply to all types of maps and mapping. Weather maps on television are a very specialized form of map presentation, but within this specialized environment there is considerable variation.

"There are many dimensions to the study of map use."

THE TELEVISION VIEWING ENVIRONMENT

The map use environment determines the ways in which the map user can and will be able to interact with the map. Traditionally, maps and map use are discussed in terms of graphics printed on paper and in the hands of the user. With these paper maps, in most cases, the user has great control over the environment in which to use the map. The user can choose when and where to study the map, can linger over the map, can use reading aids, change light levels, make measurements, and draw on the map. Torguson (1997) looks at the dynamic and interactive environments that should come with electronic atlases. In those environments, users are given control over interactive tools to work with maps and explore atlases. By contrast, the viewer of maps on television has no control over the viewing environment. Television viewers see a map appear on the screen only to disappear when replaced with another image. In most news stories, the viewer has little or no warning if a map will be presented, when it is coming, or how long it will be shown. Television viewers can only passively watch maps come and go on the screen.

"The map-viewing environment of TV weather is distinctly different from the environment of other maps seen on television . . ."

The map-viewing environment of TV weather is distinctly different from the environment of other maps seen on television because, in the weather program, the types of maps and times of presentation are consistent from day to day. The viewer knows when to tune in and has reasonable expectations of the nature and format of the material that will be shown, with new thematic information imposed on familiar map bases. And, there will be that familiar personality sequencing the maps and making interpretations. This unique viewing environment sets the use of television weather maps apart from all other types of map use, whether they are other maps on TV, paper maps, or electronic atlases.

The relatively low resolution of television technology imposes severe limitations on the presentations of map detail. Brown (1993) and Lindgren (1991) give overviews of this technology as it relates to cartographic design and the limitations on the presentation of maps on screen. HDTV, high definition television, should overcome some of the limitations of the current standards, and it will be interesting to see how the nature of television weather maps change in this new environment.

". . . it will be interesting to see how the nature of television weather maps change in this new environment. [high definition television]"

The current low-resolution technology does facilitate the presentation of colorful animated maps with flashing icons, pulsating lines, loops of radar echoes and satellite images of clouds, 3D fly-overs, and morphed fronts and air masses (Carter, 1996). Peterson (1995) emphasizes the power of animation which " ...depicts something that would not be evident if the frames were viewed individually" (Peterson 1995, 48). He goes on to note that

"...there have been few examples of cartographic animations, due largely to the complexity of their creation, presentation, and cartographer's fixation on the printed map." Carter (1996) responded that there are many examples of cartographic animations right in front of us—on television weather programs. Admittedly, cartographers have not been central to designing and presenting those maps. The fact that these animated maps are not thought of as part of cartography supports Monmonier's contention that weather maps are so readily available that they are easily overlooked.

". . . there are many examples of cartographic animations right in front of us — on television weather programs."

These animated weather maps contribute to cartographic complementarity, which Monmonier (1996, 77) notes " ... seeks efficiently informative presentations by minimizing needlessly redundant information as well as by juxtaposing or integrating multiple measurements or themes needed for insightful interpretation." Such cartographic complementarity is well represented in most television weather presentations, for it is rare that only a single map is used to show the weather. Far more common is a collection of maps to show cloud cover, radar echoes, and the synoptic map for the present and a forecast for the near future. And, maps of temperature, dew points, and areas of precipitation add even more information to help the viewer make insightful interpretations. In addition to the maps, the presenter interprets the patterns shown on the map, pointing out where the cold air is coming from, using hands and body motion to emphasize the movement of the flow around a center of low pressure, etc. Such complementarity is also found in the statistics given about the past weather and forecast conditions.

". . . cartographic complementarity is well represented in most television weather presentations, for it is rare that only a single map is used to show the weather."

In addition to this complementarity found in any one given weather program, television viewers frequently have the option to switch channels and see how another weathercaster addresses the same subject. Comments from friends and colleagues have indicated that the practice of looking at more than one weather program is common.

Muehrcke (1996, 275) argues that much can be gained from doing one's own mapping and creating one's own graphic representations where abstractions must be used. He makes this observation with respect to the growing number who will use computer systems to make their own maps. Anyone who looks at more than one weather presentation on television in order to get a feeling for what is going on in the atmosphere must be making his or her own mental map, i.e., doing the abstraction. The viewer watches a weathercaster interpret the situation and then compares that with another interpretation, and perhaps another. It may be interesting to see one presenter venture a forecast that is different from another, but these differences cannot be discerned unless a mental map of the ones previously seen has been formed. Paper maps can be laid down side by side and systematically compared, feature by feature. With television, mental images from the earlier viewing must be carried for comparison with the later. For many, a set of mental maps are being made as each person watches a presenter work through a set of complementary maps with complementary chatter, body language, and statistics.

"Anyone who looks at more than one weather presentation on television in order to get a feeling for what is going on in the atmosphere must be making his or her own mental map . . ."

The environment of television weather maps is unique among all map-viewing environments in that the viewer gets to select from a variety of colorful, animated presentations of weather with the click of a button. Further, more than a single map is viewed with integrated sequences of maps and complementary information under the control of a presenter who may be very adept at the task of presenting the material. In addition, in many places the viewer has the option to get still other map presentations about the same weather story. While television weather is map rich, the viewer has no control over how to receive those riches but does know where and when to find them.

"While television weather is map rich, the viewer has no control over how to receive those riches but does know where and when to find them."

EVOLUTION OF THE TELEVISION WEATHER ENVIRONMENT

In his history of television weathercasting, Henson (1990, 5-6) notes that weather broadcasting was being done in 1940-41, before most people were familiar with the concept of television. World War II interrupted the expansion of television, but it helped to advance the technology of weather forecasting. After the War, many ex-military meteorologists became the new television weather personalities. The news was treated with respect in those early years and weather was considered to be a subset of the news at large. Soon, television weather departed from its radio formats because, as Henson noted,

> The visual nature of television demanded 'action' in the form of weather maps and bright, attractive people who could explain them. The frontal theory of weather forecasting was then just 30 years old; weather maps had become a newspaper standby, but the workings of occluded fronts and high pressure ridges were hardly common knowledge. (Henson 1990, 6)

"The visual nature of television demanded 'action' in the form of weather maps and bright, attractive people who could explain them."

These pioneer weathercasters had to introduce to a large public such concepts as highs, lows and fronts. Using today's terminology, maps are used on television to 'visualize' the spatiotemporal nature of the atmosphere by showing components of weather systems moving across the land.

In 1952, the federal government opened the airwaves, which led to a proliferation of television stations. By the mid-50s, "Most cities with populations over 100,000 had at least two stations competing for viewers . . . " (Henson, 1990, 8). In 1982, John Coleman instituted a revolutionary concept by showing maps on television 24 hours per day, seven days per week (Henson, 1990, 99-100). Today, The Weather Channel reaches 69 million subscribers on cable, and versions of it are subscribed to by another 26 million people around the world (Petrozzello, 1997a). With the availability of retransmission consent agreements earlier this decade, LIN Broadcasting has developed local versions of 24 hour weather broadcasting in direct competition with The Weather Channel in select markets (Merli, 1997). Now, some local cable systems are providing AccuWeather weather coverage up to 24 hours per day as a complement to The Weather Channel (Petrozzello, 1997b). In the political climate of 1995, when public television came under attack and devolution of the federal government was popular rhetoric, A.M.Weather was dropped from PBS for a variety of reasons (AM Weather, 1995). This unique 15-minute morning program, with presentations of upper air patterns and a segment for pilots with maps showing visibility ratings, had been a mainstay of public television since 1978 (Henson, 1990, 97).

"In 1982, John Coleman instituted a revolutionary concept by showing maps on television 24 hours per day, seven days per week."

Currently, the weather presentations on television in the United States fall into four types:

1) Local stations that have a 2-3 minute weather segment in the local news two or more times a day. The focus is on the regional and local weather but most presentations include an overview of the national pattern. The nature and quality of these maps and presentations vary greatly (Figs. 3-14).

2) National networks that have short weather segments accompanying their morning 'news' programs, generally with simplified national maps showing the synoptic pattern and temperatures (Figs. 1 and 2).

3) Full time news channels, such as CNN (Fig. 17), having weather segments presented throughout the broadcast day.

4) The Weather Channel and, in selected areas, Local Weather Service or AccuWeather Local Cable Weather Service that present continuous coverage of weather 24 hours a day, 7 days per week (Figs. 15-16 and 18-21).

"Currently, the weather presentations on television in the United States fall into four types: . . ."

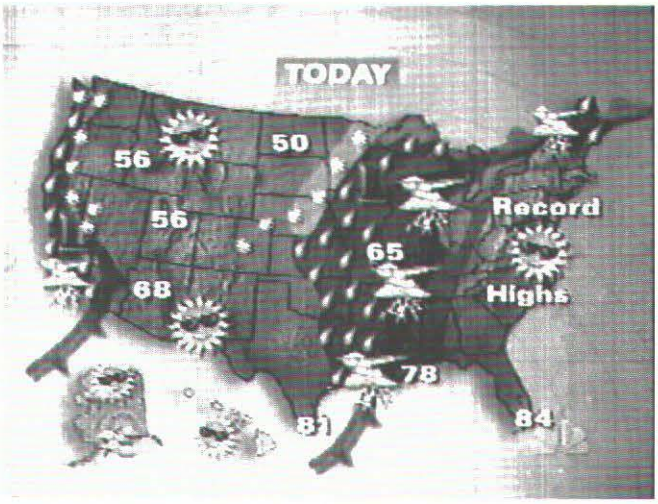

Figure 1. Map from the NBC morning program with smiling, golden faces behind sunglasses in the west, and evil thunderheads dropping rain over the Midwest. This map has everything but a presenter: numbers, text, fronts with drop shadows, and insets for Alaska and Hawaii.

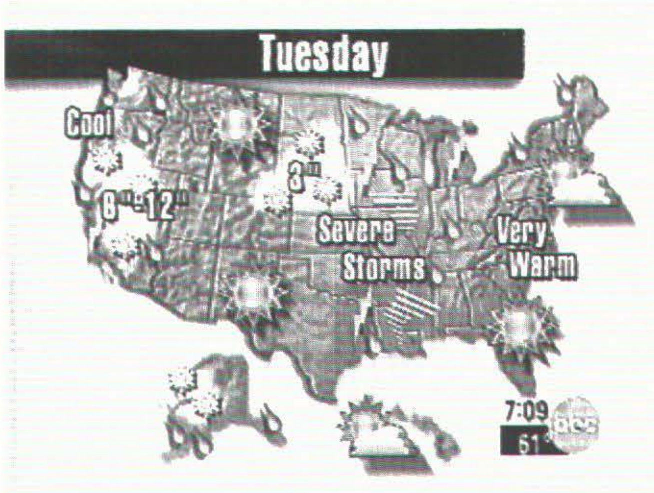

Figure 2. Map from the ABC morning program with bold text and large, colorful icons portraying the weather. This map has no fronts but does have raindrops, snowflakes, sunbursts, and hatched patterns showing the areas of severe storms. It also includes insets for Alaska and Hawaii. There is no presenter in this image.

Figure 3.

Figure 4.

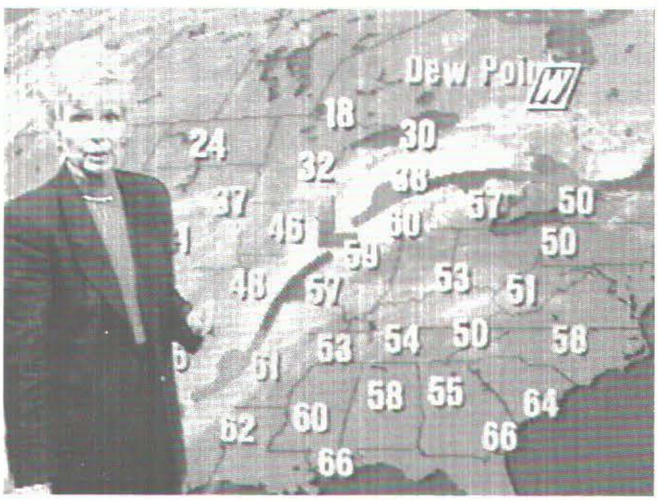

Figure 5.

Figure 6.

Figure 7.

Figures 3-7. A sequence of maps with Judy Frasier, WCIA-TV, Champaign, IL, explaining the ways the elements come together to produce this strong extra-tropical cyclone. 3 - shows isolines delimiting color filled zones representing storm potential. 4 - is a perspective view of the central part of North America showing a frontal boundary imposed over a map with cloud cover. 5 - is the next in the sequence where dew point temperatures are plotted, using different colors for the high and low values. 6 - is a loop of radar imagery moving over a larger-scale base map showing the counties of East Central Illinois in the viewing area. 7 - builds on the previous map with the addition of the frontal line and sequences of pulsing arrowheads portraying the rotation of air about the Low. There is considerable difference in the two regional base maps used in this same presentation.

Figure 8. Lee Ranson of WEEK-TV, Peoria, IL, shows the presentation of radar on a local program. This is a relatively large-scale presentation showing considerable detail in the counties of central Illinois. This is a comparatively simple presentation of radar imagery.

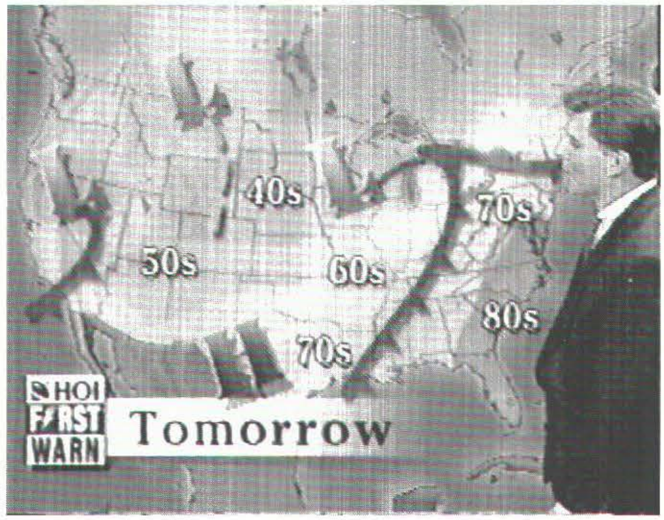

Figure 9. Ric Kearbey of WHOI-TV, Peoria, IL, with a relatively simple map of North America centered on the continental U.S., with large symbols, projected temperatures for tomorrow, and the station logo. Note the bold shadows underlying the Hs, Ls and the fronts.

Figure 10. Mike McClellan, WMBD-TV, Peoria, IL, puts his whole body into the effort to show how surface streamlines are spiraling into the Low centered over northern Iowa. Such streamline maps are used occasionally by the more technical local weathercasters when the synoptic situation produces a broad, regional pattern that viewers can understand. Note the bold station logo in the southwest corner and the dark edge along the frontal boundary.

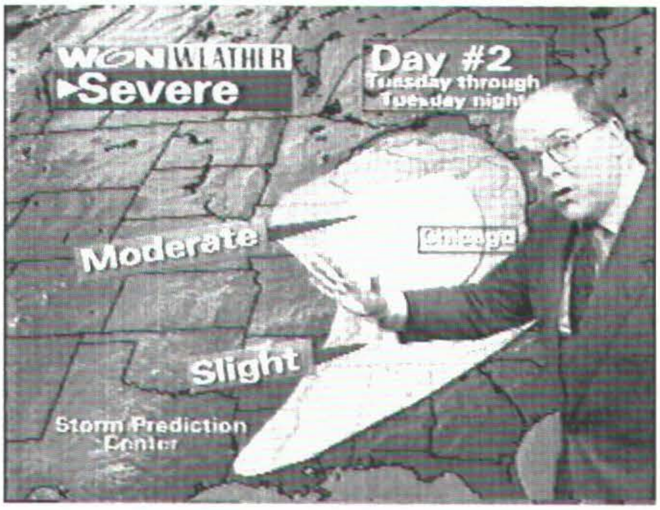

Figure 11.

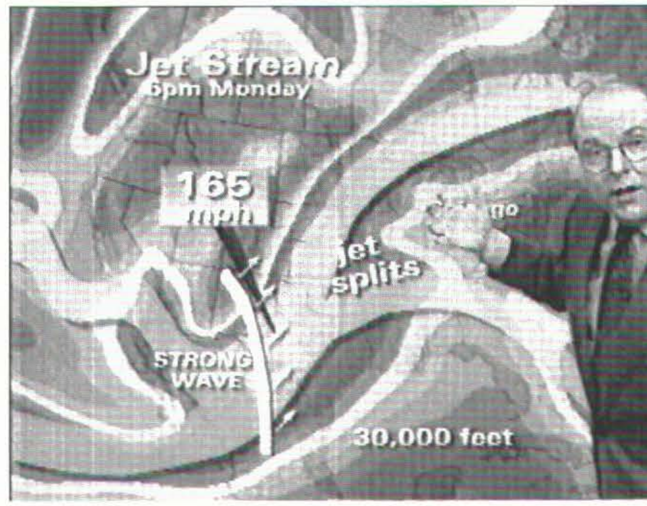

Figure 12.

Figure 13.

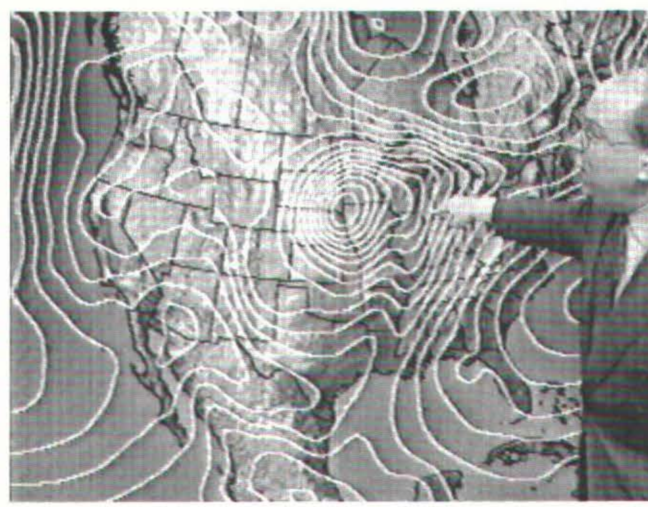

Figure 14.

Figures 11-14. Tom Skilling of WGN-TV, the Chicago super station that is available to tens of millions via cable, is known for his challenging graphics. Many meteorologists watch him, although some confess they are not certain what they have seen after his program. In this series, in one map (11) he shows the predicted areas of severe weather. In one box at the top we see the date for which the forecast applies, in another the station logo, and along the bottom is the source of the information. This is a lot to read on a map that may be on the screen less than 5 seconds. The second map (12) employs a fantasia of colors to represent jet streams converging and diverging at 30,000 feet. The third map (13) shows the current and three projected positions of fronts and centers of the Low over the next 72 hours. A considerable amount of text appears on the map, such as 'Compact Intense SNOW BAND.' At lower left the attribution is Supercomputer Model Track Guidance. The fourth map (14) employs isobars that, in this case, vividly depict the depth of the center of Low pressure. Isobars are not used commonly of television weather maps. Note that all of Skilling's maps extend seamlessly over Canada.

"To be competitive in this diverse mix, weather presenters must have some combination of personal charm, reliable forecasts, and quality graphics."

