cartographic perspectives

journal of the
North American Cartographic Information Society
Number 55, Fall 2006

journal of the North American Cartographic Information Society

cartographic perspectives

Number 55, Fall 2006

in this issue

(continued on page 3)

Letter from the Editor

Dear Members of NACIS,

It is hard to believe that I am writing my last editorial column for *Cartographic Perspectives*. As you all know, *CP* is preparing for a transition to a new editor, and a new editorial board. Starting with *CP56*, the first issue for 2007, John Krygier will begin his three-year term as editor of *CP*. John assumes editorship of a journal that is doing quite well…a journal that has grown and prospered over the past 6 years…a journal that has grown both in terms of content and prestige. Some of the changes over the past 6 years have involved the look and feel of the journal, the quality of content, the general accessibility to published articles, and the review process of manuscripts. Below I've highlighted the many changes *CP* has benefited from:

Article rejection rate hovering around 65%;
Article submission rates that have more than doubled;

(*continued on page 3*)

NACIS WEB SITE
www.nacis.org

Editor
Scott M. Freundschuh
Department of Geography
University of Minnesota, Duluth
329 Cina Hall
Duluth, MN 55812
(218) 726-6226
fax: (218) 726-6386
sfreunds@d.umn.edu

cartographic perspectives

journal of the
North American Cartographic Information Society

ISSN 1048-9085
Cartographic Perspectives is published triannually

Assistant Editor
James R. Anderson, Jr.
FREAC
Florida State University
Tallahassee, FL 32306-2641
(850) 644-2883
fax: (850) 644-7360
janderson@admin.fsu.edu

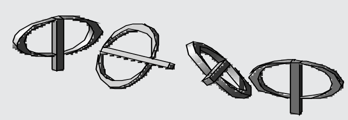
Cartographic Techniques Editor
Charlie Frye
ESRI
380 New York Street
Redlands, CA 92373
(909) 793-2853
cfrye@esri.com

Cartographic Collections Editor
Chris Mixon
Auburn University Libraries
231 Mell Street
Auburn University
Auburn, AL 36849-5606
(334) 844-1738
mixonch@auburn.edu

Reviews Editor
Mark Denil
Conservation International
1919 M Street, NW, Suite 600
Washington, DC 20036
(202) 912-1433
M.Denil@conservation.org

Opinion Column Editor
Scott Freundschuh
Department of Geography
University of Minnesota, Duluth
329 Cina Hall
Duluth, MN 55812
(218) 726-6226
sfreunds@d.umn.edu

about the cover



The cover image was created by Scott Freundschuh. The colors in the CP logo represent the diversity in NACIS.

(*letter from editor continued*)

A review process that takes about 2 to 3 months;
Indexed in GEOBASE (Elsevier);
Full text index with EBSCO;
High-quality color in every issue;
Official copyright with the library of congress;
Engaging cover art;
Creation of Visual Fields column;
And, published ON TIME.

There are a number of people that I must thank…people who have had their hand in the publication of *CP*. First off, it has been my pleasure to work with the following section editors over the past six years:

Melissa Lamont as Map Library Bulletin Board Editor *2001-2003*
Matthew McGranaghan as Essay Editor *2001-2003*
Jeremy Crampton as Online Mapping Editor *2001-2003*
Ren Vasiliev as Book Review Editor *2001-2005*
Mark Denil as Book Review Editor, morphed to Reviews Editor *2006*
Chris Mixon as Map Library Bulletin Board Editor, morphed to Collections Editor *2004-2006*
Charlie Frye as Cartographic Techniques Editor *2001-2006*

It has also been my pleasure to work with the following members of the editorial board:

Gary Allen 2001-2003
Aileen Buckley 2001-2003
Jeremy Crampton 2001-2003
Sara Fabrikant 2001-2006
Ken Foote 2001-2006
Pat Gilmartin 2001-2006
Mike Hermann 2004-2006
John Krygier 2001-2006
Michael Leitner 2004-2006
Robert Lloyd 2001-2006
Matthew McGranaghan 2001-2003
Janet Mersey 2001-2006
Elisabeth Nelson 2001-2006
Margaret Pearce 2001-2006
Michael Peterson 2001-2003
Nadine Schuurman 2004-2006
Erik Steiner 2004-2006
Ren Vasiliev 2001-2006
Carolyn Weiss 2001-2003
Denis Wood 2004-2006

Finally, and most importantly really, I want to thank Jim Anderson, the assistant editor. Jim's title provides little indication of the significant amount of work he does on behalf of *CP*. If there were to be a more descriptive name for his position, I would suggest something like:

Co-Editing—Designer—Layer-outer—Graphicsfixerupper—Problemsolver—Underappreciated—Maestro.

That about captures it, though I had to take liberty with the English language to get there. I suppose I could have just called Jim *CP*'s MVP (most valuable player), but where's the fun in that?

It has been an honor to serve as editor of CP for the past six years. The personal and professional growth, have been immense. I have learned much, read even more, and tripped up a couple of times. I have learned the healing power of, "my mistake…sorry." I have learned the power of praise and recognition, and to give it openly and freely. I have also learned to accept praise gracefully. I have sharpened my diplomacy skills, and have learned that a phone call is much more appreciated than an impersonal email. I have a deeper understanding of the diversity of cartographic research, and in peoples' ideas, opinions and beliefs. I have learned to listen…to be quiet (that was a tough one)…to consensus build…and to understand my limitations. I have learned that tough decisions are not fun. I have learned that I have many intelligent, fascinating, engaging and humorous colleagues out there who are doing awesome research. I also know who the bozos are. Lastly, I have learned that with the right group of people, a journal can accomplish just about anything.

Thanks for a wonderful 6 years.

As always, I welcome your comments and suggestions…but send them to John Krygier from now on!!

Warmest Regards,

Scott Freundschuh, Editor

in this issue

(continued from page 1)

Opinion Column
Denis Wood's article "Map Art"

Mark Denil
Chief Cartographer
Conservation International
mdenil@conservation.org

Dear Editor:

There is much of interest in issue 53 of CP, and some problematic bits as well, as befits a broad and engaging subject. My particular interest in writing concerns certain issues raised by Denis Wood's article, "Map Art". Wood seems at first to be mounting a real and badly needed challenge to the way cartography is generally conceived, but his pitch is queered by some unresolved problems. The problems lie in part with the issues themselves and in part with his manner of approaching them.

We are all quite used to problems of this nature being characterized, in the cartographic literature, dichotomously: art and science being the most typical division. Dichotomies seem to be a clear, neat, and distinct means of definition: one or the other, good or bad, with us or with the terrorists, but we know that a dichotomy can be posited without its being appropriate. Dichotomies sit at the heart of most belief systems, and their operation has been well studied. We know that in establishing oppositional binaries, one term is privileged and the other subordinated: living – dead, us – them. The decide-ability of differentiation is what makes a dichotomous system work, which is to say that one must be able to evaluate a novelty and decide its classification unambiguously.

In the course of "Map Art", Denis Wood sets up an pair of opposed categories: The art-map and the normative map. He constructs his opposition on what he would like to convince us is a clear differentiation between physical works categorizable as one or the other, and he bases his differentiation on the normative. Clearly, Mr. Wood would like us to accept this unexamined normative map as an unproblematic yardstick. The normative seems to be defined by Mr. Wood using some combination of map issuer, drawing and lettering style, and map furniture; at least that is how he goes about identifying the 1929 Surrealist map [p.9] as not-normative (and therefore, as art-map).

(As an aside, dear Editor, I finally noticed that there are two descriptions of that map: Walbergs's and Wood's. The quotation and comment are run together in manner that suggests their conflation. Something of a decide-ability problem in the text itself, eh?)

Just what exactly it is about map furniture, or which particular bit of it, Wood thinks rescues the art from the normative is less than clear. For instance, on the Surrealist map, he finds no "grid" but apparently the equator (which he does see) is a privileged part of the graticule. In the end, I cannot begin to guess exactly what, for Wood, normative practice might be. Decide-ability is already breaking down.

When we examine Wood's discussion of the art-map, however, we come up with a more concrete element for differentiation: the issue of the mask. Even with this element, however, the test is still negative: only Wood's normative map wears a mask..

What is this mask? This, at least, is uncontroversial: the mask refers to the signs employed by a map to connote trustworthiness. I have called this mask the ethos, or ethical appeal of the map [Denil 2003], and he and I seem to agree that all maps must necessarily make this appeal. Curiously, Wood then equates trustworthiness (the foundational legitimizing need of the map) with "objectivity" (one possible manifestation of legitimacy for some particular user or users); an identification which might or might not ever be true.

The main point, however, is that all maps must necessarily wear what Wood terms a mask. Fair enough, but we learn, however, that Wood identifies some *privileged* maps that can set aside or never don a mask. These are the art-maps. Clearly, this is an extraordinary and extremely problematic assertion, and leads us to a choice. Either art-maps are not maps (because they do not wear the mask) or they are specially privileged maps (since they get to parade around without masks). Neither is an acceptable alternative.

We know that the mask a map wears is not only *always* present (and always *attempts* to remain invisible); but that it is a foundational part of the article's very existence as a map. Wood very clearly sees the masks that many other observers accept as the map's face, (indeed, he has performed yeomen service over the years exposing the masks all maps wear) yet he now wants us to believe that somehow the mask can be laid aside in some special, privileged case.

It seems obvious that what is happening is that these (art-)map makers are rendering their masks transparent *in Denis Wood's sight* so that Denis *thinks the mask has gone away*. Here we see where the problematic definition of the normative contaminates the dichotomy. It would appear that in the absence of the 'normative' indicators (map furniture, a powerful map issuer, professional penmanship, whatever) Wood can no longer identify the mask. He doesn't seem to even suspect that the mask may be *embodied by the absence of the very indicators he identifies*!

Indeed, it is the very mask itself, and the power that the mask confers by its persuasiveness of legitimacy, that makes the map such an attractive and engaging vehicle for art practice. The map, by virtue of its cache of believability, can appeal in a naturalized manner to massively disparate audiences. Map-art neither employs nor needs special dispensations or powers to do this.

There is a clear identity and unity between cartographic and art practice; on a conceptual level they are identical even when they vary superficially on the level of craft, use, or audience. One must recognize that Debord, the Harrisons, Duchamp, and the Surrealists make (or made) maps, and they make them the *same way* that I as a professional cartographer make maps. *They* mold, stretch, adapt, and subvert the boundaries, contents, and the contexts of what maps are and how they function, all for reasons of their own, and *so do I*. We all of us make maps that are judged each and every time they are considered for use. What is seen on or read into a map is up to the user, and *interpretation* (what the user wants/expects/can recognize) constrains the *facts discovered*: not the other way around.

We can see that the dichotomy Wood sets up is inappropriate for an understanding of this issue. The dichotomy of normative and not-normative (art-map) is in fact a relatively fragile and deeply flawed working model and does not reflect anything essential. He is not challenging the underlying foundational mythology, but simply proposing an inversion of an ill-defined, questionably valid, conventional hierarchy. While this may or may not make a valid political program, it is not, at least as presented, sound theory.

There is no normative - art-map dichotomy: only unity. Only use defines the map. As the great Pogo once said: "We have met the Enemy, and He is Us".

REFERENCE

Denil, M., "Cartographic Design: Rhetoric and Persuasion" *Cartographic Perspectives*, 45, Spring 2003. pp 8-62

Opinion Column
Reaction to Mark Denil

Ren Vasiliev
Department of Geography
State University of
New York Geneseo
vasiliev@geneseo.edu

Dear Editor,

Here are my thoughts on Mark Denil's critique of Denis Wood's "Map Art." Use what you want, however you want to (can you believe I'm giving you this kind of latitude?!).

Two things:

First, Denil is right that Wood sets up a false dichotomy between normative maps and art maps. I don't remember if Wood defines a map. Let's use this definition: A map is a graphic representation of spatial relations (or relationships in/across/through space). If we can agree that something along the above is a true definition of a map, then anything that does so (represent graphically relationships in/across/through space)—whether recognizable as normative or not—is a map.

Second, Denil is mistaken in saying that "only use defines the map" (one of his last sentences). Use is often a good indicator of the quality of the map, but not as the defining indicator. If in what Wood calls art-maps (as in the maps that I looked at when I was discussing Maps As/In Art) the creator/artist makes things that s/he says are maps because they tell a spatial story (as Leila Daw's maps do), then they are maps. It does not matter if anyone can USE the thing as a map. If it represents those spatial relations that the creator wants it to represent, then it is a map. This view, however, also illustrates Denil's contentions that there is no normative/art-map dichotomy.

And then what's with the Pogo quote?! As it stands, it has nothing to do with anything about maps. It would mean more if it were paraphrased as: "We have met the enemy of cartography, and it is Denis Wood."

A Day With Norman J. W. Thrower

Judith Tyner
Department of Geography
California State University Long Beach
jztyner@csulb.edu

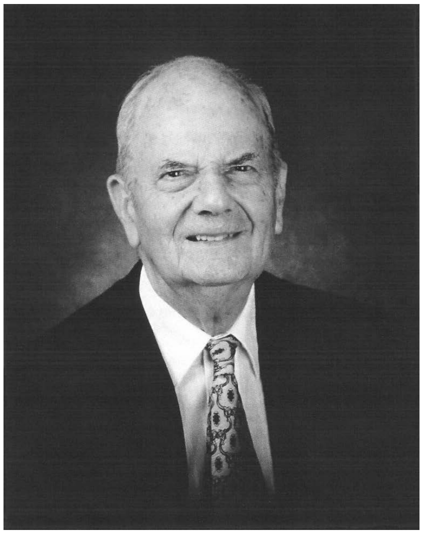


Figure 1. Norman J.W. Thrower, Courtesy Norman J.W. Thrower. *(see page 76 for color version)*

Author's note:
On June 9, 2006, I spent a day with Norman Thrower with the intent of interviewing him for an article tentatively titled, an Interview with Norman Thrower. We met in the UCLA Geography Department library, a congenial setting for Norman, surrounded by books, globes and other accouterments of academia. I was armed with a tape recorder and a list of apposite questions. However, as anyone who knows Norman Thrower well can attest, he is a raconteur and each question brought an answer and a story; I quickly realized that a simple Q&A article would not reveal nearly as much about Norman the cartographer, the scholar, the teacher, and the man, as a narrative that included the byways, detours, and back roads. Our "interview" lasted four hours including lunch at the faculty club and a return to the library. Here then, rearranged for chronology, interwoven with snippets from previous conversations and Norman's autobiography, is "A Day with Norman J.W. Thrower."

In the 1950s several important cartographers formed the first cadre of academic cartographers. Among these were Arthur Robinson, George Jenks, and John Sherman in the United States, and Eduard Imhof in Switzerland. Another who received wartime training in cartography is Norman Thrower who is better known for his work in history of cartography and exploration than research in production cartography, although he was involved in both in a career that is now in its seventh decade.

". . . a career that is now in its seventh decade."

WWII

Norman was born in Crowthorne, England, a Victorian "new town" in the Thames Valley in 1919. At an early age he showed a talent for art and won several prizes for his work; he attended art school and took some art classes at Reading University from prominent artists who lived in the Thames Valley including Robert Gibbings, a well-known graphic artist of the time. Norman says he would probably have become a commercial artist if WWII hadn't interfered. However, at age 21 he joined the British Army and was placed in an artillery regiment. On December 7, 1941 he was on a ship off the Cape of Good Hope headed for duty in North Africa. The bombing of Pearl Harbor resulted in the ship being diverted to India where his regiment would be decimated in the bloody campaign in Burma. Norman believes his ability to draw saved his life. During his artillery training he took and passed an examination for the Survey of India and was transferred from artillery to engineers for cartographic training. Instead of going to Burma, he was sent to the summer capital of the British Raj, Simla in the Himalayas.

"Norman believes his ability to draw saved his life."

In the early days of the war, the Survey of India was still creating topographic maps by field surveys and printing them from flat lithographic stones. At about the time of Norman's arrival, photogrammetry was introduced to the Survey and printing was done by photo-lithography. Norman was trained in this technology and although the training was to prepare him to serve in field mapping units at the front, he was instead sent to Delhi and later Murree, now in Pakistan, where he was employed in mapping and instructional projects. At the end of the war, Norman returned to England with four years of cartography and photogrammetry behind him and joined the Directorate of Colonial Surveys (later the Directorate of Overseas Surveys) located in Bushy Park near London where he worked on photogrammetric surveys of Gambia and Jamaica.

"... the Survey of India was still creating topographic maps ... from flat lithographic stones."

It was in England that he met his wife Betty, a nurse, who was an officer in the United States Women's Army Nurse Corps. Betty was a remarkable person in her own right; she had a BS in biology and an MS in nursing, unusual for a woman at that time. Although an American, Betty was the daughter of a medical doctor who was a medical missionary and spent her first fifteen years in India. They married in England and remained devoted partners for over 50 years until Betty's death. Norman credits Betty's support and good advice for many of his successes.

University of Virginia

Norman applied for a cartographic position at the recently founded Geographical Institute at the University of Virginia 1947. His work with the Institute gave him degree credit for certain projects and also allowed him to meet and work with a number of prominent cartographers of the time. Among those were Count Geza Teleki (son of Count Paul Teleki, former Prime Minister of Hungary and also a cartographer); Armin K. Lobeck, noted for his work on block diagrams and physiographic diagrams; and Richard Edes Harrison famous for his wartime maps in *Fortune* Magazine.

Figure 2. Norman Thrower in raconteur mode, June 9, 2006, Photo by Gerald E. Tyner. *(see page 76 for color version)*

The most important influence on Norman during his time at the University of Virginia was Erwin Raisz who left Harvard University when that Geography Department was eliminated. Norman considers him the greatest figure in academic cartography at that time. While at Virginia Norman also took classes in art including History of Art from John Canaday, a well known art critic who wrote for the New York Times. Norman received an honors BA in Geography and wrote his BA thesis on block diagrams. In later years, students in his Advanced Cartography classes, struggling to create their own block diagrams with T-square, triangle and other tools, would watch in awe as Norman would create magnificent renderings on the blackboard with only a piece of chalk. Figure 3 is an

"The most important influence . . . at the University of Virginia was Erwin Raisz . . ."

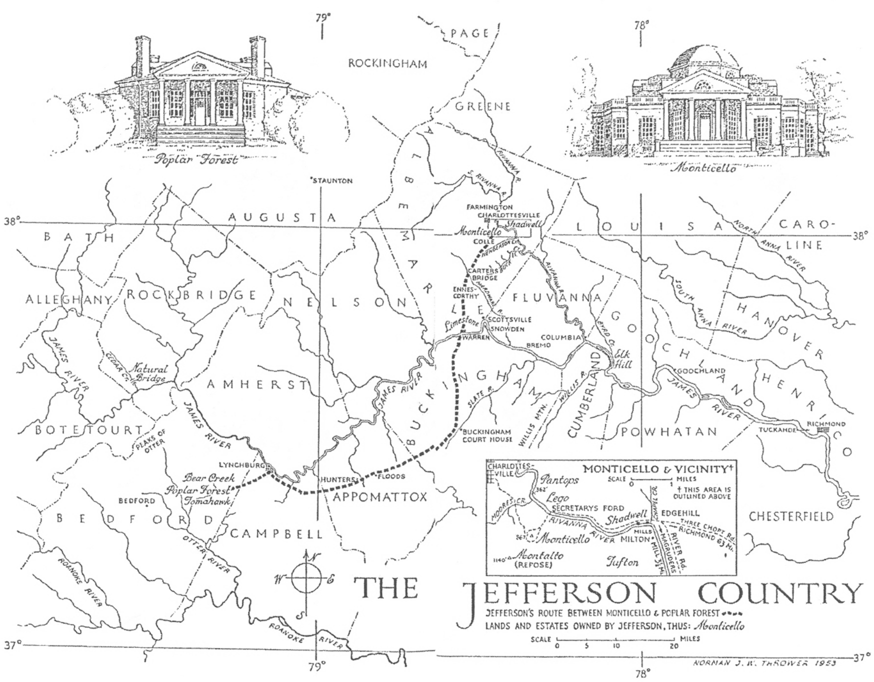


Figure 3. Jefferson Country, Courtesy Norman J.W. Thrower.

example of Norman's cartography during the Virginia years and demonstrates his artistic ability as well.

While at Virginia, Norman and Betty's first two daughters, Page and Anne were born and the young family lived in temporary student housing. A third daughter, Mary, was born after Norman and Betty arrived at UCLA.

University of Wisconsin

In 1953, Norman and his family moved to Madison, Wisconsin where he had been offered a 4-year graduate fellowship to work with Arthur Robinson, then an upcoming young professor. Norman was in Robinson's first group of Ph.Ds in the 1950s.

"Robinson was . . . a scientist, a deep thinker, and a decision maker."

While Norman worked with many prominent cartographers including Erwin Raisz, he considers Robinson to be the biggest influence in his career. Robinson was, he said, a scientist, a deep thinker, and a decision maker. Robbie let Norman loose on projects and let him follow his own methods. He remembers Robbie advising him "This [the dissertation] is just an exercise, you don't stop here, you go on."

". . . knew he would not be credited for it in the book so he worked his name into the hachures. "

While a graduate student at Madison, Norman worked on a variety of projects, some quite well known. Robinson had received a military contract to do a landform representation at topographic scale. Norman and Arthur based their work on that of Kitiro Tanaka and created a method called 'traces of parallel inclined planes' that creates a planimetrically correct, but artistic rendering of the landscape at scales of 1:62,500 and larger. Two joint articles resulted from this work (Robinson, 1957; 1969). Figure 4 is an example of the technique, drawn by Norman for the report.

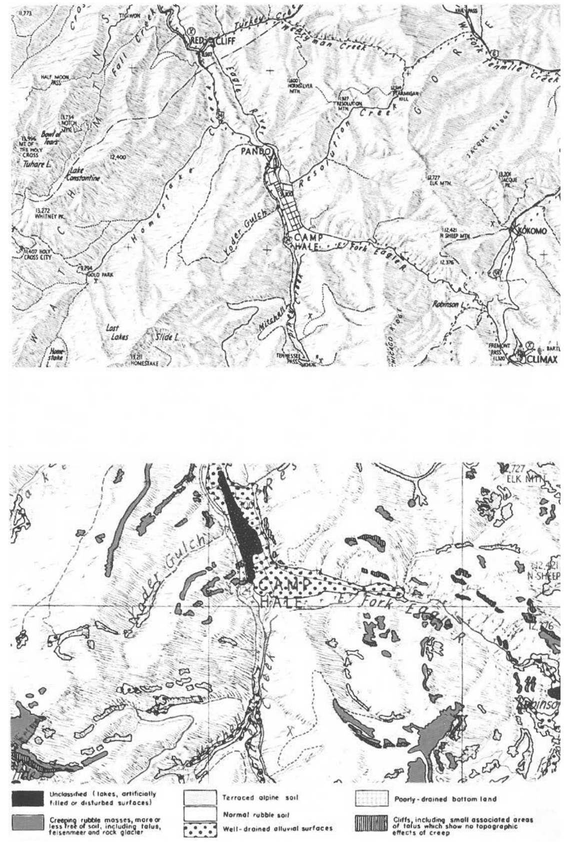


Figure 4. Camp Hale maps produced using parallel inclined traces for the United States Army, Courtesy Norman J.W. Thrower. *(see page 76 for color version)*

Figure 5 is a less well-known example of Thrower's cartography. Graduate students with the ability to draw maps in those "hand drawing days" were frequently employed making maps for faculty research and even dissertations by fellow students. Norman was asked to create this map for a general geography text, but knew he would not be credited for it in the book so he worked his name into the hachures (Finch, 1957). Later editions of the book give him credit in the caption.

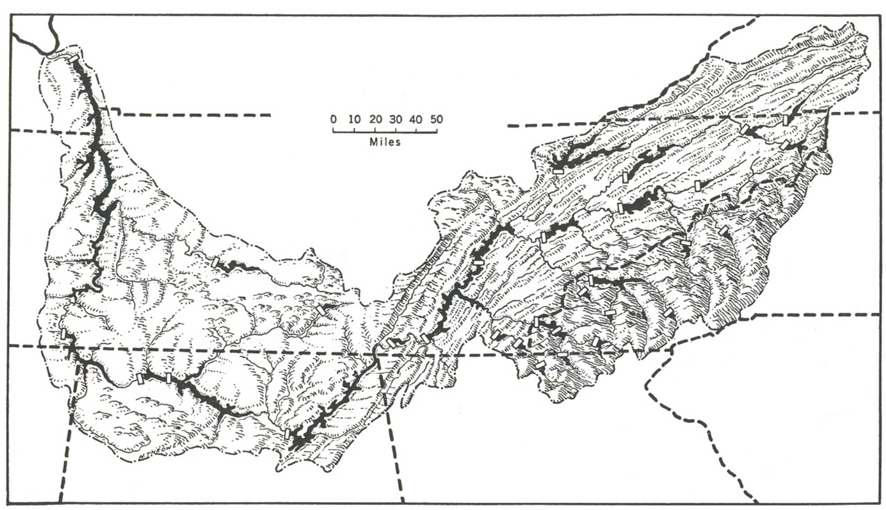


Figure 5. Tennessee Valley Map with "N Thrower" hidden in the terrain. In Finch, V. et al*, 1957.* Elements of Geography*, New York: McGraw-Hill, 406.* Reproduced with permission of McGraw-Hill Publishing Company.

Norman's dissertation was on cadastral mapping. When he first attempted to publish an article from his dissertation, the editor of a major geographical journal rejected the subject as of little interest and believed that the surveys were not accurate. His dissertation was later published by the Association of American Geographers as AAG Monograph number 4 (Thrower, 1966). Norman says he is still proudest of his work on American cadastral mapping, which he considers a much-neglected area. He notes that most of the work in this area has been done by researchers from outside the United States and speculates that Americans, having grown up with the PLSS simply don't find it unusual or worthy of study.

UCLA

In 1956, before his dissertation was complete, Norman met the Chair of the UCLA Geography Department, Henry Bruman, at a professional meeting, and Norman was persuaded to go to UCLA. UCLA enhanced the offer by providing the highest rank possible for a faculty member without a Ph.D.: Acting Assistant Professor, step 2. Norman came to UCLA in 1957, was quickly put on the regular track, and rose through the ranks. He eventually reached the highest rank possible at the time, Professor step eight, which is given only to those who have made significant contributions to their field.

"Americans, having grown up with the PLSS simply don't find it unusual . . ."

In a special issue of *Cartography and Geographic Information Systems* (McMaster, 1991), UCLA was not a featured program. However, for a short period during the late 1950s and into early 70s the program had a 'golden age'. Norman and Richard Dahlberg, both trained by Robinson, joined the faculty, and Henry Leppard, who had retired from teaching, was producing the Goode's series of base maps in the Department. Students were offered a wide range of classes (which was novel for that time period), including beginning, intermediate and advanced cartography, remote sensing, and a variety of individual study classes. Dahlberg, before leaving for Syracuse and Northern Illinois, taught the beginning and intermediate classes; Norman taught the advanced class, which included terrain representation and the history of cartography. He also introduced the remote sensing class (originally called *Air Photo Interpretation*). In later years, he introduced a class on geographical exploration. As the resident Brit, he often taught the Geography of Europe.

Norman describes UCLA as a "congenial place" for him. A major draw for his research interests were the Special Collections Library on campus, and the William Andrews Clark Memorial Library, a 'treasure-house library' owned by UCLA that specializes in 16th-18th century works. Also nearby are the Huntington Library and the Getty Museum.

"Although [he] describes himself as now 'unemployable in cartography' . . . he made many contributions in applied areas of the field."

Although Norman describes himself as now "unemployable in cartography" because he has not been involved with computers and GIS, he made many contributions in applied areas of the field. In his early years at UCLA he wrote two articles on "Animated Cartography,"(Thrower, 1959; 1961) which were some of the first articles on the subject, and are still widely cited.

He was the third map supplement editor for the *Annals* of the Association of American Geographers after Erwin Raisz and Richard Edes Harrison, and in that role he authored two and edited five poster size maps. He also created the first map supplement under the editorship of Harrison, a landform study of Cyprus (Figure 6), which is a tour de force in cartography. The sheet is full color, and consists of six different maps showing terrain types with hand shaded relief, hypsometry, general and reference maps, and text. To those who came of cartographic age after computers, this map is worthy of study. The Cyprus map was his "swan song of

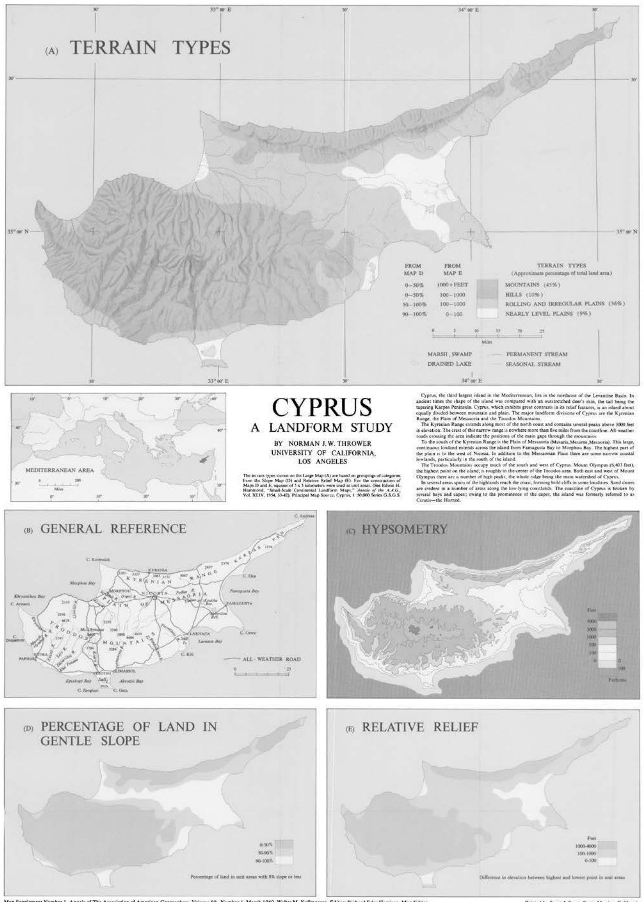


Figure 6. Annals Map Supplement # 1, vol. 50, no. 1, March 1960. Reproduced with permission of Annals of the Association of American Geographers, Blackwell Publishing. *(see page 76 for color version)*

". . . in order to be promoted, 'words, not maps, were what counted' . . ."

". . . history of cartography is where the histories of art and science come together."

production cartography," although he did design maps which others drew. In 1950s and 1960s academia, the research involved in creating an original map was not considered 'real research' or 'real geography,' and Norman realized that in order to be promoted, "words, not maps, were what counted;" written productions were the only path. This was not an onerous task for Norman, but rather allowed him to pursue his scholarly interests.

When Norman was a Ph.D. student at Madison he was required to have a Ph.D. minor. Not surprisingly, his was history of science. To him, history of cartography is where the histories of art and science come together. It was also at Madison that Norman serendipitously came across a map that led him to one of his major research subjects, Edmond Halley. While browsing in the library, he found a copy of Halley's Atlantic chart in a journal of geophysics. This chart, published in 1701, shows lines of equal magnetic declination (isogones) and was the first published use of an isometric line. Norman feels that this chart and Halley's other charts had been overlooked by cartographers, and Halley has remained a continuing thread of Norman's research. (In 1963 Norman received a Guggenheim Fellowship to continue his research on Halley in England). He considers his two-volume work *The Three Voyages of Edmond Halley in the 'Paramore', 1698-1701* (Thrower, 1980) to be his major achievement.

If, as it has been said, history is about chaps and geography is about maps, then we can describe Norman's major research projects in history of cartography as about chaps who made (or used) maps. In addition to his work on Halley, he also wrote about Prince Henry the Navigator, Samuel Pepys, William H. Emory, Piri Reis, Sir Francis Drake, and in recent years doctors and maps.

At UCLA, for a period of over fifteen years beginning in 1975, Norman had a reduced teaching load while he headed various special projects. In 1973, he was appointed by Governor Ronald Reagan to the Sir Francis Drake Commission and in 1975 assumed the Presidency of the California branch of this British-California Commission to celebrate the 400th anniversary of Sir Francis Drake's circumnavigation of the world. For Norman, personally, this was a great experience because he got to meet Queen Elizabeth II and Prince Phillip, and the Prime Minister, Edward Heath. As Norman describes the event, he "got to shake the Queen's glove." UCLA and geography graduate students also benefited from the Drake celebration. Numerous events were held on campus, at the Clark Library, and at the Huntington Library with lectures by a number of visiting scholars on Drake and the period. Norman's students were invited to attend all of the lectures and to meet the scholars. A summer institute was held at the Clark Library where a half dozen post-doctoral 'Drake Fellows' did research on the period, and met in seminars and over lunch and coffee with the visiting scholars including David Woodward, Helen Wallis, Coolie Verner, and Jeanette Black.

