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in this issue

Letter from the Editor

Dear Members of NACIS,

Welcome to CP54, the spring 2006 issue of *Cartographic Perspectives*. A quick look out my office window would hardly suggest that it is the middle of spring here in Duluth. Forty degrees…rain and snow mixed with fog…hardly a leaf in sight on the trees. Is this possible evidence that global warming is a ruse? Hardly. It's more an indication that I'm just not very good at selecting places to live that have desirable spring climates. Some geographer I turned out to be…ya, shuure, you betcha.

Jim Anderson, Lou Cross and I have revised the *Instructions to Authors* for *CP*. These are published in the back of this issue. Please take note of the expanded information on citing Internet sources, submitting illustrations, and obtaining permissions to re-publish work. Of special note are permissions to reproduce previously published

(*continued on page 3*)

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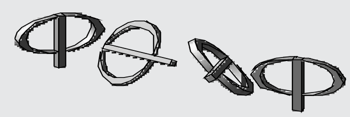
about the cover



The cover image was created by Matt Knutzen, artist, cartographer and Assistant Chief Librarian of the Map Division of the New York Public Library.

(*letter from editor continued*)

images. There is a growing trend for holders of copyrights to charge ever-increasing fees to those wanting to reproduce copyrighted images. This is especially true of large publishing houses that operate for profit…that includes, unfortunately, most publishers (thankfully not *CP*; we operate at cost). Some authors of recent works in *CP* have spent months obtaining permissions, some at significant cost. Examples include one author spending about 5 months obtaining necessary permissions, and another having to secure resources for $2500 for rights to re-publish images. "Wow" is putting it mildly. Mind you, these are the extremes, but it is something prospective authors need to be mindful of, and it is something that will be experienced more often.

In this issue of *CP*, there are four thought-provoking papers. The first is an opinion piece on ethics by Tom Koch. A paper about ethics is hardly new territory for *CP*. What is new territory, though, is that this piece comes from the perspective of those who spend their working hours making maps, rather than talking or teaching about them…the bona fide "mappers" among us. Yeah, I know I might be making categories of cartographers that might make some uncomfortable. My point is that those of us who make maps for our paychecks do have a reality different from those of us who don't make maps for our paychecks. NACIS recognizes (celebrates even) this difference with PCD (practical cartography day) the day before each annual meeting in the fall. All positive responses on this opinion column are welcome…send all the others to Tom *grin*.

Next is a paper by Alan MacEachren *et al*. on map based data exploration and decision-making using natural interfaces to large-screen displays. This paper explores novel methods to facilitate the use of spatial data for group decision-making. The research explored in this paper delves into the implementation of large screen displays that support natural, human-system dialogue within a group decision-making dynamic. Natural language user interfaces for spatial data have long been fantasized about (see NCGIA Initiative 2 report on Language of Spatial Relations (1989), and Initiative 13 report on User Interfaces for Geographic Information Systems (1992)). The work by MacEachren *et al*. helps to envision how such interfaces can impact communication with, and about spatial data.

The paper by Kennelly and Kimerling on non-photorealistic rendering of terrain representations shows the concomitant research happening in cartography and in non-photorealistic rendering. Their paper illustrates how the work in both research areas can inform each other, and lead to multiple depiction methods for terrain representation. The aim, of course, is to "improve" our spatial representations.

Last is a paper by Churchill and Stege on journalistic cartography. The publication of this paper is bittersweet, for certain. While I know that Hope Stege is proud to see her co-authored work published here, she and her friends and colleagues morn the loss of their friend and mentor, Dr. Robert Churchill. Bob passed away as this paper underwent publication. It is essentially his last publication, and with Hope's hard work and tenacity, it is a wonderful paper, very much in the spirit of Dr. Churchill's work. This paper demonstrates to us the power of "maps in press" to construct (persuade even) the general public's geographical, and more importantly, political knowledge. Enjoy!

As you all know, *Cartographic Perspectives* is healthy and strong. The current editorial board and section editors have worked tirelessly to make this happen. To insure the health of *CP*, please consider submitting your work for publication consideration. Send your opinion papers, articles and visual field contributions to me at sfreunds@d.umn.edu; send your cartographic techniques contributions to Charlie Frye at cfrye@esri.com; send your cartographic collections contributions to Chris Mixon at mixonch@auburn.edu; and contact Mark Denil at m.denil@conservation.org if you are interested in reviewing a book, atlas or software.

As always, I welcome your comments and suggestions.

Warmest Regards,

Scott Freundschuh, Editor

"False Truths": Ethics and Mapping as a Profession

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Think about this: You and your partner are the owners and operators of a struggling cartographic firm, Map-Off, Ltd. You are offered a lucrative contract, with more to come if they like your work, to make a map based on publicly available data (http://apps.nccd.cdc.gov/brfss). The client asks you to map healthy smokers over 70 years of age in the United States. You are free to find and use statistics (a bar chart, for example), graphic images (of tobacco, of smokers, etc.) and anything else that will make your map the best statement possible. Your perspective client is the American Association of Tobacconists (AAT). Knowing that tobacco is a carcinogen responsible for the deaths of some but not all users, and some non-users affected by second-hand smoke, do you take the contract? Do you make the map?

At the 2005 NACIS meetings in Salt Lake City ethics was in the air. Was it appropriate for members of this organization to "outsource" to persons in Asia and in Europe, depriving fellow members of the North American organization of work? What were the ethics of the annual "Map-off" presentations and should the maps that were presented by participants be judged on aesthetics alone or on the basis of the ethics embedded in their presentation? What would a professional ethic for working mapmakers be like?