To be competitive in this diverse mix, weather presenters must have some combination of personal charm, reliable forecasts, and quality graphics. While there have always been weathercasters with strong meteorological experience, for many years the typical weather presentation seemed to be dominated by personalities relying on comedy or sex appeal to attract audiences. Today overt sex appeal is no longer used, but a little levity is still employed by some weather presenters, particularly on the morning programs on the national networks and some local weathercasters. By contrast, the weathercasters on the all-news and continuous weather channels tend to be professional in their interaction with the subject matter and suppress

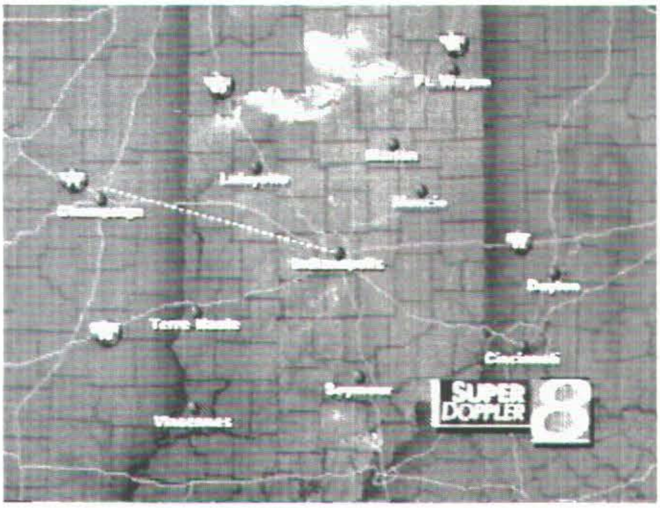

Figure 15.

Figure 16.

Figures 15-16. LWS in Indianapolis is a 24-hour weather channel tied to channel 8, the local commercial channel. The Super Doppler radar map (15) is automatically switched on regularly and viewers get to watch radar echoes march across the map of central Indiana as the scan line rotates clockwise around the central point in Indianapolis. Fig. 16 portrays the weathercaster explaining the synoptic patterns on a map with stylized cloud patterns and fronts that rise high over the land, as indicated by the shadows standing apart from the fronts. By definition, fronts on maps show the boundaries of dissimilar air masses on the earth's surface.

Figure 17. This is an example of the animated weather map series on CNN. As the fronts glide across this map, a timer bar slides along the top to show when the map situation is forecast to occur. The precision of the timer bar is fuzzy and it is difficult to focus on the timer while watching the weather patterns move over the map. The graphics system used to generate these maps was developed by a Norwegian firm. CNN has worked closely with that firm to create this system of map presentation.

Figure 18. This is but one of many possible choices from The Weather Channel. This is a non-animated regional Travel Weather map over the northeastern U.S. showing weather only to the national border. To orient viewers, interstate highways are shown, and a few are labeled. Across the top of the map is the legend, with the map title, The Weather Channel logo, and an advertising logo, in this case that of BMW. To satisfy local viewers, but add complexity, local statistics for central Illinois are overprinted along the bottom portion of the image.

any hint of comedy. Still, across all of these environments, the weathercasters note that it is important to build rapport with the audience and not appear to be too serious.

A SAMPLE OF TELEVISION WEATHER MAPS

Any discussion of the many types of maps on television requires that a sample of those maps be shown. Because the maps on television weather programs are colorful and dynamic, they are not captured or portrayed well as static frames in black and white. Many television weather maps have so little contrast in black and white that they are totally washed out when represented this way. In addition, it should be noted that some maps could

Figure 19.

Figure 20.

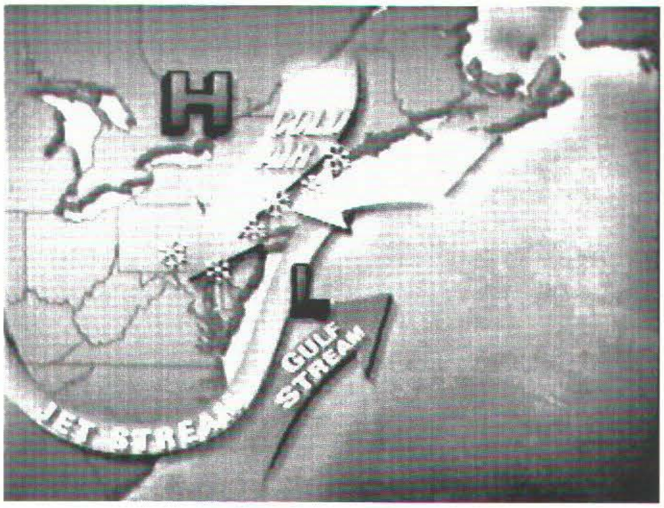

Figure 21.

Figures 19-21. This series of three thematic maps are samples from the sequence of seven such maps The Weather Channel used to explain the forces producing the Nor'Easter that swept up the coast in late spring 1997. One map shows the center of the High and the warm Gulf Stream. The flow of Cold Air and the Jet Stream are added to produce the second map. The final map has moisture blowing in off the Atlantic and many snow flakes. Such sequences of simple, straightforward maps are very effective in explaining how particular storm systems form and evolve. Such map sequences are used frequently on The Weather Channel when severe and damaging weather occurs in the U.S.

not be used because the station or channel could not give permission to print certain types of data.

While Americans can see weather maps of the entire world and separate continents on television, the maps shown here are maps of weather in the U.S. Many of these maps are representative of what appears in the Midwest during severe weather. Most of these maps were captured March 30-31, 1998, as a large weather system moved through the Midwest. The weather segments were recorded on a VCR, captured in Adobe Premiere at 640 by 480 resolution, then cut and pasted into SimpleText. The images were then processed in Adobe PhotoShop to scale them and convert them to black and white.

THE WEATHERCASTING COMMUNITY AND MAPS

The weather programs on television are the end product of an international system of data collection, evaluation, analysis, modeling, forecasting, and dissemination (Carter, 1988). In extensive interviews with many weathercasters, it became clear that the weather presentations on television are first and foremost part of a business enterprise. The stations and channels make decisions based on the need to capture market share, maintain viewers, and provide a return on investment. Even the dedicated on-air meteorologists, while concerned with getting the right information to the public, recognize their need to build audience support. Coaches and consultants are brought in to work with weathercasters to make certain they contribute to the image of the station.

Over the years, many cartographers have suggested informally that they could do a better job of designing maps for television weather presentations. Many weathercasters feel the same way and wish that they had the freedom to implement some changes. Almost without exception, the management and / or the art department choose the design of the base maps and the colors. Sometimes the weathercasters participate in the process. Many of the maps and graphics come from the firms that provide meteorological data, images, and maps to the stations. In contrast, the Weather Channel employs a formal team approach to map design and program organization that integrates representatives from all appropriate departments. They also use focus groups of viewers to guide the teams (Eck, 1997).

". . . cartographers have suggested informally that they could do a better job of designing maps for television weather presentations. Many weathercasters feel the same way . . ."

Most of the local weathercasters noted that they have almost total freedom to organize and present the weather story, as long as they maintain the image of the station and fit the time constraints. Weathercasters have their preferred set of procedures. One reported that he tries to find a story and then sequence the maps to tell the story, while his colleague tries to present a shop filled with helpful products (maps) from which the viewer can pick.

Although consultants report that the weather segment is the most watched part of the local news, that segment is considered the 'accordion' because it gets squeezed or stretched regularly. Often it is shortened up to 30% (and sometimes more), only minutes before the presentation goes on. Sealls (1994 / 95) describes the hectic environment in which the weathercaster prepares and presents maps on television. Based on interviews with weathercasters in different environments, only the full-time weather channels seem to operate with fixed time slots that are not changed moments before going on-air. Preparing maps for a presentation that may be cut significantly affects the choice of maps and map sequences that can be considered.

"Preparing maps for a presentation that may be cut significantly affects the choice of maps and map sequences that can be considered."

Weather programming is rated very highly in terms of audience appeal, by all measures. "Weather—or some aspect of weather coverage—is the number-one news draw in 11 of the top 20 TV markets, . . .92% of news viewers say weather is something they 'really want to see covered' in local news, followed by the day's local news (89%), live coverage of breaking news (89%) and health news (75%)" (Bowser, 1997, 61). This is consistent with what the local weathercasters are told by consultants, i.e., that the weather segment is the most watched part of the news. Henson (1989, 1-2) cited earlier studies giving high ratings to television weather presentations. Haddad and Cress (1993) reported that The Weather Channel is the fourth most watched of the many cable channels in the U.S. Stations pay handsomely to get ratings, but detailed television station ratings are proprietary. Although access to data is limited, there is no doubt that weather on television has a very large audience.

". . . there is no doubt that weather on television has a very large audience."

In general, weathercasters think of themselves as professionals and take pride in the programs they put together. Many have had formal training in meteorology and have degrees or concentrations in television meteorology. In addition to a number of good academic programs in meteorology, there are graduate programs emphasizing television weathercasting, some of which are predominantly correspondence training for those already working on-air (Henson, 1990, 19-20). In many of the schools there is at least one course where students make presentations and then receive criticisms from fellow students, as at Pennsylvania State University (Mirsky, 1996). Beyond the academic programs, the American Meteorological Society

(1997) and the National Weather Association (1997) have formal programs to certify on-air weathercasters. Annual meetings of both organizations include seminars and workshops designed to give weathercasters pointers and guidance on content, preparation, and presentations. Also, the weathercasters now have a place on the Web to share interests and concerns (Loffman, 1997a).

". . . it appears that academically trained cartographers have not been able to penetrate the world of television weather mapping."

Based on many interviews with people in the television industry and cartographers, it appears that academically trained cartographers have not been able to penetrate the world of television weather mapping. It is interesting to speculate why this is the case. Foremost, no one has seen the need to employ academic cartographers to improve the maps that go on-air. Stations do employ designers to build local and regional base-maps and improve the look of maps they use on air. Weathercasters praised one such consultant, Valerie Jones, for helping them come up with better maps. She received a degree in meteorology and worked on-air for a few years, then worked for one of the service providers as a trainer in support of on-air weathercasters before going on her own as a consultant (Jones, 1998). Jones has always been interested in maps and traces some of that interest to a great grandfather who was a cartographer. One can assume her progressive experience within the industry positions her to provide the cartographic link to stations that would want such a connection. That experience gives her knowledge of weather mapping, the technology of the television mapping systems, and the design constraints of the television display. The academic cartographic literature has little to say about any of these subjects.

". . .Brewer suggests that television weather has had some impact on academic cartography."

On the other hand, Brewer (1997) suggests that television weather has had some impact on academic cartography. Spectral hues that cartographers once deemed to be inappropriate are now found to be more acceptable because viewers have been exposed to those sequences in television weather presentations. "Spectral hues may now be spontaneously ordered in the public consciousness after continuous exposure to popular spectral graphics on topics such as the ozone hole and weather. The contradiction between the lack of perceived order for spectrum colors and the likelihood that the public is learning this code, through its use on most scientific visualizations that enter the public sphere, is a topic ripe for further research" (Brewer 1997, 217)

"It may be anticipated that the convergence of HDTV and quality, large-scale digital databases, in combination with the powerful computer graphics systems used for weather mapping, will lead to some interesting applications of maps on television."

There is reason to suggest that academically trained cartographers may find a place in television, but less for their design skills than for knowledge of cartographic databases. One of the people interviewed was hired as a cartographer to help integrate digital geographic databases into some of the more advanced weather mapping systems (Flanagan, 1998). He noted that some of the new databases, especially those related to Doppler radar systems, are very detailed and are being used for maps in the news in addition to weather presentations. In another conversation, a manager inquired about where to get cartographic databases that would permit the rapid production of maps that could be used in emergency situations. Additionally, another person stated that many commercial mapping organizations are discussing ways to become more involved in the television news industry. It may be anticipated that the convergence of HDTV and quality, large-scale digital databases, in combination with the powerful computer graphics systems used for weather mapping, will lead to some interesting applications of maps on television. These maps will owe a legacy to the television weather map and the audiences that have learned to use them.

Weathercasting is a map-rich activity and, therefore, as forecast information is disseminated, maps will be employed. The nature of those maps and the ways they are used in presentations on television reflect the combined efforts of the television weathercasting community made up of forecast meteorologists, service providers, television management, consultants, and TV weather presenters. Academic cartographers do not seem to be part of this community. This absence of cartographers should not be a surprise, for as Muehrcke (1996, 272) notes: "Most maps are made by graphic artists and others not formally educated as cartographers." Television weather mapping fits the norm.

USES OF MAPS IN TELEVISION WEATHERCASTING

This paper is based on many years of systematically viewing television weather broadcasts, observing the reactions of many friends and colleagues, interviewing weathercasters, reading anecdotal comments in the popular press, and delving into a fairly limited professional literature. The collection of uses discussed here represents perhaps only a small part of the many ways people use the maps in television weather presentations in the U.S., but it is a start in examining the use of weather maps on television.

Fair Weather / Foul Weather Viewing - Fair weather viewers should be expected to have a different agenda than when the weather poses a potential danger. When a hurricane is bearing down on the area or severe storms with the potential for tornadoes is present, or a blizzard is on its way, people take a heightened interest in the weather. For those in the path of potential danger, these weathercasts have immediate relevancy. Sometimes the concern will be watching for 'official warnings' and reacting to specific instructions. The U.S. National Weather Service uses such television and radio weathercasting to disseminate warnings and advisories in a government / private partnership (World Meteorological Organization, 1996).

"Fair weather viewers should be expected to have a different agenda than when the weather poses a potential danger."

In other situations, the potential for danger can be more personalized. As an example, when working at home at a computer and electrical storms are likely, it is wise to monitor the weather on TV for progress of storm cells moving through the local area. Knowing where your residence is on the local map base used to show radar, the computer can be unplugged so as not to suffer damage during the electrical storm that can be estimated to move overhead within a matter of minutes. This immediate feedback can reinforce decisions to watch the radar maps the next time such weather seems imminent.

"This immediate feedback can reinforce decisions to watch the radar maps the next time such weather seems imminent."

Recently, map analysis was employed in deciding to continue a scheduled canoe trip. The day before the scheduled event, it was cold and rainy. The leader deferred on canceling the trip until after she was able to watch the local weather programs as part of the late night news and make her own prediction on when the rain would move out of the area. Because the river was some distance away, the prediction had to be based on pulling together a number of pieces, including the trend of the boundary of the rain zone as portrayed on the radar imagery. At 10:30 PM, in consultation with the other members of the group who watched a variety of weather presentations, the decision was made to cancel the trip.

A significant proportion of the nation seems to tune in to watch severe weather events such as Hurricane Andrew bearing down on southern Florida or the 'blizzard of the century' moving across the Southeastern U.S. and up the East Coast. This can be fascinating for the viewer and the weathercasters relish the fact that they have an audience that is showing heightened interest in their interpretations and forecasts. In many ways, television weather is like sports in that it is highly graphical, the weather events are short-lived, and people can see the results. In near real-time, viewers can watch weather systems evolve as the forecasts are revised. Like sports, people spend hours watching storms play out on maps as experts give commentary. With radar and satellite image loops, there are even instant replays.

"In many ways, television weather is like sports in that it is highly graphical, the weather events are short-lived, and people can see the results."

In 1994, the Local Weather Station, or LWS, was brought online in selected market areas to compete with The Weather Channel. Thedwell (1996) noted LWS would "give 90% local and 10% national versus The Weather Channel which is the opposite." In practice, those stated proportions are greatly exaggerated. In Indianapolis, IN, The Weather Channel and Local Weather Service occupy neighboring positions on the dial at the high end of the cable service. These competing services employ different forms of radar presentations to monitor the weather. On LWS, the presentation is real-time and continuous and the viewer can watch the storm migrate across the map of central Indiana (Fig. 15). But to appreciate the motion, one must fix on reference points on the map and observe the motion relative to those points. Every ten minutes, The Weather Channel shows a loop of radar echoes over the past three hours. Viewers can watch these loops to see trends in motion across the map. These two dynamic map presentations complement each other and those who can toggle between neighboring channels can watch severe weather march across the map.

"These competing services employ different forms of radar presentations to monitor the weather."

Many weather segments are targeted at the traveler (Fig. 18). This is particularly true before major holidays when many people travel, or when snow and ice pose special problems for automobile travel. The Weather Channel, with its national coverage, particularly targets the traveler, including the business traveler who will soon fly to another location. The purpose of this information is to inform the person of the general weather conditions so they might better decide what to wear and to pack. The 'School Day Forecast' on The Weather Channel has a similar function in telling parents how to dress their children for school. On that map they use icons such as coats, sweaters, and umbrellas.

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Pilots must contend with weather as they fly into or around specific occurrences. Horne (1992, 93) gave emphasis to the role of television weathercasting for pilots when he wrote:

> ...it's a rare pilot indeed who doesn't consult his television as part of the preflight weather briefing process. For pilots without computers, graphics boards, and customized software, the television has become an indispensable tool—sometimes the only tool—for visualizing current weather and forecast trends, as well as identifying any areas of severe weather.

A.M. Weather with its upper air and visibility maps was the only program with a segment specifically targeted at pilots, but it was dropped in 1995. No television weather program has picked up this coverage, although it was reported that the program would be re-instituted (DR, 1996). The World Wide Web has many sources of maps that should satisfy pilots, so it is unlikely that any television system will take on the presentation of weather information targeted directly at pilots.

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Another set of viewers who base decisions on their interpretation of the television weather forecasts are the commodity traders. In a widely disseminated article, Dishneau (1993) wrote:

> 'At 12:20 p.m. on midsummer weekdays, the din at the Chicago Board of Trade fades as grain traders turn to small television sets scattered about the exchange floor... 'to watch Tom Skilling's WGN midday forecast of weather for the Chicago area and the Midwest.' If Tom Skilling predicts more rain for the waterlogged Midwest, corn and soybean futures prices may soar.... Traders pay attention to Skilling for several reasons: He comes on when the market is open, his unusually detailed forecasts cover the entire Corn Belt, and his predictions are free .... He also has a reputation for accuracy, earned in 1988 for his early and extensive coverage of a devastating Midwestern drought.'

Education -Local weather personalities frequently visit schools and then tell about their visits on their programs. Many schools have weather stations that provide statistical data that the local weathercasters use in their programs. These television meteorologists are often the only 'scientists' that many young people see. The Weather Channel has a formal program of education called 'The Weather Classroom,' consisting of programs for teachers to use in the classroom, a 75-page book to supplement the video segments (Moore, 1992), and a quarterly newsletter for educators. The segments are available to teachers to record, and now they sell the series pre-recorded (The Weather Channel, 1997). In all of these educational activities, little attention is given to maps.

"These television meteorologists are often the only 'scientists' that many young people see."

It is not uncommon for local stations to provide specials about weather in the area, particularly as tornado and hurricane seasons approach. In Spring 1997, WRTV in Indianapolis had a half-hour special on tornadoes. That presentation contained a segment on how radar images are employed to forecast severe weather and showed examples of how different weather events appear on radar maps. This segment was an unusual educational piece because it instructed about maps and map images.

In general, it is assumed that a viewer interested in weather knows how to read the maps. However, Spiceland (1997) noted that a number of viewers of CNN write in to request that they put the names of the states of the U.S. on the weather maps because the viewers cannot recognize the states in outline form. A number of local weathercasters expressed concern that many viewers are not able to locate themselves on the local maps they use, but they do not know how large that audience is. Sensitive presenters seek a balance between pointing out places on the map as they are mentioned without insulting the intelligence of those viewers who are comfortable with the maps. Some weathercasters take pride in their ability to inject geographic comments while pointing out weather patterns on maps. Loffman (1997b) suggests that meteorologically trained weathercasters would be well advised to add more advanced components to their presentations because he has observed that with the packaged technology there is little difference between the presentations of the well-trained weathercaster and the non-trained person who has on-air charisma. The conscientious weathercaster has an obligation to tell the story of the weather, educate the viewer, and provide the commentary.

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As a different type of education, The Weather Channel often uses fairly simple sequences of maps to illustrate the cause and effect of specific meteorological events. Such a series of maps was used to explain the evolution of a Nor'easter that hit New England and dumped a great amount of snow (Figs.19-21). All big weather events get such treatment including major blizzards, hurricanes, a penetration of particularly cold air, heat waves, extensive droughts, or a stagnating front leading to flood producing rains. Maps in these explanatory segments are normally presented in steps as each new component is overlaid on top of the previous map to illustrate the story. For example, the map sequence used to explain the evolution of the Nor'easter consisted of seven applications of icons or names overlaid on the base map as a voice in the background described how each factor added to the mix.

By contrast, weathercasters on The Weather Channel, as well as local channels have employed a variety of map movies to educate viewers about the dynamics of the temperature departures in the Pacific Ocean as the El Nino event of 1997-98 unfolded. This movie data has been available from one or more government sites so channels can pick it up and rebroadcast the maps as movies.