When the Drake Commission reached the end of its charter in 1980, Norman was appointed William Andrews Clark Memorial Library Professor, and then Director of the Clark Library from 1981-1987. Among other events during that period was an international conference on Newton and Halley, and again Norman was able to bring visiting scholars in the history of cartography to the University. Two books were a direct outcome of Norman's tenure at the Clark Memorial Library: *The Complete Plattmaker* (1978) and *Standing on the Shoulders of Giants* (1990), both of which he edited and for which he wrote chapters.

Norman's last formal position at UCLA was as director of the Columbus Quincentenary Programs, 1989-93. Once again, he was able to bring internationally known scholars to the campus and met another Queen. This time, he had an audience with Queen Sofia of Spain at her 'small' palace outside of Madrid. He was also greatly honored to receive the Orden del Mérito Civil from King Juan Carlos I, which is given in recognition of service to Spain.

Although he no longer produced maps himself, Norman Thrower was editor and/or cartographic advisor for a number of different maps and atlases. One of the best known of these projects was *Man's Domain, a Thematic Atlas of the World* (Thrower, 1968), which went into 3 editions and multiple printings. He also edited and supervised the cartography of the *Chile-California Mediterranean Scrub Atlas: A Comparative Analysis* (Thrower, 1977), which was a product of an International Biological Program. The U.S. biologists on this project came from universities that had no geography departments so Norman became "Mr. Cartography" for the project.

One of Norman's best known contributions is his brief history of the field *Maps and Civilization: Cartography in Culture and Society*, (1996) which was originally called *Maps and Man: an Examination of Cartography in Relation to Civilization* (1972). This work is unusual in that it carries history of cartography to the last decade of the twentieth century with GIS, planetary mapping, and animated cartography and ties trends in history to development of maps. Norman is pleased to point out that it has been translated into Spanish and Japanese.

"One of Norman's best known contributions is his brief history of the field Maps and Civilization: Cartography in Culture and Society . . ."

Norman is known for his energy and his wide range of interests and knowledge. While involved in teaching and research projects, Norman also found time to serve as President of the Society for the History of Discoveries, as an International Representative of the Hakluyt Society, and charter president of the California Map Society. He also served twenty years on the Board of the Guggenheim Foundation, and had the honor of recommending Arthur Robinson for a Fellowship in 1977. The Association of American Geographers presented him the Lifetime Achievement Honors award in 1998.

Reflections on the Field and on a Career

It is expected that one should ask the interviewee about the current state of the field and his opinions. History of cartography has gone in some new directions. In *Maps and Civilization*, Norman has a footnote commenting that many historians of mapping have never made a map and thus, are not familiar with the practical considerations of making a map. By the same token, he notes, practitioners are often so involved with technology that they are unaware of the broad scope of the field (1996, 261). Therefore, I asked what he felt about the new directions. He simply noted that the post-modern works are part of a growing corpus within the history of cartography and expand the field.

When asked about the advancements of technology related to cartographic production that make it easier for more people to make more maps, and specifically what has been lost, i.e. what critical skills are people not learning, his answer was short. "In a word, design." He is critical of the many poorly designed maps that are now produced. He notes that there is a lack of rigorous training in cartographic design. On the other hand, the drudgery has been taken out of map making. He also points out that the technology has made color less expensive. "Some maps cry out for color," and in the past, color was often rejected owing to costs.

Of course, I asked the requisite question, "is cartography dead?" He replied, "If so it had a very short life, since the term was only introduced in the mid-nineteenth century; but what's in a name. There will always be something under that umbrella. There is a need for [cartographic] display."

"There will always be something under that umbrella. There is a need for [cartographic] display."

When asked, what of his many activities had given him the greatest satisfaction, teaching, administration, or research, not surprisingly, he said research. He enjoys the creativity of writing and publishing, and finds it intellectually rewarding. He also felt he was able to reach more people and that there is permanence in the work. Norman continues with research and publishing; as a testament to his productivity, in 1999, the University of California presented him with the 1998-99 Constantine Panunzio Award for being the most productive Emeritus Professor of the system's nine campuses.

He does not feel he was an especially good teacher, but his former students would disagree with that assessment and, in fact, in 1991 he was given the Outstanding Mentor award by the National Council for Geographic Education. Three of his earliest Ph.D. students (John Estes, John Jensen, and Judith Tyner) presented papers in his honor, and it was pointed out that they might retire before Norman did. The students he supervised were not required to confine their interests to historical subjects, but wrote theses and dissertations on such topics as television news maps, remote sensing, and persuasive cartography. Like his mentor Robinson, Thrower turned his students loose on their projects, but gave guidance when it was needed and ensured that they wrote readable prose.

". . . gave [graduate students] guidance when it was needed and ensured that they wrote readable prose."

In any conversation with Norman, the question "what are you working on now?" comes up. Usually there are multiple projects. This day was no exception. Eight short pieces for two different encyclopedias are in press, and he is working on four articles for two volumes of the *History of Cartography*. These articles cover Edmond Halley in the eighteenth century and Erwin Raisz, Thematic Mapping, and Scientific Discovery and Exploration for the twentieth century. He would be presenting a conference paper in a couple of months on Doctors and Maps. There is also a work in press "Compass, Chart and Course: Ottoman Cartography in Context" that is the result of an invited paper at a Turkish symposium on the admiral/cartographer Piri Reis.

"You have one [project] on the drawing board, one being built, and one being launched."

Once as a young faculty member, I asked him how he managed to work on so many projects at the same time and he quoted a ship-building maxim: "You have one on the drawing board, one being built, and one being launched." It was an excellent piece of advice. For this interview, I asked, "What keeps you working, what drives you? After all you have been 'retired' for over 15 years." His answer was "The alternative is boredom, isn't it?"

Thank you Norman for a day of recollection that was anything but boring.

REFERENCES

Finch, V., *et al.*, 1957. *Elements of Geography*, New York: McGraw-Hill, 406.

McMaster, R.B., 1991. Special issue History of Academic Cartography, *Cartography and Geographic Information Systems*, 18:3.

Robinson, A.H. and Thrower, N.J.W., 1957. A New Method of Terrain Representation, *Geographical Review*, 47: 507-520.

________, 1969. On Surface Representation Using Traces of Parallel Inclined Planes, *Annals of the Association of American Geographers*, 59: 600-604.

Thrower, N.J.W. 2004. *From the Stone Age to the Electronic Age: The Saga of a Cartographer in the Twentieth Century and Beyond*, Occasional Paper No. 8, California Map Society.

________, 1959. “Animated Cartography” *Professional Geographer*, 11:6: 9-12.

________, 1961. “Animated Cartography in the United States” *International Yearbook of Cartography,* 1: 20-30.

________, 1966. *Original Survey and Land Subdivision: A Comparative Study of the Form and Effect of Contrasting Cadastral Surveys,* AAG Monograph no. 4, Chicago: Rand McNally and the Association of American Geographers.

________ (Ed.) 1968, 1970, 1974. *Man's Domain: A Thematic Atlas of the World: Mapping Man's Relationship with His Environment.* New York: McGraw-Hill.

________,1972. *Maps and Man: An Examination of Cartography in Relation to Culture and Civilization*, Englewood Cliffs, NJ: Prentice-Hall, Inc.

________, (Ed.) 1978. *The Compleat Plattmaker: Essays on Chart, Map, and Globe Making in England in the Seventeenth and Eighteenth Centuries,* Berkeley: University of California Press.

________, 1980. *The Three Voyages of Edmond Halley in the 'Paramore' 1698-1701,* Second Series, v. 156 text, v. 157 maps, London: Hakluyt Society.

________ (Ed.) 1990. *Standing on the Shoulders of Giants: A Longer View of Newton and Halley.* Berkeley: University of California Press.

________, 1996. *Maps and Civilization: Cartography in Culture and Society*, Chicago: University of Chicago Press.

Thrower, N.J.W. and Bradbury, D.E. (Eds.) 1977. *Chile-California Mediterranean Scrub Atlas: A Comparative Analysis*. Stroudsburg, PA: Dowden, Hutchinson and Ross, Inc. For the International Biological Program.

The Effectiveness of Interactive Maps in Secondary Historical Geography Education

Whitney Taylor
Orem, Utah
whitneytaylor@gmail.com

Brandon Plewe
Department of Geography
Brigham Young University
plewe@byu.edu

Social Studies, including history and geography, is a core part of most state curriculum standards for K-12 education, and for the most part is in need of improvement. Among the technological solutions that have been developed, interactive maps show promise in making the complexities of the social sciences (especially historical geography) more interesting to students, and easier to visualize and understand, without demanding significant investments by schools. A two-group experiment examined this potential for the 7th Grade Utah Studies curriculum. After completing an exercise to analyze possible historical and geographical causes of settlement patterns in Utah, students using interactive maps showed significantly better improvement between a pretest and post-test than students using paper maps. Although some of the test results were inconclusive and highlighted technological and resource obstacles to the widespread adoption of interactive mapping in the classroom, it has been shown to help students learn social studies in a deeper, more engaging manner.

Keywords: interactive cartography, web cartography, maps in education, social studies education, Utah history

INTRODUCTION

The social sciences do not enjoy a high status in today's U.S. classrooms. Indeed, geography, history, and other social sciences receive considerably less attention in classrooms than other subjects (Leming et al., 2003), at a time when it is increasingly more important for students to understand the world around them. Most U.S. students rate social studies as one of the least interesting and most irrelevant subjects in their coursework (Leming *et al*., 2003; Shaughnessy and Haladyna, 1985). According to Leming *et al*. (2003),

Not only is the level of public understanding of our history and cultural traditions alarmingly low, but the willingness of young people to participate in our common political life is also declining. Students rank social studies courses as one of their least liked subjects and social studies textbooks are largely superficial and vapid (i).

"Students rank social studies courses as one of their least liked subjects and social studies textbooks are largely superficial and vapid."

This shallow content may be difficult to understand, and geographic concepts may be so isolated (without context) that students fail to see the relevance of the subject to their lives (Tyson and Woodward, 1989). Social studies education has focused primarily on rote memorization of events and places, rather than focusing on using techniques that address distinct learning styles and higher-order thought processes. This focus likely contributes to the negative attitudes children often express about the subject (Coyle *et al*., 1996; Shaughnessy and Haladyna, 1985).

The typical social studies curriculum standard dictates the teaching of both geography and history, for good reason. Our past is a tapestry of

Initial submission, January 3, 2006; revised submission, March 30, 2006; final acceptance, April 12, 2006

interwoven spatio-temporal patterns and processes. A true understanding of history requires geographical knowledge, and vice versa. However, it can be difficult for students to learn and appreciate the wonders of historical geography using traditional educational techniques (textbooks, lectures, worksheets, etc.) because of necessity these texts tend to separate history education and geography education. Social studies classes have a tendency (often due to the educational background of the teacher) to focus on history with only passing references to geography, rather than being integrated (Gregg and Leinhardt, 1993).

Because of the aforementioned shortcomings of social studies education, there is good reason to develop new ways of teaching that would enhance the subject and excite students**.** New teaching tools can have a profound impact in the classroom, especially if they are focused directly on the most significant problems in current education. Subjects that are difficult to teach using the traditional textbook method benefit from additional teaching resources that enhance the learning process. This article investigates the use of one of these tools, the interactive map, that may help in learning social science concepts.

"Subjects that are difficult to teach using the traditional textbook method benefit from additional teaching resources . . ."

Potential Solutions

Over the past several decades, many techniques have been developed to enhance K-12 education. In particular, four technological solutions have a particularly high potential for success in historical geography: paper maps, interactive media, geographic information systems (GIS), and interactive maps.

Paper Maps, the oldest of the possible solutions, enhances social studies learning when the subject is spatial in nature. Maps have been used in education for many years. Although much of the research into maps and education has focused on the development of map reading skills for their own sake (e.g., Blaut and Stea, 1971; Boardman, 1989; Freundschuh, 1990), a few studies have shown that both thematic and reference maps can help students learn geographic facts and concepts (e.g., Bailey, 1979; Boardman, 1985; Trifonoff, 1995). Maps can increase conceptual organization and memory retention, since people tend to remember visual symbols and patterns (Rittschof and Kulhavy, 1998; Griffin and Robinson, 1997; Kulhavy *et al*., 1993; Abel and Kulhavy, 1986). Thus, maps can enhance children's understanding of the spatial aspects of cultures, environment, and economy (Bailey, 1979; Joyce, 1987; Inbody, 1960). One difficulty is that the maps in textbooks are often designed poorly and not used effectively (Gerber, 1992), especially for regional history textbooks with smaller circulation and thus less money to spend on design. Another obstacle is that because historical geography studies time as well as space, static maps may not be the ideal form of representation.

". . . four technological solutions have a particularly high potential for success in historical geography: paper maps, interactive media, geographic information systems (GIS), and interactive maps."

Interactive Media resources (such as videos, the internet, and CD-ROM's) have been useful for enhancing classroom learning, especially when students are able to use them at their own pace (Giardina, 1992). In addition, computerized learning activities can adapt to different class sizes (Schick, 1993), as long as enough computers are available. These benefits are becoming more important as school classrooms are becoming more crowded (Ready *et al*., 2004; National School Boards Association, 1999; O'Neil and Adamson, 1993). These media are also much more interesting to young people (Olson, 1997), and if they enjoy the learning activity, they are more likely to maintain focus long enough to learn the concepts being taught (Calvert, 1993-1994). Several studies have shown the need for technology in school social studies classes (Baker and White, 2003; Wilton, 1999; Noonan, 1998; Fitch, 1997), as this resource can be used to stimulate otherwise disinterested students in classrooms to become active participants in learning social studies. However, most media are not intended to portray spatial concepts, and are therefore not enough to help students understand social studies.

Geographic Information Systems (GIS) combine the benefits of paper maps and interactive media by enabling students to explore, analyze, and make decisions about spatial problems in an interactive and challenging manner (Northon, 2003; Patterson *et al*., 2003; Audet and Ludwig, 2000). Keiper (1999) found that GIS created "a shift from learning about geography to learning to do geography. (p. 57)" However, very few schools have incorporated GIS into the classroom (Baker and White, 2003; Patterson *et al*., 2003; Kerski, 2001; Audet and Paris, 1997). One of the problems of implementing GIS in classrooms is that teachers have to invest significant time in learning the software and developing lesson plans and exercises, and it requires valuable class time for students to learn as well. In addition, the costs of the software and high-end computers may be prohibitive, although hardware costs are decreasing, and GIS vendors are offering lower prices and system wide licenses to districts and even states such as Utah (Audet and Ludwig, 2000). Gradually, GIS technology is becoming a practical tool for teachers (Broda and Baxter, 2003), at least in technology-oriented classes. This rarely includes social studies, however.

"Interactive Maps *are not based on GIS software, and should provide the advantages of GIS to learn about spatial topics without as much investment of time and money."*

Interactive Maps are not based on GIS software, and should provide the advantages of GIS to learn about spatial topics without as much investment of time and money. These are standalone map-centered programs that respond onscreen to user activity and help promote information exploration and understanding (Andrienko *et al*., 2002; Audet and Ludwig, 2000; Olson, 1997; National Research Council, 1997; Krygier *et al*., 1997). Most schools today have Internet access, making this form of map cost-effective and familiar to today's web-savvy students. These maps are more flexible in their use than paper maps, since they allow users to explore data and visualize and analyze visual patterns on the computer screen. The potential of the interactive process is reinforced by several studies that have found paper maps to be especially educational when students are involved in creating them rather than just reading them (Sullivan, 1993; Bausmith and Leinhardt, 1997; Knowles 2000). The interactive map also solves the problem of teaching historical geography because it can have both a temporal and spatial dimension. Due to these advantages, interactive maps could help improve classroom curriculum in many different subjects.

"The purpose of this research is to evaluate the ability of interactive maps to improve the learning and attitudes of students in social studies in secondary schools."

Thus, it is worthwhile to test the efficacy of interactive maps in improving the learning process. Although some studies have focused on the benefits of integrating interactive maps in the classroom, the research has generally been focused on the natural sciences and physical geography (Audet and Ludwig, 2000; Linn, 1997; Olson, 1997; Murayama, 2004; Pederson *et al*., 2005). The few studies that have focused on human geography topics (e.g., Linn, 1997; Keiper, 1999) have generally had inconclusive results, and interactive map use to teach historical geography in particular has not been studied.

The purpose of this research is to evaluate the ability of interactive maps to improve the learning and attitudes of students in social studies in secondary schools. We hypothesize that interactive maps create not only a more enjoyable learning environment than traditional paper maps, but also facilitate the development of a more effective teaching technique. We also hypothesize that the use of interactive maps promotes more positive learning attitudes, and should help students understand basic concepts of geography and history and analyze how geographical factors have contributed to Utah's history.

Experiment Design

To study the role of interactive maps in education, we used an experimental research design, focused on testing students' learning during a short unit on the history and geography of Utah settlement. We chose this topic because it is part of the state Utah Studies curriculum (and thus would be taught anyway) and it is well suited for showing how a variety of factors interact spatially and contribute to changing spatial patterns. Simply asking students to memorize facts would not really promote effective learning, as true geography involves being able to link spatial phenomena and explain why certain phenomena occurred in a particular place. To really learn, students should be able to *understand, apply*, and *analyze* concepts about how various factors affected Utah settlement.

Specifically, we used a quasi-experimental, pretest-posttest nonequivalent control group design to test the effect of interactive maps on learning and attitudes about this topic. This design has been used effectively in other tests of maps and GIS in education (e.g., Baker and White, 2003; Linn, 1997). The subjects were six 7th grade Utah Studies classes at a local junior high school, in which 145 students were asked to complete tests and an exercise using map resources to answer questions that required them to locate, analyze, and synthesize geographic and historical information.

". . . students were asked to complete tests and an exercise using map resources to answer questions that required them to locate, analyze, and synthesize geographic and historical information."

A three-step procedure was used for the test. In the first step, during a 45-minute class period students were given a pretest with no materials, or help, to answer questions. In the second step, on the second-class day, the students were given an exercise (identical to the pretest), but this time with map resources to help them learn. Students still worked individually, but were allowed to get help from peers, the teacher, and the researcher. The control group was given paper maps, while the experimental group was given an interactive map. Pederson *et al.* (2005) took a similar strategy to discriminate the effectiveness of paper and (static) electronic maps.

In the last step, during a third class period that was twice as long as the first two class periods (1½ hours), students were given a posttest (similar in form to the pretest but slightly longer with different questions) and allowed to use the paper maps or the interactive map, but without help. After the tests, students completed an attitude survey that assessed their impressions of the unit and the learning materials used. We were therefore able to isolate the type of map resource as a factor in improving test scores and student attitudes. A table illustrating the above experimental design is shown in Table 1.

Group	**Pretest**	**Treatment**	**Posttest**
Experiment al	Test 1	Test 1 **Interactive map** Assistance	Test 2 **Interactive map** Attitude survey
Control	Test 1	Test 1 **Paper maps and tables** Assistance	Test 2 **Paper maps and tables** Attitude survey

Table 1. Overview of Experiment.

Test Instruments

The paper and interactive maps used in the experiment displayed the same information about Utah's settlement patterns over time (i.e., settlement/abandonment dates, census populations), along with reference information and related factors, including mining, railroads, precipitation, terrain, streams, and roads. The railroads and towns layers modeled temporal change, derived from a historical GIS of Utah. Both types of maps also used identical cartographic designs, such as proportional circles for the town populations.

The control resources consisted of a set of 16 maps, one for each decade from 1850-2000; each student was given his or her own set of maps to use. The paper maps were created using ArcGIS software and printed in color so they could be comparable to the interactive map (see Figure 1). The control students were also given printed tables listing Census data so they would have exact populations for each town.

"The paper and interactive maps used in the experiment displayed the same information about Utah's settlement patterns over time . . ."

The interactive map was created using Scalable Vector Graphics (SVG) and JavaScript, and following the recommendations of Crampton (2000) and Loben and Patton (2003), included several basic interactivity tools. *Brushing*, as shown in Figure 2, allowed users to move their cursor over a town on the map, causing it to be highlighted, and its name, county name, settlement date, and population for the selected Census year to be listed. *Toggling* (Figure 3) let users turn the thematic and reference layers on and off, including railroads, precipitation, terrain, current roads, mineral deposits, and streams. As layers were turned on, legends appeared to the right of the layer to explain the layer symbology. *Zooming* (Figure 4) was also available for focusing on a specific county.

The interactive map also included tools for exploring change over time. When the user selected a specific year from the drop-down menu, as shown in Figure 5, the city and railroad layers changed to match the chosen date. Alternatively, users could select the "Animate Map" button to watch the changes (in towns and railroads) over the entire history of Utah (1850-2000). The combination of these tools allowed users to isolate specific areas of interest and analyze a variety of physical and cultural geography factors contributing to the changing spatial patterns of settlement[1].

"The tests focused not on rote memorization, but on helping students to identify, understand, and analyze spatial relationships . . ."

The pre- and posttests were then based on the information on the maps and the learning objectives of the curricular unit. The two tests had parallel forms, so the students were presented with novel, but similar, problems. The exercise given to teach them to use the maps was identical to the pretest. Because the score improvement was calculated solely on pre- and posttest scores, students' remembering questions and answers from pretest to exercise did not affect the experiment results. The pretest contained fewer questions than the posttest because students had a shorter class period to complete the pretest.

The tests focused not on rote memorization, but on helping students to identify, understand, and analyze spatial relationships in explaining the distribution of Utah settlements over time using hypothetical attractors such as climate, terrain, water, minerals, roads, and railroads. A combination of question types was therefore used to assess different types of problem solving. The matching items required students to compare city sizes for two consecutive decades and identify the decade during which a settlement was established, thus focusing on fact-finding and *conceptual understanding* in Bloom's revised taxonomy (Anderson and Krathwohl, 2001). A section of multiple-choice questions required students to analyze data and patterns to identify possible reasons for settlement in certain

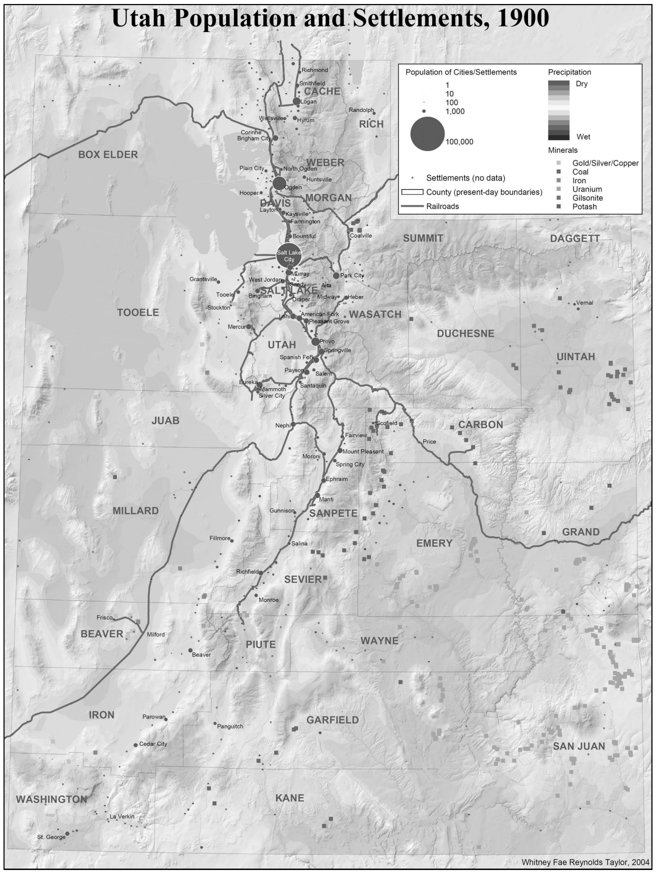


Figure 1. Sample paper map. (see page 77 for color version)

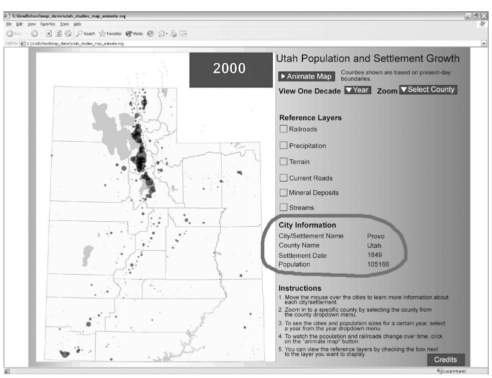


Figure 2. Brushing to view city data in the interactive map. (see page 77 for color version)

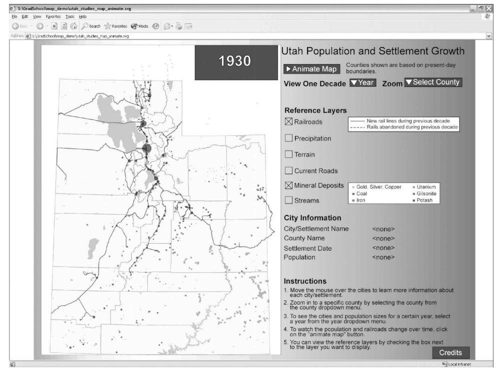


Figure 3. Toggling layers on and off in the interactive map. (see page 77 for color version)

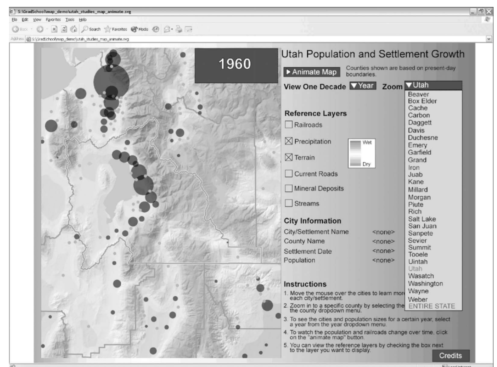


Figure 4. Zooming on a county in the interactive map. (see page 77 for color version)

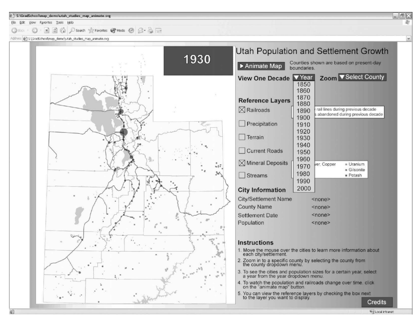


Figure 5. Selecting a year in the interactive map. (see page 77 for color version)

areas, focusing on *inference, comparison*, and *explanation*. Although multiple-choice test items are problematic because students can frequently guess the correct answer (Anderson and Krathwohl, 2001), it was chosen because it is an effective way of assessing conceptual knowledge. The short-answer portion of the test asked students to *exemplify, summarize, infer, compare*, and *differentiate* factors that may contribute to settlement patterns, and changes in railroading over time.

Before the experiment, the test questions and maps were piloted with several non-test students of the similar ages, to ensure that the questions were appropriate in wording and difficulty for the target age. The students were asked to think aloud while they answered the questions, and this feedback helped us revise the questions and eliminate any questions that were too difficult for them to understand. The following are a few sample questions from the posttest:

Matching: Match each city in Utah with the decade during which it was settled. Write the letter designating the decade for each city on the blank next to each city. Each decade may be used once, more than once, or not at all.

____ 1.	Scofield, Carbon County	a. 1871-1880
____ 2.	Hurricane, Washington County	b. 1881-1890
____ 3.	Vernal, Uintah County	c. 1891-1900
____ 4.	La Verkin, Washington County	d. 1901-1910
____ 5.	Sunnyside, Carbon County	e. 1911-1920
		f. 1921-1930

Multiple Choice: Which one of the following factors best explains why the population of Park City (Summit County) is growing and Eureka (Juab County) is declining even though the mines near both cities closed many years ago?

a. Date railroad was pulled up
b. Stream flow
c. Closeness to other towns
d. Precipitation

Short Answer: Wayne County has over twice as much area as Cache County. However, despite the difference in area, Cache County has historically had a larger population than Wayne County. Name two of the physical geography factors that have contributed to this trend.

"After students completed the posttest, they were asked to fill out a survey."

After students completed the posttest, they were asked to fill out a survey. The first part asked for information on demographic factors that have been shown to have an extracurricular effect on learning (Bangert-Drowns and Pyke, 2002; Montello *et al.*, 1999; Proctor and Richardson, 1997; Calvert, 1993-1994; Lockheed *et al.*, 1989), including gender, past social studies performance, and parents' education level. These were used as control variables in the analysis. The second part was an attitude assessment, in which students were asked to identify their impressions of the material, using a bipolar adjective scale (Burke, 1989). This section was divided into attitudes about the unit in general and attitudes about the map resources they used. Two opposite adjectives were listed for each item (e.g., confusing vs. understandable, important vs. unimportant, enjoyable vs. unpleasant), and students marked their opinion on a scale between them. A score of five was given for ratings closest to the favorable adjective in each pair, and one for ratings closest to the unfavorable adjective. The order of negative and positive adjectives was reversed on some questions to prevent students from marking a single column for all the adjectives without reading. Each student's ratings of all bipolar adjectives were summed to get his or her composite rating of the unit and the map(s) used.

Results

The test results were scored, and then analyzed using multiple linear regression. The primary independent variable was the type of map used (paper or interactive). The demographic data (gender, past social studies grades, and parents' education) were also used as independent variables to account for their possible effect on student ability. The dependent variables included the improvement from pretest to posttest, calculated by subtracting the percent correct for the test as a whole and for each question type, and the attitude ratings. Table 2 summarizes the variables used in the analysis.

Variable	Measurement	Source
Dependent Variables		
Overall Score Improvement	Posttest percent – Pretest percent	Tests
Matching Improvement	Matching posttest percent – pretest percent	Tests
Multiple-Choice Improvement	Multiple-choice posttest percent –pretest percent	Tests
Short-Answer Improvement	Short-Answer posttest percent – pretest percent	Tests
Unit Attitude Score	Add scores for bipolar adjectives	Survey
Map Attitude Score	Add scores for bipolar adjectives	Survey
Independent Variables		
Gender	Male (1) or Female (0)	Survey
Past Social Studies Grade	Grades A (1) – F (5)	Survey
Father's Education Level	Degree Attained (1 = High School; 5 = Doctoral	Survey
Mother's Education Level	Degree Attained (1 = High School; 5 = Doctoral	Survey
Map Used	Interactive map (1) or Paper maps (0)	Survey

Table 2. Independent and Dependent Variables, Measurement, and Data Sources.

The map type, past social studies grades, gender, and parents' education were thus used as predictors of the improvement scores from the pre- and posttest and the two attitude scores. The map-type coefficient in each regression model, an indicator of the maps' effect on students' learning and attitude, was then tested for significance.

Before reporting the analysis results, a limitation in data collection more than likely has affected the scores needs to be explained. Time was limited on the posttest, and some students in the experimental group did not have enough time to complete the short-answer section of the test because of the slow computer speed. Only 20 percent of the interactive-map students completed the short-answer section on the posttest, compared to 98 percent of the paper-map students. To account for this, the percentage correct on the short-answer section was based on the number of questions the students completed. For example, if a student completed four of the three-point short-answer questions and three were correct, the short-answer score would be 75 percent. Because the short-answer questions were not ordered by difficulty level, this solution to the problem was practical.

The score improvement for the different dependent variables varied. Table 3 summarizes the descriptive statistics for the control and experimental groups for the test-score dependent variables used in this research:

Variable	Group	Pretest Mean	Posttest Mean	Difference** Mean
Overall Test	Experiment Control	5.3/26 (20.5%) 5.4/26 (20.7%)	19.9/30.2* 19.2/40 (47.9%)	45.2% 26.5%
Matching	Experiment Control	2.6/5 (52%) 2.8/5 (56%)	9.1/10 (91%) 7.1/10 (71%)	38.4% 13.9%
Multiple Choice	Experiment Control	2.1/5 (42%) 1.8/5 (36%)	5.6/9 (62.2%) 5.8/9 (64.4%)	20.4% 28.2%
Short Answer	Experiment Control	0.7/16 (4.4%) 0.9/16 (5.6%)	4.8/11.2* (42.9%) 6.2/21 (29.5%)	40.1% 23.8%

* students did not finish the posttest section
** difference includes only students who completed both the pretest and posttest

Table 3. Test Descriptive Statistics

"A few students scored in the "A" range in both the control and experimental groups, and most students in both groups would have received a passing grade for this unit."