"Ethics argues a consistency between value, principle, and ethical application; it cannot prove the correctness of the underlying values themselves."

Ethics is hard stuff, as Socrates realized and ethicists ever since have understood. A recent article on medical ethics approvingly quotes words Plato puts in Socrates' mouth in The Republic: "The argument concerns no casual topic but one's whole manner of living" (Wiggins and Schwartz, 2005: 81-82). Those arguments, however, permit no obvious conclusion in the way science thinks of things as obvious. There are no tests to prove with statistical certainty A is an ethical action while B is not because ethics is not about facts but about values, principles derived from them and the application of those principles to social issues. Ethics argues a consistency between value, principle, and ethical application; it cannot prove the correctness of the underlying values themselves (Koch, in press).

"Ethics requires us to go beyond [the professional] 'I' and 'you' toward a universalizeable judgment, somehow perceived from the standpoint of the impartial spectator or ideal observer" Peter Singer

When focused within a profession— journalism, mapmaking, medicine, etc.—ethics is not just about the clinical procedure, the individual map, or the unique story. Instead it seeks to uncover the "manner of being" those acts present for an individual practicing in a profession, and for the profession-at-large. In the end, ethics is about the role of the professional as a citizen; professional ethics is about a group of citizens whose work reflects a set of values whose operational principles affect the communities at large. As Peter Singer put it, "Ethics requires us to go beyond [the professional] 'I' and 'you' toward a universalizeable judgment, somehow perceived from the standpoint of the impartial spectator or ideal observer" (Singer, 1993:12).

For North American Cartographic Information Society (NACIS) mapmakers, the trick therefore is to understand, as individuals, professionals, and as members of a society, that ideal observer's judgment of the maps they create. One way to do this is to consider the fictional tobacco company assignment and ask, *Why do we recognize this assignment as ethically questionable?* If the tobacco map is at least potentially problematic, one may then ask whether the issues it raises are those shared by other professions, and if so, what their ethical dilemmas say about the mapmakers' quandary.

The Map

If the map of long-lived smokers is simply a graphic presentation of data compiled by others then the mapmaker has no greater responsibility for the effect of the map that results than the person who designs this journal has for this article. The designer's job is to assure the article is as legible as possible on the page, not to judge the content of the page itself. Similarly, at Map-Off Ltd. you are not asked to critique the data on long-lived smokers, to judge its accuracy or gage its potential public effect. The mapmaker's charge, like the page designer's, is legible presentation of the CDC data through the appropriate choice of graphic (type font and size, call-out quotes) and cartographic (coloration, border width, etc.) elements.

"The designer's job is to assure the article is as legible as possible on the page, not to judge the content of the page itself."

The mapmaker assumes no ethical responsibility for the product that results. The only issue is whether the map meets a generally acknowledged, generally accepted professional aesthetic standard. If it does then the employer must fulfill its promise of payment in exchange for a piece of work whose value was contractually agreed upon. To do less would be a breach of contract and thus an act of bad faith, a violation of the general ethics of responsible commercial exchange. Practically, the ethics of mapmaking stops here, at the principle of reciprocity that governs commercial relations.

From this perspective, mapmakers are drudges whose job is to translate another's data and point-of-view into a comprehensible, aesthetically pleasing graphic (Wood, 2002). The effect of the map is the sole responsibility of the employer, AAT. The map that results is not a representation of reality, "the world-as-it-is", but the presentation of a reality defined by the dataset selected by the employer for his or her purpose. At this level, mapmaking is an ethically vacuous, thoroughly pedestrian craft.

The Problem

Cartographers do not like to think of themselves as drudges toiling at a trade that is ethically impoverished and intellectually vacuous. Like most citizens, they want to see their work as socially valuable and intellectually fulfilling. They want to be proud of the work they do. The problem is that it is hard to be proud of the tobacco map. At issue is not the map—a useful graphic—but the message the map presents. We know the association of smoking with longevity is a "false truth," a lie wrapped in the guise of fact (Koch, 1990). Longevity may occur in spite of long-term tobacco use, but never because of it.

"Cartographers do not like to think of themselves as drudges toiling at a trade that is ethically impoverished and intellectually vacuous. . . . They want to be proud of the work they do."

The map of long-lived smokers (Figure 1) is a problem because it suggests equivalence between longevity and tobacco use that is unsupportable. In the language of semiotics, its components are the sign that together create a signifier whose message is a relationship between smoking and longevity (for the applicability of semiotics to mapping, see Wood, 1992; Koch, 2005). The result is "unary", the presentation of what appears to be a banal fact (some smokers are long-lived) whose intent is to suggest smoking is not harmful and may be beneficial—you want to be long lived, don't you? (Barthes, 1981: 40-42). Its message is validated by the assurance of an official source, the CDC web page at the bottom of the map promotes the conclusion that "you can smoke and live a long time", a possibility