Some weathercasters are known for the extra explanations in their presentations. Tom Skilling of Chicago's WGN-TV, a so-called super-station available to some 30 million households, is well known for his explanations of meteorological events as well as his use of a great many maps (Figs. 11-14). What he chooses to show is in part influenced by what the technology lets him create. Years ago he used a 3D grid suspended over the map surface to explain a dome of high pressure. This grid was viewed from a perspective position and the surface rose and fell with the change in pressure. With a change in technology he lost the capacity to do that presentation, but gained other capabilities (Skilling, 1995). Skilling uses other interesting map presentation to show a spatial interpretation of the probability of precipitation, e.g., 30% probability of precipitation. He does this with a map of the Chicago urban area broken into a grid of square cells.

"The maps in television weather are the subject of promotion as well as a medium of advertising."

Advertising and Promotion - The maps in television weather are the subject of promotion as well as a medium of advertising. On The Weather Channel, and sometimes on CNN, many of the maps carry advertising along the top border of the map or in a sequence immediately following the presentation of the map (Fig. 18). Many of the products so advertised are related to weather conditions and often are seasonal. Cold medicines are likely to be advertised on the maps showing a Pain Index or the incidence of influenza. Makers of allergy relief medicine sponsor maps of allergy occurrence. Tires and coffee advertisements are likely on maps showing travel conditions or even the synoptic conditions. Perhaps the most novel use of maps for advertising are the spots the Weather Channel uses showing weather fans. In one ad, two fellows are sitting in a bar waiting for 'Weekend Weather' to come on. The face of the one hoping for a cool weekend is made up as a map with isotherms and blue tones, while the face of the other who is looking for a warm weekend is covered with isotherms in gold and orange.

". . . he was forced to show radar images on every show even on clear days because the station had invested in the hardware and they wanted to show off their investment."

Just as the weathercasters take pride in their map products, the stations compete with each other to attract viewers based on their ability to show better maps. As Doppler radar emerged as a new tool early this decade, stations announced that they had Doppler radar and thus viewers would want to watch their news programs. Similarly, when local stations add new systems to help with better graphic displays of maps, they are likely to advertise the technology to attract a larger audience. This need to adapt to graphics technology to remain competitive may have an impact on what is shown on television. Spiceland (1997) related a story from many years ago in which he was forced to show radar images on every show even on clear days because the station had invested in the hardware and they wanted to show off their investment. Bowser (1997, 61) suggests this attitude still exists, "There's more weather in newscasts today than there was five years ago, say market watchers. But whether more weather is a response to viewer demand or simply an 'if you've got it, use it' mentality on the part of station executives who OK spending for state-of-the-art weather equipment is open to debate."

"The scale of weather has gotten down to the local city . . . If the weather doesn't tell the story of what happened on one viewer's cul-de-sac, then that viewer isn't going to be moved."

It is interesting to look at the directions of the trends in forecasting and presentation of weather. Henson (1990, 129-30) quotes Coleman who predicted that because of budget cuts, local stations would drop weather forecasting and let The Weather Channel or a dial-up service provide the forecasts. Almost a decade later, it appears that the local stations are spending the funds to get the latest technology to compete at the local level. Dickson (1997a, 74) quotes a meteorologist who points out that, "The scale of weather has gotten down to the local city... If the weather doesn't tell the story of what happened on one viewer's cul-de-sac, then that viewer isn't going to be moved." Dickson (1997b) discusses the technology some stations have installed to be competitive. While the service bureaus make available NexRad Doppler radar from the federal government, some stations are purchasing their own radar units so that they can have more control over the radar presentations and have more current data because there is a 5 to 6 minute lag time in getting the NexRad images (Dickson 1997b, 79). As detailed digital map databases have become available, they are being incorporated into more detailed weather map systems to compete for viewership.

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There are many ways to approach an examination of the uses of weather maps on television. This discussion looks only at the use of maps in the aggregate, plus a few anecdotal stories. MacEachren (1995) has examined the ways individuals interact with maps. Many opportunities exist to learn more about how individuals use the information they get from viewing weather maps on television.

A TYPOLOGY OF TELEVISION WEATHER MAP VIEWERS

All television weather presentations in the U.S. employ maps as part of their programs. Therefore, every viewing experience must take into account the presence of maps and in most cases, a weathercaster who is interacting with those maps. After studying television weather map use for many years, a classification of viewers of such maps was developed. This typology was sent to a number of weathercasters. Follow-up interviews on the typology were conducted with the weathercasters. In total, weathercasters endorsed the typology, and one even estimated what percentage of his viewers fell into each category. Based on the many interviews, the typology was refined as below.

Meteorology Addicts are viewers who understand the dynamics of weather systems and who look at the maps and loops of cloud and radar imagery to update their mental maps of the status of the atmosphere in the region and across the country. They want to integrate surface conditions with upper air conditions and appreciate maps or images showing jet streams, ridges, troughs, water vapor, and outputs from computer models.

Weather Fans look at the maps and loops of clouds and radar to see trends in temperature, precipitation and the migration of storm systems. These viewers have a general understanding of the role of humidity, fronts and pressure systems but do not have technical knowledge of atmospheric dynamics. They must have a good knowledge of the geography and place names of their region and the nation to be able to relate weather events to the larger areas.

"They must have a good knowledge of the geography and place names of their region and the nation to be able to relate weather events to the larger areas."

Locals - Show Me types define the viewers who want to see trends in temperature, precipitation and the migration of storm systems in the local area, the potential for severe weather in the near future, and the forecast for the next day or two. These viewers may have a good understanding of the ways weather events interact with local features. To use the maps, they must be able to understand where they are on the local maps.

Locals - Tell Me types want to know what happened locally in the past few hours, current conditions, the potential for severe weather in the near future, and the forecast for the next day or two. They can get their information just as well from radio as from TV. These viewers are not likely to use the maps on TV, perhaps because they do not know where they are on the maps.

"These viewers are not likely to use the maps on TV, perhaps because they do not know where they are on the maps."

Elsewhere'ers want to know what happened, is happening and is forecast to happen in some distant area. These viewers are interested in some distant place, or places, because they will soon travel to that area, they have friends and loved ones in that area about whom they are concerned, or they have a vested interest in what is happening around the country or in some other part of the world. To learn what is happening at the distant locations, they have to read and interpret the maps and loops of imagery. This category does not include those people who are satisfied by seeing a listing of cities showing the predicted high temperature and a single word about precipitation, i.e., Dallas, 85° F and cloudy .

Storm Watchers are individuals who, during times of severe weather, choose to look at the weather presentations to watch storm systems evolve, in part as entertainment. This is particularly true of those not in the path of the threatening weather. For many of these viewers, watching a severe weather event unfold on television is comparable to others watching a sporting event on television. The ability to watch weather events progress across the country is facilitated by the 24-hour weather programs, and may be supplemented by the presentations of local weathercasters.

". . . they look at the programs to watch the individual perform, i.e., interacting with the many maps and graphs."

Fans of the Presenter are those many people who see the weathercaster as a friendly and knowledgeable personality and they look at the programs to watch the individual perform, i.e., interacting with the many maps and graphs.

Ho-Hum'ers is the term used to characterize those individuals who have little or no interest in the weather presentation but see the maps and the weathercaster only as the current thing on the screen. For many people, weather, with its many maps, is something that fills the screen until they get to the next part of the program, which is often sports, in the case of local news. Most likely, these people have never seen a full-time weather channel because they have no interest in the subject.

". . . individuals may fit into more than one type at any given time, or from time to time."

Depending on the desire and motivation of the viewers who can read and understand the maps, individuals may fit into more than one type at any given time, or from time to time. This typology of the viewers of weather maps on television is offered as an organizing theme for further study of the nature of the use of this unique map viewing experience.

SUMMARY

Television weather programming in the U.S. provides exposure to maps of many types, even though all are focused on weather related matters. Arguably the greatest map viewing audience is that of the television weather map and the greatest number of maps made day to day are the maps for presentation of weather on television across the country and around the world. It is a big business with large audiences. Besides being a business, it is a means for agencies and individuals to disseminate warnings and give guidelines, a means to transmit helpful advice, and an aid for planning activities. In the process, many people learn some geography and much about the atmospheric sciences. And, it happens in a unique map viewing environment where users can tune in at predictable times and see new information overlaid on a series of base maps with which they have become comfortable, presented by a person they are used to seeing. If only all of our maps could be seen by such large audiences with such satisfaction.

"If only all of our maps could be seen by such large audiences with such satisfaction."

Essentially, cartographers have no input into the production or presentation of weather maps on television. Certainly there are artists and weather presenters who have had some training in cartography but seemingly cartographers are not an important part of television weather mapping. Our cartographic literature and our textbooks have little to say about this most pervasive use of maps.

"Our cartographic literature and our textbooks have little to say about this most pervasive use of maps."

Although the majority of adults cannot use maps effectively, television weather, with its many maps, is the most popular part of the local news and 24-hour weather channels proliferate. This seems to be a conflicting statement. The typology of viewers of weather maps on television should serve as a foundation to learn more about what viewers want and get from viewing television weather maps. Television weather exists in a unique user environment and it may be that the appeal and use of many complementary maps in this supported environment is significantly different from the appeal and use of maps in other environments. This is but one of many questions on this subject that require further study.

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About the Quality of Maps

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Periodically throughout history, advances in technology have affected cartography. Some current forces for change in cartography are interactivity, multimedia, computer-animation and the Internet. Cartographers complain of a missing quality in the maps associated with this new technology. This paper examines the meaning of quality in cartography. It is argued that only when terms such as quality are understood in a larger, external context can the goal of map-making – making better maps – be pursued. This includes esthetical and cognitive aspects as well as aspects of communication, GIS and geographic visualization.

Keywords: Map quality, Internet cartography, Multimedia cartography

INTRODUCTION

The Internet has brought about a major change in how maps are distributed. Analogous to the invention of printing, the capabilities of the Internet for map reproduction and delivery can be seen as a revolution (Peterson 1995, 1997). Although the WWW meets most of the needs of the "new cartography" (Taylor 1994, Müller 1997), such as enabling interactive and dynamic maps and using technologies associated with multimedia, the cartographic response has focused on a missing "quality" (Dickmann 1997, Crampton 1997, Harrower et. al. 1997), in particular, the lack of graphic quality and resolution.

"Although the WWW meets most of the needs of the 'new cartography'... the cartographic response has focused on a missing 'quality'..."

This concern with the graphic quality of computer-produced maps is not new in cartography. Concerns were raised in the 1960's and 1970's about early computer maps, with similar reservations still expressed about maps produced by GIS software. This concern with graphic quality arises from subjective criteria of good and bad that are often not explicitly stated, even among cartographers. Numerous ideas have emerged in the cartographic literature about how to improve maps, without specifically defining the concept of *quality* in relation to maps. The increased use and the further development of technologies like interactivity, multimedia and computer-animation, have led to new cartographic expressions and products and intensified the questioning of map quality. Problems arise when these new products and expressions are judged using the former definitions of quality.

"This concern with graphic quality arises from subjective criteria of good and bad that are often not explicitly stated, even among cartographers."

This paper deals with the meaning of *quality* in cartography. The first section will consider the concept of quality developed in other areas, particularly philosophy and economics. The second part focuses on the more general meaning of the term *quality*, and the consequences that must be considered when thinking about the quality of maps. A synoptic interpretation of the importance of understanding quality is given in the conclusion which analyzes quality in relation to major trends in cartography, particularly developments like interactivity, multimedia and map distribution through the Internet.

GENERAL CONCEPTS OF QUALITY

The problem of defining quality is neither new nor especially a cartographic task. The meaning of quality has been examined, in general terms, by philosophers and more specifically through such economic concepts as *product value*. Some of these concepts can be seen as relevant to the question of the "quality of maps" and thus have an impact on the way cartographers think about quality.

Philosophical definitions of quality

The general branch of philosophy that is concerned with quality in terms of "value" is called axiology. Axiology is commonly divided into ethics and aesthetics. Ethics focuses, first of all, on the value of "goodness" and "badness," as, for instance, in human activities. Aesthetics deals with the worth of "beauty" and "ugliness." Both ethics and aesthetics can be seen as determinants in the development of the general meaning of *quality* in every human being, including cartographers and map users. Every perception or feeling of "good" or "beautiful" can be seen as being a result of these conceptions.

*". . . ethics and aesthetics can be seen as determinants in the development of the general meaning of **quality** in every human being, including cartographers and map users."*

Both ethics and aesthetics are important in cartography. Ethics is important because it is concerned with determining the value of various human actions, and why they have these values. The mentioned values and ethical convictions have to be seen as resulting from the judgment of the action by other subjects. Therefore, ethics can be seen as the dynamic and permanently changing result of many judgments of actions of various subjects by various persons. Because of the decisive role of those who are judging the actions, the social, cultural and spatial milieu of these people influence the result. Examples of the dynamics of ethical values can be found in our daily life. For instance, corporal punishment was once thought to be necessary in the education of children. Such punishment is no longer considered to be a part of a "quality education."

Furthermore, ethics tries to analyze and explain the conditions and determinants that influence the subjects, their actions and the ethical judgment of other subjects. In other words, our understanding of a "good map" is, like other ethical judgments, a result and an expression of our ethical understanding, which is, aside from other determinant aspects, the result of the actions (maps) of previous subjects (cartographers).

". . .our understanding of a "good map" is. . . a result and an expression of our ethical understanding. . ."

In this context, an understanding of ethics must consider the relationships between the internal and external aspects and influences of a subject. As McHaffie (1990) has pointed out with reference to cartography, "... it is difficult to imagine how cartographers can create ethical standards which do not in some way refer to values created outside the discipline." This idea has been expanded by Monmonier (1991), who has argued, that every action of a cartographer (a map) has to be seen as a "... major strand in the web of social relations by which cartographers project their values into the world." Harley states that "Each map is a manifesto for a set of beliefs about the world" (Harley 1991, p.13). This leads to Crampton's (1995) idea of a dialectical relationship between internal and external aspects of a spatial analysis system. Ethics can then be seen as the source of the cartographer's "moral authorization" in terms of the role of cartography in the world, as well as the way in which the world is represented in maps.

Aesthetics is important in explaining why we "feel" beauty, because it expresses quality in both sensory and non-sensory terms. Quality, in the aesthetical sense, includes both a judgment about the object and a judgment about the perception of the object. A statement like "this map is beautiful" is not only an opinion about the map but about the perception of the person who makes this statement. When evaluating the aesthetical quality of maps, it is necessary to consider this relationship.

"Quality, in the aesthetical sense, includes both a judgment about the object and a judgment about the perception of the object."

Besides these aesthetic / ethical-oriented distinctions, there are more value-oriented distinctions of quality that are both useful and plausible. To illustrate, two generally different ways of understanding quality can be considered. From a more idealistic viewpoint, an absolute value exists that can only be reached theoretically, but should be aspired to in any case. Examples of this view can be found from Plato ("idea of the good") to Kant ("quality as a form of perception"). The more realistic / pragmatic view of quality assumes that every value (quality) has to be seen in its relation to the being (reality), i.e., in relation to time, space and the participants (involved or acting persons). In contrast to the idealistic understanding of quality, the proponents of the pragmatic / realistic understanding do not believe that an absolute value exists (as in "this map is good / beautiful"). Rather, they argue that the understanding of quality not only changes over time, but also with the judging person and his / her (social, cultural, intellectual) background. While those of the idealistic viewpoint believe that an object, such as a mountain, retains its quality even if it is not seen for a thousand years, the proponents of the realistic view assume that the quality of the object can only be judged in its relationship to an individual perception.

"If an absolute, . . . value of quality for a map exists, and this quality is aspired to, then every map has to be judged by that value, . . . If, . . . the quality of a map means that a map only must meet the needs of a certain user in a specific situation, maps created by the new technologies can better meet this requirement."

Similar idealistic and realistic distinctions can be applied to cartography as well. For example, the system of hypsometrical representation of terrain by Imhof (1969) – "as natural-like as possible" – uses an absolute concept of quality. The development of cognitive ideas in cartography leads to an increasing application of the realistic definition of quality. These different positions can also be found in the discussions of quality and maps on the Internet. If an absolute, highest value of quality for a map exists, and this quality is aspired to (for example, by improving the graphical quality), then every map has to be judged by that value, including maps on the Internet. If, on the other hand, the quality of a map means that a map only must meet the needs of a certain user in a specific situation, maps created by the new technologies can better meet this requirement.

A pragmatic definition of quality as *value*, as suggested by Pirsig (1974), has been established in economic theories (Dobyns & Crawford-Manson 1994). Pirsig's definition of quality as the harmony of "subject and object" can be seen as a way of understanding the meaning of quality in maps. The analogous harmony of maps, the *object*, and the mental image of reality, the *subject*, can only be achieved by objects (maps) meeting a "pre-intellectual awareness" (Pirsig 1974, p.240). In Pirsig's sense, as interpreted by DiSanto & Steele (1990), *quality* is relative. Pirsig argues that quality cannot be defined as the "rational self" of a product, but must also include the cause, source and creator of subjects and objects (DiSanto & Steele 1990, p.183). In this sense, different people will judge quality differently. The quality of a particular object / subject-situation (such as driving a motorcycle through America) is neither explainable nor understandable with mind or with matter, but as a third entity, that formulated by Pirsig "... as the parent, the source of all subjects and objects." In this sense, an objective understanding of quality is not possible because quality is experienced as a meta-entity, a pre-intellectual awareness.

"The judging of the quality of maps is rarely founded in rational reasoning but is the result of just this meta-entity, a pre-intellectual awareness of sorts."

This definition of quality seems to be a plausible explanation for cartographic interpretations. The judging of the quality of maps is rarely founded in rational reasoning but is a result of just this meta-entity, a pre-intellectual awareness of sorts. If subjectivity affects the understanding of quality, then every attempt to define a general, objective theory or formalization of quality for maps will be unsuccessful.

Concepts of Quality in Economics

Quality has always been a major concern in business. Here, the meaning of quality can be seen as the ability of a product to serve in a useful capacity, in comparison to other products. This definition of quality consists of both objective, measurable criteria (for example, the chemical purity of an element) and subjective criteria. Such subjective criteria describe the comparative usefulness of similar products in satisfying specific needs.

The use of the term quality in business is mostly oriented to the needs of the user. An example would be the question of whether the quality of a horse as a transport medium decreased with the invention of automobiles. The ability of a horse to satisfy the needs of a user (to bring him / her from point A to point B) is changed in a relative sense. The meaning of *quality* in this context addresses only the ability of the object to satisfy the particular need, as compared to other products, and has no significance for the individual's perception of an object-subject-relationship (as in the example of the horse rider and the horse).

Such subjective criteria can be recorded by consistently monitoring all parts of a system, as, for example, in Deming's method of improving the quality of whole industries that was influenced by the rivalry between Japanese and American industrial capabilities. Deming (1986) pointed out that a paradigm change from a quantity production-oriented system to a quality production-oriented business system is one of the most reasonable ways of adapting the capabilities of industrial branches. In Deming's view, the key to a continuous improvement in quality is to overcome the so-called "separation beliefs" which assume that isolated decisions and actions could cause general changes in the whole system. By understanding the relationship and complexity between the main influencing parameters of a system, as in the case of industry branches, business, politics, society, or education, a continuous adaption to "better quality" becomes possible.

*"To improve the **quality** of the whole system ('to make maps') the relationships and the context of determinent parameters have to be monitored."*

By understanding cartography as a system, consisting of mapmakers, tools, products and users, similar arguments could apply. To improve the *quality* of the whole system ("to make maps") the relationships and the context of all determinant parameters have to be monitored.

CARTOGRAPHIC PERSPECTIVES ON QUALITY

To answer the question of what a quality map is, cartographers have attempted to define the map's functions. In answering what a good map is, cartographers have discussed map functions and how they might be efficiently carried out. Cartographic definitions of *quality* fall into different categories:

Maps as pleasing to the eye: Aesthetics and Pleasure

According to this view (Spiess 1996, Kelnhofer 1996), a major function of maps is their ability to stimulate a form of pleasure. Pleasure, in this sense, has to be seen as the aesthetical form of sensory and non-sensory quality, whether on the level of perceptions, feelings or thoughts. The graphic variables used in cartography (Bertin 1967) are not only important because of their role as a transmitter of quantitative / qualitative information but also because of their role in transporting aesthetical aspects (Tufte 1983, Spiess 1996). Therefore, graphics have to be seen as the tool for stimulating a form of pleasure. If the map fails in this role, it will be judged as "ugly" or of "low quality."