Overall, the students did fairly well on the posttest. The average posttest score for the students using the interactive map was 66.0 percent, whereas the average posttest score for the students using the paper maps was 47.9 percent. Although these averages are a little lower than what would be desirable for a normal test, they are good considering the condensed amount of time the students had to learn the material and concepts in the unit. In addition, this result may be attributed to the fact that the test questions required them to stretch themselves and do things beyond the recall level. A few students scored in the "A" range in both the control and experimental groups, and most students in both groups would have received a passing grade for this unit.

The experimental group's mean improvement for the *matching* section was 38.4 percent, whereas the control-group mean improvement for that section was 13.9 percent. The experimental group's mean improvement for the *multiple-choice* section was 20.4 percent, whereas the control-group mean improvement for that section was 28.2 percent. Finally, the experimental group's mean improvement for the *short-answer* portion was 40.1 percent, and the control group's mean improvement for that portion was 23.8 percent. Multiple regression analysis was then performed with overall score improvement as the dependent variable. Table 4 displays the results of the full regression model.

Independent Variable	Slope	t-value	Significance Level
Map type	17.677	5.729	<0.001**
Sex of student	0.609	0.193	0.847
Past social studies grade	-2.641	-1.141	0.257
Father's education	1.870	1.312	0.193
Mother's education	1.144	0.625	0.534

**significant at the $p = 0.05$ level, total degrees of freedom (df): 109

Table 4. Dependent Variable: Overall Improvement.

The full regression model indicated that the students in the experimental group improved an average of 18 percent better than the control group in overall score (controlling for demographic factors), which was a significant difference. None of the other independent variables were found to be significant in this model. These results indicate that the map type students used impacted their ability to answer the test questions accurately.

The key to understanding the difference between the two groups can be seen by analyzing the map-type variable for not only the full regression model, but also the models for each test section. Table 5 summarizes the results of the map-type variable for each regression model.

Dependent Variable	Slope	t-value	Degrees of freedom	Significance Level
Overall Improvement	17.677	5.729	109	<0.001**
Matching Improvement	24.233	4.743	109	<0.001**
Multiple-Choice Improvement	-5.408	-1.096	109	0.275
Short-Answer Improvement	15.065	3.876	101	<0.001**

**significant at the p = 0.05 level

Table 5. Independent Variable: Map-type.

On the regression models for the individual sections, the experimental group was significantly better ($p < 0.001$) in both the matching section and the short-answer section. However, the students using the interactive map actually improved less than the control group on the multiple-choice questions, although not significantly less.

The two sections of the attitude survey were analyzed separately. The first section (ten adjective pairs) assessed students' attitudes for the unit as a whole, and the second section (five adjective pairs) focused on students' attitude for the map(s) used for the unit. Multiple regression analysis was then performed with the map and unit attitude scores as dependent variables and the same independent variables as before. Table 6 displays the descriptive and regression statistics for both the control and the experimental groups. In both parts, the scores were not significantly different.

Dependent Variable	Group	Mean	Slope	t-value	Degrees of freedom	Significance
Unit Attitude	Experimental	32.91/50	-0.930	-0.651	112	0.517
	Control	33.26/50				
Map Attitude	Experimental	17.93/25	-1.231	-1.458	112	0.148
	Control	18.79/25				

Table 6. Attitude Statistics.

The demographic variables (gender, past performance, and parents' education) also yielded regression coefficients in each model, but none had a consistently significant influence.

Discussion

"The results illustrated that introducing interactive maps enhanced the success of some learning objectives, but some results were inconclusive."

The results illustrated that introducing interactive maps enhanced the success of some learning objectives, but some results were inconclusive. Based on anecdotal evidence and a review of patterns in the test results, there are several possible reasons for the varying results from each test section.

Matching: The matching questions asked students to report the settlement date for a given city and indicate whether a city increased or decreased its population during a given decade. Students using the paper maps may have had difficulty with these questions because they had a lot of information in the maps and tables and may have become confused. The students had been asked to use the maps whenever possible to determine whether a settlement grew or not, and during which decade a settlement started (i.e., which map it first appeared on), and use the Census tables only when necessary. However, they may have used the tables exclusively, which could be problematic. For example, the example question above asks about Scofield, which was settled in 1879, and thus appears on the 1880 map, even though it did not get counted in the Census until 1890. A student that used only the Census table (which shows a 0 for Scofield for 1880) would get this question wrong. A more complete table (e.g., with a column for settlement date) would certainly have raised the scores of the control group, but this would only have validated the usefulness of the table, not the paper maps. Students who used the interactive map, conversely, had access to all the information they needed to answer the question in one location via the brushing tool, in which Scofield explicitly states a settlement date of 1879 and a lack of an 1880 Census population, reducing confusion.

Short Answer: The short-answer portion of the test asked students to isolate certain features that may have contributed to settlement patterns and changes in railroading over time. Through toggling, the students using the interactive map were better able to isolate different contributors, such as precipitation, elevation (terrain), minerals, and streams, which likely contributed to the significant difference between the two groups. Students using the paper maps had the same information, but it was all on the maps simultaneously. In addition, they were not able to see a more detailed view of certain counties by zooming, as the students with interactive maps were able to do.

"The lack of a significant difference between the two groups for the multiple-choice portion of the test may be attributed to the speed of the computers used by the students."

Multiple Choice: The multiple-choice questions asked students to analyze data presented on the map and study the patterns to identify potential reasons for settlement. The lack of a significant difference between the two groups for the multiple-choice portion of the test may be attributed to the speed of the computers used by the students. Although the interactive map was able to run on the computers, it ran slower than anticipated because the computers were relatively old. As a result, we observed several students becoming frustrated with the delays and guessing on the multiple-choice questions rather than waiting for the map to update. Guessing is always a danger when using multiple-choice test items (Anderson and Krathwohl, 2001). Thus, this form of question may not have been the best for the students with interactive maps, who needed to patiently wait for their map to update before responding. That said, they scored about the same as the students with paper maps, so they were not guessing on everything, assuming that the students with papers maps were not guessing either.

Unit and Map Attitudes: The lack of significant results for the attitude assessment is not unique to this study; Pedersen *et al*. (2005) also found equivocal levels of satisfaction between paper and electronic maps. In our case, this appears to have been due to the relationship between the adjectives used in the assessment and the different student experiences. While in the classroom, we observed two very different levels of enthusiasm for the two map groups. The students using the paper maps quickly got bored using the maps for the different tests and exercises. The students in the experimental group were excited to try the new computer maps, but gradually got frustrated with the slow computers, a common problem in studies dependent on technology (Yang, 2001; Hara, 1998; Proctor and Richardson, 1997). In both of the groups, students complained about answering the same types of questions over and over, even though the parallel pretest/exercise/posttest structure was necessary for the experiment. Thus, the lack of significant differences for any of the adjectives may have been due to blanket attitudes: students that were generally pleased with the unit appear to have selected all the positive adjectives, students who had a generally negative attitude (for whatever reason) selected all the negative adjectives, and students who didn't care answered all the attitude questions neutrally, without carefully considering the nuances between each one.

"The students in the experimental group were excited to try the new computer maps, but gradually got frustrated with the slow computers, a common problem in studies dependent on technology."

Conclusions

The results of this study show that interactive maps offer modest learning benefits over traditional paper maps. However, some types of learning objectives and some types of concepts have more to gain from interactivity than others. Specifically, interactive maps seem well suited for conceptual learning that involves *finding*, *comparing, exemplifying*, and *explaining* geographic information and patterns. It is not as advantageous for memorizing facts or evaluating fairly simple patterns that can be adequately expressed on paper maps or other media. Unfortunately, the attitude assessment was inconclusive, and additional research is needed to see whether students prefer interactive-map learning to paper-map learning.

Findings of insignificant to modestly significant learning and attitude gains for interactive maps (and GIS) have been fairly common in similar studies (e.g., Linn, 1997; Pedersen *et al*., 2005; Keiper, 1999; Baker and White, 2003; West, 2003). One common factor, though not always recognized by the authors, is the quality of the tested materials. One must assume that the interactive map is a high quality, representative example of the genre. In this case, the Utah settlement interactive map was later refined for a different project, and the significant improvements in usability and performance made us wonder if we would have had stronger results with the newer version.

". . . interactive maps seem well suited for conceptual learning that involves finding, comparing, exemplifying, and explaining geographic information and patterns."

One of the main limitations of this study was the level of technology available at the school. Although the interactive map was tested on the classroom computers before the experiment, they were slower than the ones used to design the interactive map, making the map run much more slowly than desired. The subsequent frustration appears to have impacted both the test scores and the attitudes of the experimental group. However, this obstacle is not only at this location; budget limits often lead to schools having older, less powerful computers than in the office (and often, in the home). This is a limitation to which educational technology researchers, teachers, and students must adapt (Keiper, 1999). For example, Proctor and Richardson (1997) suggest creating paper materials (similar to our control materials) as a fallback, perhaps even making the computer-based tools optional for completing assignments.

Another limitation was that because the learning unit was experimental, the teacher gave grade points merely for students' participating, regardless of their scores—only if they "tried their best." The lack of significance for various sections could therefore be partly attributed to students who did not really care how well they performed. This lack of motivation is often a difficult obstacle in human-subjects testing, including similar studies in geographic education (Proctor and Richardson, 1997; Pedersen *et al*., 2005). In the case of this study, the teacher could not use the test scores for grading because we expected that the control group would get lower scores regardless of their ability.

". . . students who used the interactive map visibly showed more enthusiasm as they worked on the unit . . ."

Although the attitude assessment results were inconclusive, we made several anecdotal observations that suggest that the teacher and students liked the interactive maps more than was indicated by the results, and may be widely accepted once school technology improves. The teacher was eager to try something new with the unit and was excited about the things presented therein and the new tools used. The students who used the interactive map visibly showed more enthusiasm as they worked on the unit (exercises and tests) than the students who used the paper maps (who complained of boredom from doing the same task repeatedly). Several of the students using the interactive map commented that the map was really interesting and fun to use, but then complained of the length of time they had to wait for the computer to update with changes. A revised assessment instrument (to somehow avoid blanket answers), and interactive maps tailored to the performance of the school computers, may have significantly changed the results.

Although using these teaching tools in the classroom can benefit social studies education, creating interactive maps is not something teachers can easily do themselves; it took several months of programming to create the maps used in this study. Creating these maps still requires third parties who are willing to volunteer their efforts to improve social studies education in schools.

Future Research

"Future research should focus on creating interactive maps that accompany a wide variety of topics in social studies curriculum to help students learn about an assortment of concepts with the interactive maps."

The limitations of this study illustrate the need for future research in this arena. For this study, the time to create the interactive map was limited, so only one interactive map could be created before the experiment deadline. Future research should focus on creating interactive maps that accompany a wide variety of topics in social studies curriculum to help students learn about an assortment of concepts with the interactive maps. As students become more accustomed to using the computers and map interactivity in their classes, they may be able to analyze more complex changes in the subject, and focus less on the mechanics of using the tools. In addition, efforts should be made to encourage more teachers to accept new teaching resources in their classrooms so that the maximum potential of using these resources can be achieved.

Based on the anecdotal positive response students had toward using the computer maps in this study, further research into attitude differences is warranted, although obtaining a clear understanding of student feelings is difficult. Also, we were not able to study how well students *retain* what they learn using interactive maps over a longer term; this would require a longitudinal study. In addition, this study was focused on a relatively small area and a regional subject applicable to the state level, but future studies should include implementation interactive maps of various size spaces and regions.

Best Practices

For those educators who wish to design and use interactive maps, we suggest several guidelines learned in the course of this research:

- Design maps that are appropriate for the level of technology available, even if this means leaving out functionality that could be very useful or engaging. Assuming that school computers will soon become much more powerful denies the realities of budget issues in today's schools.
- Keep the interface simple and applicable to the target age, and include instructions in the software.
- Schools have limited budgets, and commercial interactive and web-mapping software can be prohibitively expensive, but software exists that can be free to develop or distribute high-quality interactive maps.
- When teachers use these maps in their instruction, they should create their own learning exercises around the maps that help emphasize the concepts they see as most important, rather than altering their curriculum to match the available resources.
- Design learning activities that require students to thoughtfully examine geographic and historical patterns, and discourage guessing.
- Collaborate with other educators who are interested in using the maps to better meet their educational needs.

". . . interactive maps can be utilized in subjects with a spatial dimension to aid learning."

Our research has shown that interactive maps can be utilized in subjects with a spatial dimension to aid learning. Interactive maps in social studies classes can create a more dynamic learning atmosphere, therefore enhancing knowledge acquisition. By using interactive maps as an additional resource in their teaching curriculum, teachers can effectively improve student learning, at least for some types of topics and learning objectives. Although the results of this study on student attitudes were inconclusive, there was enough anecdotal evidence to suggest that interactive maps have the potential to excite students about learning. As the technology available to students improves, and development tools become more prevalent and easier to use, the opportunity to design and use interactive maps in the classroom will increase greatly. Current and future teachers are encouraged to take advantage of available geographic technology to enhance their classroom instruction. Doing so will enhance the teaching of physical and human geography, while improving students' mapping and computer skills.

". . . enough anecdotal evidence to suggest that interactive maps have the potential to excite students about learning."

[1]The interactive map used for this study, as well as a version modified after the study was completed are available from the authors.

REFERENCES

Abel, R.R. and Kulhavy, R.W., 1986. Maps, Mode of Text Presentation, and Children's Prose Learning. *American Educational Research Journal* 23:2: 263-274.

Anderson, L.W. and Krathwohl, D.R., (Eds) 2001. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Addison Wesley Longman, Inc.

Andrienko, N., Andrienko, G., Voss, H., Bernardo, F., Hipolito, J. and Kretchmer, U., 2002. Testing the Usability of Interactive Maps in CommonGIS. *Cartography and Information Science* 29:4: 325-342.

Audet, R. and Ludwig, G., 2000. *GIS in Schools*. Redlands, California: Environmental Systems Research Institute, ESRI Press.

Audet, R.H. and Paris, J., 1997. GIS Implementation Model for Schools: Assessing the Critical Concerns. *Journal of Geography* 96:6: 293-300.

Bailey, P., 1979. Teaching and Learning from Landscape and Map. *Cartographic Journal* 16:1: 21-23.

Baker, T.R. and White, S.H., 2003. The Effects of GIS on Students' Attitudes, Self-efficacy, and Achievement in Middle School Science Classrooms. *Journal of Geography* 102: 243-254.

Bangert-Drowns, R.L. and Pyke, C., 2002. Teacher Ratings of Student Engagement with Educational Software: An Exploratory Study. *Educational Technology Research and Development* 50:2: 23-38.

Bausmith, J.M. and Leinhardt, G., 1998. Middle-School Students' Map Construction: Understanding Complex Spatial Displays. *Journal of Geography* 97: 93-107.

Blaut, J.M. and Stea, D., 1971. Studies of geographic learning. *Annals of the Association of American Geographers* 61: 387-393.

Boardman, D., 1989. The Development of Graphicacy: Children's Understanding of Maps. *Geography* 74:4: 321-331.

Boardman, D., 1985. *New Directions in Geographical Education*. Lewes, UK: Falmer Press.

Broda, H.W. and Baxter, R.E., 2003. Using GIS and GPS Technology as an Instructional Tool. *The Social Studies* 94:4:158-160.

Burke, P.J., 1989. Gender Identity, Sex, and School Performance. *Social Psychology Quarterly* 52:2: 159-169.

Calvert, S.L., 1993-1994. Children's Attentional Involvement and Distractibility During Educational Computer Interactions. *Journal of Educational Technology Systems* 223: 251-258.

Coyle, L., Davis, J., Kasper, R., O'Malley, M.T. and Snyder, M., 1996. *Developing Elementary Students' Geographic Knowledge and Application Skills through Curriculum Integration.* Chicago, Illinois: Master's Action Research Project, St. Xavier University. ERIC, ED406295.

Crampton, J.W., 2002. Interactivity Types in Geographic Visualization. *Cartography and Geographic Information Science* 29:2: 85-98.

Fitch, N., 1997. History after the Web: Teaching with Hypermedia. *The History Teacher* 30:4:427-441.

Freundschuh, S., 1990. Can Young Children Use Maps to Navigate? *Cartographica* 27:1: 54-66.

Gerber, R. 1992. *Using Maps and Graphics in Geography Teaching*. Brisbane, Australia: International Geographical Union Commission on Geographical Education.

Giardina, M. (Ed) 1992. *Interactive Multimedia Learning Environments: Human Factors and Technical Considerations on Design Issues.* Germany: Springer-Verlag Berlin Heidelberg.

Gregg, M. and Leinhardt, G., 1993. Geography in History: What is the Where? *Journal of Geography* 92:2: 56-63.

Griffin, M.M. and Robinson, D.H., 1997. *A Test of the Conjoint Retention Hypothesis for Learning from Geographic Maps: Mimetic Features of Spatial Layout?* Chicago, Illinois: Paper presented at the Annual Meeting of the American Educational Research Association (March 24-28). ERIC, ED414286.

Hara, N., 1998. Students *Perspectives in a Web-Based Distance Education Course.* Chicago, Illinois: Paper presented at the Annual Meeting of the Mid-Western Educational Research Association (October 14-17). ERIC, ED426633.

Inbody, D., 1960. Maps and Globes: A Story of the Earth. *The Elementary School Journal* 60:5: 270-273.

Joyce, W.W., 1987. Research Tells Us That. *Michigan Social Studies Journal,* 1:2:77-80.

Keiper, T.A., 1999. GIS for Elementary Students: An Inquiry into a New Approach to Learning Geography, *Journal of Geography*, 98:2: 47-49.

Kerski, J.J., 2001. A National Assessment of GIS in American High Schools. *International Research in Geographical and Environmental Education* 10:1: 72-84.

Knowles, A.K., 2000. A Case for Teaching Geographic Visualization without GIS. *Cartographic Perspectives* 36: 24-37.

Krygier, J.B., Reeves, C., Dibiase, D. and Cupp, J., 1997. Design, Implementation and Evaluation of Multimedia Resources for Geography and Earth Science Education. *Journal of Geography in Higher Education* 21:1: 17-39.

Kulhavy, R.W., Stock, W.A. and Kealy, W.A., 1993. How Geographic Maps Increase Recall of Instructional Text. *Educational Technology Research and Development* 41:4: 47-62.

Leming, J., Ellington, L. and Porter, K. (Eds) 2003. *Where Did Social Studies Go Wrong?* Upper Marlboro, Maryland: District Creative Printing.

Linn, S.E., 1997. The Effectiveness of Interactive Maps in the Classroom: A Selected Example in Studying Africa. *Journal of Geography* 96:3: 164-170.

Lobben, A.K. and Patton, D.K., 2003. Design Guidelines for Digital Atlases. *Cartographic Perspectives*, 44: 51-62.

Lockheed, M.E., Fuller, B. and Nyirongo, R., 1989. Family Effects on Students' Achievement in Thailand and Malawi. *Sociology of Education* 62:4: 239-256.

Montello, D.R., Lovelace, K.L., Golledge, R.G. and Self, C.M., 1999. Sex-Related Differences and Similarities in Geographic and Environmental Spatial Abilities. *Annals of the Association of American Geographers* 89:3: 515-534.

Murayama, Y., 2004. Development of environmental information WebGIS for school education, *Tsukuba Daigaku Jinbun Chirigaku Kenkyu* 28:1: 13-26.

National Research Council, 1997. *Rediscovering Geography: New Relevance For Science and Society*. Washington, DC: National Academy Press.

National School Boards Association, 1999. State of the States. The Pressure is On: The Kids Just Keep Pouring in. *American School Board Journal, Education Vital Signs*. www.asbj.com/evs/99/state.html (accessed 11 January 2005).

Noonan, K.M., 1998. Untangling the Web: The Use of the World Wide Web as a Pedagogical Tool in History Courses. *The History Teacher* 31:2: 205-219.

Northon, C., 2003. *Integrating Geographic Information Systems (GIS) Into Secondary Education: A Community-Based Learning Experience*. Anchorage, Alaska: University of Alaska Anchorage. ERIC, ED478822.

Olson, J.M., 1997. Presidential Address: Multimedia in Geography: Good, Bad, Ugly, or Cool? *Annals of the Association of American Geographers* 87:4: 571-578.

O'Neil, I.R. and Adamson, D.R., 1993. When Less is More. *American School Board Journal* 180:4: 39-41.

Patterson, M.W., Reeve, K. and Page, D., 2003. Integrating Geographic Information Systems into the Secondary Curricula. *Journal of Geography* 102: 275-281.

Pedersen, P., Farrell, P. and McPhee, E., 2005. Paper versus Pixel: Effectiveness of Paper versus Electronic Maps to Teach Map Reading Skills in an Introductory Physical Geography Course, *Journal of Geography* 104:5: 195-202.

Proctor, J.D. and Richardson, A., 1997. Evaluating the Effectiveness of Multimedia Computer Modules as Enrichment Exercises for Introductory Human Geography. *Journal of Geography in Higher Education* 21:1: 41-55.

Ready, D.D., Lee, V.E. and Welner, K.G., 2004. Educational Equity and School Structure: School Size, Overcrowding, and Schools-Within-Schools. *Teachers College Record* 106:10: 1989-2014.

Rittschof, K.A. and Kulhavy, R.W., 1998. Learning and Remembering From Thematic Maps of Familiar Regions. *Educational Technology Research and Development* 46:1: 19-38.

Schick, J.B.M., 1993. The Decision to Use a Computer Simulation. *The History Teacher* 27:1: 27-36.

Shaughnessy, J.M. and Haladyna, T.M., 1985. Research on Student Attitude Toward Social Studies. *Social Education* 49:8: 692-695.

Sullivan, M.E., 1993. Choropleth Mapping in Secondary Geography: An Application for the Study of Middle America. *Journal of Geography* 92:2: 69-74.

Trifonoff, K.M., 1995. Going Beyond Location: Thematic Maps in the Early Elementary Grades. *Journal of Geography* 94:1: 368-374.

Tyson, H. and Woodward, A., 1989. Why Students Aren't Learning Very Much from Textbooks. *Educational Leadership* 47:3: 14-17.

West, B.A., 2003. Student Attitudes and the Impact of GIS on Thinking Skills and Motivation. *Journal of Geography* 102: 267-274.

Wilton, S., 1999. Class Struggles: Teaching History in the Postmodern Age. *The History Teacher* 33:1: 25-32.

Yang, S.C., 2001. Language learning on the World Wide Web: an investigation of EFL learners' attitudes and perceptions. *Journal of Educational Computing Research* 24:2: 155-181.

A Multi-scale, Multipurpose GIS Data Model to Add Named Features of the Natural Landscape to Maps

Aileen Buckley
abuckley@esri.com

Charlie Frye
cfrye@esri.com

Cartographic Research and Special Projects Group
Environmental Systems Research Institute, Inc.
Redlands, CA

There is a certain class of features on maps that are difficult to generate from traditional GIS databases — named features of the natural landscape. Physical features, such as mountain ranges, canyons, ridges and valleys, and named water bodies, such as capes, bays and coves, are often not found in GIS databases. This results in their omission on maps or at best their addition to the map as graphic type that is not georeferenced to the data used to make the map. This paper describes an inherently multi-scale GIS data model for physiographic features, and by extension named water bodies and named islands and island chains and groups, that can be used to create many different types of maps. The semantic model (what features to include), the representation (how to define the geometry of the features and their attributes), and the symbology (the specifications for both type properties and type placement) are discussed. In addition, the sensitivity of the representations and symbology to the software used for mapping are described. These issues are reviewed in hopes that others will be better able to use GIS data and software to make maps that include these features. Cartographers know that without the inclusion of the type for these names on maps, the products created are less informationally — and cartographically — rich. If more GIS databases with these features in them were developed, non-cartographers using GIS software to make their maps, as well as cartographers who have not generally had these data at hand, could produce better products.

Keywords: cartographic data modeling, indeterminate boundaries, physiographic features, GIS

INTRODUCTION

Maps produced by cartographic organizations, both public and private, often distinguish themselves from maps produced by organizations using solely GIS methods. The presence of names for natural features is one obvious way that maps produced by cartographers can be differentiated from maps produced by non-cartography savvy GIS users. Natural features are often represented by the type for their names alone and not by any distinct boundary that is delineated on the map. These features are typical of those described as "fuzzy features" in the GIScience literature (Couclelis, 1996; Brändli, 1996, among others) and various interesting characteristics of these types of features have been discussed (Mark and Turk, 2003; Smith and Mark, 2003; Waters and Evans, 2003). Because these types of features are not currently captured in geospatial databases as a common practice, they often do not show up on maps made exclusively with GIS. In this paper, the focus is on these types of features as they relate to their cartographic representations on maps and their GIS representations in databases. On reference maps, this includes named marine water

Initial submission, June 9, 2006; revised submission, August 25, 2006; final acceptance, August 29, 2006

bodies, such as bays, straights and gulfs, as well as named terrestrial physiographic features, such as mountain ranges, deserts, and ridges. The goal is to provide guidelines for how these types of features can be modeled in a database so that they can be included on more maps that are made with GIS software.

The type for natural features that appear on maps is currently preserved in forms not readily applicable to other uses; they are often stored as a type layer for a given finished map, which rarely makes them useful for another product. They are typically stored or archived in proprietary data formats, or sometimes they are stored only in the paper product. Increasingly, names for geographic features are stored in a digital database with point locations that sometimes do not correspond to either their actual geographic position or the best cartographic position for type placement. By and large, geographic names are certainly not at this time linked to mainstream spatial information infrastructures.

To complicate matters further, the way the names of natural features without delineated boundaries are drawn on maps is highly tailored to the shape and nature of the features so as to imply their extent without having to draw debatable demarcating lines on a map. It would be valuable to have a flexible lowest common denominator GIS representation of these features (that is, a primary feature type for these features that can be used on many types of maps at many different scales). In most cases, this will be a polygon within which the type for the feature would appear. Digitized correctly, this polygon would be able to encompass the appropriate location for the type at any scale and at the smallest scales could be treated as a point for type placement. Such a versatile representation would be more useful and as a result would likely become more widely used by more map-makers to achieve a higher level of information quality as well as cartographic quality.

"The goal is to provide guidelines for how these types of features can be modeled in a database so that they can be included on more maps that are made with GIS software."

In order to discuss a practical means of doing this, there is first a need for an understanding of the types of natural named features with indeterminate boundaries that appear on maps. Then guidelines for how those features should be represented in GIS, driven by an understanding of how they have typically been depicted or symbolized on maps, is needed. How the software handles feature type can affect the mapped representations and therefore should be considered in the database development.

TYPES OF FEATURES AND THEIR GIS REPRESENTATIONS

Features with indeterminate boundaries can be organized into general themes based on the category of information they represent. There are several useful taxonomies for organizing thematic information on a map. The basis for our framework is the model discussed by Arctur and Zeiler (2004), which describes a set of themes commonly found on many base or reference maps. Those that are relevant for our purposes are: transportation, cultural, boundaries, hydrography, hypsography and surface overlays. More recent research has identified an additional base map theme, physiography, also relevant to our work (Buckley *et al.*, 2005).

Within the themes of physiography and hydrography, one can identify specific feature types. A number of taxonomies already exist which can be useful when determining the types of labeled features that will appear on maps. For some sources, the principal concept behind the taxonomy is map or GIS-based. For example, the Alexandria Digital Library (ADL) Gazetteer contains feature type classifications from three independent typing schemes (ADLP, 2004); all of the names in the database are associated with one or more feature type terms from the 1) *ADL Feature Type Thesau-*

rus, which are drawn from a variety of authoritative sources, including glossaries and government publications, and portions of the names are associated with either 2) the gazetteer type terms from the U.S. Geological Survey or from 3) the U.S. National Geospatial-Intelligence Agency (NGA). These feature types have specific descriptions and are polyhierarchical; however, they are simply descriptions that have no associated geographic feature data.

An alternate feature name and type source is the Digital Geographic Information Exchange Standard (DIGEST) data model used in conjunction with Vector Map (VMAP) data (DIGEST, 2001). The VMAP database consists of textual, attribute, and geographic data, and physiographic features are stored as points, lines or polygons (Figure 1). This is an interesting example of the implementation of a GIS database for named places; however, there are some serious limitations. The VMAP data files have a field for the name of a location (NAM) but it is rarely populated; indeed, the Named Location features in this database do not even have a name field. Instead, it is intended that the names of the feature be derived from the GEOnet Names Server (GNS) for all locations except the United States and Antarctica, which come from Geographic Names Information System (GNIS) database.

"These feature types . . . are simply descriptions that have no associated geographic feature data."

Additionally, as is apparent in Figure 1, there are some problems with the classification of feature types along source map sheet boundaries. To further complicate matters, VMAP data are available in low resolution (Level 0), medium resolution (Level 1) and high resolution (Level 2). Level 0 provides worldwide coverage of geo-spatial data and is equivalent to a small scale of 1:1,000,000; this is a slightly more detailed reiteration of the Digital Chart of the World. Level 1 data is equivalent to a medium scale 1:250,000 resolution. Level 2 data is equivalent to a large scale 1:50,000 resolution. Because of the varying scales, a feature that is represented as

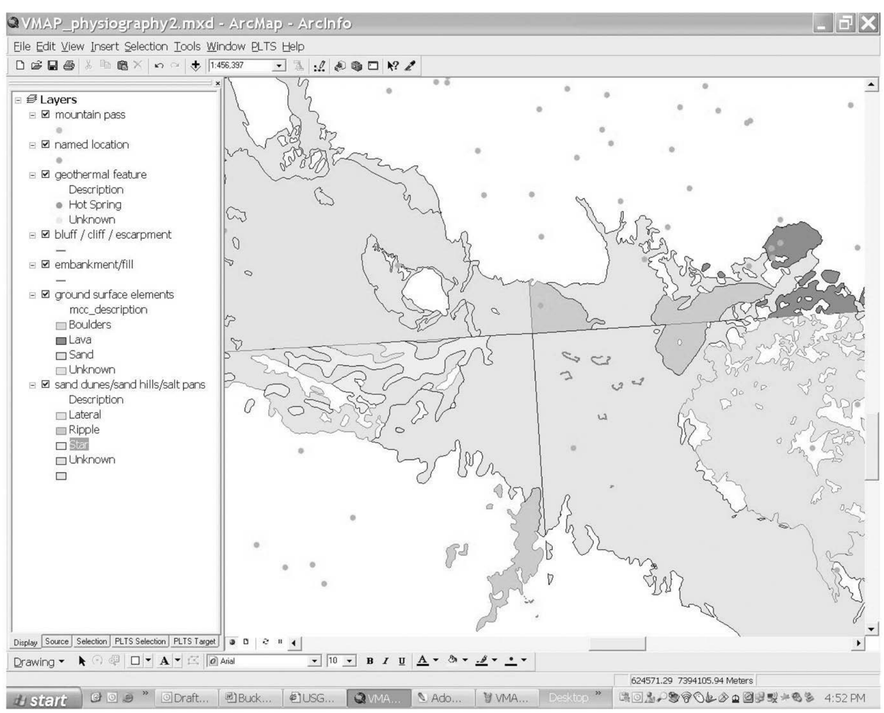


Figure 1. Physiographic features in the VMAP data are designated as points, lines or polygons. Obvious problems can occur at the boundaries of the map sheets that were used as the source documents. Not all names for these features are stored in the GIS dataset. (see page 78 for color version)

a polygon at one scale can become a point at smaller scales. The varying feature representations and the technicalities related to maintaining the names linkages make using these data for multipurpose, multi-scale maps problematic.

A third example of a physiographic feature taxonomy can be derived from the types of features found on the U.S. Geological Survey (USGS) topographic map series (USGS, 2002). Features on the USGS topographic maps have been divided into the following categories: coastal features and shorelines, escarpment features, glacial features formed by alpine glaciation, glacial features resulting from continental glaciation, miscellaneous features, mountain features, plains features, plateau features, solution features, valley features, volcanic features, water features, and wind features. Definitions of many of the features are provided in the National Mapping Program Standards for maps at various scales (USGS, 2005); however, not all of the features are described or defined therein. Furthermore, features that appear only as type for names on USGS maps, such as named landforms, exist only in the GNIS database as point locations that represent the cartographic position for type placement on the original map, and these locations sometimes do not correspond to their actual geographic positions.