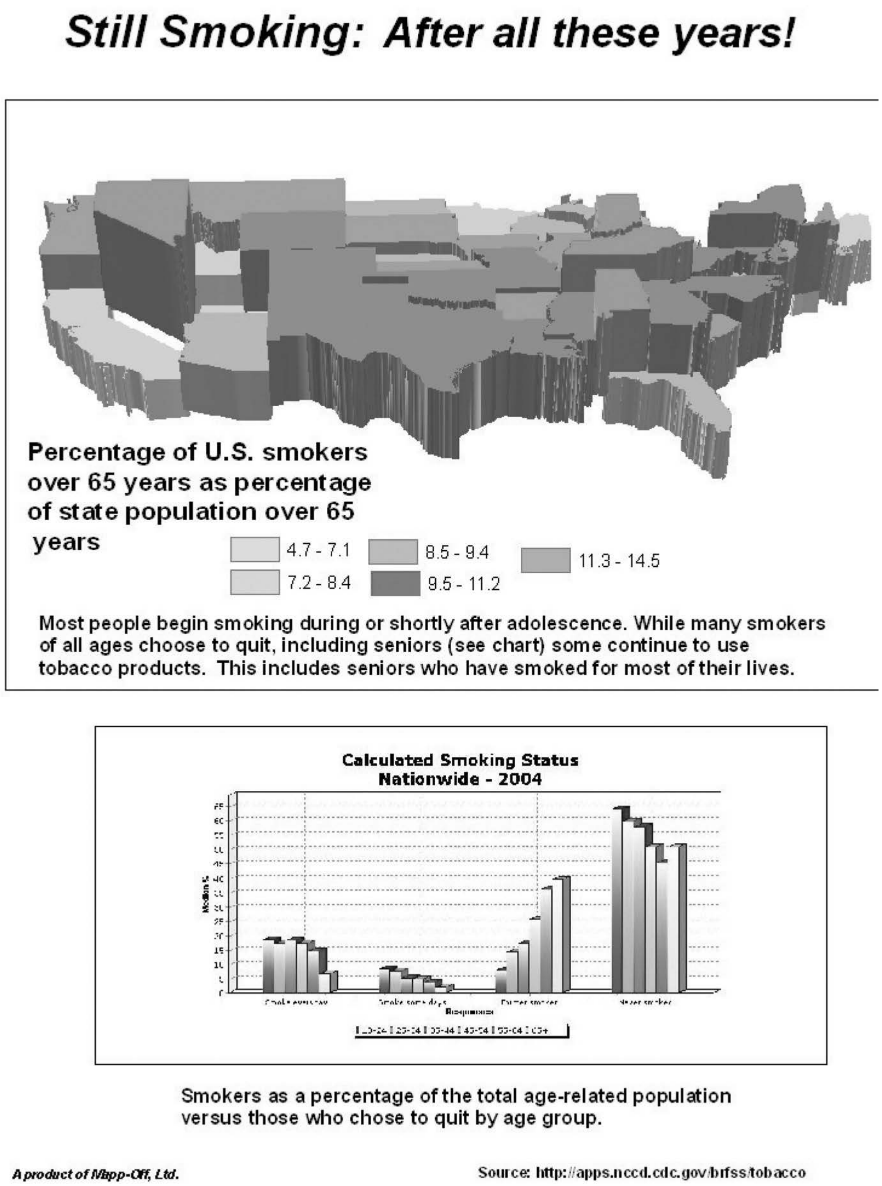

Figure 1. Long-lived smokers is a potential response to the hypothetical ATT contract for a map of data on smokers over 70 years of age in the United States. Map by author. (see page 81 for color version)

that skillfully ignores the greater likelihood of early death resulting from long-term tobacco use.

The problem is not with the map but the intent of the employer for whom the map was made. Ethical discomfort would disappear, for example, if the National Cancer Institute (NCI), not AAT, commissioned a map of long-lived smokers for use in a smoking cessation campaign aimed at elderly tobacco users. Singer's "impartial specter," thus, would find the same map unacceptable and dishonest if promoted by AAT's interest in long-term smokers, but acceptable if commissioned by NCI for an anti-smoking campaign. Singer's professional 'I', in other words, would criticize the AAT map as misleading while applauding its use by NCI in an anti-tobacco campaign. "Many smokers live long lives" is misleading and potentially harmful while "after all those years, long-lived smokers need to quit" is socially useful. The result insists the ethics of mapmaking resides not in the map itself but the use to which it is put, not simply its

"The problem is not with the map but the intent of the employer for whom the map was made."

truthfulness—both maps are identical except for their heading—but the use to which limited truths are put. The question then becomes: are mapmakers responsible for the way their maps are employed?

Representation Versus Presentation

The distance between mapmaker as drudge and mapmaker as ethically complicit citizen, between map-as-neutral graphic and map-as-social artifact is precisely what Leman's so-called "critical geographers" have sought to reveal (Lemann, 2000). In the last two decades the works of Harley (1989; 2004) and Wood (1993; 1996), among others, has argued that maps are not simple vehicles for the dissemination of data but social constructions laden with meaning for which the mapmaker bears some responsibility. Harley, for example, called for consideration of the "rightness of the social consequences of map-making" (Harley, 1991: 9). The implication is that mapmakers have a responsibility that goes beyond the accuracy of the geography their maps present.

"The implication is that mapmakers have a responsibility that goes beyond the accuracy of the geography their maps present."

Either the map is, as Robinson and others have suggested, a representation of the world for which no ethical responsibility exists, or as Harley and Wood separately insist, a presentation with ethical implications for the mapmaker as well as his or her employer. The idea of maps as representations existed largely without challenge in the decades after World War II because cartographers of that generation saw themselves as self-consciously representing the work of others, transforming the resolution of spatial problem into solutions.