". . . a major function of maps is their ability to stimulate a form of pleasure. Pleasure, in this sense, has to be seen as the aesthetical form of sensory and non-sensory quality, whether on the level of perceptions, feelings or thoughts."

The statement that an Internet-map has "low quality" often arises from this point of view and means that the map does not meet some sort of aesthetical standards. The concern is, therefore, focused on the graphical design and potential of the map. Judgments like this, referring to the poor or missing aesthetical aspects of maps, do not take into consideration the other functions of the map.

Aesthetical aspects are only a part of cartographic quality. The graphics developed by cartographers may be viewed as a continuous improvement to meet the aesthetical and perceptive demands of the map users. Cartographers throughout time have tried to improve their maps, with a major part of these improvements focusing on the aesthetical functions. Research on perception, graphic variables and map design supports this concern (MacEachren 1995).

Maps as a Communication Device

By defining a map as a communication device (Robinson 1952, Robinson & Petchenik 1976), the meaning of quality changes. In this view, the map has *high quality* when the map transfers information and the user receives the message clearly, i.e., the user receives the message the cartographer has in mind. Therefore, a cartographer would judge a map as good if the user receives the intended information without interference. The graphical-aesthetical aspects are important here as well because of their ability to enhance or interfere with the communication process. For those who view the quality of a map as a communication device, it is, nevertheless, possible to speak of a good map, even if the map is "graphically poorly designed," as long as the information has reached the receiver correctly (Morrison 1978).

". . . the map has high quality when the map transfers informaton and the user receives the message clearly . . ."

If the concept of quality considers the source, object and subject, as do the theories of Deming and Pirsig, then the quality of a map can not be judged by its graphical-aesthetical design alone. By defining graphical design, it becomes a suitable means to reach improved quality.

Processing Maps in the Mind: Cognitive Quality

The quality of a map, in terms of cognitive quality (Peterson 1994), has to be judged by its ability to conform to the way maps are mentally processed. In Peterson's opinion, maps are internalized in some way and are connected to former and future knowledge. At a later time, the stored mental image or information stored in non-image form can be used. The mental processing of maps is described as interactive, dynamic, multimedial, and multi-dimensional, consequently, Peterson rates the quality of maps in terms of their similarity to these attributes. The recent technological innovations like interactivity, multimedia and animation are, therefore, helpful steps in improving the quality of maps because of their greater similarity to the mental processing of maps.

"The quality of a map, in terms of cognitive quality, has to be judged by its ability to conform to the way maps are mentally processed."

According to this view, a map can be judged as good if it moves into the receiver's mind in such a way that it can be connected with stored knowledge (mental maps) or is stored for future use. The map's primary function, then, is not to be found in the production, presentation or immediate reception, but in how it helps our mental processing of spatial information. Therefore, it is possible that *graphically poorly designed* maps can be seen as having *high quality*. In fact, the quality of a map cannot be determined until long after it has been used.

". . . a map can be judged as good if it moves into the receiver's mind in such a way that it can be connected with stored knowledge or is stored for future use."

Furthermore, proponents of this view extend the meaning of quality from beyond the actual communication process to the impacts and consequences that the map's information has for the mental processing of spatial information. This could help to overcome one of the weaknesses of information theory associated with cartographic communication, by explaining how knowledge can be acquired by the receiver that the sender had not intended.

Using this definition, the meaning of quality is not only expanded, but an adequate explanation of the new cartographic products that have resulted from the use of technologies such as interactive maps, multimedia, computer-animation or hypermedia can be given. Earlier concepts of quality in cartography often cannot judge the quality of these new cartographic expressions. By using the concept of "cognitive quality," a more adequate evaluation of these new cartographic expressions becomes possible.

The GIS Approach

Cartography has been intensely influenced by the development and use of geographic information systems (GIS). With such a powerful influence on the cartographic community, the development of GIS has led to different ways of viewing the meaning of *quality* and enhancing the analytical potential and usage of maps.

For GIS, a map is a derivation of an abstract and scale-less ("primary") model of a part of the world (Bartelme 1995, Maguire & Dangermond 1991). Therefore, the quality of a map has to be seen not only in its ability to meet the *aesthetical and informational* demands of the user but also in its ability to meet the *technological* needs of the GIS-system. As a consequence, quality, according to this view, is a measure of how well the map ("secondary model") is derived from the model and how well it meets the demands of the system in terms of supporting the presentation and visualization tasks (Bill 1994, Mark & Frank 1995).

". . . quality, . . . is a measure of how well the map is derived from the model and how well it meets the demands of the system in terms of supporting the presentation and visualization tasks."

The secondary model requires the use of generalization methods. Many doubt that general formalization algorithms for an automatic derivation of maps from a primary model can be found (Kelnhofer 1996). Therefore, this major aspect of the understanding of the *quality of a map* in context with GIS, the *quality of derivation*, can be seen as using absolute concepts by defining a highest goal ("formalized and automated derivation"), to which we should aspire.

The Visualization Approach

Geographic visualization (Gvis), as formulated by DiBiase (1990) and MacEachren (1994), has to be seen in close relationship to the development of computer graphic data processing. In this approach, the functions of a map can be divided into presenting, communicating, analyzing and exploring spatial data. The definition of quality is, therefore, extended to the ability and capacity of a map to lead to more questions. By extending the definition to include the ability to interact with a map (as a result of technological development), maps have not only the function to present something known but also to make something unknown perceivable and knowable.

"The definition of quality is, . . . extended to the ability and capacity of a map to lead to more questions."

Understanding quality according to this approach has to be seen as technology-oriented and usage-oriented. Technology-oriented because geographic visualization demands that maps have specific abilities and characteristics such as interactivity and dynamic processing, and usage-oriented because the quality of a map is judged by its ability to enable "visual thinking" and to meet the needs (explanation, confirmation, synthesis and presentation) and interests of the user, whether private or public.

This usage-orientation of geographic visualization implies "some connotations" (MacEachren 1995, p. 452). MacEachren has noted that by trying to define the goal of visualization as making presentations as pictorial as possible ("moving toward realism"), implications for the interaction between scientists and the society can be expected. The potential of "scientific representations more like the real world" (p.452) at the societal level, in terms of becoming public, can be seen as another approach to the meaning of quality in the context of cartography.

CONCLUSION

The recent developments in cartography, driven by technological innovations, have led to new forms of cartographic expression and to new cartographic products. The common definitions and understanding of quality may not be useful in judging these new forms of mapping. This assessment should not be misinterpreted as a justification for *lower quality* maps on the Internet where suitable methods are developed to fit the needs (and deficiencies) of technology, but should be seen as an attempt to find appropriate and fair judgment criteria.

To further develop the understanding of quality, theories in both philosophy and business offer sophisticated concepts and ideas that can lead to a better understanding of the meaning of quality in cartography as well. In this context, it is necessary to realize that the definition of quality changes with time, space, and social context. Cartography is also dynamic. A statement such as "this map is a quality map" has different meanings with changing time, space or social context, and has, therefore, to be seen as both a statement about the perception of the user and as a statement about the map. This suggests that any improvement in quality must take this view into consideration.

"Maps on computer screens cannot compare with paper maps in their graphical resolution; nevertheless, they can have higher quality."

Cartographers often use deontological (concerning the rules) forms of thinking when considering the *quality* of maps. By considering the goals and the consequences of an action (the map) in a teleological (concerning the goals) way of thinking (like the cognitive quality approach by Peterson or the visualization approach by MacEachren), actions (maps) would be valued that tend to promote the realization of the right goals as good, and the realization of bad goals as bad.

Maps on computer screens cannot compare with paper maps in their graphical resolution; nevertheless, they can have higher quality. For some cartographers, this statement is problematical. It may become more acceptable if the term *quality* is replaced with the term *value*, as Pirsig suggests. DiSanto & Steele (1990) make the same point when they note that: "I can understand that a Ford Taurus may be a better value than a Rolls Royce, but I have a hard time seeing it as having greater quality."

"In pursuing the goal of cartography to make 'better' maps, it is . . . important . . . to understand and comprehend what 'better' means."

In pursuing the goal of cartography to make "better" maps, it is not only important to adapt, develop and monitor cartographic techniques, algorithms, methods and theories but to understand and comprehend what "better" means.

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Using Flow Maps to Visualize Time-Series Data: Comparing the Effectiveness of a Paper Map Series, a Computer Map Series, and Animation

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Motion and change through time are important aspects of thematic maps. Traditionally, such data have been visualized using a series of paper maps that represent multiple snapshots of a location over time. These maps are visually compared by the map reader when analyzing change over time for a location. This static view of change over time has worked well for cartographers in the past, but today computer animation allows cartographers to emphasize the dynamic nature of this data. By animating a map, change over time can be represented on one map rather than in a traditional map series. This study compared a paper map series, a computer map series, and animated maps of the same data to assess the effectiveness of each technique for memorizing data symbolized by graduated flow lines. Subjects were asked to study the maps and to memorize two types of information: quantity data at specified locations on the maps and trend patterns that occurred over the maps. Memorization of the information was subsequently tested using a series of multiple choice questions. Analysis of response times and accuracy rates for these questions suggest that animation does not improve learning ability for quantity evaluations. It does appear, however, to improve subjects' abilities to learn and remember trend patterns in the data. Results also indicate gender differences in using animated maps.

INTRODUCTION

Visualization is defined by Tufte (1983) as the process of using visual representations to describe, explore, and summarize sets of data to better comprehend their patterns and relationships. Geographic visualization deals primarily with the representation of spatial data. The emergence of thematic mapping in the late eighteenth and early nineteenth centuries is considered by many to be the beginning of visualization in cartography (MacEachren 1992). By focusing on the location and distribution of a single feature, thematic maps present specific information and aid in discovering previously hidden aspects of the data.

Motion and change through time are important aspects of thematic mapping. In fact, MacEachren (1992, 126) notes that "[g]eographers are seldom interested in a static view of the world." Understanding how and why changes occur over time requires the ability to see what has changed and where it has changed. In visualizing temporal change on static maps, cartographers have traditionally chosen between two strategies. They may either depict limited aspects of temporal change on a single map, or they may use a map series to show multiple snapshots of a location over time. The resulting map sets are then visually compared by the map reader when analyzing change over time for a location.

"... static views of change over time have worked well for cartographers in the past. Through animation, cartographers can incorporate temporal change directly into the map."

These static views of change over time have worked well for cartographers in the past. In today's computer-oriented world, however, animation can be used to emphasize the temporally dynamic nature of data. Through animation, cartographers can incorporate temporal change directly into the map. Time-series data can be viewed in continuous succession or as movement across the screen rather than as separate static events. This capability is certainly intriguing and bound to capture the imagination, but what advantages, if any, does it bring to map reading and map use?

"The study reported here . . . evaluates subjects' abilities to memorize and recall temporal patterns and information when mapped using either a paper map series, a computer map series, or animated maps."

The study reported here provides some insight into this question by evaluating subjects' abilities to memorize and recall temporal patterns and information when mapped using either a paper map series, a computer map series, or animated maps. Subjects were asked to study the maps and to memorize two types of information: quantity data at specified locations on the maps and trend patterns that occurred across the maps. Memorization of the information was subsequently tested using a series of multiple choice questions to evaluate how well each map display worked for obtaining and recalling these two quite different forms of geographic information.

"An animated flow line . . . could allow the map reader to focus on one point, the forward tip, throughout the animation. Since the data represented by points on the line are sequential, the change in data will be followed smoothly by the eye . . . making this technique more easily transferred into an animated format."

The thematic mapping technique used to symbolize the temporal data in this study was the graduated flow line. The choice of the graduated flow line was deliberate. There has been no research conducted into the proper visualization of linear from-to relationships in an animated form (Tobler 1987). Instead, the majority of animation research has focused on areal representations (Moellering 1984; Slocum, Robeson, and Egbert 1990), although dot symbolization has also been examined (Dorling 1992). Results of these studies suggest that animated maps using such symbolization techniques require the map reader to constantly shift eye focus throughout the animation. The obvious consequence of this requirement is that it is not possible to observe changes in one section of the map while concentrating on another section. Therefore, since the map is constantly changing, portions of the data are missed. An animated flow line, however, could allow the map reader to focus on one point, the forward tip, throughout the animation. Since the data represented by points on the line are sequential, the change in data will be followed smoothly by the eye. This characteristic of graduated flow lines should make this technique more easily transferred to an animated format.

THEMATIC MAPPING USING FLOW LINES

In thematic cartography, line symbols are used to show a variety of relationships. In their simpler forms they may show connectivity between places, boundaries separating regions, or differences in categorical attributes of linear objects. The symbolization of such data is most often accomplished using qualitative methods, where cartographers represent differences in values by varying the direction, color, or shape of the lines in question. When the goal of the map is to show quantitative differences, then symbolization becomes more complex. Here, differences in data values are shown most frequently by varying line widths to match the varying data values. This technique is commonly referred to as graduated flow line mapping. It was first introduced in the early to mid-nineteenth century to aid investigators in creating external visualizations of new topics and relationships (Wood 1994).

Graduated flow line mapping is ideal for symbolizing data that contains a distinct from-to relationship (Dent 1993). Monmonier (1993, 189) notes that "[f]lows - of people, products, or information - often seem to beg for cartographic portrayal." While size or value may be a secondary variable to impart importance to the linear feature, direction has the dominant role. The movement from one place or area to another deserves prominent and unambiguous symbolization and this can be achieved quite clearly by using graduated flow lines. In choosing a symbol to represent migration data, for example, Tobler (1987, 157) states that "[t]he simplest graphic is the rectangular flow band with width proportional to the flow and stretching from starting centroid to ending centroid."

Tobler also notes, however, that there are no rules that allow an unambiguous choice for the scale of the line. Most perceptual studies on graduated symbols have concentrated primarily on circles, squares, wedges, and text (e.g., Flannery 1971; Crawford 1971; 1973; Cox 1976; Groop and Cole 1978; Shortridge 1979). In her review of graduated symbol studies, Fraczek (1984) found that few studies deal with symbols other than circles. The few references found on the subject of graduated flow lines do offer suggestions for symbol scaling. Tobler (1987) notes that having the width proportional to the flow magnitude is thought to be more correctly interpreted than other methods, although he points out that this has not been proven. Monmonier (1993) states that thick lines are cumbersome and that size is less flexible when using line symbols as opposed to point symbols. There are no known studies examining the scaling of flow lines or the utility of flow line mapping in an animated context.

VISUALIZING TIME-SERIES DATA

Regardless of the thematic mapping technique chosen, the cartographer's goal is ". . . to provoke intuitive appreciation of the salient characteristics of a data set" (Robertson 1988, 243). Time-series data has traditionally been difficult for cartographers to handle due to the limiting factors of the printed static map. Fortunately, many of these restrictions disappear in a digital cartographic environment. The electronic map is an ideal medium for the organization, presentation, and communication of the growing volume of today's digital spatial data. New mapping techniques associated with the digital realm, however, need to be studied by cartographic researchers. Results of research that have been gathered on the perceptual and cognitive aspects of traditional printed maps and subsequently used to improve map design may very well not apply to these new forms of spatial visualization. Taylor (1993, 50) goes so far as to state that "[r]elatively little cartographic research has been carried out in this area but its obvious importance may lead to a revitalization of research and applications in the field of cartographic communication."

"Time-series data has traditionally been difficult for cartographers to handle due to the limiting factors of the printed static map."

Traditional Visualization Techniques. To effectively map change in data over time, two strategies have been traditionally used in cartography. The first is a single map that shows limited aspects of change in or across space. The second is a series of maps that can be visually compared (MacEachren 1992). Single map representations can take the form of either dance maps or change maps (Monmonier 1990). Dance maps, a term coined from choreography diagrams, often use directional symbols to portray change over time. These symbols can vary in size to represent relative magnitude, or vary in label, color, or pattern to represent a particular group or time period. An example might be a map showing the changing center of population for the United States over some specified time period. Change maps depict only the change between time events. Symbols vary in value, size, or some other visual variable to represent change in direction, rate, or absolute amount of change. In this case, the map might be a choropleth map of the United States where change in the population for each state is shown for a given time period.

Map series representations present individual snapshots of a single time period for each map in the series. These maps have been called chess maps, after the diagrams of chess matches published in newspapers (Monmonier 1990). Sometimes a dynamic process can only be observed by a series of single-data cartographic snapshots. A set of separate maps evenly spaced in time allows the reader to assess direction, pace of change, and patterns of density for individual dates. Scale, format, symbols, and classification must be standardized between the separate maps in the series to facilitate comparisons. Juxtaposition is also desirable to aid the eye's need to jump back and forth between maps to detect differences (Monmonier 1993). If the maps are not juxtaposed on the same page, this may cause confusion as the map user flips between pages to compare the maps. Such confusion will naturally hinder the communication of information to the map user (Campbell and Egbert 1990). To avoid these problems, several researchers have proposed using animation to bring both the temporal and spatial aspects of data together in a single, integrated display (Moellering 1980; Calkins 1984; Campbell and Egbert 1990; Weber and Buttenfield 1993).

Animation as a Visualization Technique. Animation has been a topic in cartography for over thirty-five years (Thrower 1959; 1961). As a potential visualization technique, it has been recognized as a way to give an impression of continuous change to match the constantly changing process of the mapped phenomena. The computer entered the realm of animation in the mid-1960's, allowing individual frames to be photographed straight from the monitor (Cornwell and Robinson 1966). Today, advances in both hardware and software allow the cartographer many options in representing geographic data (Gersmehl 1990).

Visualizing geographic data using animation can be accomplished in a variety of ways (see Moellering 1984; DiBiase, et al. 1992; Dorling 1992). Of these, Dorling's (1992) work is most closely aligned with this research. Dorling separates animation into three categories. He defines animating space as the process of panning and zooming around a two-dimensional static image. This is not normally considered cartographic animation. Animating time is a process where actions are played out on a non-moving map. Hence, time is used to show differences in space and movement is used to represent a function of time. Three-dimensional animation is the process that makes use of movement, perspective, shading, and shadows to compensate for the lack of an actual third dimension. In his experiences experimenting with cartographic animations, Dorling found that animating space was the most useful technique. He found animating time useful in illustrating change to other people, but less useful for investigational purposes. This technique works best when movement is involved. The brain's poor visual memory was identified as a factor in these results. Three-dimensional animation was found to be confusing, though this is the direction currently being pursued in scientific visualization.

"Cartographic animation is a visualization tool that may be used to increase understanding of data distributions over and above that gained from traditional paper map series or computer map series."

Cartographic animation is a visualization tool that may be used to increase understanding of data distributions over and above that gained from traditional paper map series or computer map series. Caution must be exercised when using animation so that the data relationships are of primary importance and animation is used as a tool and not just to showcase technology (Calkins 1984; Campbell and Egbert 1990). For example, in a study on sequenced choropleth maps, the test subjects greatly preferred the animated sequencing; however, test results did not support the usefulness of the technique (Slocum, Robeson, and Egbert 1990). Research with regard to information retention, visualization ability, choice of thematic method, graphic symbolization, and legend design, as well as the new choice of dynamic variables, is needed to ascertain the best ways of displaying animated maps (Campbell and Egbert 1990; MacEachren and DiBiase 1991; DiBiase et al. 1992; Karl 1992; Monmonier 1992; 1993; Peterson 1995).

RESEARCH HYPOTHESES

Graduated flow maps illustrate the movement of any measurable quantitative variable from one area or place to another (Dent 1993). Map readers typically use flow maps to ascertain movement of quantities, whether depicted exactly or in classes. For time-series data, they can also use flow maps to determine general trend patterns. A general question of whether the technique of animation allows the map reader to better learn and remember flow line data was broken into two separate research hypotheses. These hypotheses, stated below, were designed to test two map reading tasks, quantity evaluation and trend pattern recognition:

- When compared to printed and static computer map series, animated map displays should not significantly improve map reader's response times or accuracy rates for quantity evaluation tasks.