Since no ideal GIS databases exist that can be used for mapping features with indeterminate boundaries in order to show their geographic names on maps, the challenge was to determine how that type of database could be specified, compiled and used. It was determined that all these features could be stored as either points (in a very few cases) or polygons. Lines could be used but they do not scale as well as polygons. With polygon features, the label can shift location based on the scale and extent of the area being mapped; with line features the text must be placed relative to the line that likely was drawn for a particular scale and extent. Because the features are only used to label the map, a further categorization of the point and polygon designations was formulated so that they can be used to specify particular placement properties for the feature types based on polygon geometries. These distinctions are clarified further in the "Reclassification of Feature Types" section below.

"Since no ideal GIS databases exist that can be used for mapping features with indeterminate boundaries in order to show their geographic names on maps, the challenge was to determine how that type of database could be specified, compiled and used."

The left column of Table 1 lists some of the most common types of natural features that lack delineated boundaries on maps. The content of the table was extended to show how other types for non-physiographic regionalizations could also be considered; however, in this paper the concentration is only on the first three types of features. The second column

Types of Features with Indeterminate Boundaries	**GIS Theme**	**Required Topology**
Named Marine Water Bodies	Hydrography	Must Nest, No Overlaps
Named Physiographic Features	Physiography	May Nest or Have Partial Overlaps
Named Islands and Island Chains and Groups	Physiography and Hydrography	Must Nest, No Overlaps
Neighborhoods and Districts, Vernacular Regions	Cultural and Transportation	May Nest or Have Partial Overlaps
Land Cover, Geology, Soils and Other Overlays	Overlays	No Overlaps

Table 1. Thematic organization of features with interminate boundaries.

shows where, relative to a base map data model, these features should be modeled within the GIS database. The Topology column shows the nature or restrictions of the spatial relationships of features within each theme. Topology is closely related to the semantic model for how these features are defined by our languages and cultures, as are the mereological (that is, the part-to-whole) relationships. It is therefore useful to consider the mereotopological relationships, which marries wholes, parts and boundaries with their topological roles and relations (Smith, 1994 and 1995; Varzi, 1997). These relationships are discussed for each of the three types of features described in this paper.

Many features with proper names exist within each of these types, and they often have indeterminate boundaries. For the most part, only the type for the names of these features are depicted on maps, and map readers draw conclusions about the actual location of the features from the contextual relationship that the type has with other features on the map. For instance, a map may have the names of canyons on it and the context that helps map-readers are the contour lines and a hillshaded representation of the terrain.

The following section describes the semantic model for the types of geographic features considered in this paper. Because the type specifications and the placement rules may vary for different feature types, it is useful to develop a set of valid feature type values that can be used as an attribute to distinguish the features in the GIS dataset. The valid values for the feature types should be based on (1) the requirements to make a certain set of maps at varying scales, and (2) the source documents from which the features were delineated. In the development of other semantic models for typing the features, both these factors should be kept in mind. Other semantic models could be derived from any of those that currently exist (e.g., the ones developed in this research, ADL, DIGEST, or others), and they could be easily modified to meet the mapping requirements for other projects or organizations.

"For the most part, only the type for the names of these features are depicted on maps, and map readers draw conclusions about the actual location of the features from the contextual relationship that the type has with other features on the map."

Named Marine Water Bodies

A suggested set of feature types for named marine water bodies is:

- Bay
- Bight
- Channel
- Firth
- Gulf
- Inlet
- Ocean
- Passage
- Sea
- Sound
- Strait

The mereotopology for named marine water bodies is that they must nest and that they do not overlap. For instance, the Straits of Florida do not overlap the Gulf of Mexico or the Atlantic Ocean.

It may be desirable to include features that are either antiquated, like the Sargasso Sea, or legendary, like the Bermuda Triangle. These features should be managed as exceptions to the rule, unless modeling a database that is devoted to all but contemporary water body names and locations (i.e., those that are currently in use or in use at the same time). If these features are included in the database, an attribute should be used to define the feature type for marine water bodies; valid values may include historical, relic, and legendary types of water bodies.

Since marine water bodies are typically represented with type only on maps, the feature types can be categorized from the semantics for the feature names. That is, these feature types are based solely on the name rather than some taxonomy relating to physical characteristics. Thus, the

Gulf of Mexico is a gulf; the Sea of Japan is a sea, etc. The type is displayed so that the largest water bodies have the largest type sizes. Type is typically aligned along the graticule, or, for protracted water body shapes, along the major trending axis. For reference maps, if the scale of the map is such that the type will not fit roughly into or just slightly overrun the bounds of the feature, it should not be shown on the map. If the water body is too small to contain its type, but is critically important to the purpose of the map (i.e., has notoriety), then a leader line should be used to identify the location of the water body.

Figure 2. Small-scale representation of named physiographic features and regions (Raisz, 1965).

Named Physiographic Features

Identifying and classifying named physiographic features relates to work that others have done in regionalization. Geographers and others (Lobeck, 1932 and 1947; Fenneman, 1938; Fenneman and Johnson, 1946; Raisz, 1957) have sought, at small scales, to regionalize the United States and North America based on broad geologic or geomorphic characteristics. Figures 2 and 3 are excellent examples of such work.

A digital example of physiographic regionalizations such as those illustrated by Raisz is the United States Geological Survey dataset (USGS, 1992) of named physiographic *Divisions, Provinces, and Sections* that regionalizes the United States based on a 1946 map by Fenneman and Johnson (1946) (Figure 4).

These kinds of smaller-scale regionalizations are used as the basis for further definition of medium-scale physiographic features. Currently, individual physiographic features are typically not part of GIS or spatial data repositories. Although some GIS

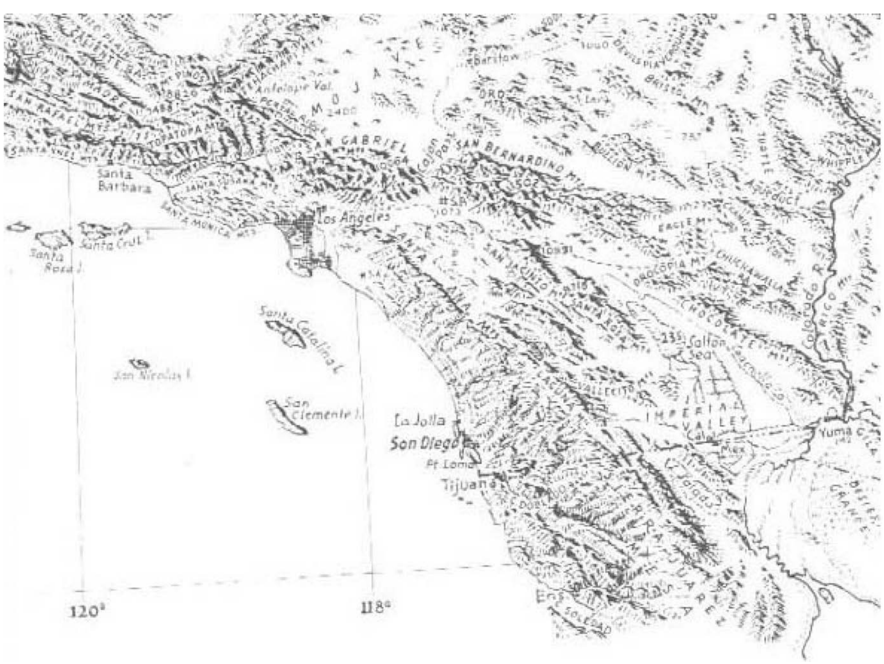


Figure 3. Medium scale representation of named physiographic features and regions (Raisz, 1965).

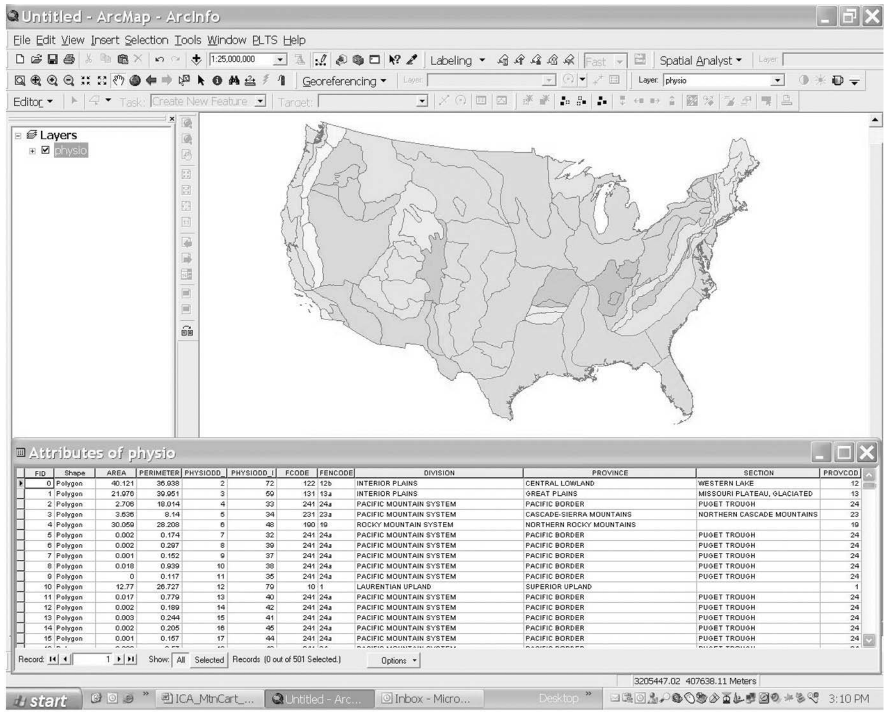


Figure 4. USGS dataset of physiographic regions and provinces for the conterminous United States. (see page 78 for color version)

datasets with limited utility do exist, as described earlier, most digital representations of these features are managed in place names indexes with no associated geometric representation useful for cartography. Data for larger scale maps is even more critically lacking, underscoring the need for a model that envelops more local features such as peaks, ranges, mountains, valleys, deserts, canyons, flats or playas, passes, etc.

As with named marine water bodies, the development of a set of physiographic feature types should relate to the map or map products that will be made from the data, as well as the source documents used to compile the dataset. The set of feature types for named physiographic features developed in this research include:

". . . the development of a set of physiographic feature types should relate to the map or map products that will be made from the data . . ."

- Badlands
- Bar
- Basin
- Bend, Land
- Bend, Water
- Bluff
- Butte
- Canyon
- Cape
- Carolina Bay
- Cliff
- Crater
- Delta
- Desert
- Dunes
- Escarpment
- Fault Zone
- Gap
- Hill
- Hills
- Incline Flow
- Incline Flow, Earthen
- Incline Flow, Lava
- Incline Flow, Rockslide
- Incline Flow, Slope
- Island
- Isthmus
- Landfall
- Lowlands
- Mesa
- Moraine
- Mountain
- Mountain Range
- Natural Arch
- Natural Bight
- Pass
- Peak
- Piedmont
- Pinnacle
- Plains
- Plateau
- Playa
- Promontory
- Ridge
- Saddle
- Terrace
- Uplands
- Valley
- Volcano, Active
- Volcano, Inactive

A few of these feature types warrant further description. Playas include all flats (mud, sand, etc.). Peaks are only the uppermost portion of a named mountain and do not slope upward to other peaks or mountains; peaks may have no logical or semantic link to mountains with "peak" in their name. Islands refer to exposed named land masses within inland water bodies — islands within named marine water bodies are managed in a separate dataset, as discussed below.

The mereotopological relationships for physiographic features vary by type; therefore, the general rule for the topology of named physiographic features is that they may nest, or they may have partial overlaps. Unlike named marine water bodies, some named physiographic features are polyhierarchical with respect to the fact that for different map scales, there are different contemporary regimes of features, sometimes more than one at the same scale. One cannot assume that the mereotopological relationships from one scale will necessarily hold for other scales, at least for the purposes of mapping. For instance, mountain ranges may contain mountains, which contain one or more peaks, but sometimes mountains contain other mountains and a single mountain can contain more than one peak. The impact of cultural and linguistic history is not necessarily logical when it comes to the names of these types of features. Also, unlike named marine water bodies which can be suitably categorized by the feature type indicated in the name, some physiographic features cannot be semantically categorized this way. For example, a flat may be a playa or a mud flat, and a mount may be a peak or a mountain or even a small rise. The name of the feature does not always clarify the distinction.

Named physiographic features, like named marine water bodies, are typically represented on the map with type, unless the feature is too small at a given map scale, in which case the type should not appear at all unless it is determined to be a critically important feature. Unlike named marine water bodies, the type for these features is not aligned to the graticule. Rather, type placement for physiographic features is guided more by the geometric major trending axis. In addition, the representation of the terrain should be used to guide how to drape, nestle, or span the type for a given feature. This is a rather artistic process that requires the map-maker to adequately imply where the feature exists by the positioning of the type.

"This is a rather artistic process that requires the map-maker to adequately imply where the feature exists by the positioning of the type."

Named Islands and Island Chains and Groups

Islands and island chains and groups generally have these terms in their proper names, and there are only a small set of synonyms, such as archipelago and chain. This makes the semantic model for, and the identification of these features fairly simple and straightforward.

The set of feature types for islands and island chains and groups developed for this research is:

- Archipelago
- Chain
- Islands
- Atoll
- Group
- Isle
- Barrier Island
- Island

The mereotopological relationships for islands and island chains and groups are pretty straightforward. Islands may or may not be part of an island chain or group; therefore, the topological restriction is that they must nest with no overlaps. Island chains and groups, however, are cartographically represented with type that is by necessity drawn outside the geometric bounds of the individual island features.

In the cartographic representation of islands, the extent of terra firma is generally neither fuzzy nor indeterminate. The type for an island is placed inside the island if it fits at the given map scale. If an island is too small to contain its type, the label is placed outside the island using methods for positioning type associated with a point features. The typeface for islands that are countries typically differs from those that are not. If an island is not a country, the country that has dominion over that island may be shown as well.

Island chains and groups are more complicated, as the type placement for the name of the features is somewhat similar cartographically to that of mountain ranges. Ideally the type extends over of geographic space for all islands shown that are officially part of the chain or group. The type for an island chain or group may overlap islands, that is, it does not have to be positioned without exception outside of the geometry of the individual islands. Typically the type for an island chain or group follows the major trending axis of the chain or group. If a group or chain of islands is labeled, the type placement is more similar to that of larger named marine water bodies in that the type is aligned to the graticule, and is positioned large enough within the group or chain to imply virtual ownership of the islands by the group or chain.

GIS REPRESENTATIONS FOR CARTOGRAPHIC USE

"A key factor is that these features will be used expressly to produce maps."

This section discusses what to store in the GIS database for the geometry of features without definite boundaries. A key factor is that these features will be used expressly to produce maps. To successfully store representations that facilitate mapping, the common assumption that the geometric representation of a feature in a GIS is the most accurate representation possible will be contradicted. Typically some process of cartographic abstraction happens prior to representing a GIS feature on a map. Conventional wisdom or logic dictates that the abstracted representation cannot enhance the accuracy or precision of the feature's geometric coordinates. However, if a feature's geometry describes a shape that adequately encompasses that feature's location, rather than the feature itself, an inherently non-specific cartographic representation of that feature can be abstracted and potentially function as a better representation on a given map.

To facilitate the abstraction of GIS data into cartographic representations, cartographic attributes must often be stored with the GIS representation. These attributes, together with an adequately encompassing geometric representation stored in a GIS, are the inputs to the cartographic abstraction process for map production. The following sections provide a discussion of how specific types of features with indeterminate boundaries might be modeled in the GIS so that they may be used as the basis for cartographic representations. As the title of this article indicates, one key aspect is that a single GIS feature must serve as the basis for multiple cartographic representations at varying scales. As suggested, in most cases, this requires a polygon within which the appropriate location for the type could appear at any scale, and that at the smallest scales could be treated as a point for type placement.

Named Marine Water Bodies

The GIS representation of a named marine water body feature is a polygon with the following attributes:

- **PolyID** [Integer]: This is used as a primary or foreign key in a join or relationship to other databases, such as a names database or a revision information table.

- **Name** [Text]: This is the proper name of the feature as it would appear on the map.
- **FeatType** [Integer]: This is used to categorize features based on different type style or placement requirements. In cases where the semantics of the name do not match the actual type of feature, this attribute also stores the actual feature type.
- **SizeClass** [Integer]: This is based on the area of the polygon and is used for two purposes: 1) to determine whether the feature will be represented on a map at a particular scale, and 2) to determine the size of the type that will be used to represent that feature at that scale.
- **Sources** [Integer]: Ideally this is used as a primary or foreign key for a join to a look-up table of sources. Unless an agency has performed the primary research to determine the name of a feature, this field can be used to identify at least three independent sources demonstrating that the feature name exists in the public domain.

"The symbolization and placement of the type is performed by the GIS software using the polygon geometries and attributes in the application of the type style and placement rules."

Figure 5 shows the GIS representation of named marine water bodies between the southern United States and northern Central America. Notice the lines that separate unique named bodies of water.

Figure 6 shows the cartographic representation, which does not indicate the feature outlines but does display type that is appropriately sized and positioned within each water body relative to the chosen map scale. The symbolization and placement of the type is performed by the GIS software using the polygon geometries and attributes in the application of the type style and placement rules. The polygon attributes are used to determine the content of the text string, how to set the type style, and whether to include it at a given map scale. The polygon geometries are used to determine the type placement.

Figure 5. GIS representation of named marine water bodies as non-overlapping polygons with an extent adequate to label the features at multiple scales.

Figure 6. Cartographic representation of named marine water bodies.

Named Physiographic Features

The GIS representation of a named physiographic feature is a polygon, with the exception of named summits, in which case the representation is a point. As with named marine water bodies, the polygon features are never actually drawn on the map. Rather, they are the basis for creating and placing the type on the map at any scale. Along with named marine water bodies, named physiographic feature polygons are excellent examples of multi-purpose datasets because they can be used for any map at any scale. This method of feature representation provides a vast improvement in efficiency over traditional methods of only maintaining the type for the feature, which serves a very narrow range of cartographic purposes (i.e., maps).

". . . named physiographic feature polygons are excellent examples of multi-purpose datasets because they can be used for any map at any scale."

The GIS representation of a named summit is a point with the following attributes:

- **PolyID** [Integer]: This is used as a primary or foreign key in a join or relationship to other databases, such as a names database or a revision information table.
- **Name** [Text]: This is the proper name of the summit as it would appear on the map.
- **FeatType** [Integer]: This is used to categorize features based on different type style or placement requirements. This is also used for filtering out smaller features like hills, or for showing only mountain top elevations.
- **Elevation** [Integer]: This is an integer only because most maps do not require specification of elevations as the sub-foot or -meter level.
- **Units** [Short Integer or Boolean]: This is used to denote whether the elevation is in feet or meters.
- **Sources** [Integer]: Ideally this is used as a primary or foreign key for a join to a look-up table of sources. Unless an agency has performed

the primary research to determine the name of a feature, this field can be used to identify at least three independent sources demonstrating that the feature names exists in the public domain.

The GIS representation of a named physiographic feature is a polygon with the following attributes:

- **PolyID** [Integer]: This is used as a primary or foreign key in a join or relationship to other databases, such as a names database or a revision information table.
- **Name** [Text]: This is the proper name of the summit as it would appear on the map.
- **FeatType** [Integer]: This is used to categorize features based on different type style or placement requirements. As above, this is also used for filtering out smaller features or for showing only selected features.
- **Order** [Integer]: In general, this is a classification of the size of the features, although the values of this attribute for individual features could also be modified to reflect their notoriety.
- **Sources** [Integer]: Ideally this is used as a primary or foreign key for a join to a look-up table of sources. Unless an agency has performed the primary research to determine the name of a feature, this field can be used to identify at least three independent sources demonstrating that the feature name exists in the public domain.

"Unless an agency has performed the primary research to determine the name of a feature, this field can be used to identify at least three independent sources demonstrating that the feature names exists in the public domain."

Figures 7 and 8 give an indication of how the GIS features for named physiographic features look. In Figure 7, the extents of the physiographic features stored in the GIS can be seen. Colors relate to the size of features to emphasize the smaller features in this display. Features for all potential map scales are represented; for example, the canyons shown in Figure 8

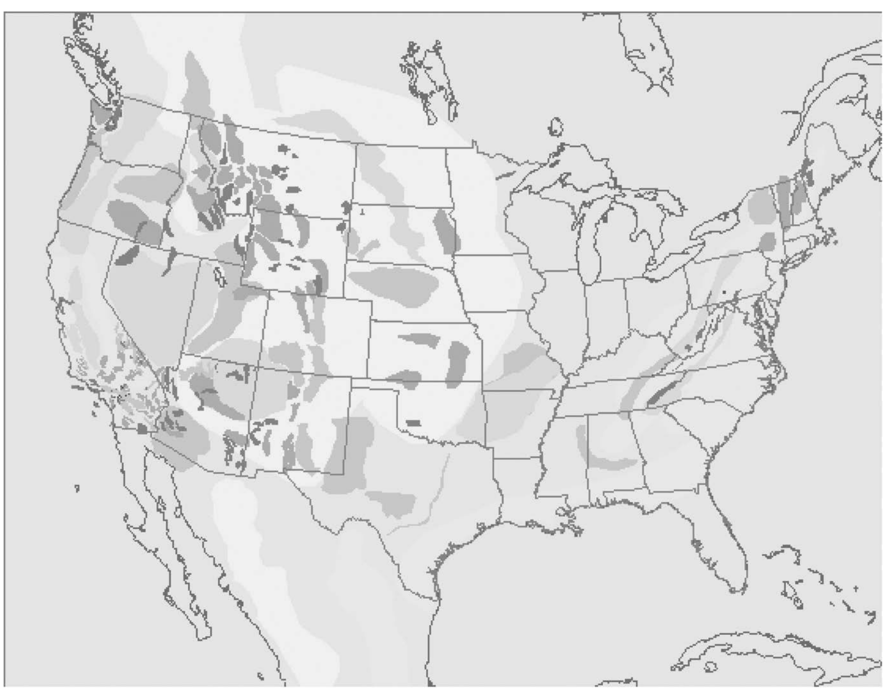


Figure 7. GIS representation of named physiographic features as polygons for a portion of North America. These GIS data do not represent a complete inventory of physiographic features in the area mapped. (see page 79 for color version)

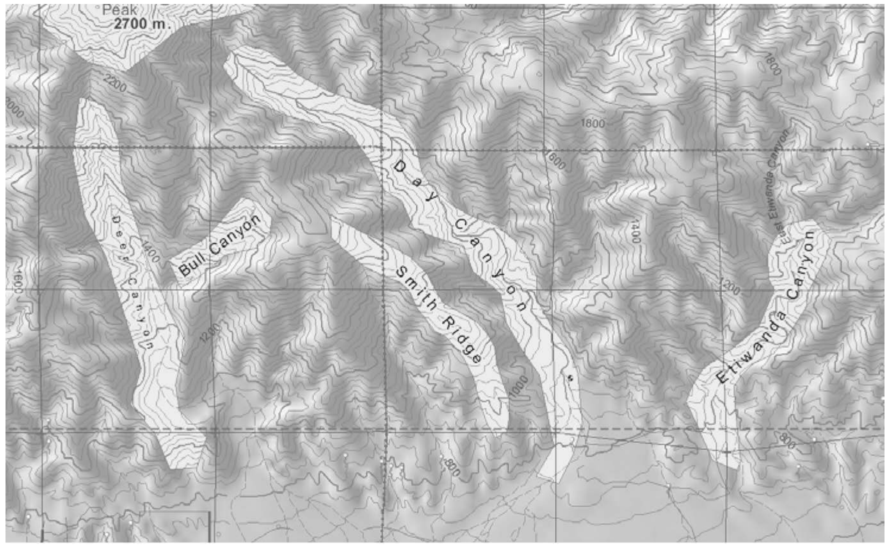


Figure 8. A portion of a 1:100,000 scale topographic map showing the GIS representation (as polygons) and the cartographic representation (as type) of several canyons in Southern California. *(see page 79 for color version)*

are in the dataset but they are too small to be seen at the scale mapped in Figure 7. In Figure 8, notice that the canyon polygons fit the terrain such that they do not extend too far up the side slopes and they extend far enough up the canyons that if only the upper portion of the feature appears on a map it will be still be represented.

Named Islands and Island Chains and Groups

The GIS representation of both islands and island chains and groups is a polygon. The polygon for island chains and groups should fully encompass all islands in the chain or group and allow some extra space for the type that should be placed. The island chain or group name should be placed inside the polygon if possible, or it can overrun the polygon just slightly. Additionally, the type for each island should be placed within its polygonal outline if possible, but the type may be allowed to overrun the outline if there is lack of sufficient space. For islands that are too small to contain most of the name, the type should be placed as if the island were a point.

"For islands that are too small to contain most of the name, the type should be placed as if the island were a point."

The GIS representation of islands and island chains and groups is a polygon with the following attributes:

- **PolyID** [Integer]: This is used as a primary or foreign key in a join or relationship to other databases, such as a names database or a revision information table.
- **Name** [Text]: This is the proper name of the feature as it would appear on the map.
- **TerritoryOf** [Text]: This is the proper name of the country with sovereignty over the island or island chain or group that would appear on the map.
- **FeatType** [Integer]: This is used to identify which features will be labeled as islands and which features will be labeled as chains or groups.
- **InGroup** [Short Integer or Boolean]: This is used to denote whether a feature is part of a group of features also represented in the GIS

database. For example in Figure 9, San Clemente Island is in an island group called the "Channel Islands".
- **GroupID** [Integer]: This is the ID of the group polygon.
- **Sources** [Integer]: Ideally this is used as a primary or foreign key for a join to a look-up table of sources. Unless an agency has performed the primary research to determine the name of a feature, this field can be used to identify at least three independent sources demonstrating that the feature name exists in the public domain.

Figure 9 shows the GIS representation and the associated type style and placement for an island group that contains a number of islands. Both the islands and the island group are stored as polygons in the GIS dataset, but the polygon for the island group would not be displayed on the map; it is shown here to illustrate the extent of the polygon in the GIS dataset.

RECLASSIFICATION OF FEATURES BASED ON SHAPE TYPE AND AREA

A reclassification of the features based on their geometry (i.e., shape type and size) can be used to further refine the placement of the type on the map. When labeling a map using GIS label placement algorithms, it does not matter if a polygon is a canyon or a bluff if the same text specifications (that is, size, color, kerning, curved or horizontal placement, etc.) are being used for those polygon labels. The subdivision of features into categories, such as canyon or bluff, which are not helpful when labeling is pointless as well as unproductive. Instead, the categorization of features into label classes should be dependent on two things: (1) any variation in the type specifications and (2) any variation in the label placement specifications. If the labels will look different or be placed differently, then they need to be in different label classes so they can be handled differently by the GIS label engine. Often times, type placement variations are dictated by the size

"The subdivision of features into categories, such as canyon or bluff, which are not helpful when labeling is pointless as well as unproductive."

Figure 9. GIS representation of islands in an island group. In the cartographic representation, the islands are labeled using point placement rules, and the island group is labeled as a polygon.

and shape of the feature; therefore, it would be useful to have a method for classifying the features based on these properties. This classification then becomes the basis for the creation of the various label classes that can be used to specify the style and placement of the type. Examples of some features in different shape classes are shown in Figure 10.

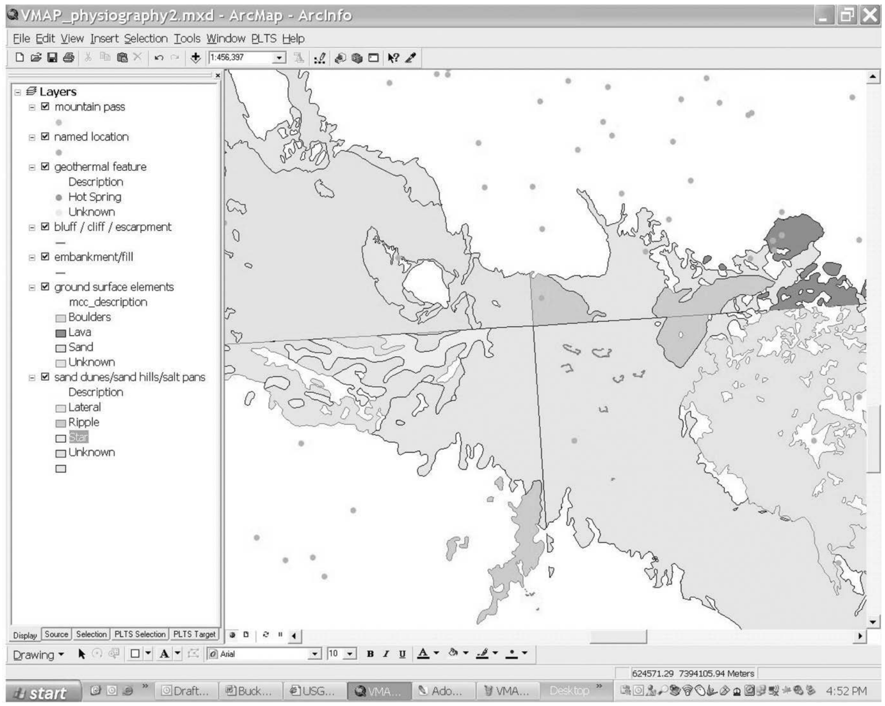


Figure 10. Features can be classified based on shape type which allows label classes to be created that are used to specify how the type is to be placed. (see page 80 for color version)

The classification of features by label placement properties is new to this research and bears further elucidation. First, the label placement capabilities of the software will drive the assignment of features to label classes. If the software is able to provide more refined placement options based on such properties as the size and shape of the feature, then these attributes can be used for label classification. To that end, a set of seven feature types that are used to specify label classes and variations in label placement properties were developed. These are:

"The classification of features by label placement properties is new to this research . . ."

1. Long
2. Long and Skinny
3. Oblong
4. Round
5. Snaky or Pronged
6. Splotch
7. Snaky or Pronged and Skinny

A cartographer might choose to specify different classes based on the requirements for their maps, keeping in mind that the assignment of features to different label classes is a function of the placement rules and type specifications, which are in turn a function of the map being produced. These seven classes, however, seem to work well for a variety of maps at different scales.

It would be extremely tedious to sort these features into classes by interactively selecting them and calculating a ShapeType attribute to store the unique class numbers that are then used to separate the features into label classes. Instead, it would be useful to have an automated method for performing this sort. This can be done using the minimum-bounding rectangle (MBR) which is then used to determine the proportion of the shape area to the MBR area (Figure 11). A better solution is to use the Rotated MBR, or RMBR (Brinkhoff *et al*., 1993), which allows rotation to align the bounding rectangle to the axes of the feature. The RMBR area is then used to calculate: (1) the Shape_Area/RMBR_Area proportion as a percent, and (2) the ratio of RMBR length.

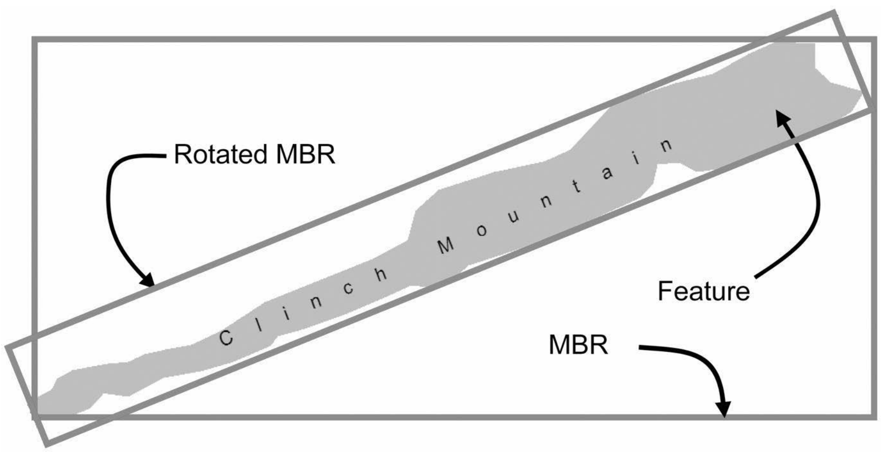


Figure 11. The traditionally calculated MBR versus the rotated MBR which is used to calculate two metrics used in the classification of features into label classes.