"They would come to the office," Robinson said of his years of military mapping during World War II, "the main office, my office, and be assigned to a cartographer. He would go over all their needs, establish what data they had and what data we had to provide, usually the base data" (Cook, 2005: 48). Robinson's cartographers were guardians of what's real, the "base data" onto which was grafted the military client's data (bombing targets, for example). Cartography gave reality to its clients; its ethics began and ended with the resulting map's ability to present the client's problem and solution in as clear a graphic as possible. The ethics of representation is the ethics of cartographic disengagement. It limits cartographic responsibility to locational truths (these places are here, and here, and here) irrespective of the values a map presents.

Theoretical opposition to this posture has built exponentially since the 1992 publication of Wood's *The Power of Maps*, which grounded the fundamentally academic, historical arguments of Harley in the pedestrian maps of roads and tourist sites. Wood's book has been instrumental in developing the argument that mapmaking is not an ethically neutral activity and that cartographers bear responsibility for the maps they make, for their effect in society.

"The distance between presentation and representation is not unique to cartography. Daily news reporters face a similar tension in their careers."

The Map As Story

The distance between presentation and representation is not unique to cartography. Daily news reporters face a similar tension in their careers. The daily reporter's task is the accurate representation of an editorially assigned subject's statements in a coherent manner conforming to general standards of news writing. They bear no responsibility for those statements—no matter how foolish they may be—beyond assuring the accuracy of attributed statements (Koch, 1990). That is why journalism is the fourth estate: It broadcasts the statements of the prior, more powerful estates of society (Koch, 1991).

Consider a reporter working for the Raleigh, NC News and Observer (N&O) who is assigned to cover a press conference called by AAT president and well-known local philanthropist Ralph Gleason. At his press, conference reporters are given a copy of the Map-Off, Ltd. map and a print version of Mr. Gleason's talk. The newspaper's cigar-smoking city editor orders a 14-inch long story on Gleason's to be run with the map under a 30-point headline: "Some Smokers Long-lived". The map's source in six-point type, *http://apps.nccd.cdc.gov/brfss*, is the graphic equivalent of the journalistic "he said," or, "she said". It assigns responsibility for the map's content to the US Center for Disease Control. The reporter uses quotes to justify a story that quotes Mr. Gleason saying, "Many tobacco users are long lived!" Just as the map represents AAT's perspective, the news story represents the subject's conclusions. Both present a false truth that is unary, the banal fact that not all smokers die young because of tobacco use.

"The map-as-story has become a journalistic staple."

That the ethical frame for cartography and journalism are similar is not surprising. The map-as-story has become a journalistic staple. Consider the typical example presented in Figure 2. On November 8, 2005 the Associated Press moved a map-story whose headline, "War with insurgents ramped up," was set above an annotated map of Iraq. The map itself

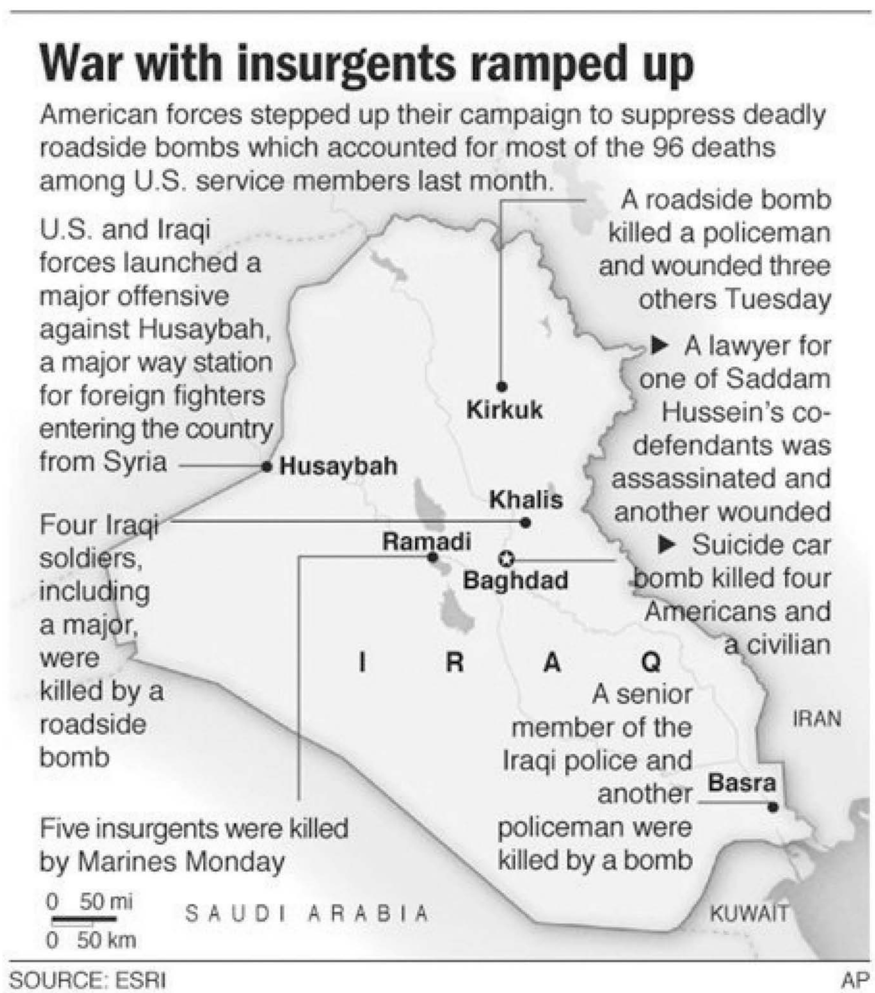

Figure 2. This map-story by the Associated Press of military events in Iraq argued for increased US military activity in response to "foreign" insurgents. (AP Graphic). Accessed 8 Nov. 2005 at http://global.net/. (see page 82 for color version)

(Source: ESRI) was embedded in text identifying mapped locations where US troops, and their allies, had been killed by bombs.