- Map readers should be able to complete trend pattern recognition tasks more quickly and more accurately in an animated environment.

"A general question of whether the technique of animation allows the map reader to better learn and remember flow line data was broken into two separate hypotheses . . . that were designed to test two map reading tasks, quantity evaluation and trend pattern recognition."

It is expected that the emerging visualization technique of animation will not improve the evaluation of specific flow quantities. Quantity evaluation is more of an informational or investigative task. Dorling (1992) reports that animation does not serve this purpose well. Quantity evaluation is site and time specific; each point in each time period is learned separately. To properly evaluate the amount of flow, not only does the map reader have to locate the points of interest along the line, but also compare the width of the line at those points to the legend. Animation should not aid in the comparison between the map and the legend.

It is expected, however, that animation will improve the recognition of flow trend patterns. This expectation also is derived from Dorling (1992), who found that animations were useful when illustrating change to map readers, especially when movement was involved. Since patterns are not dependent on studying the legend, the points of interest can be observed and compared directly over time. Attention does not have to shift away from the animated sequence. Also, animation allows the map reader to view changes over time on a single display by expanding or shrinking the line accordingly. In contrast, paper map series and computer map series require the map reader to make comparisons across multiple maps to judge differences in line widths over time.

EXPERIMENTAL DESIGN

This study compared subjects' abilities to learn time-series graduated flow line data using three different visualization techniques: paper map series, computer map series, and animation. The primary intent was to assess the usefulness of these different visualization techniques for two types of spatial tasks: quantity evaluation and trend pattern recognition.

Subjects. Sixty-five volunteers from undergraduate geography classes at San Diego State University participated in the study. The subject group consisted of 39 males and 26 females. Participants received class credit for completing the experiment.

Materials. The maps used were highly simplified, imaginary representations of a river and its surrounding watershed. The river was made up of twenty-three line segments, roughly equal in length. Two points representing water flow gauging stations were identified along the length of the river. These stations, identified by leader lines on the map, were located at the mid-points of segments four and eighteen. A title, legend, and year indicator were also included (Figure 1). The legend showed flow lines for five absolute quantities. These quantities represented aggregate annual water flow for the river depicted. For each of the five flow quantities in the data set, a corresponding line width was assigned. These widths were measured in pixels for the computer maps and in inches for the paper

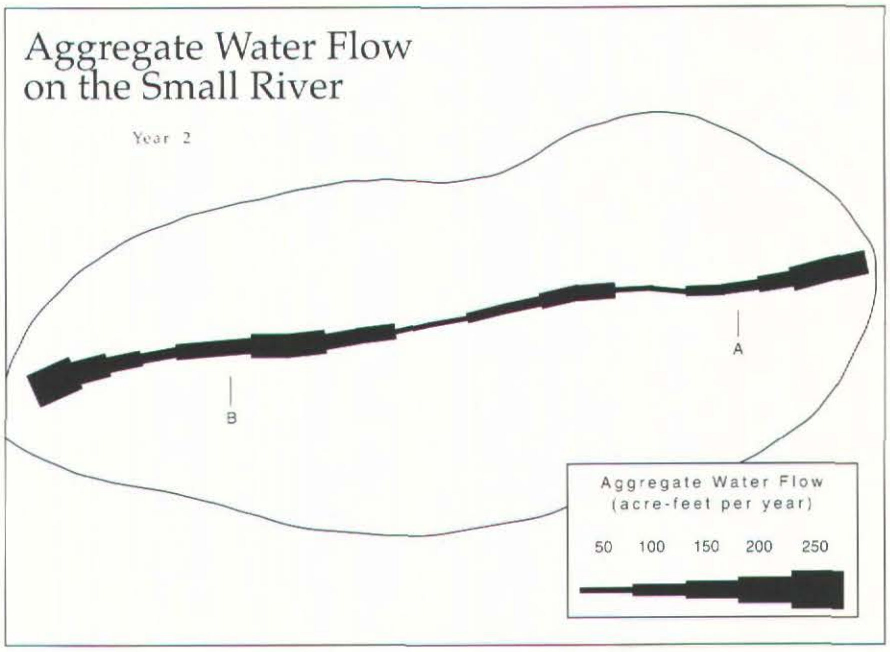

Figure 1. Typical test map

maps. The paper maps were rendered to match the computer maps as closely as possible in all aspects of design.

Data Sets. Four independent data sets representing aggregate annual water flow were created for the experiment, two for each type of map task. For the quantity evaluation task, data were generated for the two line segments containing gauging stations by rolling a six-sided die. Once the gauging station values were determined, the values for the remaining segments of the river were assigned to create a roughly smooth flowing surface. This method was repeated three times to establish data for each of three different time periods. As the trend pattern recognition data were assigned specifically to enforce trend patterns at each of the two target line segments over a six year time interval, no die roll was employed. Identical methods were used to generate the second data sets.

The extra data sets were necessary to effectively evaluate the visualization techniques. In an earlier pilot study, subject responses indicated that learning the quantities and trend patterns at three points over six time periods led to accuracy rates no better than chance. Two changes in the experimental design provided subjects with a better chance of completing the tasks successfully. First, the number of gauging stations on the test maps was reduced from three to two. The data sets used in testing were also shortened from six years worth of data to three years for the quantity evaluation tasks. This change in experimental design reduced the total number of possible tasks for the subjects to perform. The use of additional data sets counteracted this effect. Using two data sets, subjects completed twenty-four tasks. Half the tasks were quantity evaluations and half were trend pattern recognition tasks. Six tasks of each type were composed from each data set.

". . . subjects completed twenty-four tasks. Half the tasks were quantity evaluations and half were trend pattern recognition tasks."

Once the data were determined, answer sets were generated. Random rolls of a six-sided die determined the order of question presentation. Each question had three choices, presented to the subject in a multiple-choice format. Die rolls also determined the values for the two incorrect choices, as well as the position of the correct answer on the question display. Three test maps (one for each year's worth of data) were then rendered for each of two data sets; these were used for the quantity evaluation tasks. For the trend pattern recognition tasks, six maps were rendered for each data set.

Visualization and Testing Procedures. Each subject was randomly assigned to one of three groups. The control group viewed a series of paper maps. The second group viewed a series of static maps similar to the paper maps on a computer screen. This group was included to represent a middle ground between the paper and animated environments. The final group viewed animated map sequences. Subjects in all groups performed the same two task types: quantity evaluation tasks and trend pattern recognition tasks. Each subject performed practice tests prior to taking the actual experiment. These tests allowed them to become familiar with the specific task requirements and the method of query and response used. Different data sets were used for these preliminary tests.

"The quantity evaluation tasks tested subject memory of data quantities for multiple time periods."

The quantity evaluation tasks tested subject memory of data quantities for multiple time periods. Subjects, tested individually, studied the quantities represented by the graduated flow lines at each gauging station for three years. Those assigned to the paper map group studied a set of three paper maps. Subjects who viewed the maps on the computer studied a series of maps in sequential order by year. Subjects assigned to the animation group viewed a sequence of three years' worth of data in a controlled animation program.

The animation sequence was such that when the sequence began, the linear feature had no data represented; the line was thin and of uniform width (Figure 2). The linear feature was then over-written by line seg-

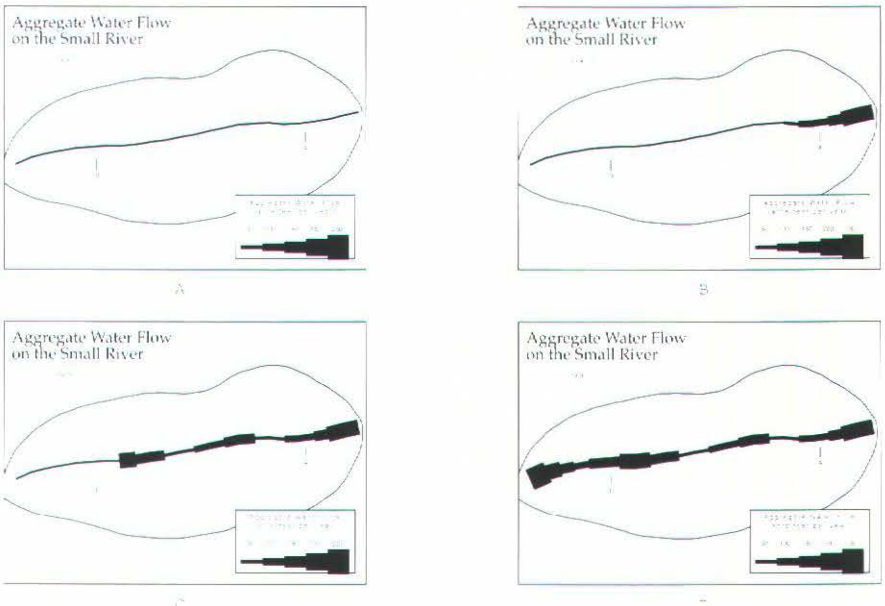

Figure 2. Flow line animation process. Plate A represents the test map before the animation begins. The animation proceeds through plates B and C until the entire line is represented, as shown in Plate D.

ments representing the aggregate flow data for the year being shown. This overwriting moved from the starting point to the ending point of the line. Duration of the overwriting movement was six seconds. Once the first year's data were fully represented, another second passed as the time period incremented. The first year's flow line was then overwritten by the second year's flow line (Figure 3). This process continued until all three years had been presented. The screen was then cleared to indicate to the

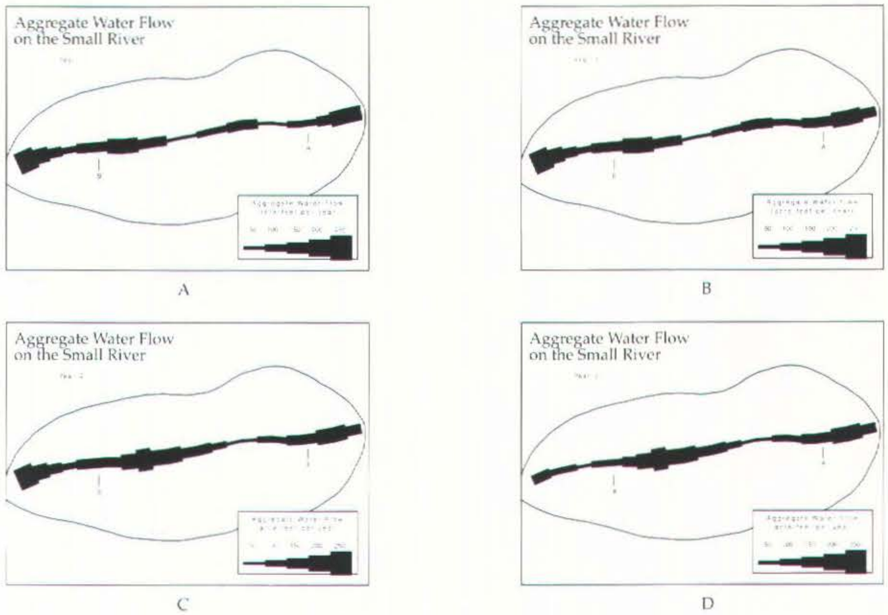

Figure 3. Continuation of the flow line animation process. Plate A represents the test map after the first year has been depicted. The animation continues as the line is overwritten by new data as shown in plates B and C until the entire line is represented by new data, as shown in Plate D.

subject that the cycle was complete. The entire sequence was then repeated using the same data for two more cycles.

The static computer display operated in a slightly different manner. Each map was viewed for seven seconds and then was replaced by the next map in the series. The entire static computer map series was repeated three times. Subjects could not control either the animation or static computer display sequence. The total viewing time for each of the computer displays equaled the length of time that subjects in the control group studied the paper maps (approximately 1 minute). The viewing time, as well as the cycling time for the computer generated maps and animation, were determined during a pilot study undertaken before gathering data for this study. At the conclusion of the specified viewing time, the paper maps were removed from view, and both computer visualizations ended.

All subjects, regardless of the group to which they were assigned, answered the test questions on the computer so that reaction times could be recorded. Subject short-term memory was purged by displaying a text screen containing instructions on the correct method for answering the test questions. The elapsed time taken to read the instructions was between thirty and sixty seconds. Each subject was then shown a computer graphic depicting the outline of the river and the gauging station locations without any data representation. When the test questions began, a specific gauging station, year, and three numeric quantities were shown under the reference graphic (Figure 4). The subject was asked to indicate which of the values best described the quantity of flow that occurred at that station for the year in question. The answer and response time for each query were recorded, as was the type of visualization strategy used to memorize the data. Subjects made responses by pressing one of the three labeled keys on the computer keyboard. After completing the questions for the first data set, they repeated the process for the second data set. Twelve queries were made in this section of the study.

"When the test questions began, a specific gauging station, year, and three numeric quantities were shown under the reference graphic. The subject was asked to indicate which of the values best described the quantity of flow that occurred at that station for the year in question."

The trend pattern recognition tasks tested subject memory of overall trends for six years. In this section of the study, subjects learned trend

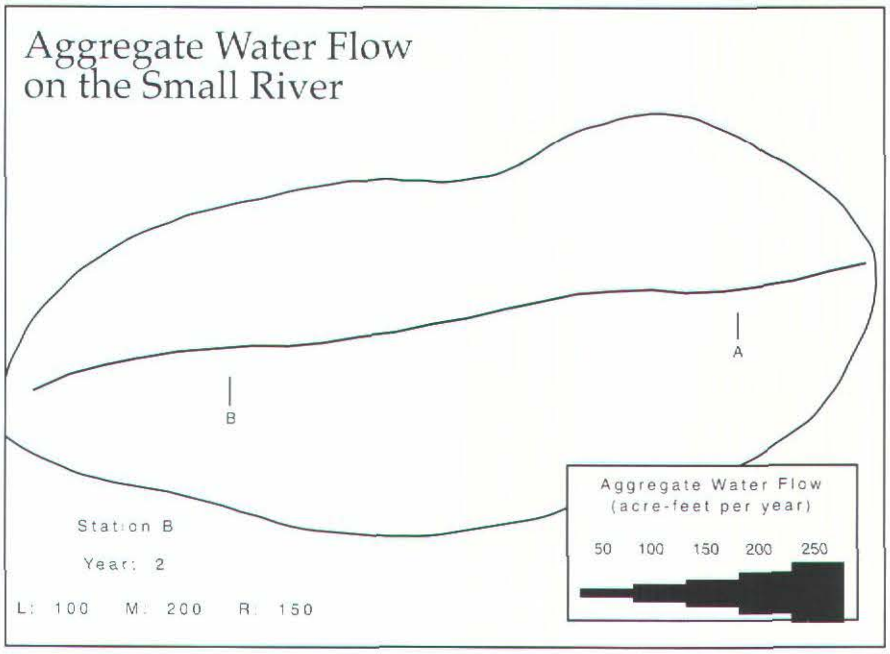

Figure 4. Query screen for quantity evaluations.

patterns over time at each gauging station rather than specific quantities. Except for the type of questions asked, the testing and data collection processes were similar to the quantity evaluation section of the experiment. Here, subjects determined if the trend between a specified pair of times was increasing, decreasing, or unchanged (Figure 5). The number of years viewed was increased from three to six to better illustrate changing trend patterns. Since the total number of years was increased, the number of viewing cycles for the static computer display and animation groups was also increased from three to four cycles. As with the quantity evaluation section, the total viewing time for each of the computer displays

"The trend pattern recognition tasks tested subject memory of overall trends for six years. In this section of the study, subjects learned trend patterns over time at each gauging station rather than specific quantities."

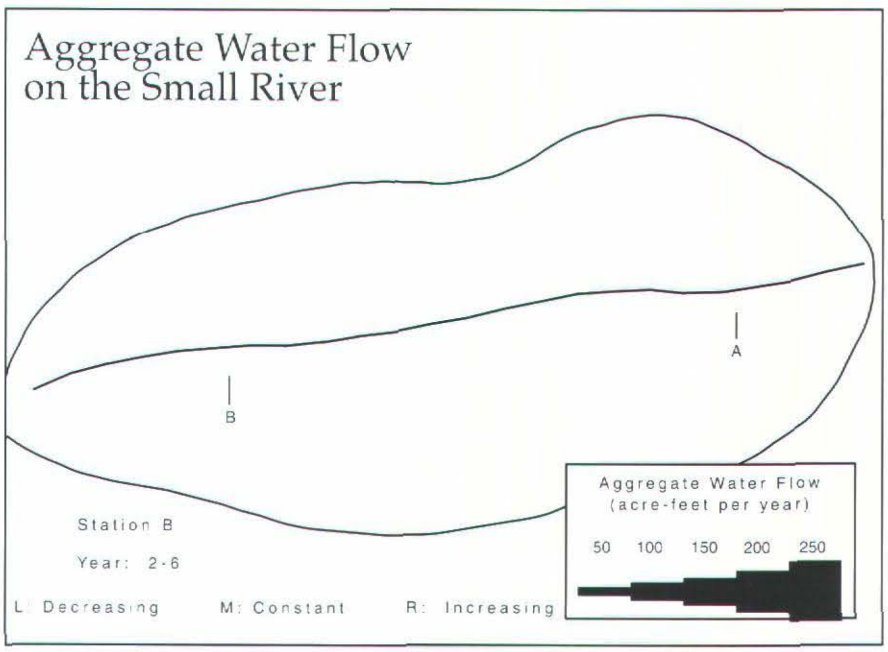

Figure 5. Query screen for trend pattern evaluations

equaled the length of time that subjects in the control group studied the paper maps (approximately 2 1/2 minutes). Two data sets were used and a total of twelve queries was also made in this section of the study.

The final section of the study required that each subject group view the other visualization techniques. Viewing times were only for as long as the animation sequence took to run through one cycle. The purpose here was not for subjects to memorize data, but for them to form impressions of the other visualization strategies available in the study. An informal written survey was then given to ascertain their impressions of these visualization techniques.

DATA ANALYSIS

The method of analysis used in this study was a standard analysis of variance (ANOVA). The dependent variables used in these analyses were reaction times and accuracy rates. Visualization method (paper map series, computer map series, animation) and map reading task (quantity evaluation, trend pattern recognition) were recorded for use as the independent variables. Gender was not originally included in the experimental design; however, due to the high turn-out of female volunteers, a gender factor was included in the model.

The analysis was performed using the General Linear Model of the SPSS statistical software package. Subject responses and reaction times were aggregated separately over the map reading tasks, which resulted in two data sets of 126 observations each. As is usual with reaction time analysis, times for incorrect answers were treated as missing data and therefore not factored into the aggregate reaction time data set. The general model tested the following main effects and interactions: GENDER, MAP TASK, VISUALIZATION GROUP, TASK*GROUP, GENDER*GROUP and GENDER*TASK*GROUP. These interactions were chosen to specifically evaluate the comparisons between visualization techniques. Custom hypothesis tests were also developed to address the interaction effects in greater detail. These were specified as planned comparisons and as such do not necessarily have to have a significant overall F from the ANOVA to carry them out or return a significant result (Snodgrass, Levy-Barger, and Haydon 1985).

"... females completed the map tasks more accurately when using the paper map series, while males performed the tasks more accurately on the computer."

Accuracy Rate Evaluations. Table 1, which provides the results of the overall ANOVA for accuracy rates, clearly shows that the model was not significant at the .05 level. Of all the main effects and interaction effects tested, only the GENDER*GROUP interaction was significant. Figure 6b shows graphically the form that this interaction took. This graph suggests that females completed the map tasks more accurately when using the

Source	df	F	Significance
Model	11	1.262	.255
Gender	1	.427	.515
Map Task	1	1.094	.298
Map Group	2	.566	.569
Task*Group	2	.312	.732
Gender*Group	2	3.597	.031
Gender*Task*Group	3	1.556	.204
Error	114		
Total	126		

Table 1. ANOVA Results for Accuracy Scores

paper map series, while males performed the tasks more accurately on the computer. Custom hypothesis tests confirmed that there was a significant difference in accuracy rates for female subjects who used the paper map series versus females who used the computer map serires to complete the map tasks ($F(1,119) = 5.155$, $P = 0.025$). Differences in accuracy rates between animation and the other visualization techniques were not significantly different for females. There is a definite trend, however, suggesting that female subjects who used the paper map series performed the tasks more accurately than those who used animation (see Table 2 for mean accuracy scores). No significant differences were found between the accuracy rates of the different visualization techniques for male subjects.