The logic for using these values is described in detail in an article by Frye (2006) and is not elucidated further here. The result, however, is that each feature can then be assigned to a label class using an attribute that designates the basic shape of the feature. Combining that with any required variations in the text specifications creates the full set of label classes used by the software to properly label the features. This helps to overcome deficiencies of the software to place text with greater variations for placement and style. As a result, the time required to edit the automated type placement can be greatly reduced.

LINKING TO STANDARDIZED GEOGRAPHIC NAMES DATABASES

An additional step might be to link the geographic features to a standardized names database. The advantage of doing this is to be able to manage the names of places in one location. For databases that will be used to create a number of map products, using a centralized standardized database makes even more sense as any updating of names in the database would be reflected across all maps products.

In some cases, it may be desirable or necessary to defer the decision about which names to use on maps to a geographic names authority that has such a database. For example, the Getty Thesaurus of Geographic Names (TGN, 2004) includes names and associated information about places. Places in TGN include administrative political entities (e.g., cities and nations) and physical features (e.g., mountains and rivers). Both current and historical places are included. The position of a place is indicated by geographic coordinates, and bounding coordinates and elevation may also be included. As another example, the GEOnet Names Server (GNS) provides access to the NGA's and the U.S. Board on Geographic Names' (US BGN) database of foreign geographic feature names or, for names in the U.S. and Antarctica, the GNIS. The utility of these datasets can be

"For databases that will be used to create a number of map products, using a centralized standardized database makes even more sense as any updating of names in the database would be reflected across all maps products."

limited, though, as the point location or bounding box position of the place name may not coincide adequately with the geographic feature in the GIS database. If such a names database does exist, and the challenges in linking to a geographic feature dataset can be overcome, then it might be advantageous to use this approach for name management.

In any case, the use of a centralized names database assures that the names are maintained in one location, and that the contents of that database can be reflected in all the maps that an organization creates. The amount of time to render the labels would be impacted by the size of that database that is related to the features. To speed up processing time, the geographic names fields that will be used for labeling could be permanently joined to the feature attribute table in a product version of the GIS dataset that contains the features geometries. Additionally, the names database could contain much more information about the place names such as historical, vernacular or variant names. The identification of sources (as with the physiographic feature polygons) could be circumvented by using a standardized geographic names database, although it might still be desirable to indicate the sources used to determine the geographic extent of the feature to be used for type placement.

CONCLUSIONS

This paper described three different types of natural features with indeterminate boundaries (named marine water bodies, named physiographic features, and islands and island chains and groups) and how they are modeled in a GIS database to support cartographic representation. Each of these three general types of features differs semantically and topologically. For all but summits, polygons with cartographic attributes were used as the GIS representation of the features. This framework for representing features with indeterminate boundaries worked very well to demarcate an adequate extent for the type on the map.

Type placement algorithms in GIS were insufficient for final type placement in the earlier stages of this research, and type had to be hand edited in order to sufficiently and elegantly imply the locations of the features. These shortcomings of type handling in GIS are well known by cartographers. Nonetheless, the automated type placement algorithms saved a great deal of time by placing the type so that only minor adjustments were required. An enhancement that continues to be explored to address this problem is the automated division of feature types into different label classes based on their shape type and area properties. These properties are then used to more carefully specify the style and placement of the type through the use of label classes. This enhancement reduces the amount of time and effort required for type placement and style changes.

"Modeling GIS data with the appropriate geometry and attributes for cartography will help make the data more versatile for multiple map purposes . . ."

Also important in the consideration of type style were the cartographic attributes SizeClass for named marine water bodies and Order for named physiographic feature polygons. These attributes allowed the GIS to vary the type size relative to the map scale, and only the relative type size variations needed to be referenced instead of the specific type sizes (e.g., smaller and larger font versus 10 and 12 point font). Other attributes such as polygon area are not always sufficient to make this determination, as features of the same size may vary in cultural and geographic significance. Assignment of this attribute using polygon area for the named marine water bodies was done through automation, and the attribute for named physiographic features was manually assigned.

In this paper, one assumption was that a primary purpose of a GIS database is to make maps. Modeling GIS data with the appropriate geometry and attributes for cartography will help make the data more versatile for multiple map purposes, and with this increased utility, cartographic GIS data may become more prevalent. The development of appropriate models for cartographic GIS data requires that cartographers become more involved in the design of GIS databases by contributing their knowledge and expertise. Since cartographers know that the type for such features as physiographic and marine places should be on many maps, it would benefit both the cartographers and others who need this information to have the data in their GIS databases. As a result, the GIS data will be more cartographically rich and the GIS software can be used to aid in the sometimes tedious and time consuming task of placing all that type on the maps.

"As a result, the GIS data will be more cartographically rich . . ."

REFERENCES

ADLP *(Alexandria Digital Library Project)*, "Correlation data relating words/phrases in place names to associated classification terms from three typing schemes", June 4, 2004, <http://www.alexandria.ucsb.edu/gazetteer/>, (June 7, 2004).

Arctur, D. and Zeiler, M., 2004. *Designing Geodatabases: Case Studies in GIS Data Modeling.* Redlands, California: ESRI Press, 393 pp.

Brändli, M., 1996. Hierarchical Models for the Definition and Extraction of Terrain Features. In Burrough, P.A. and Frank, A.U. (Eds.) *Geographic Objects with Indeterminate Boundaries*, 257-269. London: Taylor & Francis.

Brinkhoff, T., Kriegel, H-P. and Schneider, R., 1993. Comparison of Approximations of Complex Objects Used for Approximation-based Query Processing in Spatial Database Systems. *Proceedings of the 9th International Conference on Data Engineering*, Vienna, Austria, 40-49.

Buckley, A. R., Frye, C., Buttenfield, B. and Hultgren, T., 2005. An Information Model for Maps: Towards Cartographic Production from GIS Databases. *Proceedings of AutoCarto 2005*, March 18-23, Las Vegas, Nevada.

Couclelis, H., 1996. Towards an Operational Typology of Geographic Entities with Ill-defined Boundaries. In Burrough, P.A. and Frank, A.U. (Eds.) *Geographic Objects with Indeterminate Boundaries*, 45-55. London: Taylor & Francis.

DIGEST, *Digital Geographic Information Exchange Standard*, 2001, <http://www.digest.org/>, (May 26, 2006).

Fenneman, N.M., 1938. *Physiography of the Eastern United States.* New York: McGraw-Hill Book Company, 691 pp.

Fenneman, N.M. and Johnson, D.W., 1946. *Physical Subdivisions of the United States* (Map): U.S. Geological Survey, 1:7,000,000, 1 sheet.

Frye, C., 2006. Shape Types for Labeling Polygon Features with Maplex. *Cartographic Perspectives* 54:69-73.

TGN (Getty Thesaurus of Geographic Names), "About the TGN", July 13, 2004, http://www.getty.edu/research/conducting_research/vocabularies/tgn/about.html>, (June 9, 2006).

Jenness, J., "Topographic Position Index (TPI)", March 22, 2006, <http://www.jennessent.com/arcview/tpi.htm>, (June 9, 2006).

Lobeck, A.K., 1932. *Atlas of American Geology*. New York: The Geographical Press, Columbia University, New York, 92 pp.

Lobeck, A.K., 1947. *Historical Geology of the United States.* New York: The Geographical Press, Columbia University.

Mark, D.M. and Turk, A.G., 2003. Ethnophysiography Workshop on Spatial and Geographic Ontologies, September 9, prior to COSIT03, Ittingen, Switzerland.

Raisz, E., "Landforms of California and Nevada: 1:500,000", Map published 1965, November 10, 2004, http://www.panorama-map.com/Raisz/Calif.%20Nevada/Raiszcalif500.html, (June 9, 2006).

Raisz, E. and Atwood, W.W., 1957. *Landforms of the United States*, 6th Ed. Map, Cambridge, MA: E. Raisz.

Smith, B., 1994. Fiat Objects. In Guarino, N., Vieu, L. and Pribbenow, S. (Eds.), *Parts and Wholes: Conceptual Part-Whole Relations and Formal Mereology, 11th European Conference on Artificial Intelligence, Amsterdam, 8 August 1994*, 15-23. Amsterdam: European Coordinating Committee for Artificial Intelligence.

Smith, B., 1995. On Drawing Lines on a Map. In Frank, A. and Kuhn,W. (Eds.) *Spatial Information Theory –A Theoretical Basis for GIS*, International Conference COSIT '95, Vol. 988, Lecture Notes in Computer Science, 475-484. Berlin: Springer-Verlag.

Smith B. and Mark, D.M., 2003. Do Mountains Exist? Towards an Ontology of Landforms. *Environment & Planning b: Planning and Design,* 30:3:411-427.

Smith, B., 1996. "Mereotopology: A Theory of Parts and Boundaries", *Data and Knowledge Engineering* 20: 287-303, also <http://ontology.buffalo.edu/smith/articles/Mereotopology1.pdf>, (June 9,2006).

USGS (U.S. Geological Survey). 1992. "Physiographic Divisions of the Conterminous U.S.", January 3, 2002, <http://water.usgs.gov/GIS/metadata/usgswrd/XML/physio.xml>, (June 9, 2006).

USGS (U.S. Geological Survey). *USGS Topographic Maps Illustrating Physiographic Features*, August 26, 2002, <http://rockyweb.cr.usgs.gov/outreach/featureindex.html>, (June 7, 2006).

USGS (U.S. Geological Survey). *National Mapping Program Standards*, December 2, 2005, <http://nationalmap.gov/gio/standards/>, (June 7, 2006).

Varzi, A. C., 1997. Boundaries, Continuity, and Contact, *Nos* 31, 26--58.

Waters T. and Evans, A.J., 2003. Tools for Web-based GIS Mapping of a "Fuzzy" Vernacular Geography. *Proceedings of the 7th International Conference on GeoComputation*, University of Southampton, United Kingdom, 8-10 September.

Wood, J., *Landserf*, June 11, 2005, <http://www.soi.city.ac.uk/~jwo/land-serf/>, (June 9, 2006).

Wood, J., 2004. A New Method for the Identification of Peaks and Summits in Surface Models", *Proceedings of the GIScience 2004 Conference*, University of Maryland University College, Adelphia, Maryland, 20-23 October, 227-230.

cartographic techniques

Views of the Rivers: Representing Streamflow of the Greater Yellowstone Ecosystem

Erik Strandhagen
Department of Geography
University of Oregon
ers_carto@yahoo.com

W. Andrew Marcus
Department of Geography
University of Oregon
marcus@uoregon.edu

James E. Meacham
InfoGraphics Laboratory
University of Oregon
jmeacham@uoregon.edu

INTRODUCTION

Cartographers often work with temporal data associated with a spatial phenomenon that requires a novel method for representation. This article presents a pixel-based graphing technique for representing temporal data that is not fraught with the "amplified cartographic challenge" [Harrower 2003] that comes with animating a map. Temporal variables such as day and year may be used as coordinates to plot a pixel-based map of variations over time for any given phenomenon at a specified location.

Temporal streamflow data is one example where this pixel-based technique can be applied to produce a raster hydrograph. This method offers increased visual analysis of multi-dimensional data. As hydrologists and water resource managers experience a tremendous growth in geographical and temporal hydrologic data [Fuhrman 2000], this method of visualization can help them interpret, model, and disseminate data and information. This technique also provides a baseline that supports collective decision making [Brewer I et al. 2000, MacEachren, in press]. The raster methodology enhances the plotting of temporal streamflow data for water resource management, collaboration, and public outreach, which is a major need in GIScience [Marcus et al. 2004].

SETTING

The Greater Yellowstone Area (GYA) encompasses Yellowstone National Park and a surrounding area of approximately 7.7 million hectares [Keiter and Boyce 1994]. The GYA contains the headwaters of three major river systems: the Snake/Columbia, the Yellowstone/Missouri, and the Green/Colorado, but the semiarid climate and seasonality of flow make this an area of water scarcity. The GYA's wide variety of water data users and managers, the diverse river systems, and the need for improvements in collaborative management throughout the region prompted the influential Hydrologist Luna Leopold to state in 1986 that: "Both government agencies and private groups must understand the hydrology of Yellowstone's rivers and streams before meaningful policy may be achieved" [Dana 1990: 78]. Innovative visualization methods like the raster hydrograph contribute to an improving understanding of magnitude, frequency, and timing of peak and low streamflows in the GYA. That better understanding then enhances the collaborative management of surface water resources in the region.

PORTRAYAL METHODS OF TEMPORAL VARIATIONS IN STREAMFLOW

Traditional portrayals of temporal variations in flow are typically shown by graphs. Exceedance probability graphs (or their inverse - recurrence interval graphs) are widely used and display the probability that a flow of a given size will be equaled or exceeded in a given time. Exceedance probability charts are available for all gauged rivers in the United States through the U.S. Geological Survey (USGS) online database (Figure 1). These powerful displays provide a simple way to see temporal magnitude-frequency relations in large datasets.

Hydrographs plot discharge versus time and are also widely used to portray variations in streamflow over time (Figure 2). Hydrographs are familiar, easy to understand, and available online from the USGS. Hydrographs, however, can fail to display the full range of within-year and between-year variability, especially for large datasets. Figure 2A, for example, shows between-year variability from 1921 to 2003, while Figure 2B shows within-year variability for the 1996 water year at the same site. Detailed within-year fluctuations are not displayed in Figure 2A, nor are between-year fluctuations displayed in Figure 2B. A more robust plotting technique is needed to display inter- and intra-annual variability simultaneously.

Koehler [2004] advocates a new raster-hydrograph approach, originally developed by Keim [2000], which uses dual-time axes to show inter- and intra-annual variations simultaneously. Figure 3, shows the raster hydrograph which enables the user to determine temporal changes based on overall brightness and color distribution, with sharp borders representing discontinuities. The inter-annual streamflow patterns shown

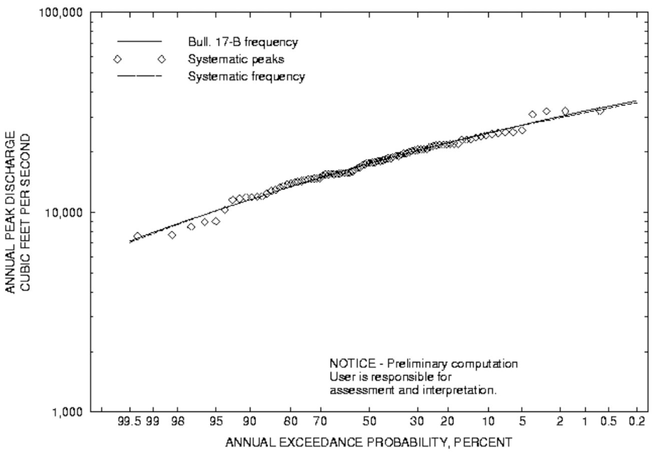


Figure 1. An exceedance plot of annual peak discharge for the Yellowstone River at Corwin Springs, MT 1911-1998. The chart provides a simple way of visually portraying 87 years of data. The exceedance probability indicates the likelihood that a discharge of a given size or greater will occur in a given year (USGS 1998: http://mt.water.usgs.gov/freq?site=06191500).

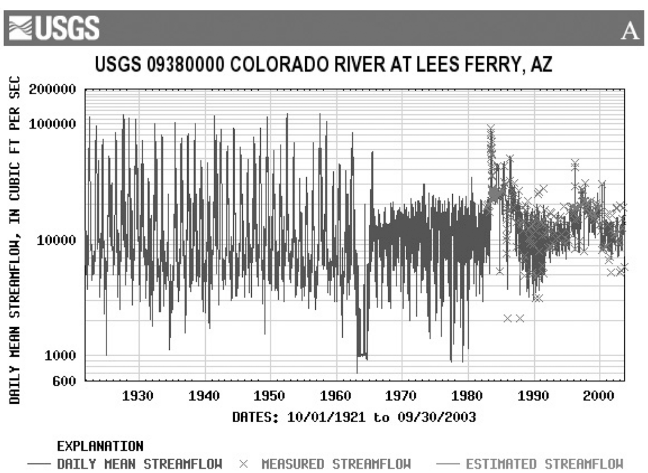


Figure 2a. Hydrograph depicting average annual flow from 1921 to 2003 at Lees Ferry on the Colorado River. (USGS 2005a: http://nwis.waterdata.usgs.gov/az/nwis/nwisman/?site_no09380000&agency_cd=USGS).

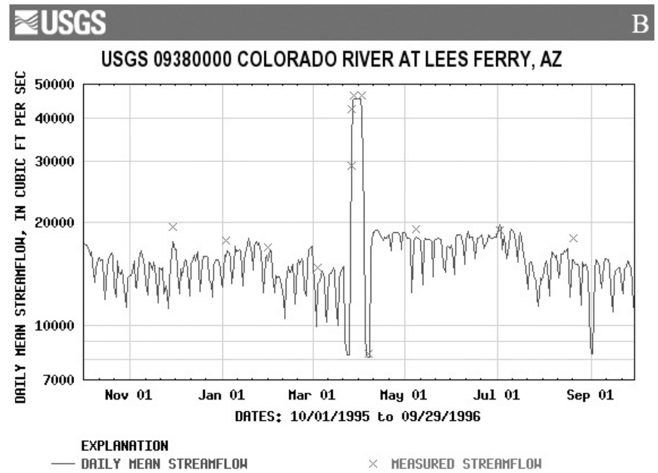


Figure 2b. Hydrograph depicting average daily flow in 1996 at Lees Ferry on the Colorado River. (USGS 2005a: http://nwis.waterdata.usgs.gov/az/nwis/nwisman/?site_no09380000&agency_cd=USGS).

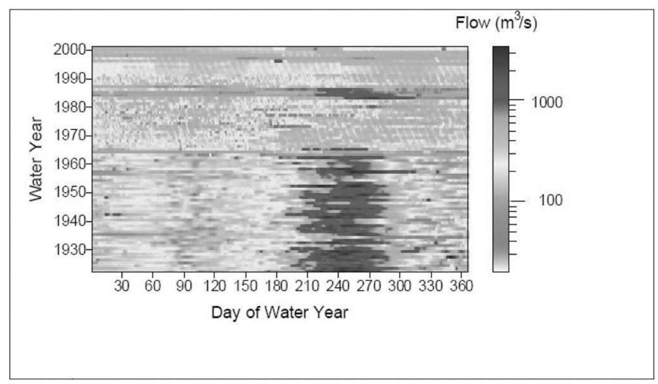


Figure 3. Raster hydrograph shows inter- and intra-annual variability simultaneously, Colorado River at Lees Ferry, AZ 1921-2002 (Koehler 2004:161). *(see page 80 for color version)*

in Figure 2a are apparent, as well as intra-annual streamflow of Figure 2b, but not for every single year of record, thus providing a denser display of inter- and intra-annual variations than the traditional hydrograph. Moreover, these pixel-based patterns provide visual representation of the frequency and clustering of events of a given discharge, thus providing similar information to that of the recurrence interval plot (Figure 1).

Poff and Ward [1990] developed a technique similar to the raster hydrograph that displays long-term at-a-station discharge in three-dimensions to reveal within- and between-year variability (Figure 4). The three-dimensional surface plot shows inter- and intra-annual streamflow simultaneously, but the heights on the vertical axis are difficult to interpret and are not as precise as the planar view of the raster hydrographs. The sequence of temporal records values also increases towards the axes' origins, which is not intuitive for time series data.

RASTER-BASED TEMPORAL VIEWS

The raster hydrograph is a multivariate representation of data where the X-axis is the day of water year, the Y-axis is the water year, and the Z-axis is the log10 of the daily mean streamflow value. We applied the raster-based techniques [Keim 2000 and Koehler 2004] to determine the potential of this technique for visualization of variations in streamflow. We developed raster hydrographs (Figure 5) for the Snake River, which is dam-regulated, and the Yellowstone River, which has no dams. Mean daily discharge values from the USGS included 36,529 observations at the Snake River near

Moran and 33,969 observations at the Yellowstone River at Corwin Springs.

The hydrologic time-series data were formatted in Microsoft Excel to the described X, Y, and Z values and then imported to Golden Software's Surfer 8.0, a commercially available contouring, gridding, and surface mapping software product. Surfer supports conversion of X, Y, Z tabular data into a grid and displays the result as a raster image. The gridding method used nearest neighbor sampling to create grid files (.grd) without interpolation so every pixel in the raster grid represents an observation in the he X-axis and year on the Y -axis as an Image Map. In place of latitude and longitude used on conventional Image Maps, the raster hydrograph method uses the temporal variables of day (X) and year (Y) as coordinates to plot a map of streamflow (Z) over time.

Discharge in Figure 5 is broken into visual classes using a sequential multi-hue color scheme based on the percent of all discharge values equal to or below a given value. This percentage-based approach provides equivalent color schemes for both hydrographs and enables quick visual comparisons between the two stations. Class breaks for the percentiles (Figure 6) follow class breaks used by the USGS WaterWatch system [USGS 2005b]. The classification system standardizes the data allowing for comparison between sites thus highlighting spatial variations.

Colors used to show percentage classes follow sequential lightness steps with a partial spectral transition in hue from yellow to green to blue (Figure 6). The sequential multi-hue color scheme maximizes

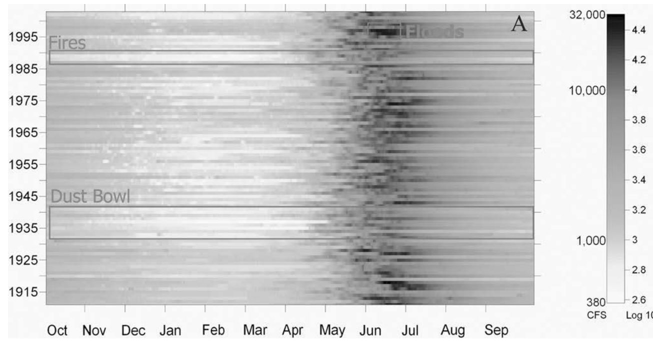


Figure 5a. Raster hydrograph for the Yellowstone River at Corwin Springs, MT. (see page 81 for color version)

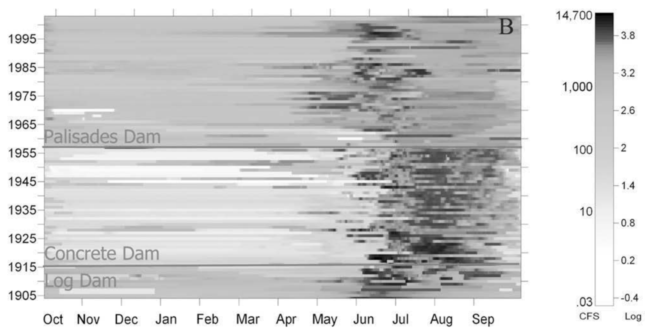


Figure 5b. Raster hydrograph for the Snake River near Moran, WY. (see page 81 for color version)

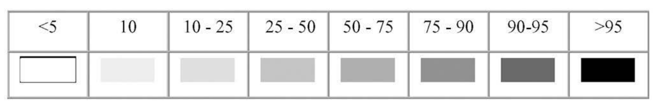


Figure 6. Percentile class breaks with corresponding multi-hue color scheme. (see page 81 for color version)

the ability to see small differences in values [Keim 2000], while the use of progressively darker steps with increasing amounts of blue for larger flows fits with viewer expectations, an important consideration with a quantitatively sequential dataset [Brewer 1994]. Anomalies are represented with the use of white for flows less than the 5th percentile and black for flows greater than the 95th percentile. This sequential multi-hue color scheme differs from Koehler's raster hydrograph spectral color scheme (Figure 3) which is not as intuitive for quantitative data and is better suited for qualitative data.

Visual analysis of the raster hydrograph for the Yellowstone River (Figure 5A) reveals rich patterns. The overall pattern shows variations in inter- and intra-annual flows consistent with the signature of a wild and unregulated river. Apparent within these generally consistent annual gradients are anomalies such as the floods of 1996 and 1997 and the Dust Bowl drought during 1933 through 1940.

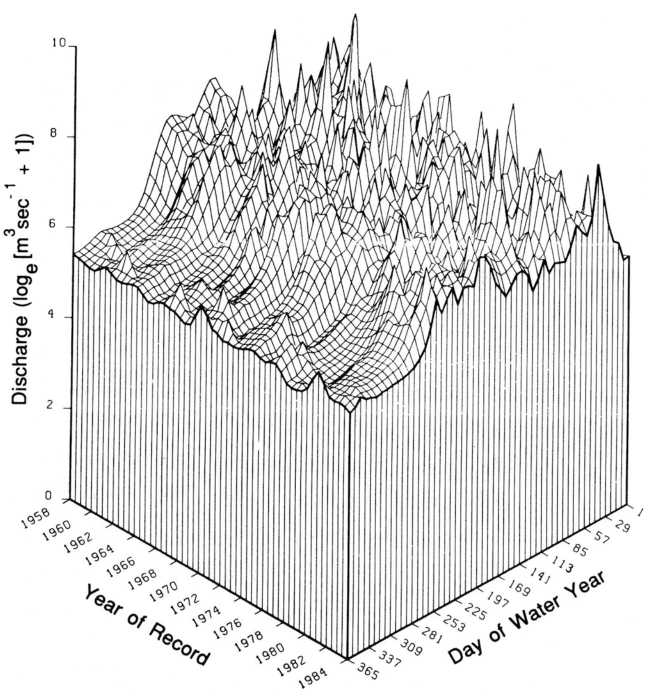


Figure 4. Poff and Ward 3-D hydrograph. (Poss and Ward 1990:637).

In contrast, the raster hydrograph for the Snake River (Figure 5B) reveals abrupt changes in flow patterns that are indicative of a regulated river. The U.S. Bureau of Reclamation built the Jackson Lake dam in 1916, shifting annual peak flows to late summer. The completion in 1958 of the Palisades Dam approximately 100 miles downstream allowed the Bureau to shift discharges again and create an earlier seasonal peak and maintain higher winter flows.

THREE-DIMENSIONAL RASTER HYDROGRAPHS

The raster hydrographs (Figure 5) create a narrative of flow at a point along a river. By preserving the day, year, and discharge dimensions of the data, this approach reduces the loss of resolution that occurs when data are averaged, or when only peak values are highlighted. However, these temporal views may be difficult for non-experts to interpret and even experts require some training to grasp the concept. Therefore following Poff and Ward [1990], we developed a three-dimensional plotting technique to determine whether it would provide a more intuitive method for visualizing discharge data. The three-dimensional hydrographs in Figure 5 differ from the Poff and Ward [1990] work because we use a raster rather than vector–based representation. We also use a sequential multi-hue color scheme, and the temporal values increase away from the axes' origins, which is more intuitive for quantitative time series data.

Our three-dimensional surface hydrographs (Figure 7) were produced using Surfer to render 3-D Surface Maps from the grid file. Daily mean discharge is represented as surface heights using percentile-based color classification schemes identical to those used for the previously described planar raster hydrograph. The two stations dramatically illustrate the difference between natural (Figure 7A) and regulated (Figure 7B) flow regimes. Fueled by spring runoff, seasonal pulses of streamflow characterize the natural runoff of the Yellowstone River, which appears as a wave. In contrast, sharp spikes and abrupt declines in discharge in the regulated Snake River create a "flowscape" that takes on the appearance of an urban skyline.

The longer-term discharge patterns are more pronounced in the three-dimensional images than in the planar raster hydrographs. However, the three-dimensional oblique view compromises accuracy and precision; some data points are hidden and it is difficult to estimate discharge along the z-axis. Some experts recommend avoiding three-dimensional graphs for these reasons [Helsel and Hirsch 1991, Tufte 1983]. Yet, based on required degrees of precision or accuracy, different plotting techniques support varying levels of perceptual tasks [Cleveland and McGill 1984]. The plan view raster hydrograph supports perceptual

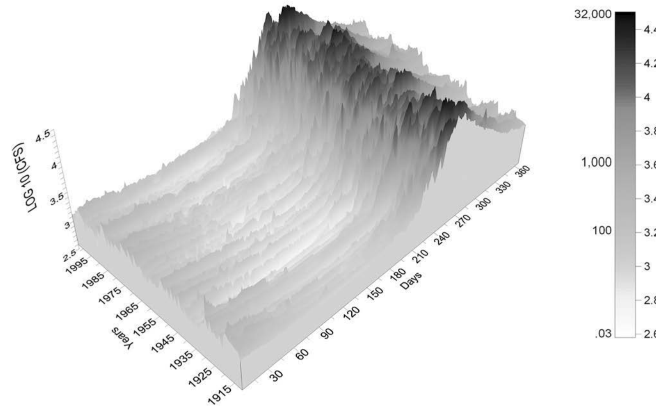


Figure 7a. Three-dimensional raster hydrograph for the Yellowstone River at Corwin Springs, MT. (see page 82 for color version)

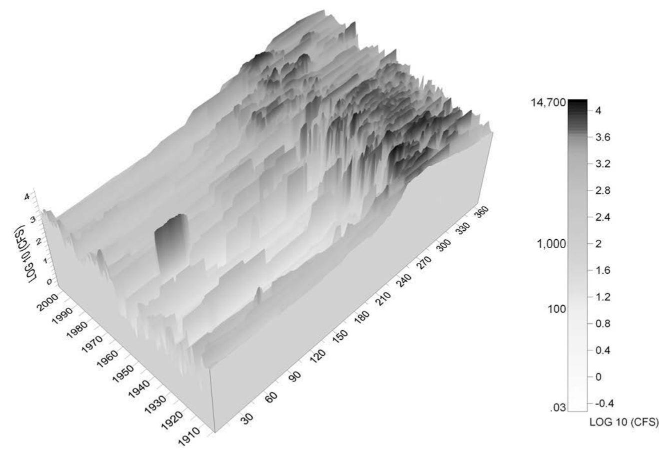


Figure 7b. Three-dimensional raster hydrograph for the Snake River at Moran, WY. (see page 82 for color version)

tasks that require accuracy and the ability to extract quantitative information, while the three-dimensional surface plots are useful for visualizing broad trends. Presenting both three-dimensional surface and planar raster hydrographs on one page offers the advantages of both techniques without compromising accuracy (Figure 8).

DISCUSSION

Water resource managers need improved graphical communication tools [Koehler 2004]. Cleveland [1984] indicated that better use of data graphics in science could be accomplished by developing guidelines for presentation. In addition, traditional methods are inadequate to characterize the multi-dimensional nature of long-term historical records, and that there is a need for the research and development of new methods for data presentation of time-series streamflow data. The development of guidelines for streamflow data is addressed in the following section.

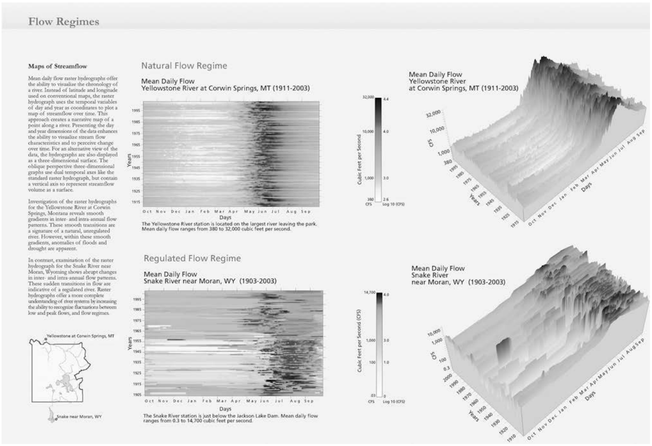


Figure 8. The Flow Regimes *page pair. (see page 83 for color version)*

Guidelines for Plotting Streamflow Data

In the process of producing graphics we identified and followed a series of general guidelines for producing streamflow graphics. The guidelines highlight key concepts related to working with dense data sets and surface water records. The recommendations from Tufte [1983] and Koehler [2004] and our own work provide the criteria for the effective display of streamflow data:

- Show all data equally and truthfully, avoiding distortion.
- Maximize data to ink ratio.
- Avoid "chart junk", which is non-data ink that distracts and confuses.
- Use an intuitive color scheme for quantitative data.
- Use a classification schemes that allows for comparison between sites.
- Present inter- and intra-annual streamflow patterns simultaneously.

The raster hydrographs (Figures 8) fulfill these guidelines. They show short- and long-term streamflow patterns simultaneously, give equal coverage to all 70,000 data points, use a minimum of ink to show these points, use a sequential hue color scheme that is intuitive (black for the highest flows, white for the lowest flow periods), and use a percentile classification scheme that facilitates comparing patterns between sites.