The multiple locations of anti-US bomb attacks (here and here and here!) are the map's sign. Together they signify aggression against the U.S. military and its allies. The message is a necessary and just increase in US military activity ("ramping up") against "insurgents," some of them "foreigners," seeking to do them harm. The ultimate sign, implicit but obvious, is the "War on Terrorism" taken to Iraq by US troops legitimately engaged against foreign fighters using bombs.

The map-story tells a small truth: military officials say that at these map coordinates, bombs killed US troops or their allies. That small truth is made authoritative by the map's pretense of impartiality, "This happened. No question." The result is validated by the ESRI attribution at the bottom of the page. ESRI provided the "base data" of the map onto which a justification for "ramping up" US attacks was announced by military public relations personnel at a press conference.

"The map story tells a small truth . . . made authoratative by the map's pretense of impartiality."

The military truth represented leaves out too much that is critical from the perspective of Singer's impartial observer. Absent from the map-story are the many sites the US military has bombed, killing both opposition and civilian populations. The identification of Husaybah as a "way station" for foreign fighters (they have to be stopped!) ignores the critical fact that US troops also are foreign invaders with less reason to be engaged than the neighbors from Syria. Nor does the map permit acknowledgement that while some combatants are not Iraqi citizens, many are Iraqi nationals opposed to the US invasion and subsequent occupation of their homeland. The result is a small truth (bombs here and here and here) hiding a greater falsehood (US forces defend against bomb-carrying foreigners) promoting US expansion of military activity.

News cartographers are, like their reportorial counterparts, generally uninvolved with their work at this level. Monmonier's history of *Maps with the News*, tracing public mapping in the media, does not include an index entry for "ethics" or "social responsibility" (Monmonier, 1989). Nor does Monmonier's book include an entry for "propaganda" or "war" despite the importance of the maps in twentieth century military campaigns (Cosgrove, 2006). Indeed, Monmonier insists journalists and mapmakers have "divergent foci—editors towards facts and opinions, and artists toward decoration and packaging—a view that appears to utterly deny map content and social responsibility as cartographic concerns (Monmonier, 1989). He is clearly wrong, here. The focus is identical and the result equally problematic.

"The result is a small truth hiding a greater falsehood promoting US expansion of military activity."

At issue is not *How to Lie with Maps* (Monmonier, 1996), because as representations maps that lie are not the mapmaker's problem. The real question is whether truth telling beyond the trivial is an ethical principle professional cartographers wish to embrace.

Maps As Science

In theory, maps accompanying scientific reports can be assumed to have a higher standard, abjuring the false truths common to journalism and the commercial mapmaker. This assumption ignores, however, the carefully constructed nature of science, and the limited truths it typically presents. The problem is made more difficult in this discussion by the tendency of cartographers advancing cartography within Geographical Information Science (Schurmann, 1996 for example) to treat science as a modifying adjective whose meaning is clear, rather than a noun whose history is complex and difficult to define (Shapin, 1994; Shapin and Schaffer, 1985).

Certainly, "Science" maps often are as misleading as commercial and journalistic maps. Consider, for example, two maps of waiting times for liver transplantation (Figure 3) included in a National Institutes of Medicine (NIM) report prepared by scientists charged by Congress to evaluate national graft organ allocation programs in the United States (National Institute of Medicine, 1999). The maps distilled a wealth of data on graft liver transplant waiting times. The result supported a conclusion that while the system was not necessarily efficient, neither was it inequitable. "No significant effects of race or gender were observed," in the words of one author, "indicating that the system is equitable for women and minorities once listed (Gibbons, Meltzer and Duan, 2000).

""Science" maps often are as misleading as commercial and journalistic maps."

Even if true, the conclusion is true only in the most limited sense. It ignores thousands of potential recipients who never made it *onto* the list—were not listed as potential organ recipients—because they lacked healthcare to pay for transplant services. Unconsidered were those sufficiently impoverished that they were not listed because their home situations