A custom hypothesis test was also performed for the TASK*GROUP interaction, plotted in Figure 6a. This graph suggests there were no significant differences in the accuracy with which different tasks were performed between the visualization groups. Further testing using planned comparisons confirmed this interpretation of the graph.

Reaction Time Evaluation. As Table 3 shows, the overall model for reaction times was not significant at the .05 level either. Furthermore, none of the main effects or interaction effects tested were significant in this model. A custom hypothesis test designed to look more closely at the TASK*GROUP interaction showed that there were no significant differences in response times for quantity evaluation tasks across visualization groups ($F(2,119) = 1.700$, $P = 0.187$). This test did indicate, however, that there was a significant difference in response times for the trend pattern recognition tasks across the visualization groups ($F(2,119) = 3.651$, $P = 0.029$). Figure 7a suggests that subjects using the paper map series had the most difficulty answering trend pattern recognition questions, while those in the animation group had the least difficulty (see Table 4 for mean reaction time scores). Planned comparison tests confirmed that the mean reaction times for subjects using the paper map series were significantly longer than those using the animation ($F(1,119) = 7.265$, $P = 0.008$). The difference in means between subjects using the paper map series and those using the computer map series were not significantly different, nor were there any significant differences between users of the computer map series and the animation users.

Figure 7b shows the interaction of GENDER*GROUP visually. Planned comparison tests for this interaction effect indicated that there was a significant difference in mean response times for males across the different visualization groups ($F(2,199) = 6.736$, $P = 0.002$). Further testing showed that there was a significant difference in the means between male subjects using the paper map series and those using animation to complete the tasks ($F(1,119) = 12.993$, $P = 0.000$). There were also significant differences between male subjects using the computer map series and those using animation

Map Task	Total	Male	Female
Total	9.11	9.26	8.90
Paper Map Series	9.26	8.82	10.14
Computer Map Series	8.98	9.65	8.36
Animation	9.10	9.42	8.56

Table 2. Means for Accuracy Scores

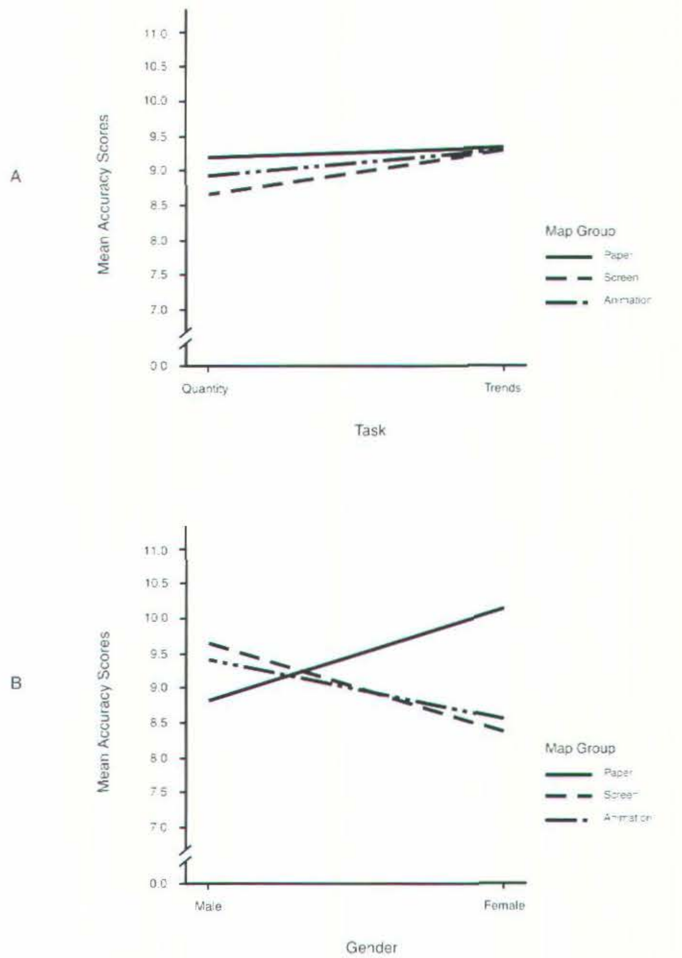

*Figure 6. Accuracy interaction plots for (a) group*task and (b) group*gender*

(F(1,119) = 5.385, P = 0.022). No significant difference was detected between the subjects using the paper map series and those using the computer map series. The planned comparison tests also showed no significant differences in visualization group means for female subjects.

DISCUSSION

Results from the statistical analyses suggest that there were no significant differences in the accuracy with which subjects performed the quantity evaluation tasks for the different visualization groups. Subject response times for this type of task were also not significantly affected by the visualization group to which the subject was assigned. Both of these results support the hypothesis that animation would not significantly improve subjects' abilities to complete these types of spatial tasks. Quantity evaluations are informational tasks that utilize not only the flow line but also the map legend. Since animation does not aid in comparisons between the flow line and the legend, it makes sense that animating the mapped data for these types of tasks would not improve one's ability to perform them. In fact, animation could possibly cause map readers to ignore the legend altogether by drawing their attention to the moving line.

Source	df	F	Significance
Model	11	1.613	.104
Gender	1	.221	.639
Map Task	1	.448	.505
Map Type Group	2	2.668	.074
Task*Group	2	.979	.379
Gender*Group	2	2.293	.106
Gender*Task*Group	3	.596	.619
Error	114		
Total	126		

Table 3. ANOVA Results for Reaction Times

A

B

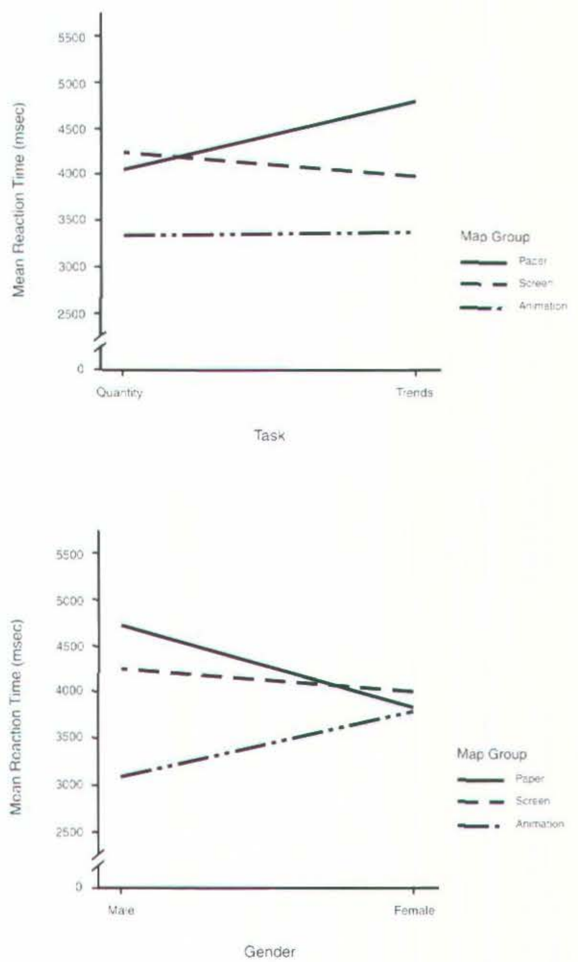

*Figure 7. Reaction time interaction plots for (a) group*task and (b) group*gender*

The accuracy with which subjects completed the trend pattern recognition tasks was also not significantly influenced by visualization group. However, subject response times for these tasks did differ significantly on the basis of the visualization technique used. Those subjects who used the animation to answer these questions responded significantly faster than subjects who used paper map series. Although accuracy rates were not significantly higher with this visualization technique, as had originally been hypothesized, they were not significantly lower either. This, coupled with the significantly faster reaction times suggest that animation may be a useful tool for communicating trend patterns to map users. Such illustrative tasks, where a direct comparison between the data on the map and the legend is not necessary, seems to be better illustrated with animation than informational tasks, a finding that is supported by Dorling (1992).

Though not a strict gender study, the number of female participants prompted the inclusion of a gender factor in the data analysis. Since the hypotheses and experimental design were generated prior to the inclusion of the gender factor, discussion of gender results are treated as informational only and not related to the hypotheses directly. The significant interaction between gender and visualization group for accuracy rates was primarily a consequence of the high scores by females using the paper map series (Table 5). Average response times for females did not differ significantly between the different visualization groups. Since females achieved a significantly higher accuracy rate with the paper map series, but took roughly the same amount of time to access the answers from memory, it appears that they retained spatial information better from the paper maps. The constant reaction times, however, suggest that they were not able to process the information any more easily when using this form of cartographic representation.

Reaction time data gathered from the male subjects indicates that they completed the tasks significantly more quickly when using animation. Furthermore, there does not appear to be a trade-off between response time and accuracy, as accuracy rates did not differ significantly for males across the visualization techniques. This suggests that the males in this study learned and remembered information better when using animation.

Subjects also participated in an informal written survey conducted at the end of the experiment. The purpose of the survey was to gain insight into the preferences of the subjects regarding the visualizations used in the study. Subject observations, suggestions concerning the animation process, and comments regarding ways to improve the communication of data were recorded. Table 6 illustrates the preferences of the subjects by visualization group. Results show that each group preferred the visualization technique on which they were tested. It is interesting that the paper map series were chosen second by both computer groups. Group totals show paper maps were preferred by close to half of the subjects, with animation second and the computer map series last.

Table 7 presents the breakdown of preferences for males and females. Again, the paper map series was the most preferred method of visualization by both groups. The strong preference by females also coincides with the higher accuracy rates they scored with the paper maps. Males, on the other hand, actually performed more poorly with paper maps. The large percentage of subjects who prefer the paper map series may result from the control they had in examining the sets of maps. Subjects from all groups indicated that control of map viewing was an important factor in their preferences. Those who participated in the computer map series and animation groups stated that user control of the animation was necessary for proper examination of the data.

Several subjects also suggested incorporating color into the animation as a way of improving this visualization technique. The animation used in this study employed only one color throughout the animated sequence. Subjects in all visualization groups felt that evaluations for the quantity section of the study would have been easier had each quantity had its own separate color. They believed that color would have been a better visual cue than comparing widths to the legend. While an interesting idea, implementing this in a graduated flow context could be complicated.

Map Task	Total	Male	Female
Total Mean	3965	4018	3888
Paper Map Series	4424	4724	3823
Computer Map Series	4107	4239	3987
Animation	3363	3089	3809
Trend Recognition	4051		
Paper Map Series	4792		
Computer Map Series	3975		
Animation	3385		

Table 4. Means for Reaction Times

Gender	Accuracy Rates	Reaction Times
Male		
Paper Map Series	8.82	4724
Computer Map Series	9.65	4239
Animation	9.42	3089
Female		
Paper Map Series	10.14	3823
Computer Map Series	8.36	3987
Animation	8.56	3809

Table 5. Gender Means for Accuracy Rates and Reaction Times

"Since females achieved a significantly higher accuracy rate with the paper map series, but took roughly the same amount of time to access the answers from memory, it appears that they retained spatial information better from the paper maps."

". . . males in this study learned and remembered information better when using animation."

Visualization Group	Number of Subjects	Map Type	Preference Percentage
Paper Map Series[a]	22	Paper Map Series	77.3%
		Computer Map Series	4.5%
		Animation	18.2%
Computer Map Series[b]	20	Paper Map Series	40.0%
		Computer Map Series	45.0%
		Animation	15.0%
Animation	21	Paper Map Series	28.6%
		Computer Map Series	9.5%
		Animation	61.9%
Total Group	63	Paper Map Series	49.2%
		Computer Map Series	19.1%
		Animation	31.8%

[a]Subject number includes a subject not used in the formal analysis.
[b]One Subject did not state a preference.

Table 6. Test Group Preferences of Visualization Techniques

Gender	Number Of Subjects	Map Type	Preference Percentage
Male	36	Paper Map Series	44.4%
		Computer Map Series	19.4%
		Animation	36.1%
Female	27	Paper Map Series	55.6%
		Computer Map Series	18.5%
		Animation	25.9%

Table 7. Gender Preferences of Visualization Techniques

Relating changes in color to changes in quantity is not a visually intuitive procedure. Furthermore, the varying visual perceptions of colors would need to be addressed. An interesting alternative, however, might be to vary not only line widths, but also the color value of the line to cue users to quantity changes.

CONCLUSION

This study compared the traditional time-series visualization technique of paper map series to the emerging techniques of computer map series and animation. The general research question examined which visualization technique allowed a map reader to better learn and understand the data presented. Human subjects were asked to perform two separate map reading tasks. The first involved learning specific data values, while the second required learning trend patterns. The expected results were based on Dorling's (1992) findings that informational or investigative purposes of map reading are not well served by animation, while illustrating change through time is enhanced by this technique.

Results of the study indicated that animation did not improve learning ability for quantity values (an informational task), but did enhance the learning of trend patterns (an illustrative task). The study also showed that females preferred the paper map series and completed tasks significantly more accurately with them, while males appeared to learn better with animation. Average reaction times for males were significantly faster with animation. Accuracy rates, however, failed to show a significant increase over the paper map series. Perhaps the difference being seen in this study is related to exposure and use of computers between the genders. It has been suggested, in the popular media at least, that during adolescence males tend to spend much more time using computers than their female counterparts. If true, that could be a factor in the preferences and differences in reaction times and accuracy rates seen between the two groups.

". . . animation did not improve learning ability for quantity values . . . but did enhance the learning of trend patterns."

Interestingly, the study group as a whole preferred the paper map series to either of the other visualization methods. Paper was also the preferred technique by both males and females. Subjects felt they had more control with the paper map series than with either the computer map series or the animation. Suggestions for improving the animation technique included allowing the subjects to have direct control over the animated sequence and color coding the quantity values to make them more distinguishable.

Future Research. Animated maps are now possible given current computer technology. Whether or not they are preferable is questionable. Continued study focusing on computer map symbolization, including graduated flow lines, and the effectiveness of animation on perception and memory retention is needed. This study examined two purposes of visualization as outlined by Dorling (1992), investigative and illustrative, using the same symbolization method and representation as used by standard paper maps. The next step would be to separate these two different purposes and research the methods and representations that would improve communication of the data for each one. The methods developed for the investigative purpose might also be carried over into exploratory visualization.

"It has been suggested, in the popular media at least, that during adolescence males tend to spend much more time using computers than their female counterparts. If true, that could be a factor in the . . . differences in reaction times and accuracy rates seen between the two groups."

The proper scaling of quantitative flow lines should also be examined in a dynamic environment. The ability to zoom in and out, changing the scale of the map, has consequences for the interpretation of graduated flow lines. How does changing the scale of the flow line, and consequently the legend, affect the ability of the map reader to comprehend the data?

The use of color in an animated flow line sequence should also be examined. The suggestion of the test subjects that quantity be based on hue differences is an intriguing one. The choice or choices of hue and the decision to vary saturation or value or both are all issues that need to be explored. Do you vary width as well as color? The importance of this continued research is a consequence of technological forces. Advances in technology have put the ability to make maps into the hands of non-cartographers. Desk-top mapping programs, developed by non-cartographers, are being used by the general public to create pretty, aesthetically pleasing maps. The meaning of the data is often lost as default classification schemes and color palettes are used. Cartographic techniques for dynamic and static screen-based exploration, classification, and symbolization of data need to be developed so that software manufacturers can incorporate them into end-products to improve cartographic renditions.

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reviews

ATLAS OF THE NEW WEST: Portrait of a Changing Region. Center of the American West, University of Colorado, Boulder. General Editor, William Riebsame; Director of Cartography, James J. Robb; Photographs by Peter Goin; Essays by Patricia Nelson Limerick and Charles Wilkinson. 192 pp.; maps, diagrs., photgs., notes, index. New York and London: W.W. Norton and Company; 1997. $35.00 (cloth), ISBN 0-393-04550-1.

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Every so often an atlas comes along that is good enough to drive other atlases into the shadows. One such volume was the atlas by James Allen and Eugene Turner, *We the People: An Atlas of America's Ethnic Diversity*, a winner of the J.B. Jackson prize in 1989; another was the first *State of the World Atlas*. There is the Cole Harris-edited *Historical Atlas of Canada*, and certainly yet another—and still evolving—is Bill Bowen's electronic atlas for the California Geographical Society; so accessible, so potent, so visionary, and an example of cartography in the service of the public good [**http://www.geogdata.csun.edu**]. The *Atlas of the New West*, under the general editorship of geographer William Riebsame at the University of Colorado, Boulder, with photography by Peter Goin and cartography hailing from James Robb's Boulder operation, has locked in a new mark for the high bar.

Published under the aegis of the Center of the American West, this is not just an atlas for westerners, but something for everyone interested in cartography, in the production of handsome books, and in a well thought out regional portrayal. It gives good weight—and intellectual strength—to the larger cause of regionalism which many of us still believe in, but which has been tortured by various inner doubts and self-inflicted demons for the last couple of decades as a kind of sideswiped victim of drive-by social (pseudo) science. As an atlas and peroration, this works very well, for the most part. There are a few bumps in its path, but as anyone who has traversed dirt tracks in the American West realizes full well, when driving washboard roads there's a certain speed (usually just between 45 and 48 mph) when you start skimming the top of any corrugations, and drop back into little valleys between each high point only when you deign to slow. To be thoroughgoing, those declivities in the Atlas will get some exploration here, but the bottom line is truly a simple one: any geographer or historian or poet or essayist of the West who tries to escape the implications (and ownership) of this atlas is slacking off. Read it and think.

With 50-some maps by Jim Robb and his cartographic team, 20 photographs by the University of Nevada's Peter Goin, an extremely healthy collection of graphs and tables, credible discursive texts by William Riebsame and assistants Hannah Gosnell and David Theobald, and two keynote essays by potentates Patricia Nelson Limerick and Charles Wilkinson, each of the University of Colorado, Boulder, this is predominantly a Colorado operation, and one that brings together a variety of perspectives on what has been called the "New West." That term has come to us thanks largely to the work of the so-called Gang of Four—Patty Limerick herself, Richard White, Donald Worster, and William Cronon, who together worked to challenge the Frontier School vision of the American West popularized by Frederick Jackson Turner almost exactly 100 years ago. There was, in fact, not so much wrong with Turner's vision of human-land interactions, but his disciples tended to more doctrinaire and deterministic views than Turner ever would have himself, converting the West into a kind of battlefield for the triumph of manifest destiny and a litmus test for the determination of a somehow new American man (with no accidental emphasis upon the male). In response, Patty Limerick and her confrere argued that there is no single "West," but instead many indeed, and this volume documents that modern day diversity. It does so, in fact, far more readily than the tens of thousands of words in something like Richard White's *It's Your Misfortune and None of My Own*, a massive textbook that never once uses the "f" word—"frontier"—within its pages. That's what makes a really good atlas better than anything else; it summons a multitudinous assault upon the senses, in photographs, in the brightly-colored and evocative maps, in substantive charts and tables, and latterly, in words.

What, then, is this atlas about? In short, it's a testament to regional identity. I remember too well in the early 1980s sitting in a cow camp working through Bernard DeVoto's introduction to B.A. Botkin's *A Treasury of Western Folklore*, in which DeVoto offered the best imaginable capsule definition of the American West as a cohesive region. He concerned himself with both physical realities and assorted cultural traits (though he would never have called them that). As with this atlas, there was little worry about historical fact—and for an atlas constructed by a group made up predominantly of historians and resource geographers, that elision might seem a little odd. History is slighted; this is contemporary late-'90s fare, and, for that, quite fresh. The subject is the New West, which is defined with less than complete care. In passing this volume around to various colleagues, the one question they raised, to a person, also has to be asked here, since it isn't answered in the Atlas itself: Why use these singular boundaries? All of California, Oregon, and Washington west of the Sierra-Cascade ranges is excluded from the thematic maps of this volume. Now, quite a few times I've taught "The American West," and about half the time have invidiously excluded California from consideration (usually because there's a whole separate course to be taught on the Golden State). And there are some good reasons to set aside what Earl Pomeroy called the Pacific Slope from consideration—but those reasons should really be made explicit, and they aren't. To say that California is not part of the New West requires arguing that a defining feature of the region is a (relative) absence of population—and that, naturally, is what Frederick Jackson Turner claimed a hundred years ago, and it didn't work especially well even then. The western boundary for the *Atlas of the New West* instead runs along the drainage divide of the Sierra Nevada, slicing down to include Barstow—and quixotically, Palm Springs. The eastern boundary puts the Front Range of the Rockies in the New West, but none of the plains of New Mexico, Colorado, Wyoming, or Montana. Geographers will muse about such things, as I am here, but the point is, it helps to know how an area is defined, and that isn't made clear.