The principles from the guidelines have been widely ignored in the creation of hydrologic graphs and this is not exclusive to streamflow specific temporal maps. Use of these guidelines allows the presentation of inter- and intra-annual streamflow variations simultaneously and improves the ability to compare and contrast regulated and unregulated flow regimes. Raster hydrographs offer a more complete understanding of river systems by increasing the ability to recognize fluctuations between low and peak flows and flow regimes. The application of these guidelines for plotting streamflow enhances dissemination, communication and collaborative understanding of complex hydrologic systems.

SUMMARY

The utility of this time-series raster-based graphing technique is not limited to streamflow data; it may be applied to a variety of temporal data. Any type of time-series data collected in intervals such as months to years or minutes to hours may be plotted with this approach. Climatic and transportation data for example are complex datasets well-suited to be plotted as raster images to visualize multi-dimensional properties. In addition, statistical techniques exist for analysis of patterns on the raster hydrographs. Spatial pattern analysis permits quantifiable measurements and delineation of patterns on a raster image. FRAGSTATS, a landscape ecology public domain software application can compute patch-analysis statistics of these temporal graphs.

Temporal graphs use coordinates to plot a pixel-based image of variables such as streamflow by applying sound cartographic theory of color schemes and data classification. The technique displays all data points simultaneously providing a powerful static representation and an alternative to map animation. This new pixel –based technique allows for increased visualization of time related factors for a wide variety of data exploration and cartographic representation.

REFERENCES

Brewer, C. 1994. Color Use Guidelines for Mapping and Visualization. *Visualization in Modern Cartography*, ed. A.M. MacEachren and D.R.F. Taylor, p.123-147. New York, NY: Elsevier Science Inc.

Brewer, I., MacEachren, A. M., Abdo, H., Gundrum, J., and Otto, G., 2000. Collaborative Geographic Visualization: Enabling shared understanding of environmental processes. *Information Visualization. IEEE Symposium on Information Visualization 2000*. p.137-141.

Cleveland, W. 1984. Graphs in Scientific Publications. *The American Statistician*, 38(4):261-269.

Cleveland, W., and McGill, R. 1984. Graphical Perception: theory, experimentation, and application to the development to graphical methods. *Journal of the American Statistician*, 79:531-554.

Dana, A. 1990. Water Resource Management. *The*

Yellowstone Primer, ed. J. Baden and D. Leal, p.49-79. San Francisco, CA: Pacific Research Institute for Public Policy.

Fuhrmann, S. 2000. Designing a Visualization System for Hydrologic Data. *Computers & Geosciences*, 26:11-19.

Harrower, M. 2003. Tips for Designing Effective Animated Maps. *Cartographic Perspectives*, 44:63-65.

Helsel, D.R. and R.M. Hirsch. 1992. *Statistical Methods in Water Resources*. Amsterdam, NY: Elsevier.

Keim, D. A. 2000. Designing Pixel-Oriented Visualization Techniques: Theory and Applications. *IEEE Transactions on Visualization and Computer Graphics*, 6(1): 59-78.

Keiter, R. B., and Boyce M.S. 1991. The Greater Yellowstone Ecosystem, Redefining Americas Heritage. New Haven, CT: Yale University Press.

Koehler, R. 2004. *Raster Based Analysis and Visualization of Hydrologic Time Series*. Tucson, AZ: Department of Watershed Management, The University of Arizona.

MacEachren, A. In Press. Moving Geovisualization Toward Support for Group Work. *Exploring Geovisualization*, ed. J. Dykes, A.M. MacEachren, and M.J. Kraak. Tarrytown, NY: Elsevier Science. May 6, 2005. http://www.geovista.psu.edu.

Marcus, W. A., Aspinall, R.J., and Marston, R.A. 2004. GIS and Surface Hydrology. *Geographic Information Science and Mountain Geomorphology*. ed, J. Schroder and M.P. Bishop, p. 343-379. UK: Praxis Scientific Publishing.

Poff, N. L., and Ward, J.V. 1990. Physical Habitat Template of Lotic Systems: Recovery in the context of historical pattern of spatiotemporal heterogeneity. *Environmental Management,* 14(5): 629-645.

Tufte, E. 1983. *The Visual Display of Quantitative Information*. Cheshire, CT: Graphics Press.

United States Geological Survey. *Montana Flood-Frequency and Basin-Characteristic Data*. 1998. May 5, 2005. http:mt.water.usgs.gov/freq?site=06191500.

United States Geological Survey. *Surface-Water Data for the Nation*. 2005a. May 5, 2005. http://waterdata.usgs.gov/nwis/sw.

United States Geological Survey. *WaterWatch*. 2005b. May 5, 2005. http://water.usgs.gov/waterwatch/.

reviews

The Gay & Lesbian Atlas
Gary J. Gates and Jason Ost
Washington, D.C.: Urban Institute Press, 2004.
Paper, 11" x 8.5", 242 pages, $49.50
ISBN 0-87766-721-7

Reviewed by Mark Harrower
University of Wisconsin, Madison

While it may come as no surprise that San Francisco and New York are home to large gay and lesbian populations, few might guess that Albuquerque and Jersey City are among the country's "gayest" cities, nor suspect that North Dakota and Wyoming rank among states with the highest concentrations of senior gay and lesbian couples. Insights such as these can be found throughout *The Gay and Lesbian Atlas* created by demographers Gary Gates and Jason Ost. The *Atlas* is the first detailed spatial account of America's gay and lesbian households and offers a unique statistical and geographic portrait of these understudied communities. Published by the Urban Institute Press, *The Gay and Lesbian Atlas* mines Census 2000 data on the characteristics of 594,391 same-sex "unmarried partner" couples, a category which appeared in the Census for the first time in 2000 allowing researchers their first nation-wide look at just exactly where same-sex couples call home.

Gates and Ost acknowledge that there is an unambiguous political dimension to this atlas, and they seek to raise awareness and dispel stereotypes. "While the words 'we are everywhere' can be heard frequently at gay at lesbian political events, Census 2000 provided the first empirical confirmation of the rallying cry. The finding that same-sex unmarried partners were present in 99.3 percent of all counties in the United States was one of the most commonly reported statistics from [its] release." (p. 2). They go on to say

> "Of course, the importance of understanding the location patterns of gay and lesbian couples goes beyond simply acknowledging that they exist. It goes beyond recognition of their political clout. Gay and lesbian service providers, activist organizations, and an increasing number of companies seeking to market to the gay and lesbian population can all benefit from a more precise understanding of the location patterns and demographic characteristics of this population." (p. 3)

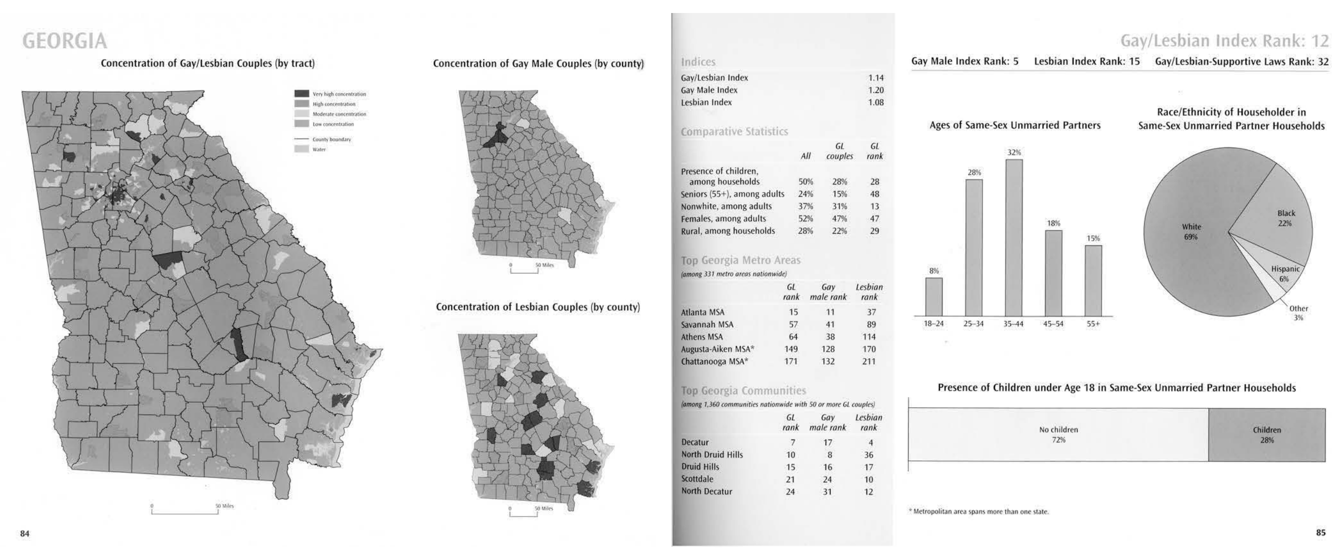
This is a surprisingly large atlas that contains roughly 300 maps spread across 232 color pages. The atlas is uncluttered and easy to read. The layout, type, and color schemes are attractive and professional, if somewhat restrained and spare. The first 58 pages explain the data and methods used, as well as the larger socio-political context of Census 2000 and its findings. While the maps may be the main attraction, the dozens of tables, which reveal differences among same-sex couples by race, income, dependents, and neighborhood characteristics (and how they compare to opposite-sex couples), seem just as informative and interesting. Fortunately, these authors avoided the temptation to make every graphic pointlessly 3-dimensional or dressed-up with the all-too-common drop shadow and glowing edge effects, favoring instead a restrained and color-coordinated design aesthetic that should look good in the years to come.

Although the authors never stray from their basic choropleth map design, the chief strength of this atlas is that it depicts the geography of gays and lesbians at three spatial scales (the nation as a whole, the individual states, and 25 metropolitan areas) *and* at various spatial resolutions (states, counties, zip codes, and census tracts). In other words, these authors recognized that the spatial patterns of the queer experience (like so many geographic stories) change with the scale of analysis: simple patterns of the national level become ever-more fragmented and interesting as one zooms in. Seeing the same data repeatedly, but at different resolutions, pulls readers deeper into the atlas and reminds us that simplistic characterizations (e.g., cities have more gays than rural areas) don't really hold-up under scrutiny.

Select findings from the Atlas include:

- Vermont has the highest concentration of same-sex couple households in the country, followed by California, Washington, Massachusetts, and Oregon. Of cities with fewer than 200,000 people, Santa Fe, N.M., ranks first in the study's per-capita ranking of same-sex couples, just edging out Burlington, Vermont. The less-obvious cities that round out that list include Bloomington, Indiana, Iowa City, Iowa, and Barnstable-Yarmouth, Massachusetts on Cape Cod.
- Same-sex couples with children often reside in places not known for large gay communities. In fact, the states where same-sex couples are most likely to be raising children are (in order) Mississippi, South Dakota, Alaska, South Carolina, and Louisiana; states that have some of the most restrictive laws regarding same-sex partnering.
- Mirroring larger demographic patterns, the South dominates the rankings of states by the concentration of African-American same-sex couples among all households and among other gay and lesbian couples. Similarly, Texas finds itself at the top of list for per capita Hispanic same-sex couples.

In Figure 1 you can see the two-page layout used for each of the 50 states, this one for Georgia. The main map on the left side depicts the concentration of same-sex couples (by census tract) with two smaller maps showing only gay male and only lesbian couples. Throughout the atlas, these two additional maps reveal just how different the spatial distribution of gay men and lesbians really is. While gay male cou-



Indices

Gay/Lesbian Index	1.14
Gay Male Index	1.20
Lesbian Index	1.08

Comparative Statistics

	All	GL couples	GL rank
Presence of children, among households	50%	28%	28
Seniors (55+), among adults	24%	15%	48
Nonwhite, among adults	37%	31%	13
Females, among adults	52%	47%	47
Rural, among households	28%	22%	29

Top Georgia Metro Areas
(among 331 metro areas nationwide)

	GL rank	Gay male rank	Lesbian rank
Atlanta MSA	15	11	37
Savannah MSA	57	41	89
Athens MSA	64	38	114
Augusta-Aiken MSA*	149	128	170
Chattanooga MSA*	171	132	211

Top Georgia Communities
(among 1,360 communities nationwide with 50 or more GL couples)

	GL rank	Gay male rank	Lesbian rank
Decatur	7	17	4
North Druid Hills	10	8	36
Druid Hills	15	16	17
Scottdale	21	24	10
North Decatur	24	31	12

Figure 1. Reproduction of two page spread from The Gay and Lesbian Atlas*. Used by permission of the Urban Institute Press.*

ples often flock to well-defined urban gay ghettos in major cities (e.g., New York and Los Angeles), lesbian couples are less spatially concentrated and often favor smaller towns. Authors Gates and Ost suspect lesbians are attracted to mid-sized cities that have a reputation for being politically active and are seen as a good place to raise a family (e.g., Madison, WI).

As seen in Figure 1, the right hand side of the atlas layout presents additional demographic data including how that state compares to others, the age structure of the state's same-sex couples, race/ethnic percentages of those couples, and how many have children. Lastly, it shows how the top five metro areas in each state rank nationally (e.g., Atlanta ranks 15th in the nation). While one wonders if these few graphics needed an entire 8.5" x 11"page—resulting in low data density more typically seen with run-of-the-mill powerpoint—they nonetheless add interesting information not shown on the maps.

Throughout the atlas the data are standardized and presented using the same 4-class scheme: *very high*, *high*, *moderate*, and *low concentration*. This was a wise decision because it takes little time to memorize the scheme and it allows readers to compare any map to any other. The one frustration I had, however, was that the meaning of those classes (in the real world) is vague, and it wasn't clear how meaningful the break points between those classes are. The data are standardized in a logical and thoughtful way by using an index which is a ratio of the proportion of same-sex couples living in a region to the number of households in that region.

While the atlas is well executed, there are a number of important limitations that should be mentioned. First, these data are far from perfect. This is no fault of the atlas or the authors, but it is an unavoidable fact that many same-sex couples will not self-report even with the anonymity of the Census. Fortunately, Gates and Ost are keenly aware of this and include a small chapter on undercounting and ways to deal with it. Second, this is not an atlas of all gays and lesbians, it only maps the location of same-sex couples who co-habit. While the number of couples is a reasonable data proxy for the queer population as a whole, it will no doubt have a different geographic pattern, and these maps (I suspect) under-represent urban concentrations of single gay men in particular. There is, however, no other nation-wide dataset available today and the stories these data tell are still fascinating. Overall this is a well done and original atlas.

The Commerce of Cartography: Making and Marketing Maps in Eighteenth-Century France and England

Mary Sponberg Pedley

Chicago: University of Chicago Press, 2005.
345 pp., 41 b&w illustrations, 8 color plates, 7 appendices, notes, bibliography, index. $40.00, Hardbound
ISBN 0-226-6531-2

Reviewed by Judith A. Tyner, Ph.D.
California State University, Long Beach

> "Of singular importance in understanding the meaning of maps and their influence is the work of placing maps in their political, cultural, intellectual, and social context." (p. 10)

Mary Pedley's *Commerce of Cartography* is an important addition to the literature of the map trade. Her stated purpose is "to study the commercial factors affecting the production and consumption of printed maps in the eighteenth-century France and England," but in doing so she provides a context for the maps of the period that should be required reading for all who want to read hidden meanings maps. That is not to say that maps are without such meanings and bias, but rather, that to truly understand what a map says, it is necessary to understand the processes that went into its making. This work is not a study of maps of the period, but of map *making* and map *selling*. The book is organized in three parts and five chapters plus introduction and conclusions, which together follow the process of mapmaking from survey to consumer. Thus, the first section is "Making Maps," including survey, compilation, and production costs. Part Two is "Selling Maps," which includes funding through subscriptions and partnerships, plagiarism (which was a way of cutting costs), and protection of intellectual property. This section presents a case study of the dissemination of maps of Narragansett Bay. The final section, "Evaluating Maps", describes what cartographers and consumers considered good maps, and the *mémoires* produced by cartographers to describe the accuracy and value of a map.

The process of cartography (and the book) begins with survey and compilation; "Getting to Market," discusses the costs of surveys and the costs and methods of compilation. These were the greatest expenses in the map making process, and this fact is important in later chapters that detail the cost of atlases and the reasons for plagiarism.

Working cartographers will find Chapter Two, "The Cost of Map Production" especially interesting in that it details the nitty-gritty of the steps in making a map three hundred years ago and the costs of each step. The sections on engraving, for example, focus not on the mechanics of using a burin, but on how much the copper cost, how long it took to engrave the map, and such wonderful tidbits as how long it took the engraved map to dry (six weeks!).

Knowing that it cost 2s 6d to color a map in the middle eighteenth century is meaningless out of context, but if you know that it cost the same amount to buy a bushel of apples and that a year's lodging was 30 the figures are more meaningful. Not only are relative costs and comparisons between France and England described in the text, but a series of seven appendices provide information for map production costs in France, England, and North America, plus map and print prices along with wages and expenses in France and England.

Although this is fascinating reading for current working cartographers, it is vital to those who would evaluate maps of the eighteenth century. This information has not previously been readily available to scholars and certainly not in one volume.

As in the twenty-first century, funding for cartographic projects was a problem in the eighteenth. Commonly, money was raised for atlases and other large projects by selling subscriptions. Decisions had to be made about how many maps to include and for what amount. For maps or atlases that were not sold by subscription, distribution became a problem and, at times, getting paid at all was an even larger problem for the draftsmen and others who worked on the maps. These considerations are detailed in Chapter Three, "Getting and Spending."

Chapter Four, "Plagiarism and Protection" notes that copying maps could reduce costs for a map seller in that it eliminated the biggest expense, that of surveying. The differences between 'privilege' in France and 'copyright' in England are explained. Lawsuits, and the ways in which a cartographer could prove his case against a copyist, make fascinating reading. That counterfeit maps could also be dangerous is noted here. In one lawsuit it was claimed that engravers had used portions of a 1710 map and of a 1740 map from the Delisle firm and sold the resultant copy in 1745 with the claim that it was "based on the most recent observations." The suit, brought by Philippe Buache, asserted that such maps were "nothing but a deceit of the public." (p. 111)

Chapter Five, "Multiplying Maps," is a case study detailing surveying and printed charts of Narragansett Bay, Rhode Island. All of the previously discussed processes: surveying, printing, publishing, and plagiarism, are detailed for this group of maps.

Chapter Six, "Giving Pleasure to the Public: Telling Good Maps from Bad" in the section on evaluating maps gives a wonderful perspective on the interactions between different cartographers and between map sellers and the public. Like the chapter on plagiarism, this chapter includes squabbles and sniping over the quality, aesthetics, and accuracy of various maps.

The affordability of maps in France and England are discussed, because, to the public, price was often the deciding factor in a purchase. It was also a reason for plagiarism — copied maps, which, again, did not require original surveys, were much cheaper. During the eighteenth century, atlases were often 'customized', that is, the map buyer would select the maps he/she wished to have and the seller would have the maps bound.

Within this chapter, Ms Pedley describes *mémoires* published by French cartographers to accompany their maps. The *mémoires*, of which many modern writers are unaware, describe the cartographer's sources, his reasons for choosing a particular projection, and other details the cartographer felt would show that a map was accurate and worthy of purchase. In the eighteenth century, as in the twenty-first, there was a difference in what a Geographer/Cartographer considered a "good" map and what the customer considered good.

The section on >blank spaces' is of especial interest to cartographic historians who often are not trained in map making . Blank spaces, which are frequently simplistically interpreted by historians as deliberate silences, were not necessarily nefarious, but a matter of aesthetic design choices. Cartographers of the period acknowledged that omissions could be caused by negligence and bias, but also noted that there were various other reasons for empty areas and lack of information.

This chapter also includes contemporary thinking on symbols, color, and language. Consumers were not always aware of the meaning of conventional signs on maps. Although legends are found on many late seventeenth century maps, symbols were not standardized. Symbols for parks, windmills, trees, cities, and the like were a comparatively recent addition to maps, so aids had to be devised for the reader. One such aid was a >practice' or teaching map, the forerunner of modern teaching maps that show typical features and lettering that might be encountered.

Ms. Pedley also dispels the myth that color was the provenance of ladies of straitened means. While certainly some women were employed in map coloring, much was done by men who were apprentices to engravers or professional artists. This can also be seen in the United States, where the cost books of Mathew Carey list male map colorists.

The Commerce of Cartography displays meticulous research that utilizes largely primary sources, including letters, *mémoires*, cost books, and maps; the list of secondary sources is exhaustive. Sources in both French and English are utilized, and Ms Pedley, who obviously is fluent in French, has translated passages from the *mémoires* that would otherwise be unavailable to English speakers.

The writing, while scholarly, is refreshingly free of jargonistic phrases and catch words. It is unusual to find an academic book that is not only informative, but a good read; *The Commerce of Cartography* is such a book.

I am enthusiastic in recommending this book to anyone who has an interest in cartography, whether applied or historical.

Plotting the Globe: Stories of Meridians, Parallels, and the International Date Line
Avraham Ariel and Nora Ariel Berger
Westport, Connecticut and London: Distributed by Praeger Publishers, 2006.
235 pages with maps, pictures, and illustrations (all black and white) $49.95 hardcover.
ISBN 0-275-98895-3

Reviewed by Fritz C. Kessler
Department of Geography, Frostburg State University
Frostburg, MD.

Plotting the Globe cleverly intertwines the stories of dozens of colorful individuals who, through greed, personal gain, political advancement, adventure, and, of course, scientific pursuit helped explore and establish three imaginary circles: the Prime Meridian, International Date Line, and Equator. The individuals and their intriguing stories are woven together into a narrative that on the one hand traces the history of how these circles came into existence, and the other hand, describes how simple ideas, such as a Prime Meridian, could cause considerable international and personal turmoil.

The adage (attributed to Admiral Grace Hooper, the Grandmother of the programming language COBOL) "one measurement is worth a thousand expert opinions" succinctly summarizes the human endeavors that are related throughout this book. The reader is introduced to numerous instances where the supposed accurate measurement taken by one scientist was subsequently refuted and replaced by another measurement that was deemed more accurate by yet another scientist. The authors point out, however, that in most cases each new measurement gained 'accuracy', but the results were never accurate.

Opening the book's front matter, the reader is introduced to a passage from Lewis Carroll's *The Hunting of the Snark* that illustrates the humanistic irony that is echoed throughout the book. The Table of Contents, which follows, organizes the book's material into four parts: The Meridians, The Prime Meridian, The International Date Line, and The Equator. Next, a Preface briefly describes the book and relates the maritime experience of the lead author. The Acknowledgements wrap up the preliminary matter and illustrates the breadth of information gathered in researching this book.

The Introduction lays out foundational material about the key imaginary lines used to define our world. The section begins with the authors emphasizing that this book is not a "textbook on the history of cartography or exploration" (p. 1), but rather a narrative on the great circles of the Equator, Prime Meridian, and International Date Line and how and by whom they were discovered and the legacies these circles have imparted, and continue to impart, on society in general. The authors further illustrate that the book will not appeal to members of the Flat Earth Society; a society that claims there is insufficient proof that the Earth is spherical and whose principles are lightheartedly denounced. The authors' writing then changes to a more serious tone as they present a concise overview of the Equator and other, smaller, circles of latitude. Longitude is discussed next, highlighting the Prime Meridian and the International Date Line. The information on these imaginary lines helps form a basic level of understanding on which the remaining chapters of the book build.

Part 1 discusses The Meridians and is divided into three chapters. The first, entitled "The Lemon or Orange Debate", examines the great debate between Jean Dominique Cassini (Cassini I) and Sir Issac Newton over whether the Earth was shaped like a prolate spheroid (Cassini's lemon) or an oblate spheroid (Netwon's orange). In the opening paragraphs of this chapter, Jean Picard's experiment with pendulum motion is highlighted as the catalyst for the prolate/oblate debate. However, the primary focus of the chapter is on the history of the Cassini Dynasty and their impressive contribution to French cartographic pursuits, and pointing out how, in spite of irrefutable quantitative data, Jacques Cassini (Cassini II) continued to support his father's stance that the Earth was a prolate spheroid.

The second chapter, "What is the Shape of the Earth", tells the tale of two expeditions that would cement the conclusion to the prolate/oblate controversy. The first of the expeditions, to what today is Ecuador, led by Godin, Bouguer, and Conamine, and the other, to Lapland, under the direction of Pierre-Louis Moreau de Maupertius, are each discussed in considerable detail emphasizing the personalities involved. Another component of this chapter is an overview of the meridian survey that took place in Africa under the auspice of Abbé Nicolas Louis de Lacaille. Jules Verne's recently discovered novel *The Adventures of Three Englishmen* *and Three Russians in South Africa* makes its way into this section and presents an interesting glimpse into Verne's perspective on the adventure of measuring a meridian in Africa's Kalahari Desert.

The third chapter is titled "How Long is One Meter", and it traces the efforts of Jean Baptiste, Joseph Delamber, and Pierre François André Méchain to establish the length of a meter as determined by measuring the length of a meridian quadrant (e.g., 0º to 90º N). Their endeavors eventually led to the formalization of the metric system when seventeen nations signed the 1875 Paris Treaty of the Meter. As illuminated in this chapter, modern measurements tell us that the length of the meter is not 1/10,000,000 of a meridian quadrant but is closer to 1/10,002,290. This measurement, of course, is an average value at best, and any meridian quadrant will give different results depending on the chosen meridian, furthering the adage of Admiral Grace Hooper.

Part 2, "The Prime Meridian", is comprised of the next five chapters. The fourth chapter "From Hipparchus to Pulkovo" discusses the early history of using various meridians as the origin for longitude prior to the establishment of the Prime Meridian at Greenwich. The chapter illuminates the confusion that engulfed society when there was no internationally agreed upon Prime Meridian. This confusion is further highlighted in that many countries, mostly as a sense of national pride, used the line of longitude that passed through their own observatories as the Prime Meridian. In some cases, Russia, England, France, and other countries chose different observatories as the location of the Prime Meridian for different maps, often without any explanation that justified the selection. For example, the Prime Meridian selected for Russian nautical charts variously used the observatories at Greenwich, Pulkovo, or Ferro while their land maps used the observatories at either Ferro, Pulkovo, Warsaw, or Paris.

Chapter five, or "Greenwich – the Ultimate Prime Meridian", traces the interesting characters of John Flamsteed, Edmund Halley, James Bradley, and George Airy, and the personal accounts that shaped their professional careers. It is interesting to read how four out of the seven Astronomers Royal felt compelled to physically move the location of the meridian at Greenwich – each attempting to improve on accuracy. Flamsteed established the first meridian at Greenwich. His friend, turned adversary, Halley established the second meridian at Greenwich 73 inches east of Flamsteed's original location. Bradley established the British prime meridian a further 436 inches eastward, and Airy moved the final adjustment in the world's prime meridian 19 feet further east.

The chapter "Greenwich Goes International" follows, and details the international recognition the need for a universal Prime Meridian and the difficulty that ensued in establishing just one meridian as 0º longitude. With the European nations embroiled in nationalistic conflicts, the United States hosted the International Meridian Conference in 1884, in Washington, D.C. This historic conference sought agreement between twenty-five nations, with , the United States, in the end brokering the resolution specifying that the Prime Meridian passes through the Royal Observatory at Greenwich, England. Twenty-two nations approved the resolution.

The seventh chapter, entitled "1984 beats 1884 – GPS", reviews the influence that GPS has on coordinate locations, especially longitude. GPS coordinates are periodically adjusted for continental drift, a concept not contemplated by George Airy and his predecessors. Attention is also given to the evolution of WGS84 and its relationship to terrestrial reference systems such as ITRS2000 and ETRS89. In fact, according to the WGS84 datum, the current position of the Prime Meridian lies about 336 feet to the east of 0º longitude established by George Airy.

"Time and Tide Wait for No Man, Especially at Greenwich" (chapter 8) presents an overview of time and how time is influenced by longitude. The authors point out how time calculation is a modern problem first encountered on a large scale with the expansion of the railroads. The fluctuations in Earth's rotation that impact the calculation of time are examined with considerable flair. The establishment of Coordinated Universal Time to address these and other issues is also reviewed. The authors add interesting anecdotes on various customs that celebrate the passage of time (e.g., lowering the time ball from the top of the Royal Observatory in Greenwich at 1:00 p.m.).

The three chapters of Part 3 examine the International Date Line. The first of these, "The Paradox: Lost by Magellan, Found by Fogg" describes various attempts at circumnavigating the Earth. Explorers such as Ferdinand Magellan and Sir Francis Drake are used to illustrate how a day is lost or gained while sailing around the world. For instance, when, in 1522, Magellan's ships sailed into Sanlúcar de Barrameda, Spain his crew thought the day was Saturday although they heard the bells summoning the parishioners to Sunday service. They had 'lost' a day during their east-to-west voyage as they crossed the yet to be established International Date Line. On the other hand, in Jules Verne's *Around the World in Eighty Days*, Phileas Fogg wagered a sizeable sum of money to prove he could sail around the world in eighty days. Fogg thinks he has lost the bet as he arrives in London on a day he believes to be Sunday, day 81. In fact, on his west-to-east voyage, Fogg 'found' a day, thereby arriving on Saturday and winning the wager.

The tenth chapter, which is entitled "The International Date Line – Truth or Myth", presents a revealing tale of this imaginary line. In this section, the authors argue that the date line is not a single line, but rather an imaginary series of great circles, and is not international, but is in fact subject to spontaneous changes in position. According to the authors, there has been no international agreement on the location of the International Date Line. Part of the myth associated with the 180th meridian are the fictitious Morrell and Byers Islands that were fraudulently reported by Benjamin Morrell and resulted in a kink in the 180th meridian to keep these islands in the same date as the other Hawaiian Islands.

The eleventh chapter, "The International Date Line and the Millennium", relays how countries have manipulated the location of the International Date Line to serve their own purposes. The authors dwell on the 'hype' associated with the new millennium and the erroneous assumption by most people that the new millennium began at midnight on 01/01/00. In actuality, since there was no year assigned as zero, the new millennium began at midnight on 01/01/01. In this section, the authors pose, and in turn discuss, two questions: 1) at which place did midnight first appear on 12/31/99, and 2) where was the sunrise of 01/01/00 first seen?

Part 4 covers the Equator in two chapters. "Crossing the Line" comes first, and recounts the lead author's experience of crossing the Equator as the second officer of the *Yehuda*. Seafaring tradition holds that anyone crossing the Equator for the first time must be inspected by King Neptune and his court. This personal anecdote humanizes the significance of the Equator to mariners.

The next chapter, "Who did it First", intrigues the reader as it tries to determine who was the first explorer to cross the Equator. The authors weigh the merits of the legendary voyages of Hanno and the Chinese Admiral Zheng. Other, more credible accounts, of Prince Henry the Navigator and Diogo Cão crossing the Equator are also discussed. This chapter concludes with a cautionary voice suggesting that while these high-seas adventurers pursued riches and fame, indigenous people often faced unfortunate outcomes and unnecessary hardships as a result.

In the primary author's personal conclusion, "End of the Story", he laments the loss of daring and intrigue from the seafaring profession. Commercial shipping has replaced the adventure once associated with sailing while air-travel has become the norm as a means of travel. The lead author suggests that the ultimate goal of this book is to encourage future generations to explore the unknowns in their own world while adding to the wealth of knowledge accumulated by the individuals whose accounts have been related in this book.

The "End of the Story" segment is followed by a lengthy "Notes" section that is filled with interesting bits of information about the events and topics presented. The "Internet Sites" section comes next, and presents a two-page listing of various relevant web sites that can prove useful to readers wishing to further explore the topics. The text concludes with an Index containing names, ideas, and places found throughout the book.

The primary strength of this text is its readability. The authors successfully take on, and add a sense of intrigue to, topics that most people would find dry. For example, one would expect an account of the International Meridian Conference of 1884 discussion in Chapter 6 to be rather dull. However, the authors add personal commentary about the representatives of each of the twenty-five nations in attendance and their voting habits. For example, in the voting for Resolution II, the adoption of the Prime Meridian passing through Greenwich, England, San Domingo did not approve. In poking fun at San Domingo's vote, the authors ask "What grudge did that world power have against Great Britain? Was it bad memories of English buccaneers, Britain's' historical role in the slave trade, mere muscle flexing to demonstrate black power? Or did the French buy the delegate" (p. 104)? This text is greatly enhanced by the writing style, which is filled with relevant factual material and detailed end notes, but maintains an easy flow throughout the chapters. In another example, after discussing the specifics of adding leap seconds to time as a result of a slowing in the Earth's rotation, the authors reassure the reader that imminent danger "is not about to strike. During the 185 years since 1820, the length of a day has increased by only two thousands of a second. You may finish your beer peacefully and perhaps even head to the fridge for another one" (p. 119).