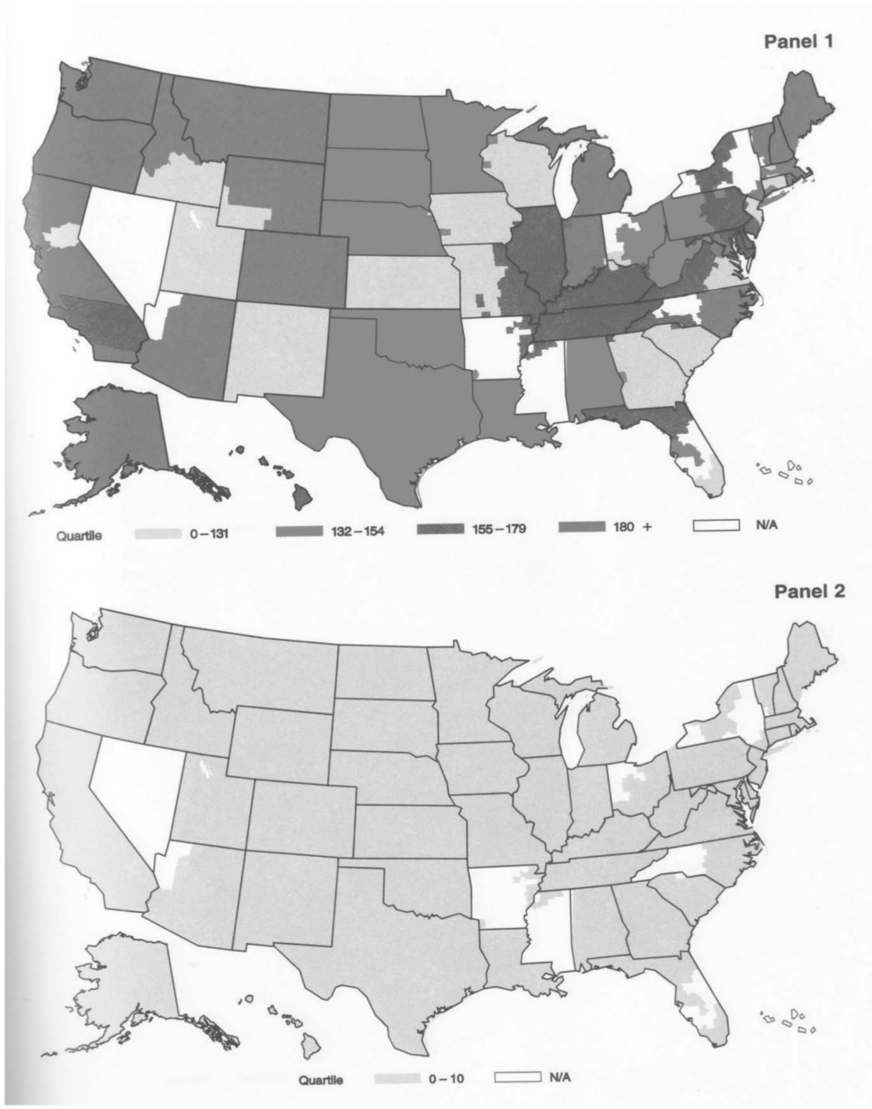

Figure 3. The map of liver transplant candidate waiting times for all those with liver disease (top) and those in urgent need of a liver transplant argued equality of service for critical patients but variable waiting times in some places for non-urgent patients. Source: National Institute of Medicine. Organ Procurement and Transplantation, 58a. (see page 83 for color version)

were unsatisfactory and their income insufficient to pay for post-operative medical care and drugs (Koch, 2001). Nor does the second map give careful consideration to those folks represented in the first map who died before they get to the second map because of other complications resulting from poor healthcare and poverty. Hidden in the maps was the inequitable national distribution of transplant performing hospitals requiring potential transplant recipients to travel hundreds of miles at their own expense to transplant centers, a trek with a potentially adverse effect on survival (Hudd, 1997).

Like the map of Iraq insurgents, the NIM map is a false truth, correct in a limited, unary fashion but hiding in its limits a range of systematic inequalities in the US organ transplant distribution system (Koch and Denike, 2003; Koch, 1999). Like the AAT mapmaker, the NIM mapmaker was also a hireling employed by scientists hired by Congress to report, albeit within very specific parameters, on the equity and efficiency of the US organ transplant distribution system. The difference is that as a science-map, the NIM graphic seemed to present findings that carried a greater than limited truth rather than a representation of limited truths that hid at least as much as it revealed. The message must be that, however it is defined, "Science" carries no greater guarantee of ethical objectivity. It offers no less a problematic field for cartographic presentations.

". . . "Science" carries no greater guarantee of ethical objectivity. It offers no less a problematic field for cartographic presentations."

Reputation

Why not just accept that 'truth and the social effect of representative maps' are the client's responsibility? It certainly would be easier to accept the true lies maps so often tell in the same way journalists accept the false truths of attributed news stories. Why worry ethics at all? The best answer is that to do so hurts our self-esteem. We want to think of ourselves as more than drudges, as socially valuable citizens performing work that serves society-at-large.

Mapmakers want to be taken seriously and for that to occur people need to trust the map or story that represents events in the world. One option is journalistic: the only truth promised is the accurate distillation of another person's work irrespective of its veracity. The result is unsatisfactory from the perspective of the impartial observer representing society's demand for something more and the mapmaker's belief in the social value of his or her craft.

The tension between individual self-interest (take the contract, stupid!) and the greater social good (It's a lie, refuse it) is a "public goods problem," whose common solution is that people generally seek to act in the public interest rather than out of pure self-interest (Milinski, Semmann and Krambeck, 2002). We cooperate for the good of all even when the result diminishes our own immediate store of goods, however it is defined. This appears to be an innate tendency embedded in our social constitutions, a species attribute Darwinian in its evolutionary power (Hauert, *et. al.* A socially beneficial posture advances the greater society, returning to the individual pride in who they are and what they do in society.

"It certainly would be easier to accept the true lies maps so often tell . . ."