Once over that bump, a number of the maps are strong indeed. As a trade volume, it's perhaps unsurprising that the colors are a trice more lurid than a button-down collar academic publisher might countenance. There is a bit of the flavor of *USA Today*—which has, after all, done quite a bit for visual and data literacy in the American population (and has been home to a regular column on western matters by Prof. Limerick herself). The best of these maps are minor masterpieces whose collective effect is better even than that. There is, for example, the extraordinarily simple map showing percentage of public land in each western state, representing that proportion with a reduced image of the state itself: Nevada is 83 percent public land, so the public land proportion shows the state at 83 percent size; Colorado is only 36 percent public, so its public land proportion is teenie, but still huge compared to Kansas, at just 0.8 percent public. This is lively and intelligent cartography—as Edward Tufte reminds us, in *The Visual Display of Quantitative Information*, effective communication always wins out with "the revelation of the complex" (p. 191). There are maps that reveal "A Nuked Landscape"—nuclear testing, mining of fissionable materials, and the location of facilities for the design, production, and storage of nuclear and atomic weapons, fuels, and waste. Where "The Old West Lives On" turns out to be almost everywhere; the map contrasts the location of feral horse and burro range (across basically all of the New West) with the homes of cowboy poetry festivals, PRCA sanctioned rodeos, and dude ranches. A map solid in production and concept shows the "Strongholds of the Traditional Economy," where more than 35 percent of a population in either 1980 or 1994 was employed in ranching, mining, logging, or farming—an overall area strikingly reduced in the last fourteen years. Home prices are featured (the West's are high, and the map includes all of the United States to make clear just how comparatively pricey the West really is), as are the election of women—seven states in the west make the top-ten list in the US for proportion of women voted into office. Swooping arrows make it clear indeed that the West is growing swiftly, with a positive net migration of nearly two-thirds of a million people from other parts of the United States into the New West—over four years almost 400,000 of them abandoning California. The resources, variation in ethnicity, details of the tourist and recreation economy, are all made clear in trenchant maps.

One offering is "War and Peace in the West," mapping locations that have joined in the so-called county supremacy movement (Figure 1). In a remarkable act of cartographic wisdom, the map juxtaposes the county-sovereignty advocates with selected bioregionalist watershed coalitions (on the Gila, Virgin, Animas, Carson, Salmon, and others). In doing so, it tracks two profoundly different political movements, each arguing for a much greater degree of local control than a progressivist federal government has been willing to permit. This is a map that has real depth—after all, what's really being mapped is a localized rejection by two movements that hail from what would typically be considered opposite ends of the political spectrum, yet which have identical purposes: overcoming a hegemonic federal patronage to regain a measure of local control. What's shown is, in effect, yet another pitched battle in the Sagebrush Rebellion. And in case this seems far-fetched, consider the series of full-page ads that 1997 and 1998 have seen taken out in the *New York Times* by a coalition of national environmental groups, spearheaded by the inimitable David Brower, protesting U.S. Forest Service policy. (It is somehow especially telling that the ads are placed in the *Times*.) In particular, the ads lambaste the Forest Service's willingness to consider in the Plumas National Forest a cooperative management agreement with the coalition of local community people, commercial timber interests, and resource professionals. Altogether, these forces make up the so-called Quincy Library Group,

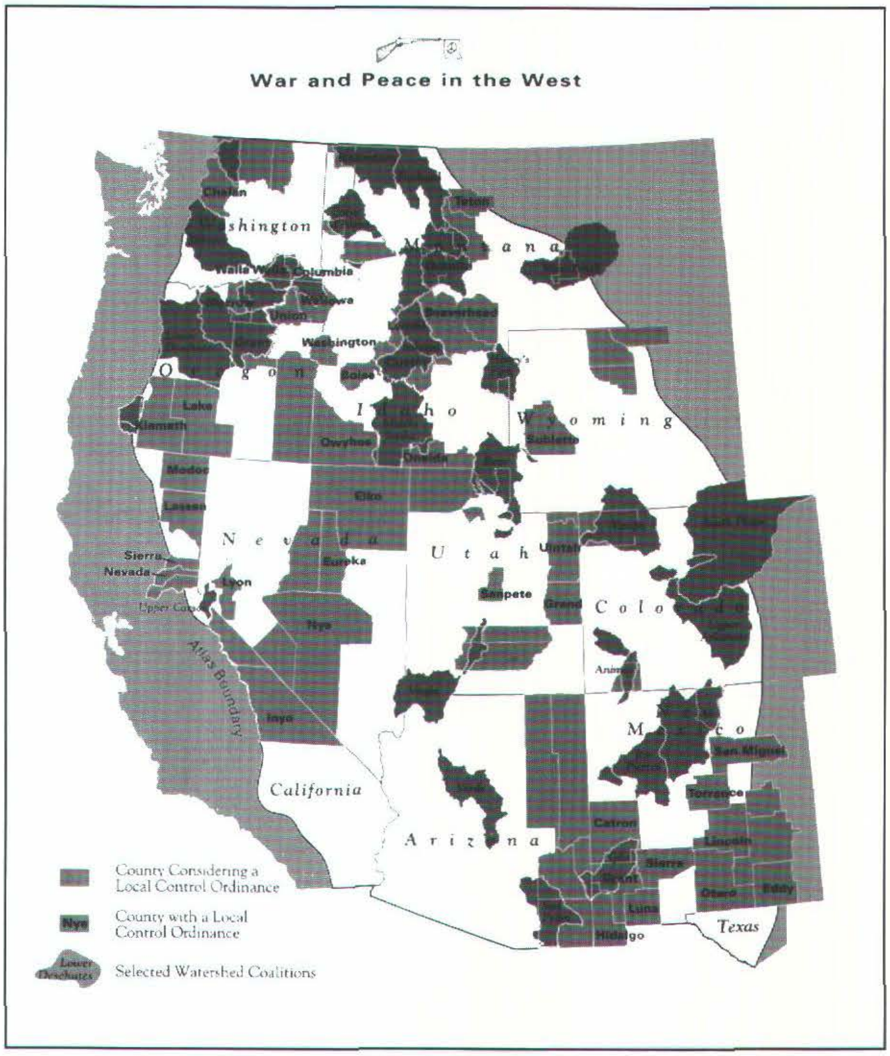

Figure 1. War and Peace in the West

which Charles Wilkinson addresses in closing his long essay in this atlas. Here is yet another expression of evolving local versus global thinking—demonstrated cartographically.

The photographs by Peter Goin are fully equal to the maps; they capture the realities of the New West with a nuance that is hard-countenanced yet amused. Goin's neorealism is a long distance from the soppy and romantic fare of a David Muench or Jay Dusard; like the best of the maps, Goin's photography is provocative. The long essays by Patricia Limerick and Charles Wilkinson would be less effective by half without the reflective images by Goin. If there is any single abiding problem with this work, it is text that doesn't live up to the promise of the photographs that accompany the two principal essays. Limerick's long concluding essay is a sterling bit of work, finely edited and crafted, and with the wit and wisdom that we expect from the doyenne of the New Western History. She remains notably grumpy about the New West, regarding many of the newer arrivals as poseurs who are changing the West in ways not for the best. About Charles Wilkinson's essay, there is less to be said. For someone striving with such conspicuous effort to try to be our latter-day Wallace Stegner, Wilkinson's material is hardworking, sincere, and quite competent. But his meditation captured nothing extra or special for me in the New West. Maybe, with one book here and another book there, Wilkinson has spread himself too thin of late and a little of his earlier charm has worn away. Wallace Stegner had the rarity of a genuine humanism that always accompanied his nonexclusive vision for the West. But Wilkinson's is an honest effort.

At their best, a number of these maps and texts work wonderfully and are thoroughly thought-provoking. There are a few problems: (some of the entries are simply silly) "The Cultured West" is too vague for words; the symbols used in "The Ugly West" could be a little less cartoonish; and in isolated instances, the subject matter approaches self-parody (as does the New West). But let it be said—the conception of the Atlas is solid: a small map of the "New Age in the New West" might be trivial, except for the long list below the map of "Opportunities to Join the New Age," with its survey of New Age self-repair nostrums. And on the facing page (with white text on a black background!) is a "Declaration of War on the New Age," by an assortment of northern Plains Native American groups upset by the New Agers's appropriations of Indian ritual and practice. There is one heinous error, a falling from statistical grace that, at the very least, a copyeditor should have found—if not the fully adult authors who presumably read over these materials in preparation: A table shows the "Interior West Growth Pole," listing in one column a state-by-state percentage of population growth from 1990 to 1994. But the next column shows doubling time, in years. Nevada, for example, saw a population growth of 21.2 percent in four years. But the "doubling time" is far from 3.3 years, as the table asserts. Doubling time is based on yearly population growth, not a four-year total—in fact, the yearly population growth for Nevada averaged 5.3 percent (one-quarter of 21.2 percent), and its doubling time is therefore almost fourteen years, not a little over three. The mistake is reproduced ritually for every state. That's first-year statistics, folks... and a howler. Fix it, please, for the next printing.

This is a kind of atlas that should be coming out more often: fine thematic mapping with sensible accompanying text and photographs, charts and tables. All the hallmarks of an inescapable volume are on hand—no one who works in the West, or writes or teaches or lives here—should go without. If there are individual details that can be picked on, that's the sort of discussion that such a book should inspire. And, overall, the symphony is sonorous and striking.

cartographic techniques

Low Altitude Videography as a GIS Data Source

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Overview

Low-altitude, visible spectrum videography provides a relatively low-cost opportunity to detect detailed surface features, and may be a practical media choice for monitoring such surface feature changes over time. However, this type of imagery has not been widely used as a resource for developing thematic data in Geographic Information Systems (GIS). This article describes a process for converting the video frames into composite still images and for georeferencing these images to an existing set of base GIS themes.

Interest in exploring this process arose in 1997 when resource managers at the South Slough National Estuarine Research Reserve (NERR) in Coos Bay, Oregon, wanted to evaluate the change in the distribution of eel grass beds (*Zostera marina* and *Z. japonica*) in the slough. The eel grass beds provide shelter for a wide variety of fish and invertebrates and are an important component in the slough ecosystem. Field observations conducted in 1991 and 1992 were used to develop GIS data layers showing the approximate distribution of the beds at that time. Base themes for the GIS, such as the channel location and shoreline, were developed using 1991 aerial photos (1″ = 1,000′) and 7.5 minute USGS maps (1″ = 2,000′) (Figure 1).

Video Characteristics

In 1996, visible spectrum Hi-8 video was filmed by Charles Rosenfeld, Department of Geosciences, Oregon State University, for a major portion of the slough. The camera altitude varied from approximately 1,000′ to 1,500′, and the scale of the resultant digitally converted images was approximately 1″ = 100′. At 72 DPI, this corresponds to a resolution of about 1.4′ per pixel. By comparison, shuttle radar and SPOT resolution is typically 10 m, and Landsat thematic mapper (TM) and multispectral scanner (MSS) images range from 30 m to 120 m resolution.

Each frame of the video contained locational coordinates obtained from a GPS. However, the sensitivity of the GPS equipment recording the latitude and longitude was such that the values did not keep pace with the movement of the aircraft. At several points, the coordinate values are lost completely for a period of a few seconds to over a minute. Consequently, the latitude and longitude values were useful only for very general placement of

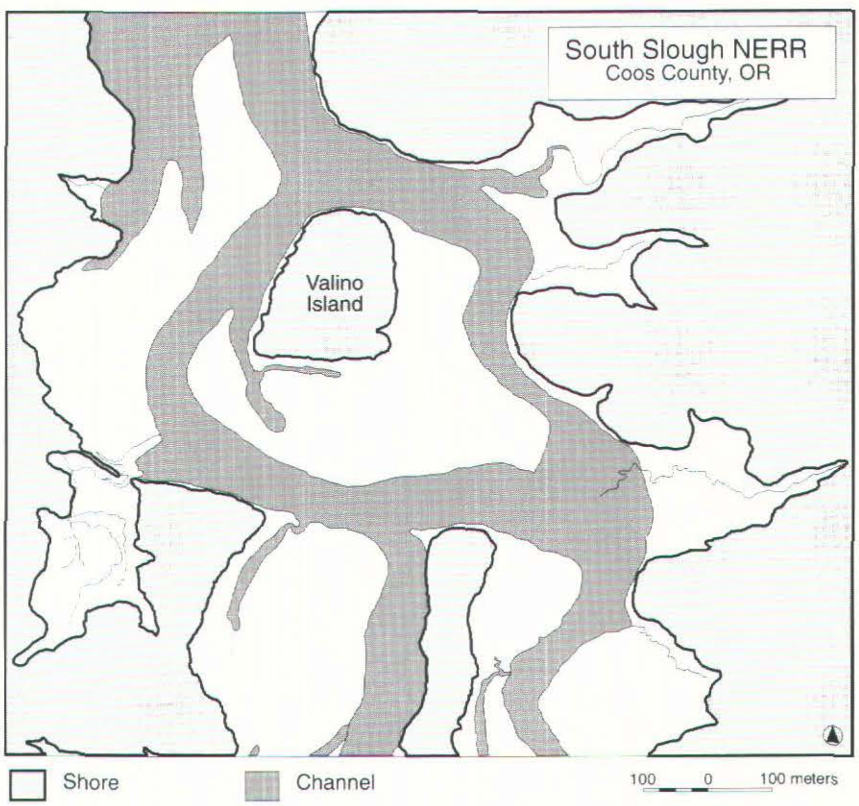

Figure 1. South Slough Base GIS Data from 1991 Aerial Photography

geographic location, such as identifying the approximate beginning and ending range of footage for the study area. No flight plan was provided with the video.

Georeferencing of the videography is further complicated by the differences in distortion between the 12 mm lens for the videography and the 152 mm lens used for the aerial photography. The misalignment is primarily longitudinal, as the video imagery coincides reasonably well in the north-south direction.

Software and Hardware

MacIntosh System 8.0:
 Adobe Photoshop 4.0
 Adobe Premiere
 Macromedia Freehand 7.0
 Kandu CADMover 4.0
Windows NT:
 ESRI ArcView 3.0a

Process Description

The four major parts of this process are 1) the conversion of the video frames to still imagery, 2) compositing the individual stills, 3) delineating the new surface feature vector information, and 4) importing the new surface feature vector data to the GIS.

Video Conversion to Still Imagery

Adobe Premiere video editing software was used throughout this part of the process, with full screen settings (640 x 480 pixels), to view and capture video data.

1. Capture two sample frames for start and two sample frames for end positions each time plane began and ended a pass to determine total number of passes, orientation of each pass and geographic extent.
2. Use the rough latitude and longitude coordinate values on the video and USGS quad map to determine which sections covered the study area. Of the eight identified passes, only the first seven covered the study area.
3. Capture frames of the study area as PICT images. In order to have sufficient overlap between frames, capture approximately 1 frame per second, or every 30th frame. Each frame image is about 8" x 6.5" and at 72 DPI is approximately 900 KB. For our project, the number of images per pass varied from 30 to 40. Thus, about 220 MB of disk space was required to store all the individual frame images.

Creating the Composite Images

The challenge in the compositing process is to place the individual frames so that features in the resultant image are in their proper geographic location with respect to some set of base features. Since the GPS locations provided on the video were not precise and there were no other comprehensive set of control points available as reference, the existing GIS vector data representing shorelines and the channel were used as the base for georeferencing.

The software tools used in this compositing process were ESRI's ArcView 3.0a for GIS data manipulation, and Macromedia Freehand 7.0 , which was selected because it uses both vector and raster data, and allows linking to the individual image files without actually storing them as part of the composite file. This helps to reduce the amount of disk space required and the processing time. Adobe Photoshop 4.0 was also used to preprocess the PICT images and convert them to TIFF.

1. Display the base data in an ArcView View window, using distinct symbology for shore and channel features. Export the View as an Adobe Illustrator format vector file, and open with Freehand 7.0 .
2. Rescale the vector features in Freehand to approximate the size of the anticipated finished

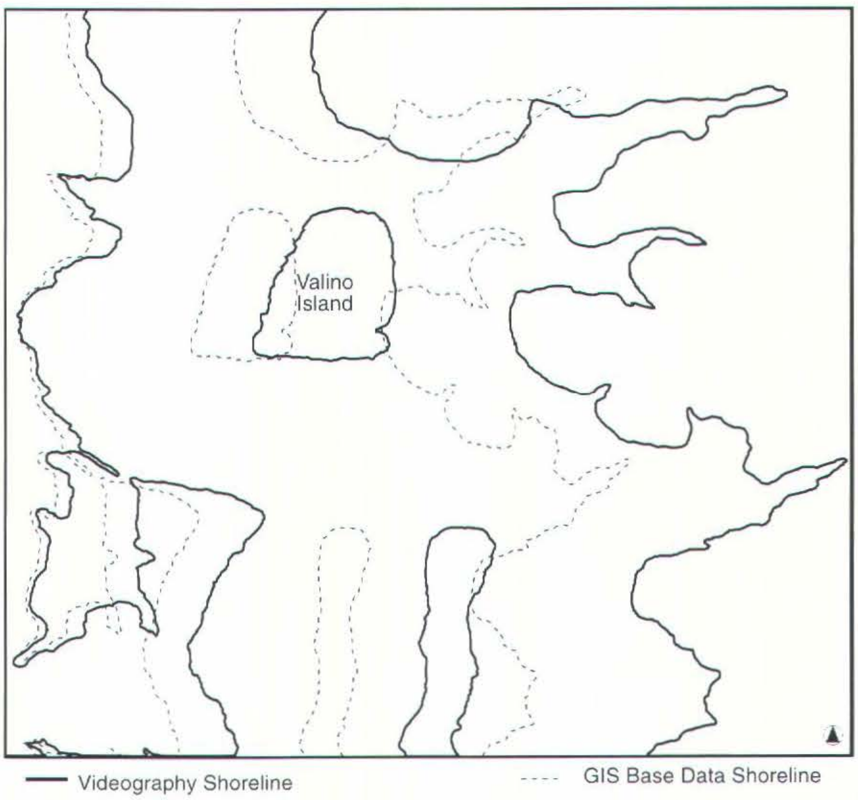

Figure 2. Comparison of Camera Lens Distortion Effect on Shoreline

composite image. The rescaling percentage may be estimated based on a preliminary joining of several adjacent images from each pass to determine the final size of the total image. In this project, a 2000% overall enlargement was applied, then a 72% horizontal resizing was used to compensate for the difference in lens distortion between the video camera and still aerial camera that provided the 1991 images for the base GIS data (Figure 2). It is important to note the rescaling percentages because once features are delineated from the composite image, the resultant vectors will be scaled inversely (in this case, increased horizontally by approximately 139%) to create data consistent with the original base data and the other existing data in the GIS.

3. Using Photoshop 4.0, open each PICT and clip out only the central portion of the image, plus a minimal overlap, and paste it into a new file to be saved as a compressed TIFF. This reduces the individual image file size typically by 70 - 80%, and allows the linking function in Freehand. PICT files, when imported into Freehand, are automatically embedded in the working file regardless of the preference setting that controls linking.

4. Open the Freehand 7.0 base file, and import the individual TIFF images as links, working on one pass at a time. Create a separate layer for each pass, and position/scale the images to fit the base data. In this project, scale adjustments were made uniformly for all the images in a single pass, although the percentage adjustment varied from pass to pass depending on variations in the video camera altitude between passes. Adjustments were made to each pass based on the inclusion of adjacent passes, distributing the perceived error throughout the area to achieve the best fit with the boundaries of the base data.