The authors are also keen to link these many historically significant events to contemporary life. In Chapter 6, the authors point out that the French resisted some of the adopted resolutions of the 1884 conference. In fact, France did not fully recognize the Prime Meridian through Greenwich until 1914 when its nautical charting became compliant. In preparation for the infamous 2000 millennium celebration, the French planted a 600-mile long row of trees, extending from Dunkirk south to the Spanish coast in commemoration of the meridian that Jean Dominique and Jacques Cassini used to counter Newton's oblate spheroid claim. Festivities throughout 2000 included a picnic along the meridian in which there were hundreds of thousands of participants. The French still are irked by the loss of the Prime Meridian and the authors point this out by stating that an "educated Frenchman will tell you that Greenwich is just a line, west of Paris. The very educated will add that it is 2º 20′ 14.025″ away" (p. 108). Although the authors do criticize the actions and attitudes of many countries, they do seem to be biased against the French.

As I read through *Plotting the Globe*, I couldn't help but compare it to John Wilford's *The Map Makers*, which was published in 1981 and generally covers the same breadth of material. Both works were written by non-geographers. *The Map Makers* was written by a science correspondent, and the lead author on *Plotting the Globe* became a freelance writer after spending his formative years on his own sea-faring adventures. Neither book is envisioned to be a textbook – rather, both texts present the material in a non-technical fashion that is approachable by the lay person. Thus, those interested in learning the foundations of geography, geodesy, history, or science would likely be among the readership of these books. If both texts appeal to the same audience, then one contrasting comparison that can be made is in reference to the specific content of each work and the way in which it is presented. In *The Map Makers*, Wilford often includes detailed discussions of procedures, such as how Eratosthenes went about measuring the Earth's circumference. In *Plotting the Globe*, Eratosthenes is briefly mentioned but his measurement process is not explained at all. This type of omission represents a missed opportunity to describe how the various characters approached difficult problems. Similarly, in Chapter 13, the lead author gives a personal account of using a mathematical conundrum to test how students in his Merchant Ship Economic class approach and try to solve a hypothetical problem on the Equator, but he does not apply that same curiosity to other topics covered in the book.

Two other points of contention with this book are worth mentioning: the skimming over of important events and the limited discussion of how things work. In *The Map Makers*, Wilford presents the difficulties and accomplishments that John Harrison went through while building his chronometer, an obviously important event. In *Plotting the Globe*, John Harrison is unfortunately mentioned only in passing, and the significance of his chronometer is largely left to an endnote. Without Harrison's timepiece, it is hard to say how long it would have taken for longitudinal positions to be determined, a point which should have been emphasized.

In the Preface, the lead author reports to have been associated with ships and navigation all his life. More specifically, he states that he was reared by the "sextant, the chronometer, the magnetic compass, and the hand lead" (p. xi). What a shame then that he didn't include an explanation on the actual use of one of these instruments and of their historical merits. Other procedures, too, such as leveling, measuring a portion of a meridian arc, or dead reckoning are presented without much discussion of "how-to", leaving readers a bit unfulfilled in their quest for knowledge. Moreover, an explanation of some of these processes would shed light on just how difficult it was to make these measurements and, as a consequence, the reader would appreciate how miraculous it was that these scientists were able to obtain the results they did. It is likely that the authors sought to keep the book as non-technical as possible while still conveying the overall history and the persons involved. However, a few examples and more detail on the mechanics of the measurements incorporated into the text's light-hearted approach would have enriched the reading experience and conveyed to the reader why there have been so many measurements made throughout this book.

In summary, *Plotting the Globe* is an interesting read. The book is filled with stories of human endeavors, personal conflicts, and the quest for knowledge (springing from a variety of the motivating factors). The book relates more about individuals and their efforts than about the mechanics of procedures. The authors do, in fact, in the Preface, stress that the text is a "tribute to the astronomers, explorers, and land surveyors who gave us those lines, measured them, made their derivatives part of our daily lives, and sometimes even died for them." (p. 1). Thus, the reader should expect the focus to be on the individuals and their accomplishments and contributions to meridians and parallels. For those interested by the personal dynamics of exploration, nationalistic pride, scientific pursuits, political angst, and convention in the context of geography, then this text will not disappoint. For those readers that also thirst for details on how the characters actually accomplished these amazing measurements, this book is lacking in telling "how", but still creates a firm foundation from which to seek additional knowledge.

REFERENCES

Wilford, John, W. 1981. *The Map Makers; The Story of the Great Pioneers in Cartography from Antiquity to the Space Age*. Vintage Books/Random House Publications, New York, NY, 414 pages.

A Railroad Atlas of the United States in 1946, Volume 2, New York & New England
Richard C. Carpenter
Published by The Johns Hopkins University Press, Baltimore, 2005.
256 pages, 164 maps. Hardbound.
ISBN 0-8018-8078-5

Reviewed by Gordon Kennedy

In the 1920s a letter posted by my grandmother in Bismarck, North Dakota would be delivered to her sister in Manderson, Wyoming the next afternoon. That today's parcel carriers can hardly perform this 560-mile delivery more efficiently—and certainly not cheaper—is testament to the amazing railway post office system of that era. The RPO system was based on a vast network of railroad lines reaching cities and villages throughout the United States.

Richard Carpenter's *A Railroad Atlas of the United States in 1946* documents and pays homage to this great system at the close of the era of railroad primacy in American industry and technology. Railroads were the powerhouse of American industry in the first half of the 20th century: driving innovation, economic vitality and radically changing culture and customs. This atlas maps the American railroads at what many consider "their finest hour"; the culmination of the Second World War, during which American railroads transported massive quantities of materiel and personnel. It is this railroad network that Carpenter celebrates in his atlas.

The author states his objective clearly: "The story of American railroading in its heyday was, and is, a story well worth telling. And I became determined to tell it with a clear, easy-to-read atlas." It is a story worth telling, indeed. Railroads today are but a ghost of what they were in 1946. Mainline trackage at that time amounted to about 400,000 miles, while today it is only about 170,000. Then, there were dozens of major railroad companies; today there are just seven Class 1 railroads in all of North America. A huge workforce was occupied with the construction and maintenance of equipment and infrastructure. Steam locomotives were the predominant motive power and passenger trains served thousands of communities. Railroad operations were controlled by labor-intensive communications based on the telegraph. That this huge, complex, low-tech system could work at all was a wonder of engineering, organization and management. The year 1946 was the penultimate moment for this system, and an apt moment for Carpenter to take the measure of what American railroading was prior to its transformation to its present form of an efficient, high-tech, multi-modal transportation business, largely unnoticed in our daily lives.

This atlas is the second of a series being produced to encompass the United States. Both published volumes are printed on bright, sturdy paper handsomely bound in green cloth. The first volume, subtitled *The Mid-Atlantic States*, covered Delaware, the District of Columbia, Maryland, New Jersey (with New York City), Pennsylvania, Virginia and West Virginia. The volume reviewed here covers Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont. In the Introduction, Carpenter provides the historical context for his project and lays out his motivation and goals. He hopes that "by producing a graphic record of this transportation network, present and future generations may learn valuable lessons from one of the most glorious episodes of our transportation history." He offers brief profiles of each state included in the volume. He describes how the maps were developed and discusses how the data are represented. A map of the entire region covered in the atlas provides context and orientation and a Key Map shows how the individual map pages are laid out over the region. A detailed legend precedes the 162 map pages.

The maps are 30-by-30-minute quadrangles based on United States Geological Survey maps. Many data-rich areas are enlarged in detail maps. A substantial amount of information is presented in the maps: the many different railroad companies are distinguished by color and abbreviation; there are symbols for stations (passenger and non-passenger), viaducts and major bridges, tunnels, mileposts, interlocking towers (in service and abandoned), telegraph station call letters, coaling stations and more. Base-map reference information includes civil boundaries, place names and hydrography. Each quadrangle is named and has geographic coordinates labeling its 15-minute neatline ticks.

Following the maps, a considerable amount of reference material is provided: a list of railroad name abbreviations, "Notes on the Maps" (in which a sentence or two of explanatory detail or interesting trivia is offered for each and every map sheet), references to source documents. The atlas concludes with a set of "Indexes" amounting to a railroader's gazetteer: "Index of Coaling Stations," "Index of Interlocking Stations," "Index of Passenger Stations," "Index of Track Pans," "Index of Tunnels" and "Index of Viaducts."

This atlas succeeds in conveying the complexity and extent of railroads in 1946. Railroad aficionados and transportation buffs will readily see the contrast between the world of 1946 and that of today, but the story may not be so clear to the general reader who encounters this book as a rail or transportation novice. Examining the Portland, Maine maps, for example, the story of the city's railroading comes to life if you know how to interpret the map symbols and what they imply. Portland was a maritime connection and hub for rail lines to the north and south. The Portland Terminal Company operated trackage in the central Portland area, interchanging with the Boston & Maine to the southwest and south, and with the Maine Central and Canadian National to the north and northwest. Abandoned segments of the Boston & Maine and the Kennebec & Portland suggest a history of competing railroads in Portland prior to 1946. The Portland Terminal Company, according to the map information, was associated with the B & M and Maine Central, perhaps jointly owned or operated through a contractual agreement. This put the Portland area railroad network under uniform management, thus improving operational efficiencies. The Canadian National, however, reached independently into Portland, a sign that they were not party to the Portland Terminal common operating arrangement. The atlas shows us that multiple railroads competed in Portland's industrial core for a time but by 1946 two had entered a joint operating agreement for mutual benefit, one had retired from the competition, and another continued to go it alone.

The ability to infer such information, and more, from this atlas is a sign of its success. As an atlas should, this volume presents data in a cartographic depiction that enables the reader to develop new knowledge by integrating the mapped information into their own knowledge.

There are some puzzling aspects to this book, however. It is beguilingly simple in concept but idiosyncratic in execution. The most intriguing oddity for cartographers is probably the fact that the maps are *hand-drawn*, and that is to say drawn *by hand*. The linework wavers and jogs, the text occasionally sags and shrinks, and colors vary in intensity as the penmanship varies. The maps were apparently drafted on a single, multi-color original and then scanned for the printing process. All ten colors are screened. The cyan used for shorelines, the black neatline and black lettering all show screen patterns upon close inspection. *Everything* on the maps is screened. Manual separation of colors as a cartographic technique was unused; it was left to the printer to create printing plates from a single, color original. While not consciously visible to most readers, the screened linework possesses a softness of edge that suits Carpenter's freehand style, and gives the maps a look in keeping with their handmade origins. At first one might find little reason to object to this technique—the maps are legible and graphically inoffensive and the freehand work has a pleasing directness and informality. His colors and symbols are logically and precisely employed to present data with clarity and legibility and his lettering is always neat and sharp, even when tiny and crowded. The maps look like very well executed manuscripts ready to be turned over to a cartographer.

Perhaps his technique is a personal and practical choice for producing the kinds of maps he wanted, but the atlas as an entire work is diminished by the graphic limitations of this choice. The Key Map, for example, is a maze of tiny lettering with solid and dotted lines. Because his technique precludes screening a color to background faintness, he uses dashed and dotted linework in an attempt to reduce graphic competition with the foreground material. The shorelines are rendered in blue dotted lines; boundaries in black dotted lines. In spite of these attempts, it is a chore to use this map. Other basic cartographic techniques also are unused; for instance, the maps are all linework with no area fills, so the distinction between water and land can be confusing. On the Providence map the numerous bays, rivers and inlets are visually interchangeable with islands and peninsulas.

Carpenter includes little more than hydrography for geographic context. There are no roads or other non-railroad landmarks to orient the reader to the landscapes of either 1946 or of today. There are islands in Upper New York Bay—Ellis, Liberty and Governors, but they are not labeled to remind us which is which. The name Niagara Falls is found for three railroads' passenger stations and an interlocking tower, but the falls of the river are not indicated.

Another oddity is the inconsistency between the maps and their surrounding material (map titles, map numbers, page numbers, etc.). These have been produced with more refined graphic methods, so that text and lines are sharp-edged and solid (probably because they were produced by commercial publishing software). Carpenter might have enhanced the atlas's overall hand-made look had he used his manual, freehand technique for this material as well as for the maps. The homespun, naïve cartography is a refreshing departure from the computer-generated artwork so prevalent today and this could have been used to greater effect in the design of the entire book.

Finally, this atlas will be most at home in the hands of those who already have knowledge of railroads. Those railroad historians and fans already well versed in railroad history will find this an important and impressive book; a treasury of fascinating information.

For others, however, this atlas is unlikely to provoke fresh interest or appreciation for railroads and their history. The reader approaching this atlas as a way of learning about an unfamiliar topic will encounter, at the least, a good deal of unexplained terminology. Carpenter provides some limited technical explanations in the introduction, but does not specifically discuss the significance of items selected for display on the maps. What, for instance, is an interlocking plant, a track pan or a car shop, and why might they be important to understanding the railroads of 1946? These features are on the maps, but the reader gets little help with their interpretation.

A more geographic approach would have broadened its usefulness by helping readers interpret railroads in their real-world context. A more expert cartographic technique would have helped tell the story more vividly and aesthetically. But these were not the author's objectives.

Carpenter's atlas is a personal work, a result of his passion for railroad history. It certainly is the result of countless hours of painstaking research. He acknowledges sources and assistants but has no real collaborators. This was *his* project. It is a railroading book for railroading aficionados, a personal statement by an intrepid and patient researcher. As such, it is an impressive accomplishment and will likely be well loved and well used by rail buffs and historians of industry who want a picture of American railroads in their moment of glory.

visual fields

What is Unique About the Imagery of mapformation?

Derek Tonn
mapformation
220 South Burns Avenue
Springfield, MN 56087
datonn@mapformation.com
www.mapformation.com

While our style of map design is similar to those produced by many other design firms, our subject matter (3D perspective building depictions on collegiate campuses) tends to be the particular characteristic of our work that has helped us develop a growing reputation throughout North America and portions of Europe. We also tend to work with electronic applications (web based tours, scalable imagery, etc.) in mind as much/more as the traditional print piece, which has helped us to evolve in the way that our graphics are created. We also tend to draw all of our streets, sidewalks and parking facilities as negative space in our mapping projects, while many firms that we are aware of will draw these features as objects, with landscaping serving as the negative space. This tends to give our work a subtle yet important distinction when it comes to evaluating our portfolio. It takes more time to design maps using this technique, but we believe that the resulting "look" is worth the extra effort.

VECTOR

University of Nevada, Las Vegas
http://www.mapformation.com/portfolio/campus/unlv3D.pdf
This was an INCREDIBLY challenging project, in that the UNLV campus is filled with some of the most unique collegiate architecture in the United States. Also, we were asked to depict the southern half of the campus within only 20 percent of the entire map area... in order to reposition elements on the map to center a reader's attentions on features found on the northern half of the campus. Developed in Corel Draw 12.

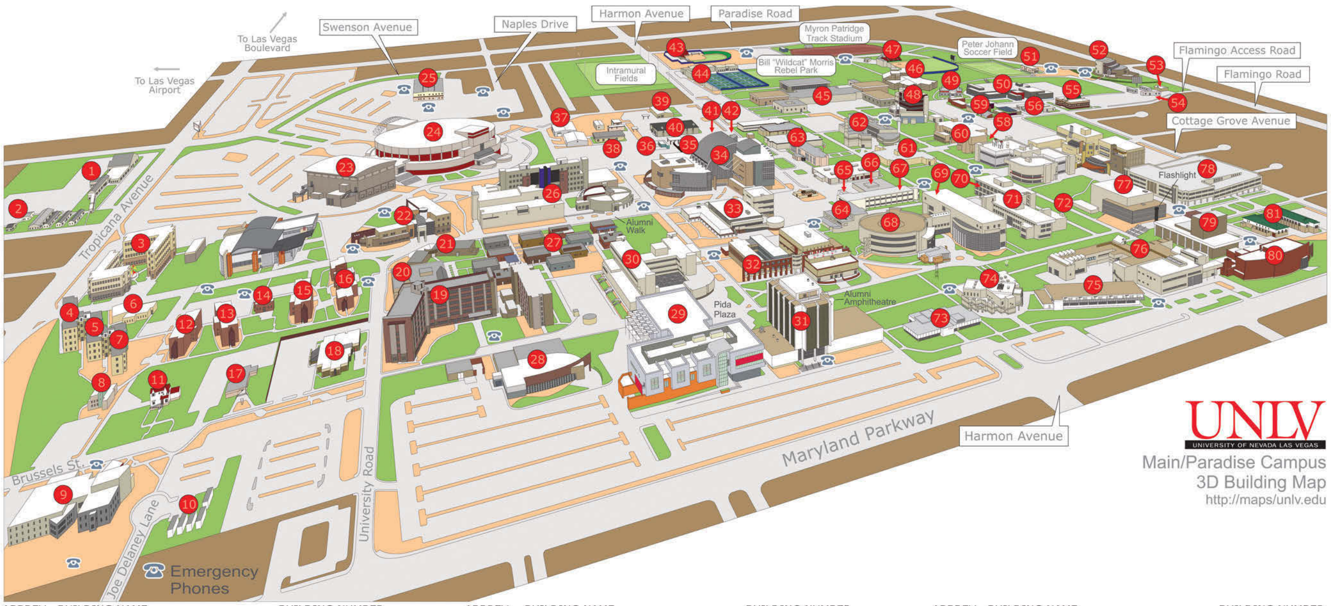
Downtown Minneapolis, Minnesota
To see the true MADNESS of just how far things can be taken by our designers when it comes to detailed building depiction, this graphic was developed as a generic piece that is intended to be used for a variety of commercial
applications. It is easily the most detailed and dense" map area that we have developed to date, with literally hundreds of buildings and tens of thousands of objects drawn. Developed in Corel Draw 12.

RASTER

Pulaski Technical College
http://www.mapformation.com/portfolio/campus/pulaskitech3D.pdf
This small campus mapping project is very clean and efficient, and is an excellent marriage between wayfinding needs and aesthetic sensitivity which helps to reinforce an institution's overall branding and identity efforts. Developed in Adobe Photoshop.

HAND-RENDERED

Ohio Northern University
http://www.mapformation.com/portfolio/campus/onu3D.pdf
While computerized map design has been steadily gaining overall market share during the past decade, there will always be a place for designs that are created at the drafting table, with pen and pencil in hand. This project illustrates this fact, and also provided the perfect testing ground for us to embed numerous post-design effects to the map using Adobe Photoshop. Five of the map's drawn imagery (excluding text labels and other symbology) were added after-the-fact in Photoshop, thought we challenge anyone to see if they can accurately identify those five elements!

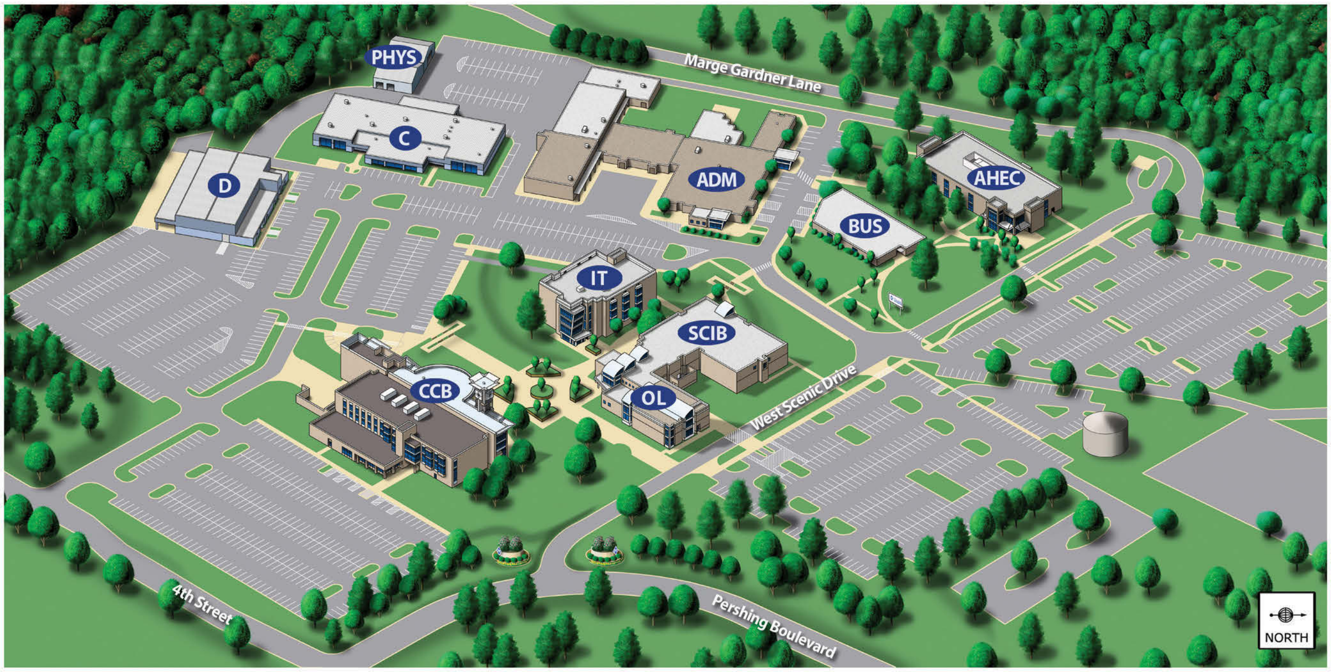


ABBREV.	BUILDING NAME	BUILDING NUMBER
ARC	Paul B. Sogg Architecture Building	9
BDC	Bennett Professional Development Center	49
BEH	Frank and Estella Beam Hall	30
BGC	John D. "Jackie" Gaughan Boy's & Girl's Club	55
BHS	Rod Lee Bigelow Health Sciences	48
BKS	Bookstore	28
BMC	Beam Music Center	80
BPB	Robert L. Bigelow Physics	62
BSL	William S. Boyd School of Law	68
CBC	Classroom Building Complex	26
CDC	Central Desert Complex	27
CEB	William D. Carlson Education	71
CEB-HEA	Holbert H. Hendrix Education Auditorium	72
CET	Carlson Education Trailer	69
CHE	Chemistry	61
CPB	Cox Pavilion	23
CSB	Campus Services Building	25
CWH	Claudine Williams Residential Hall	4
DAY	Dayton Complex	3
DIN	Hazel M. Wilson Dining Commons	20
EMS	Eller Media Softball Stadium	43
EPA	Environmental Protection Agency	63
FDH	Flora Dungan Humanities	31
FMA	Facilities Management Administration	39
FND	Foundations Building	81
FRA	Maude Frazier Hall	73
FTC	Frank and Vicki Fertitta Tennis Complex	44
GRA	Archie C. Grant Hall	75
HAB	Residential Life Housing Admin. Building	6
HCH	Artemus W. Ham Concert Hall	77
HFA	Alta Ham Fine Arts	76
HOU	Houssels Building	11
HUH	Mitzi & Johnny Hughs Hall - Building A	16
HWB	Herman Westfall Business Services	40
IGI	Stan Fulton Building - Int'l Gaming Institute	52
ISC	Interfaith Student Center	17
JBT	Judy Bayley Theatre	79
KRH	Kitty Rodman Residence Hall	7
LAC	Lied Athletic Complex	46
LBC	Lynn Bennett Early Childhood Dev. Center	59
LDS	LDS Institute of Religion Student Center	18
LFG	Lilly Fong Geoscience	65
LLB	Lied Library	34
MFH	Margie Faiman Residence Hall - Building D	12
MPE	Paul McDermott Physical Education	45
MSB	Robert Miller Soccer Building	51
MSM-HRC	Marjorie Barrick Museum and Harry Reid Center	33
MSU	Donald C. Moyer Student Union	29
NTS	North Trailer Site (6 Trailers)	56
O&M	Operations and Maintenance (4 Warehouses)	37
PAR	Paradise Campus	1
PCT	Paradise Campus Trailers (2 Trailers)	2
PES	Paradise Elementary School	50
PKG	Parking Garage	78
PRO	Publications/Reprographics/Copy Center	35
PSB	Claude I. Howard Public Safety	41
RAB	Research Administration Building	38
RHB	Gym Road Residence Hall - Building B	15
RHC	Gym Road Residence Hall - Building C	13
RHW	Gym Road South Resident Services Building	8
RPL	Radiation Protection Laboratory	67
RRC	Rebel Recycling Center	54
SCS	System Computing Services	64
SHS	Claude I. Howard Student Health Services	21
SSC	Student Services Complex	22
STS	South Trailer Site (5 Trailers)	10
SWC	SideWalk Café	70
TAC	Richard Tam Alumni Center	74
TAY	William D. Taylor Hall	53
TBE	Thomas T. Beam Engineering Complex	57
TEC	Technology Building	66
TMC	Thomas & Mack Center	24
TON	Tonopah Residence Complex	19
UNH	University Hall	42
USB	University Systems Building	36
WBH	William S. Boyd Residence Hall	5
WBS	Earl E. Wilson Baseball Stadium	47
WHI	Juanita Greer White Life Sciences	60
WHT	White Hall Trailers (2 Trailers)	58
WRI	John S. Wright Hall	32
WRL	Eugene R. Warner Residential Life Building	14

Main Campus: 4505 S. Maryland Pwy. Las Vegas, NV 89154   Paradise Campus: 851 E. Tropicana Ave. Las Vegas, NV 89119

University of Nevada, Las Vegas

Downtown Minneapolis, Minnesota



Produced and last updated for Pulaski Technical College in May 2006 by mapformation

PTC PULASKI Technical College

Dedicated to your success

3000 West Scenic Drive
North Little Rock, AR 72118
Phone: (501) 812-2200
www.pulaskitech.edu

CAMPUS MAP LEGEND

ADM	Administration Building	C	Industrial Technology
AHEC	Allied Health Education Center	IT	Information Technology Center
D	Automotive Technology	OL	Ottenheimer Library
BUS	Business Building	PHYS	Physical Plant
CCB	Campus Center	SCIB	Science Building

Pulaski Technical College

Parking Lots: A-Y

1 Northern on Main
2 Dukes Memorial
3 Lehr Memorial
4 Hill Memorial
5 Hill Memorial Annex
6 James F. Dicke Hall
7 Presser Hall
8 Elzay Gallery of Art
9 Wilson Art Building
10 Tilton Hall of Law
11 Taggart Law Library
12 Student Development Center -Lehr Kennedy House
13 Stambaugh Hall
14 Student Health Center
15 University Place Apartments
16 McIntosh Center
17 Weber Hall – Admissions/Financial Aid
18 Taft Memorial
19 Clark Hall
20 Heterick Memorial
21 Burgett Pavilion
22 English Chapel
23 Counseling Center
24 Multicultural Center
25 Child Development Center
26 Physical Plant Grounds Dept.
27 Physical Plant Offices
28 Affinity Village
29 Commons Building
30 Freed Center for the Performing Arts
31 Brookhart Hall
32 Lima Hall
33 Roberts Hall
34 Park Hall
35 Founders Hall
36 Maglott Hall

Campus Village Apartments:
37 Klondike's Den
38 Northern Commons
39 Polar Place
40 University Terrace
41 Lakeview
42 New Apartments
43 Delta Sigma Phi
44 5 University Parkway
45 Phi Mu Delta
46 Sigma Pi
47 The Dicke House – President's Home
48 Dial-Roberson Stadium
49 Maintenance Facility
50 WONB Radio Transmitter & Tower
51 Picnic Pavilion – Shelter House
52 Northern House
53 1 University Parkway
54 ONU Sports Center/King Horn
55 Biggs Engineering Building
56 Science Annex
57 Meyer Hall of Science
58 Robertson-Evans Pharmacy Building
59 The Hakes-Pierstorf Family Pharmacy Education Center

Ohio Northern University

color figures

A Day With Norman J. W. Thrower

Judith Tyner

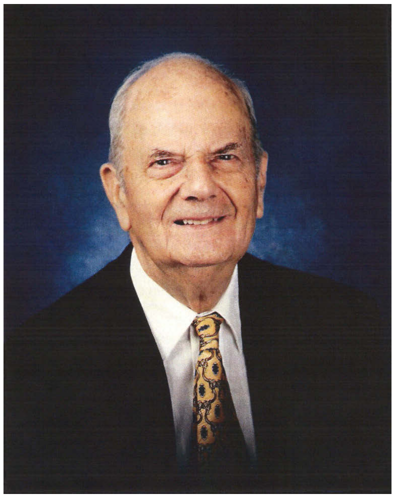


Figure 1. Norman J.W. Thrower, Courtesy Norman J.W. Thrower.

Figure 2. Norman Thrower in raconteur mode, June 9, 2006, Photo by Gerald E. Tyner.

Figure 4. Camp Hale maps produced using parallel inclined traces for the United States Army, Courtesy Norman J.W. Thrower.

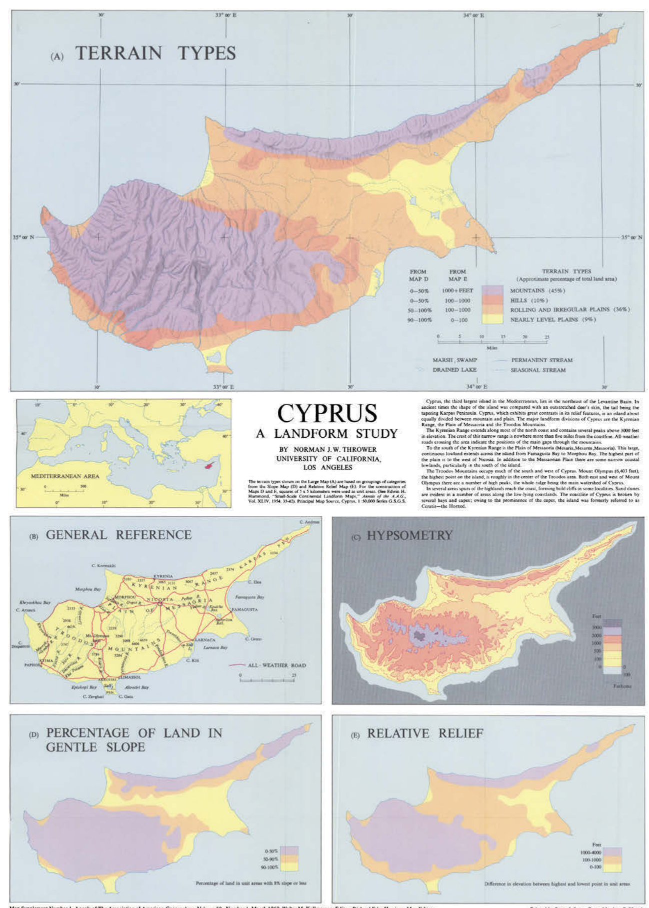


Figure 6. Annals Map Supplement # 1, vol. 50, no. 1, March 1960. Reproduced with permission of Annals of the Association of American Geographers, Blackwell Publishing.

The Effectiveness of Interactive Maps in Secondary Historical Geography Education

Whitney Taylor and Brandon Plewe

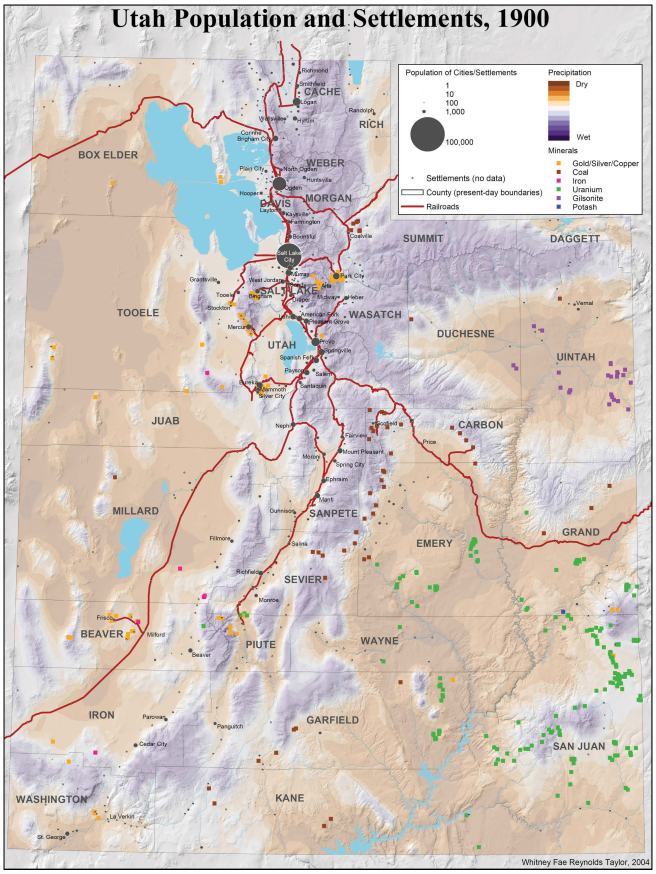


Figure 1. Sample paper map.