Saying mapmakers want to believe their craft contributes to society and ethics, is a way of assessing the contribution a map may make not simply to the employer, but to society-at-large. Admitting we do not present a best estimate of the truth, but instead truthfully represent a client's false truths diminishes our role socially and diminishes the craft in the eyes of its practitioners. We therefore care about ethics in mapping to the extent we care about mapmaking as a social good. A concern for ethics thus is about what Goffman (1959) called, *The Presentation of Self in Everyday Life* and the degree to which as professionals, mapmakers or others create a social presentation. Goffman's (1959) sociology is ethics in a different frame occurring when a person or group requests others take seriously the public self that is presented, in this case an impression of knowledge and expertise.

Professional Ethics

Professional associations are typically developed to define a craft or profession, to delineate its standards of conduct, and to set ethical parameters for its members. This is who we are, associations state; this is what we do and how it serves the common weal. It is why we should be taken seriously, and trusted. Those who violate professional standards can be censured, disciplined, and if the offence is egregious, expelled from the professional body. The model is medicine's Hippocratic Oath, an ethical statement that has "served as a model for almost a hundred generations" (Nuland, 1988). The entirety of the oath can be divided into two broad injunctions: physicians must (a) respect each other and (b) care for their patients, doing no harm to either colleagues or patients.

In one form or another, professional societies typically formulate similar injunctions. They demand respect for fellow practitioners, "professional courtesy" in all the meanings of the phrase, and secondly, enjoin against harm and for the promotion of social good. Most are careful in their definitions to limit the parameters of their ethical guidance in a manner that does not restrict either the client base or the services that can be rendered to those clients.

"Professional societies typically demand respect for fellow practitioners . . .and enjoin against harm."

Journalism has made objectivity an ethical goal irrespective of the truthfulness or falsity of the statements reportorial subjects present (Ward, 2005). To do otherwise is to make journalists into arbiters of the work of others, something reporters and editors are neither trained nor equipped to do (Koch, 1991). The American Advertising Federation's (2006) (AAF) code of ethics states that "Advertising shall tell the truth, and shall reveal significant facts, the omission of which would mislead the public". There is, however, no compunction for advertisers to consider what an advertiser's limited truth mean within the greater community. In these professions, and in cartography, the representation of limited truths is the standard and a standard rationale for what results.

From the viewpoint of the impartial observer, this is not a particularly satisfactory state of affairs. At present there is no simple standard, however, which can judge a map's representation, except that of the accurate representation of limited data, of false truths and true lies. This is a convenient, not necessary, state of affairs. NACIS members could choose to engage the hard work of deciding where objective presentation ends and false representation begins. This would require complex discussions among NACIS members about what it is they do and believe, not simply as mapmakers, but as citizens, and the extent to which the ethics they espouse as members of society should define professional practice.

A commitment to an ethics greater than the attributive would begin with a committee whose task was to consider seriously the responsibility of members, and the degree to which mapmaking is a representative service or a presentative responsibility. The committee would struggle to formulate a code of responsibility inhibiting, at least in theory, contracts for maps whose results were patently misleading. The organization-at-large, if it took a greater ethic seriously, would offer awards to members who refused contracts from companies that did not meet its social standards and "bad map" awards for those whose false truths were especially egregious.

In the process, cartography would be transformed over time into a profession advocating responsibility for the presentation of data with a degree of confidence in its surety.

Conclusion

There is no ethics unique to mapmaking. There is, however, a general ethics that applies to mapmakers as it does to all other citizens. Typically mapmakers share with advertisers, journalists, and writers a very restricted ethical charge that accepts a very narrow avenue of responsibility for the work they contract to complete. Ethical responsibility is limited to the contractual ethics of business even if, as citizens, mapmakers carry the weight of social responsibility that in theory all members of society accept. For mapmakers to take ethics seriously would require paying attention to Singer's "impartial observer," to the context of the data they are asked to present and to its social context. It would insist that the limited, personal benefit of a single assignment is always outweighed by the effect as judged by Singer's impersonal observer, and not the employing client or supervising editor. It absolutely would be worth doing, and it is something professional mapmakers are unlikely to address seriously anywhere except in an erudite paper in a professional journal like this one.

"There is no ethics unique to mapmaking. There is, however, a general ethics that applies to mapmakers . . ."

ABOUT THE AUTHOR

A former journalist, Tom Koch (http://kochworks.com) is a gerontologist, medical ethicist, and medical geographer with appointments at the University of British Columbia and Simon Fraser University. His most recent book is *Cartographies of Disease* (2005).

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Supporting Map-based Geocollaboration Through Natural Interfaces to Large-Screen Displays

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Groups usually carry out science and decision-making activities involving geographic information. However, current mapping and related geospatial technologies are not group-friendly, and attempts to extend (or reinvent) technologies for group use have been largely ad hoc. Elsewhere, we have developed a comprehensive conceptual approach to geocollaboration that provides a framework for both studying collaborative work with geospatial information (and technologies) and the development of new technologies designed to support group work. We are applying that approach to a range of prototype systems that support same- and different-place as well as same- and different-time group activities.

Our focus in this paper is on same-time, same-place group work environments that enable that work through use of large-screen displays supporting natural, human-system dialogue and multi-user interaction. Two environments are described and compared. Both make use of hand gestures as a mechanism for specifying display locations. One adopts a combined wall map/white board metaphor while the other adopts a drafting table metaphor. We focus on crisis management as a typical use case.