Delineating New Feature Data

Now that the TIFF images have been composited, capture the desired surface features as vector data in Freehand.

1. With the spatially referenced TIFF images as background layers, create a new layer for the new surface feature data. It is possible to work at the scale of the original videography by zooming in on the image, and full-size plots may be used as an additional source of information.

2. The new feature data will be scaled to the size of the video images. Apply the inverse scaling described above to the new feature data and the base data to set it back to the original dimensions of the base data.

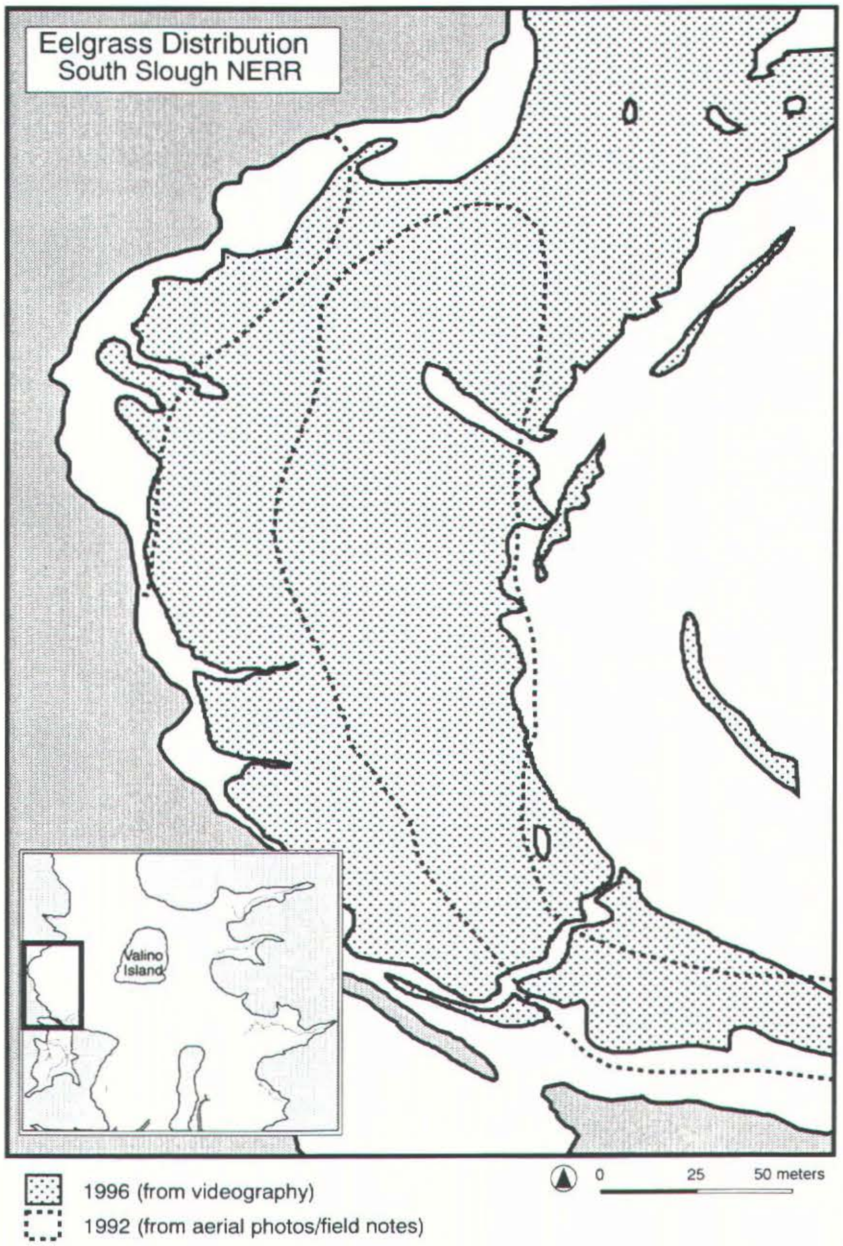

Figure 3. Eelgrass Distribution at South Slough NERR

Importing the New Surface Feature Data to the GIS

The final step is to convert the new feature vector data from Freehand to a format that the GIS recognizes, with the correct geographic placement relative to the other data in the GIS.

1. Save the Freehand layers containing the new feature data and the base data as an Adobe Illustrator format file.
2. Open the Illustrator file with Kandu CADMover, and convert the file to DXF. Don't worry about adjusting the scale factor and units to try and match the GIS data at this point.
3. In ArcView, turn on the CADReader extension. Open a new view, and import the DXF file as a new theme. Import the original base data shapefiles. The data will not line up properly because the DXF data will reflect the Freehand units and placement, while the base GIS data will be in real world units, according to its projection.

4. To georeference the DXF file, create a 'world' file using a text editor, and associate it with the DXF theme in the 'Theme Properties' menu. A world file is simply a text file that contains the x, y coordinates for a location in the DXF file and the x, y coordinates for the corresponding location in the GIS data. Enter the coordinate information for 2 discrete locations, with one location per line (see the ArcView on-line 'help' text for an example). The DXF data should now align with the base GIS themes.

Considerations

An important consideration in the compositing process is the actual size of the images to be manipulated. Reducing the image resolution and/or dimensions will reduce file size and processing time, but will also result in the loss of surface feature detail. However, presumably much of the value of using low-altitude video is its ability to illustrate a greater degree of surface detail than would otherwise be evident from other image sources (Figure 3). Working with a tool, such as Freehand, that allows linking to the TIFF images helps to reduce the impact of file size on the compositing process.

Acknowledgments

Support for this project was provided by the Oregon Division of State Lands and the South Slough National Estuarine Research Reserve. The contributions of Dr. Steven Rumrill, SSNERR Research Program Coordinator, Michael Graybill, SSNERR Manager, Masao Matsuoko, InfoGraphics Lab Cartographer and Jim Meacham, InfoGraphics Lab Director, are also gratefully acknowledged.

NACIS news

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from the Editor
continued from page 1

phenomenal effort. Thanks also need to be extended to the NACIS organization at large and to all of the executive officers and Board members that have continued their strong support for the publication.

I would like to take this opportunity to introduce the new staff of *Cartographic Perspectives*. The Assistant Editor, James Anderson from Florida State University, handles all aspects of production, duplication, and distribution. Without his efforts, *Cartographic Perspectives* would not make it to paper, nor to you. James Meacham from the University of Oregon is the Cartographic Techniques Editor. The Cartographic Techniques section of the journals deals with issues of map design and production. Melissa Lamont is the Map Library Editor. She recently moved to Woods Hole Oceanographic Institute. The Map Library Bulletin Board reports on developments at major map libraries in North America. Finally, Joanne Perry, Map Librarian at Oregon State University, is the Book Review Editor. I am fortunate to have such a capable group of individuals working with me as Editor of *Cartographic Perspectives*.

You may have noticed that *CP* is expanding. We have had to change to a different method of binding to handle the larger issues. We are also pleased to report that the journal is being indexed by UnCover and SCSI.

Finally, the editors invite you to contribute to the Journal. Ultimately, it is your publication - not ours. Please take a moment to consider how you could contribute to the journal and then contact one of the editors. We hope to see you in print.

NACIS XVIII PROGRAM

The Eighteenth Annual Meeting of the North American Cartographic Information Society

October 7-10, 1998
Milwaukee, Wisconsin

MAPS and MINDS: A HISTORY OF CARTOGRAPHY IN GEOGRAPHY EDUCATION
A preconference symposium sponsored by the Newberry Library and NACIS

WEDNESDAY, OCTOBER 7, 1998

8:00 a.m. - noon
Registration / Coffee

9:00 a.m. - noon

Part I: Traditions

Maps in the 18th Century British Geographies
Barbara McCorkle, Yale Univ. retired

The Design and Evolution of 19th Century American School Atlases
Jeffrey Patton, Univeristy of North Carolina-Greensboro

Cartography in Late 19th Century and Early 20th Century American Geographic Education
Susan Schulten, Univ. of Denver

Old Maps, New Geographies: Historic Maps in the K-12 Classroom
James Akerman, Newberry Library

noon - 1:30 p.m.
Luncheon

1:45 p.m. - 5:00 p.m.

Part II: Prospects

Cartography, Theory and Geography Education
Roger Downs, Penn. State University

GIS, the Web, & the Future of Cartographic Education
Charles Fitzpatrick, ESRI

Stone-Axe Multimedia: Designing Multimedia for Real Students
Phil Gersmehl, Univ. of Minnesota and Carol Gersmehl, Macalester College

General Discussion

NACIS XVIII
WEDNESDAY, OCTOBER 7, 1998

8:00 a.m. - 7:30 p.m.
Registration

3:00 - 5:30 p.m.
NACIS Board Meeting

7:30 - 9:00 p.m.
Opening Session
Keynote Speaker: Michael K. Duckett
Southeast Wisconsin Professional Baseball Park District

9:00 - 11:00 p.m.
Poster Session / Exhibits and Reception
See www.nacis.org for a listing of presenters

THURSDAY, OCTOBER 8, 1998

8:00 a.m. - 4:00 p.m.
Poster Sesssion / Exhibits

8:30 - 10:00 a.m.

Session A. The Petchenik Map Award with Special Reference to the Nature of Creativity in Cartographic Design

The Barbara Petchenik Children's Map Award 1993-1999
Jacqueline M. Anderson, Concordia Univ.

The Nature of Creativity in Cartographic Design: Some Thoughts for Discussion
Henry W. Castner, Pittsboro, NC

Creativity, Art, and Cartography in Geographic Education
Karen M. Trifonoff, Bloomsburg Univ.

Session B. Metadata and Education

Exploring Scale and Metadata Issues
Carol Gersmehl and Susanna McMaster, Macalester College

E.O. 12906, Metadata, and the U.S. Census Bureau
Kristen O'Grady, Census Bureau

Wisconsin State Cartographer's Office - Outreach and Education
Ted Koch, Univ. of Wisconsin - Madison

10:30 a.m. - noon

Session C: Educating with Maps

Poets and Maps in Education
Adele J. Haft, Hunter College

Goode's World Atlas: 20th Century Classic
Valerie Krejcie, Cartographic Consultants

Thoughts on Making an Atlas Fly
Karen Severud Cook, George F. McCleary, Jr., and Darin Grauberger, Univ. of Kansas

Session D. Examining Map Design
Design of Street Maps
Dennis McClendon, Chicago Cartographics

Mapping the Ohio & Erie Canal: What Goes Around, Comes Around
Claudia James, Univ. of Akron

noon - 1:30 p.m.
Luncheon and Annual Business Meeting

1:45 - 3:15 p.m.

Session E: Educating with Multimedia
Integrating Multi-Media Lessons into Large College Classrooms
Amy K. Lobben, Michigan State Univ.

The U-Boat Narrative: Data Exploration Possibilities for the U-boat Conflict of 1939-1945
Fritz C. Kessler, Univ. of Kansas

Interactive Educational Software in Action
David L. Howard and MarkWherley, Pennsylvania State Univ.

Session F: Roundtable Discussion
Custom Cartography Business Roundtable
Alex Tait (Organizer), Equator Graphics;Dennis McClendon, Chicago Cartographics; Martin von Wyss, Hybrid Designs

3:30 - 5:00 p.m.

Session G: Digital Library Issues
The Digital Map Library as a Moving Target: Evaluation of Technology and Knowledge
Barbara P. Buttenfield, Ming-Hsiang Tsou, Andrew D. Smith and Suzanne Larsen, Univ. of Colorado - Boulder

Scanning Early Aerial Photos for Collection Conservation and Access
Jenny Marie Johnson, Univ. of Illinois

Online Library Catalog for Cartographic Data: Collection, Conversion & Organization of Cataloging Records for a GIS-based Map Retrieval System
Lixin Yu, Florida State Univ.

Session H: Digital Resources
New Products for Visualizing Census Data Through a Cooperative Research and Development Agreement (CRADA) Between the Census Bureau and ESRI
Stephen Jones, Census Bureau

The Water Resources Atlas of Florida: From Idea to Reality
James R. Anderson, Jr., Florida State Univ.

The "Outline Map Home Page" and Related Virtual Cartography Resources
Paul S. Anderson, Illinois State Univ. & Paul B. Anderson

5:30 - 9:00 p.m.
Reception and Lecture
American Geographical Society Collection

From Township Plats to Bird's Eye Views: the Role of the Federal Government in Preserving Wisconsin's Cartographic Heritage
Ronald Grim, Library of Congress

FRIDAY, OCTOBER 9, 1998

8:00 a.m. - noon
Poster Session / Exhibits

8:30 a.m. - 10:00 a.m.

Session I: Technical Aspects of Map Construction
Selecting Appropriate Age Classes for Population Maps
Richard Lycan, Portland State Univ.

Automated Names Placement Software Development by the U.S. Census Bureau and Rutgers University
William Thompson, Census Bureau

Symbol Functionality and the Role of Selective Attention in Cartographic Design
Elisabeth S. Nelson, San Diego State Univ.

Session J: Planning for Quality Mapping
Census 2000 Data Access and Dissemination System: Improved Customer Service
Timothy Trainor, Census Bureau

About the Quality of Maps
Georg Gartner, Vienna Univ. of Technology

Making it Easy for Anybody to Make Good Thematic Maps
Charlie Frye, ESRI

10:30 a.m. - noon

Session K: Understanding Maps
Spatial Cognition of Small and Large-scale Spaces
Scott M. Freundschuh, Univ. of Minnesota - Duluth

Maps as Stories, Maps as Arguments
Steven R. Holloway, Univ. of Montana

Leila Daw's Maps: Is This Art Cartography?
Ren Vasiliev, SUNY - Genesco

Session L: Panel Discussion
Interactive Cartography: Current & Future Research Paths
Rex Cammack (Organizer), Southwest Missouri State Univ.; Brandon S. Plewe, Brigham Young Univ.; Charles P. Rader, Univ. of Wisconsin-River Falls; Michael P. Peterson, Univ. of Nebraska-Omaha; Jeremy Crampton, George Mason Univ.; Keith W. Rice, Univ. of Wisconsin-Stevens Point

noon - 1:30 p.m.
Lunch Break
Editorial Board Meeting, *Cartographic Perspectives*

1:30 - 3:00 p.m.

Session M: Data Challenges

Mapping Custer's Last Stand
Paul D. McDermott, Montgomery College

Volunteers, Street Tree Inventory, and GIS
Joseph Poracsky, Portland State Univ.

Integrating Disparate Data Sets in an Environmental GIS
Mark Wiljanen, SUNY - New Paltz

Session N: Visualization

Existing and Proposed Sources of Data for On-Board Databases toSupport Aircraft Synthetic Vision Systems
Ronald M. Bolton, National Oceanic & Atmospheric Administration

Visualizing Properties of Spatial and Temporal Periodicity in Geographic Data
Robert Edsall, Mark Harrower, and Jeremy L. Mennis, Pennsylvania State Univ.

Three-dimensional Visualization as a Cartographic Problem
Cidney J. Freitag, U.S. Geological Survey

3:30 - 5:30 p.m.
NACIS Board Meeting

6:00 - 10:00 p.m.
Annual NACIS Banquet

SATURDAY, OCTOBER 10, 1998

WORKSHOPS
Held at the Univ. of Wisconsin - Milwaukee

8:30 a.m. - 10:00 a.m.

Using Freehand 8 and Map Publisher
Kathryn Thorne, Mansfield Univ.

8:30 a.m. - 4:30 p.m.

Multimedia, Mapping and the Web
Michael Peterson, Univ. of Nebraska - Omaha

10:30 a.m. - noon

Creating, Displaying and Manipulating Digital Elevation Models
Janet Mersey, Univ. of Guelph, and Andrew A. Millward, Univ. of Waterloo

1:30 p.m. - 4:30 p.m.

QuickTime VR for Cartographers
Tom Patterson, National Park Service

SATURDAY AFTERNOON ACTIVITIES
Brewery Tour (1:15 - 3:30 p.m.)
Self-guided Walking Tour of Downtown Milwaukee

SATURDAY EVENING EVENT
6:30 p.m. - 10:00 p.m.
Night at Comedy Sportz

submissions

The editors of *Cartographic Perspectives* welcome manuscript submissions. Please follow these guidelines.

FEATURED PAPERS

Each issue of *Cartographic Perspectives* includes featured papers, which are refereed articles reporting original work of interest to NACIS's diverse membership. Papers ranging from theoretical to applied topics are welcome. Prospective authors are encouraged to submit manuscripts to the Editor. Papers may also be solicited by the Editor from presenters at the annual meeting and from other sources. Ideas for special issues on a single topic are also encouraged. Papers should be prepared exclusively for publication in *CP*, with no major portion previously published elsewhere. All contributions will be reviewed by the Editorial Board, whose members will advise the Editor as to whether a manuscript is appropriate for publication. Final publication decisions rest with the Editor, who reserves the right to make editorial changes to ensure clarity and consistency of style.

REVIEWS

The Book Review Editor, Joanne M. Perry, will solicit reviews of books and atlases. Publications are to be sent directly to Joanne M. Perry, Map Librarian, The Valley Library - 121, Oregon State University, Corvallis, Oregon 97331-4501 or perryj@ccmail.orst.edu. Reviews of maps and mapping software will be solicited by the Editor of *CP*. Prospective reviewers are invited to contact the Editor directly at geolib@unomaha.edu.

CARTOGRAPHIC TECHNIQUES

Articles that concern all aspects of map design and production are solicited by the Cartographic Techniques Editor, James E. Meacham, Director, InfoGraphics Lab, Department of Geography, University of Oregon, Eugene, OR 97403-1251 or jmeacham@oregon.uoregon.edu.

MAP LIBRARY BULLETIN BOARD

The Map Library Bulletin Board Editor, Melissa Lamont, solicits reports on the current status of map libraries. Submissions are to be sent directly to Melissa Lamont, Data Library, McLean Laboratory, Woods Hole Oceanographic Institution, WHOI Mail Stop 8, Woods Hole, MA 02543 or mlamont@whoi.edu.

TECHNICAL GUIDELINES FOR SUBMISSION

Literature cited should conform to the Chicago Manual of Style, 14th ed., University of Chicago Press, Chapter 16, style "B." Examples of the correct citation form appear in the feature articles of this issue. Authors of Featured Papers should submit four printed copies of their manuscript for review directly to Michael Peterson, Editor of *Cartographic Perspectives*, Department of Geography / Geology, University of Nebraska at Omaha, Omaha, Nebraska 68182. Manuscripts are reviewed by three referees. The Editor will contact all authors to notify them if their paper has been accepted for publication and if revisions are necessary prior to publication. The following technical guidelines should be followed for all accepted manuscripts (these guidelines also apply to book, map, and software reviews).

Material should be submitted in digital form on 3.5" diskettes. Please send a paper copy along with the disk. Text documents processed with Macintosh or Windows software, such as *WordPerfect or MS Word*, are preferred.

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NACIS membership form

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(NACIS) was founded in 1980 in response to the need for a multidisciplinary organization to facilitate communication in the map information community. Principal objectives of NACIS are:

§ to promote communication, coordination, and cooperation among the producers, disseminators, curators, and users of cartographic information;

§ to support and coordinate activities with other professional organizations and institutions involved with cartographic information;

§ to improve the use of cartographic materials through education and to promote graphicacy;

§ to promote and coordinate the acquisition, preservation, and automated retrieval of all types of cartographic material;

§ to influence government policy on cartographic information.

NACIS is a professional society open to specialists from private, academic, and government organizations throughout North America. The society provides an opportunity for Map Makers, Map Keepers, Map Users, Map Educators, and Map Distributors to exchange ideas, coordinate activities, and improve map materials and map use. *Cartographic Perspectives*, the organization's Journal, provides a mechanism to facilitate timely dissemination of cartographic information to this diverse constituency. It includes solicited feature articles, synopses of articles appearing in obscure or non-cartographic publications, software reviews, news features, reports (conferences, map exhibits, new map series, government policy, new degree programs, etc.), and listings of published maps and atlases, new computer software, and software reviews.

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