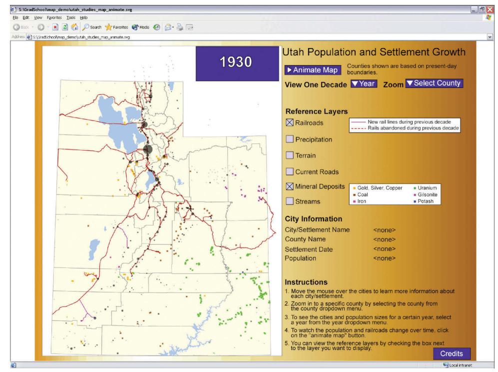


Figure 3. Toggling layers on and off in the interactive map.

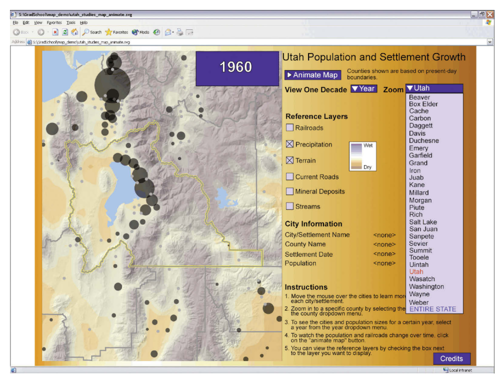


Figure 4. Zooming on a county in the interactive map.

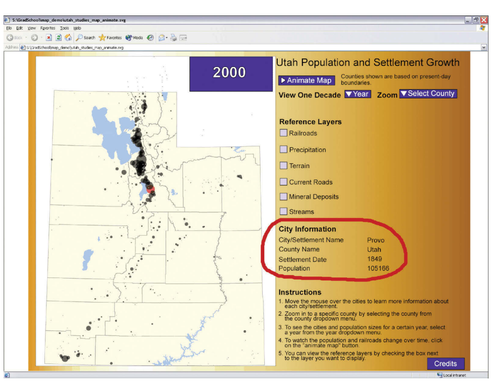


Figure 2. Brushing to view city data in the interactive map.

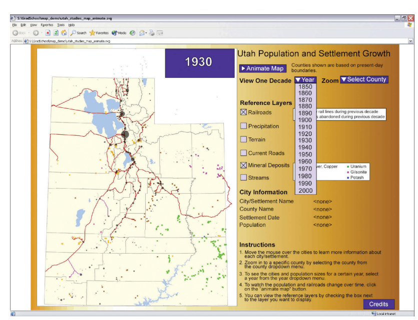


Figure 5. Selecting a year in the interactive map.

A Multi-scale, Multipurpose GIS Data Model to Add Named Features of the Natural Landscape to Maps

Aileen Buckley and Charlie Frye

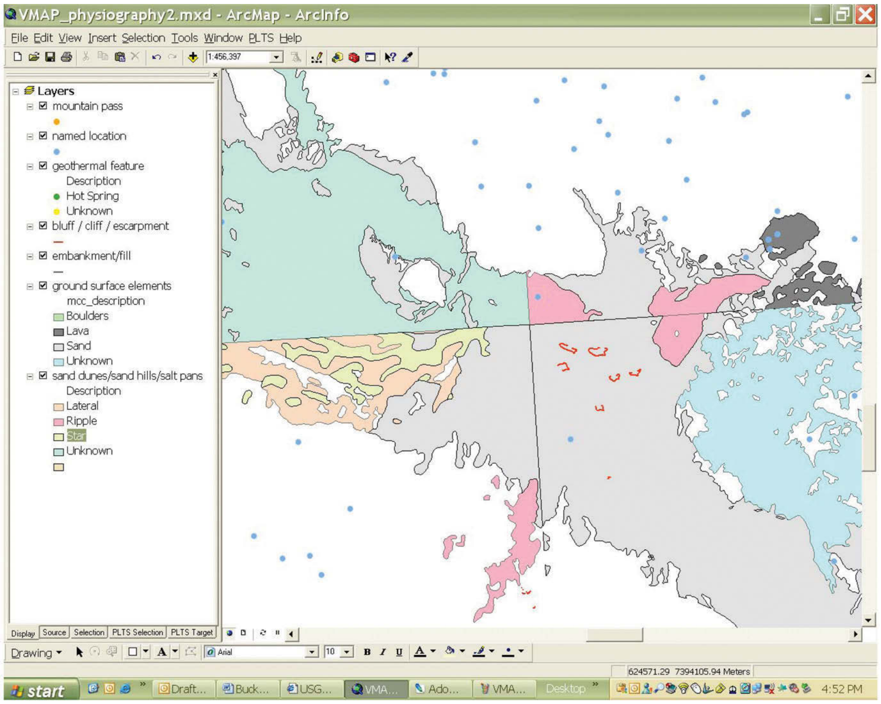


Figure 1. Physiographic features in the VMAP data are designated as points, lines or polygons. Obvious problems can occur at the boundaries of the map sheets that were used as the source documents. Not all names for these features are stored in the GIS dataset.

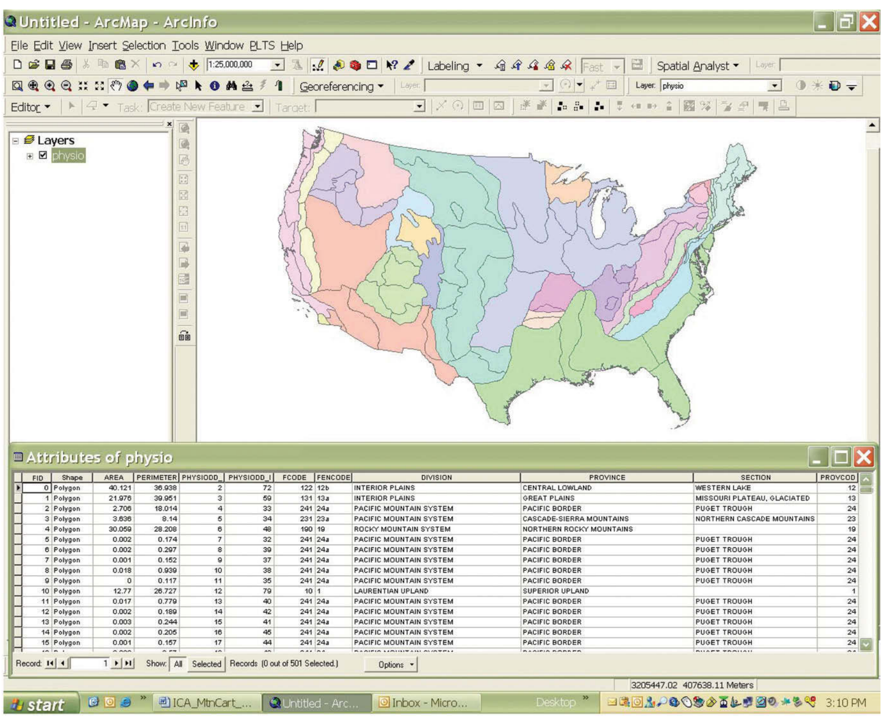


Figure 4. USGS dataset of physiographic regions and provinces for the conterminous United States.

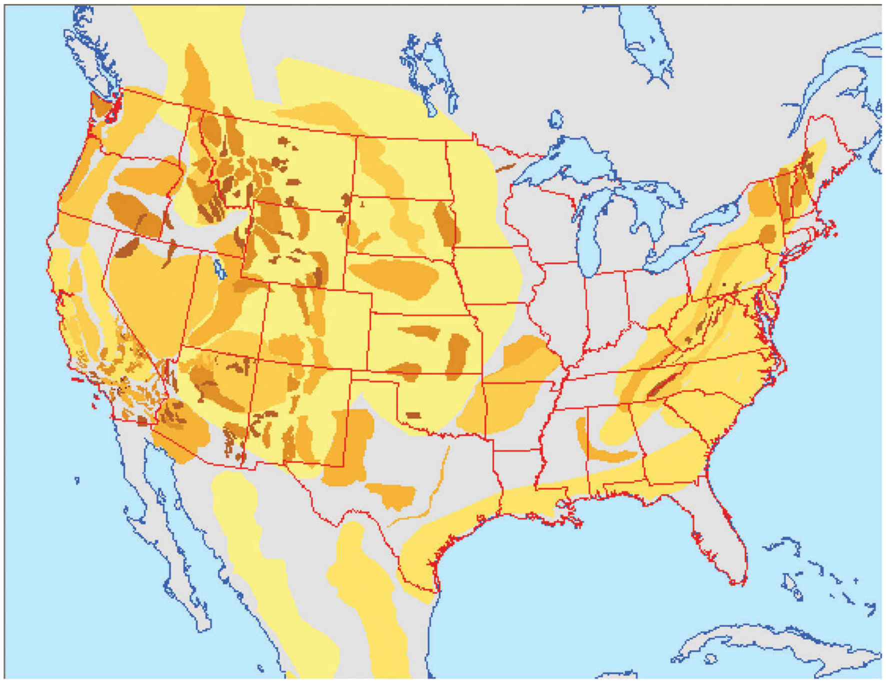


Figure 7. GIS representation of named physiographic features as polygons for a portion of North America. These GIS data do not represent a complete inventory of physiographic features in the area mapped.

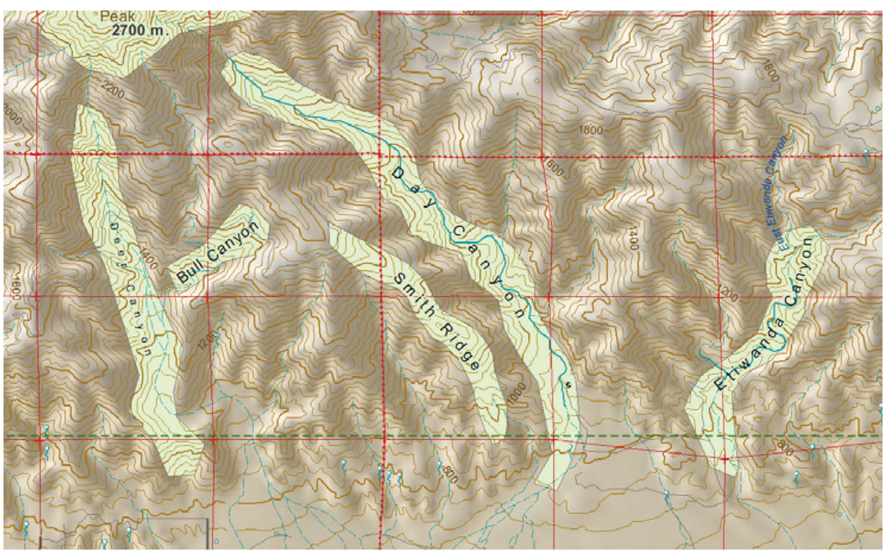


Figure 8. A portion of a 1:100,000 scale topographic map showing the GIS representation (as polygons) and the cartographic representation (as type) of several canyons in Southern California.

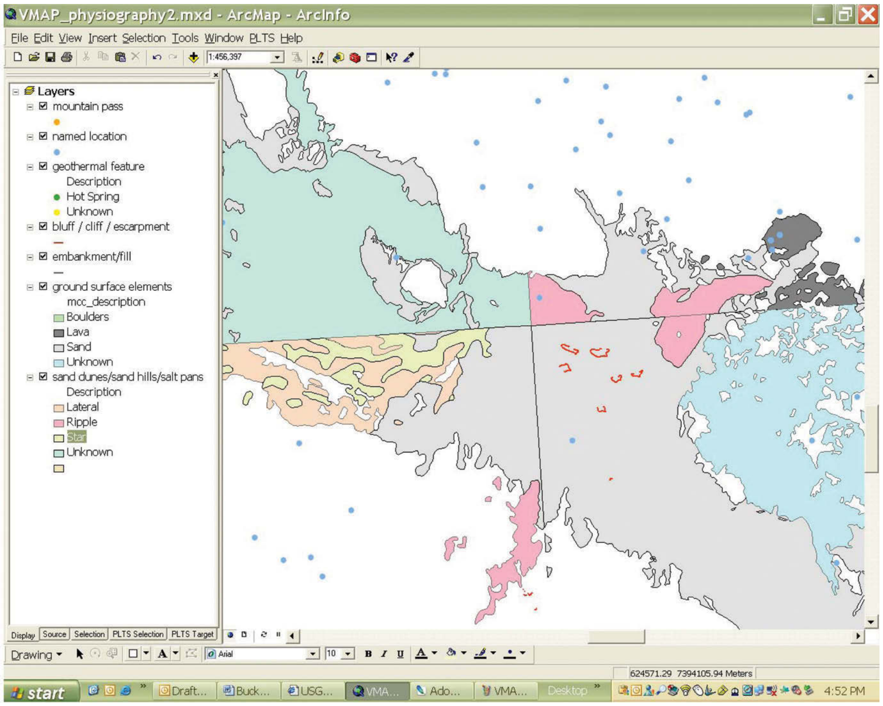


Figure 10. Features can be classified based on shape type which allows label classes to be created that are used to specify how the type is to be placed.

Views of the Rivers: Representing Streamflow of the Greater Yellowstone Ecosystem

Erik Strandhagen, W. Andrew Marcus, and James E. Meacham

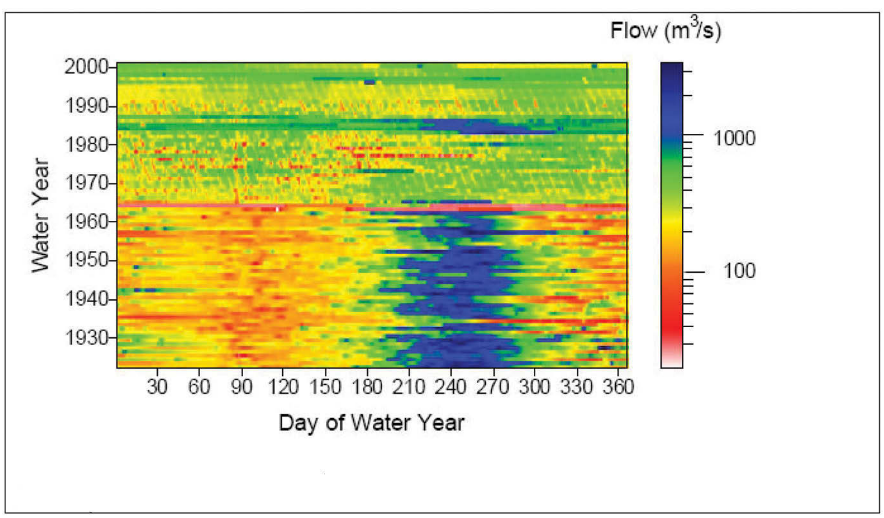


Figure 3. Raster hydrograph shows inter- and intra-annual variability simultaneously, Colorado River at Lees Ferry, AZ 1921-2002 (Koehler 2004:161).

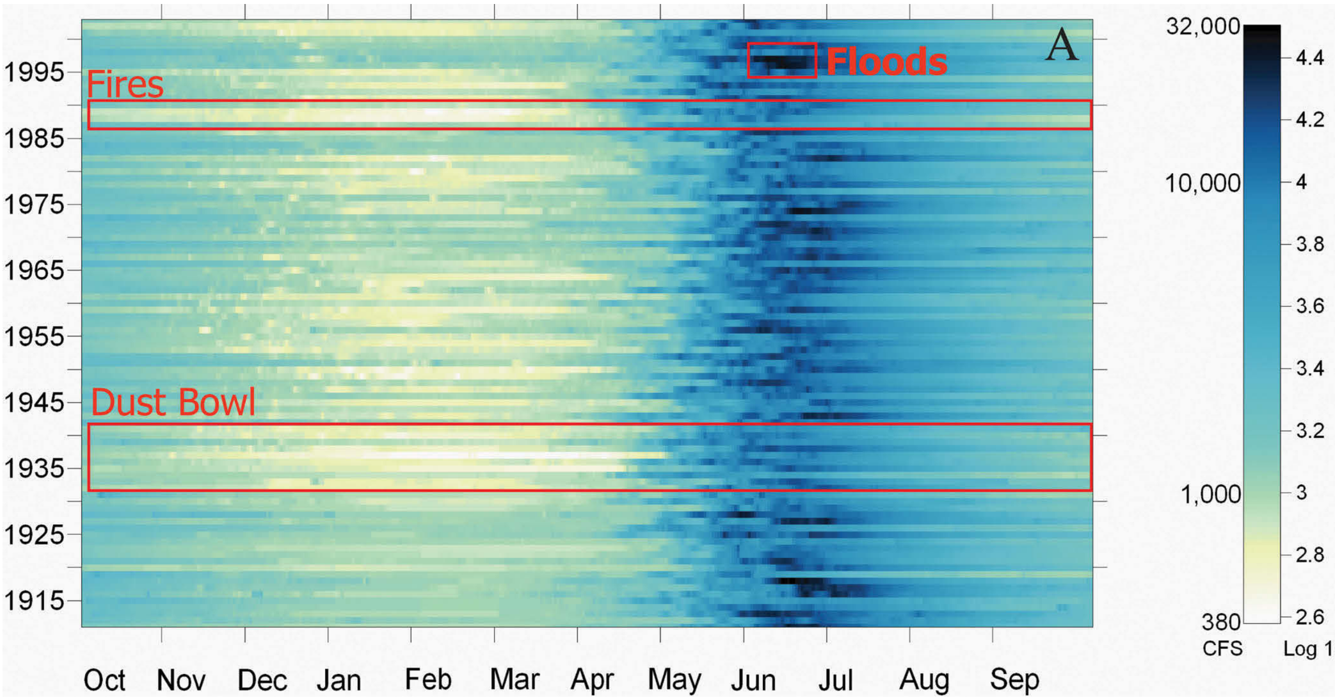


Figure 5a. Raster hydrograph for the Yellowstone River at Corwin Springs, MT.

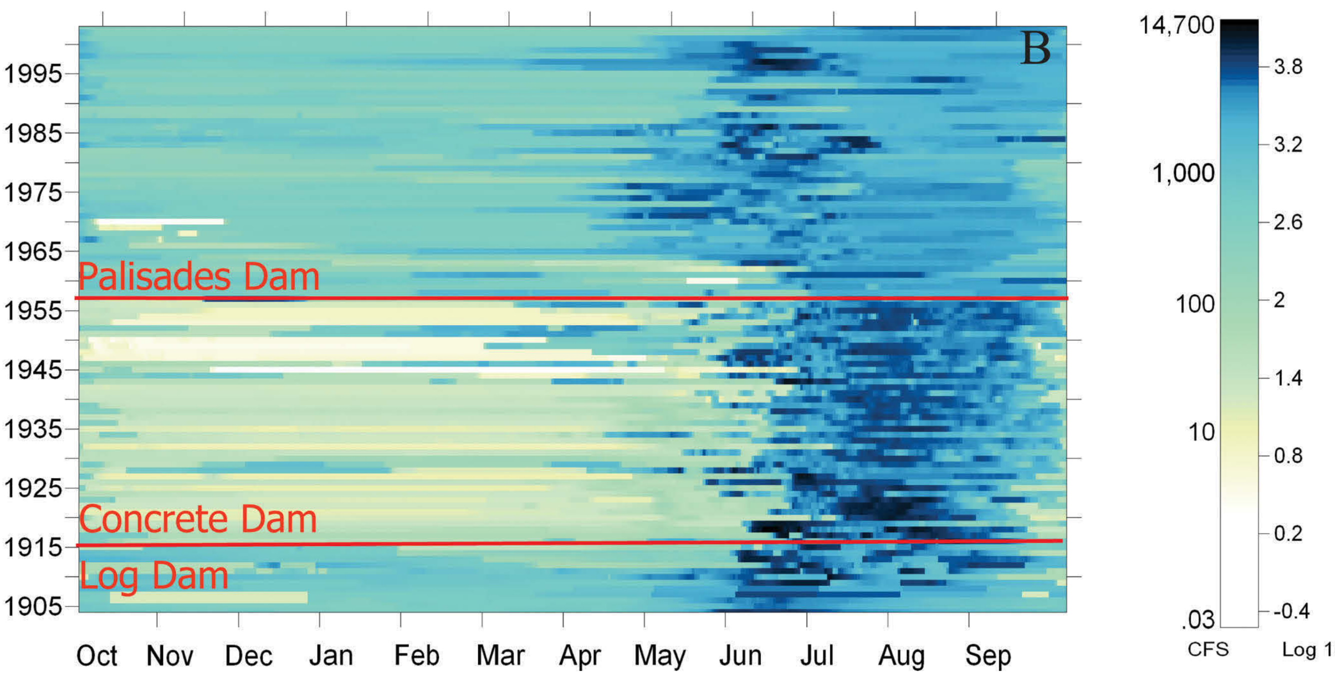


Figure 5b. Raster hydrograph for the Snake River near Moran, WY.

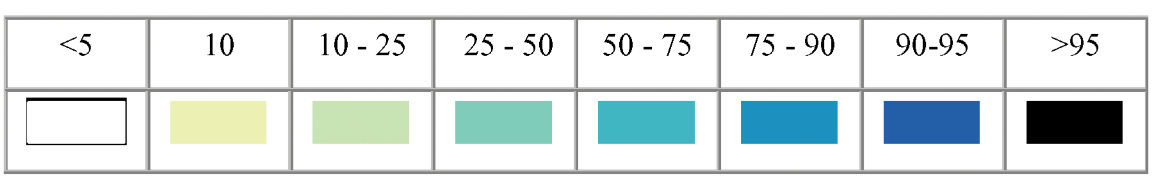


Figure 6. Percentile class breaks with corresponding multi-hue color scheme.

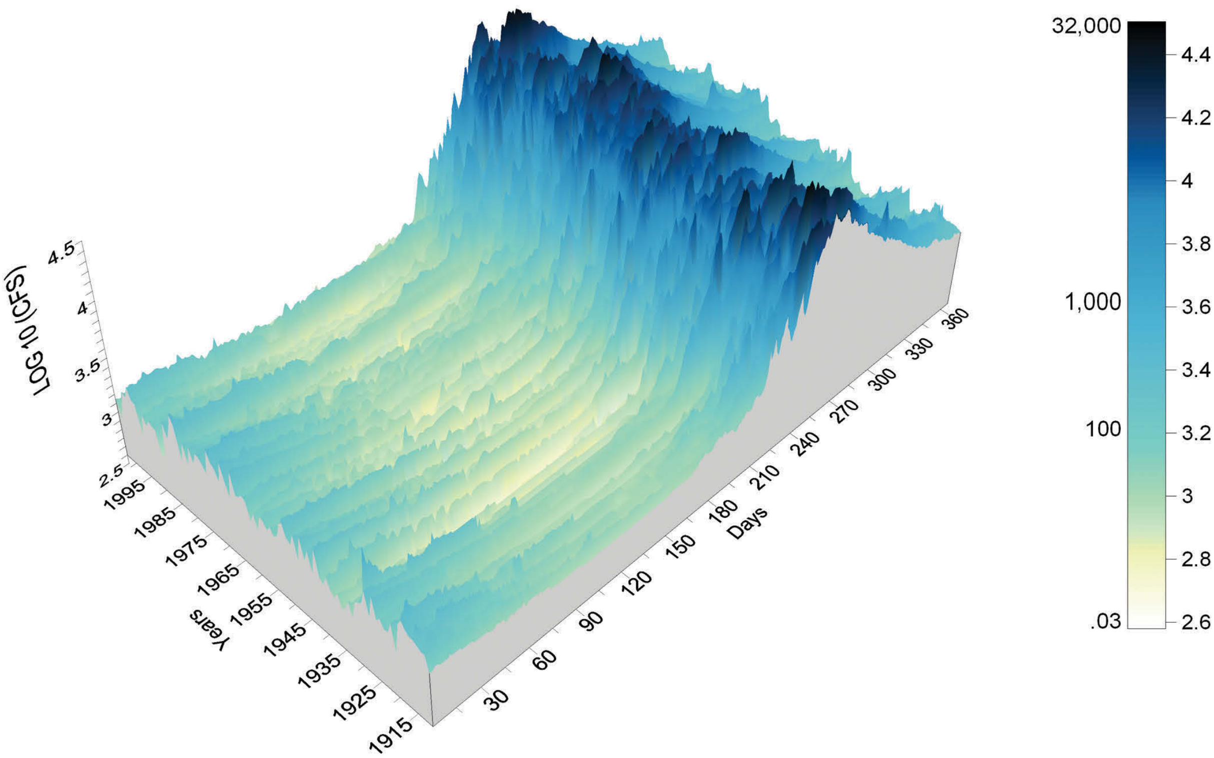


Figure 7a. Three-dimensional raster hydrograph for the Yellowstone River at Corwin Springs, MT.

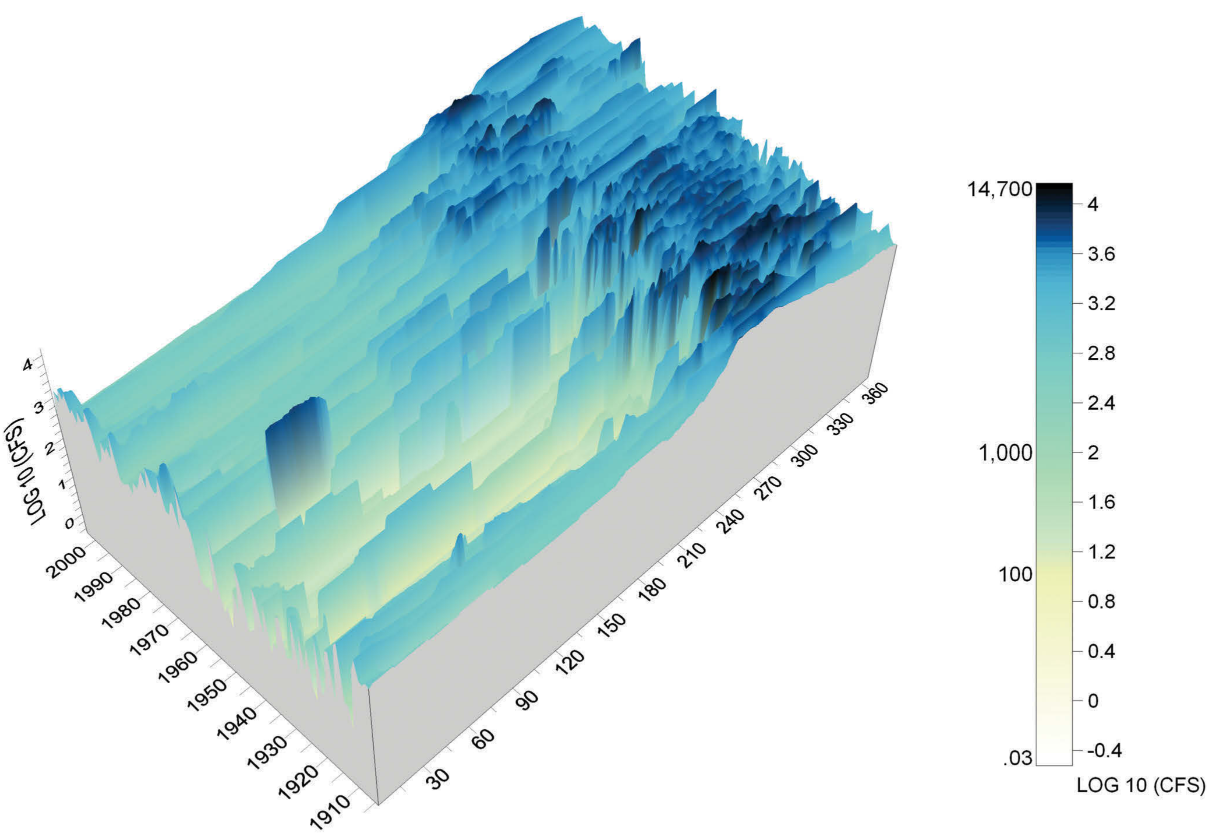


Figure 7b. Three-dimensional raster hydrograph for the Snake River at Moran, WY.

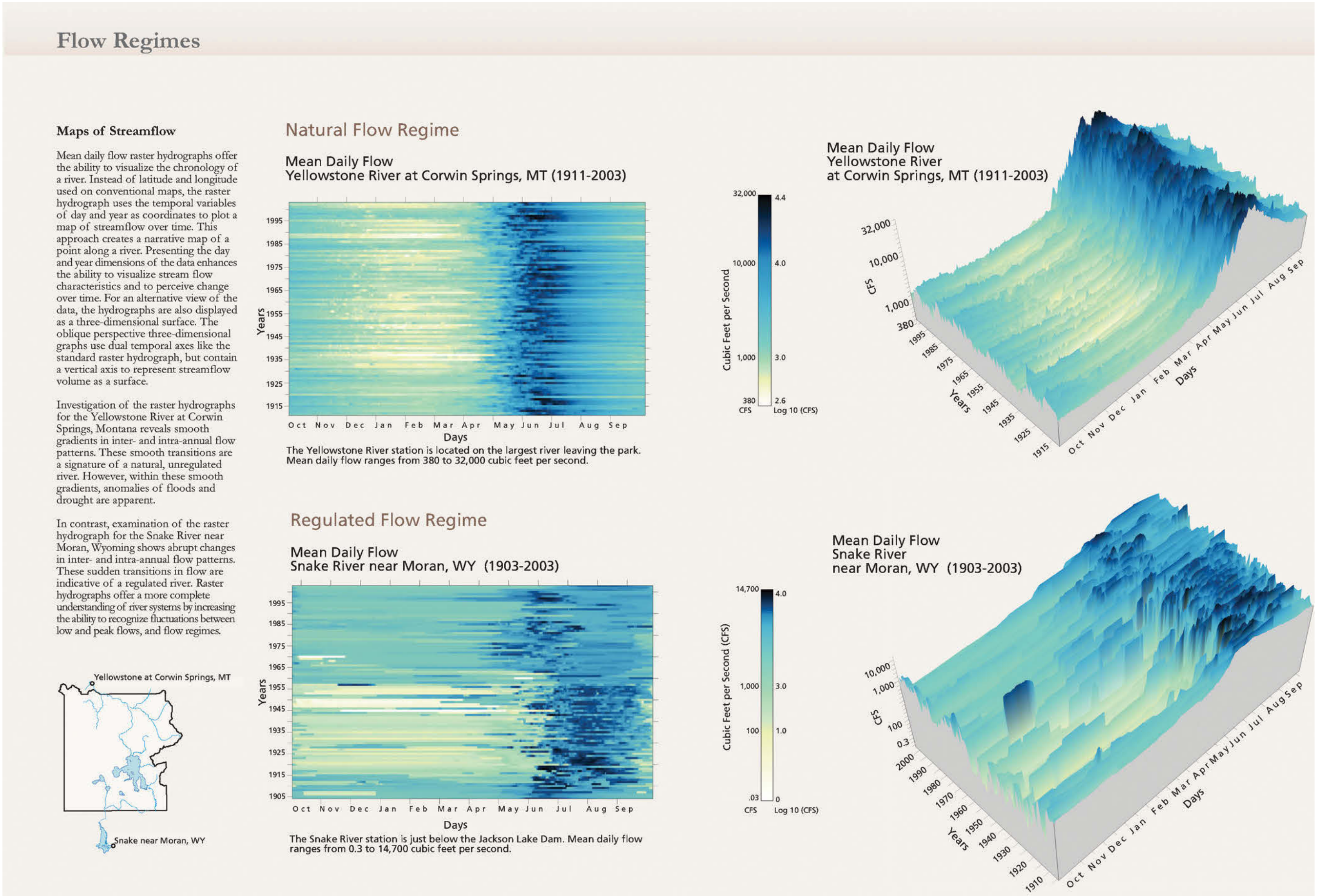


Figure 8. The Flow Regimes *page pair.*