Keywords: large-screen display, multi-modal map, HCI, interaction metaphors, geocollaboration

INTRODUCTION

Visual displays of geospatial information in the form of maps and images have long served as enabling devices for group work. For example, scientists and industry analysts carrying out data exploration tasks often work collaboratively around large paper maps (e.g., when developing a national ecoregion map or identifying promising locations for oil or mineral exploration). Urban and regional planners also gather around large paper maps to discuss master plans or specific development choices and these same large format maps are used as the object of discus-

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sion at subsequent public meetings. Military strategists use large paper maps in similar ways to plan the distribution of supplies and to coordinate actions. Similarly, teams involved in crisis management use large maps to carry out situational assessment, plan logistics, and guide performance of damage response activities.

The above, traditional situations are rudimentary examples of what we label *geocollaboration.* As an activity, we consider geocollaboration to be group work about geographic scale problems facilitated by geospatial information and information technologies. As a field of research, we consider geocollaboration to be the study of these group activities, together with the development of methods and tools to facilitate them.

"As an activity, we consider geocollaboration to be group work about geographic scale problems facilitated by geospatial information and information technologies."

Although geographic information technologies have advanced rapidly over the past decade, they still generally impede rather than facilitate geocollaboration. Desktop displays are designed for individual use. In addition, interfaces to GISystems and related technologies remain complex and difficult to learn and use – despite repeated calls for more natural, easy to use systems (Mark, 1999; Mark & Gould, 1991; Muntz *et al*., 2003). Recent advances in display hardware and interface devices are making it possible to merge: (1) the advantages of large format representations that facilitate group work, (2) advances in methods and mechanisms for individual and group interaction with information displays, and (3) progress in natural, multimodal interface technologies that require less prior training and less conscious attention during use than is needed for standard mouse-keyboard interfaces. Some examples of initial steps in this direction are discussed in (Cohen and McGee, 2004; Hopkins *et al*., 2001; Sharma et al., 2003). This union of recent advances into group work methods and tools is likely to have a substantial impact on group productivity. Beyond simply increasing the speed and productivity of work, dynamic, large-format displays having natural interfaces designed specifically to support group work have the potential to dramatically (and qualitatively) change the manner of group work with geospatial data by creating fundamentally new types of geocollaboration. Easy to use large displays can dramatically shorten the time it takes now to get a large format map in front of a team that needs it to make a decision. More importantly, once the team is working with the map, the map can be updated in response to requests from the team members for more or different information or in response to rules for providing new information that helps the team maintain its situational awareness.

This paper provides a new perspective on large format maps as an object of and support for group work. This perspective derives from two ongoing projects that develop map-based methods and tools to support geocollaboration – among humans and between human and computer agents. The research builds on a human-centered conceptual approach to both design of geocollaboration environments and evaluation of environment usability. The overall approach integrates perspectives from cognitive science (particularly distributed cognition), semiotics (particularly the mechanisms through which representations are devices for sharing meaning), and usability studies (particularly cognitive systems engineering). For details of the overall conceptual approach and of its instantiation in a series of multimodal prototypes, see: (MacEachren and Brewer, 2004; MacEachren *et al*., 2005). Here, we focus on comparing alternative metaphors for support of group work with large screen displays and on some of the key display design decisions that underlie the natural, multi-user interfaces we have implemented.

". . . we focus on comparing alternative metaphors for support of group work with large screen displays and on some of the key display design decisions that underlie the natural, multi-user interfaces we have implemented."

We begin below (in section 2) with a brief overview of recent research on large-screen, map-based displays and their use in facilitating group work. In section 3, we describe and compare two environments: DAVE_G (Dialogue Assisted Virtual Environment for Geoinformation) and HI-SPACE (Human Information Workspace). Both make use of large displays and natural interaction to enable same-time, same-place group work with geospatial information. The HI-SPACE environment, developed by May (May, 1999), supports joint use of exploratory geovisualization tools, while DAVE_G, developed by our research team, is directed toward crisis response facilitated by GIS. Section 4 focuses on crisis management as an application context within which both natural, easy-to use interfaces and large-screen map-based displays to geospatial information are needed. Here, we also report on selected findings from our empirical study of geospatial information and technology use within crisis management, specifically those findings related to large-screen, map-based displays. Section 5 provides discussion of ongoing challenges in mapping to support geocollaboration.

"The advantages of large format maps as group situation-assessment and decision-making tools have prompted multiple authors to consider the potential of dynamic, large-format, map-based displays for group work with geospatial information."

BACKGROUND

The advantages of large format maps as group situation-assessment and decision-making tools have prompted multiple authors to consider the potential of dynamic, large-format, map-based displays for group work with geospatial information. Florence, *et. al.* (Florence *et al.*, 1996), for example, proposed (but did not implement) the *GIS wallboard*, an electronic white board envisioned to support sketch-based gestures (of the sort implemented for smaller, tablet devices by Oviatt (1997) and Egenhofer (1997)). In the precursor to our multiuser DAVE_G system (discussed in section 3) our colleague Rajeev Sharma and his research team successfully implemented a natural multimodal (speech-gesture) interface to a large screen dynamic map (Kettebekov *et al.*, 2000; Kettebekov and Sharma, 1999) and extended the system to support a crisis response scenario used to test robustness of the interface methods (Kettebekov *et al.*, 2000).

Large screen, group work environments can be based upon at least three different metaphors: wall map/white board, drafting table/light table, and real world. Work with each is outlined below.

White board/wall map

The environments mentioned above all adopt a wall map or white board metaphor. A white board metaphor implies a display that is initially blank, with the primary functionality being the ability to write/draw on the display using different colored pens and to erase selectively. A wall map metaphor implies a display that initially contains a map, perhaps with the ability to point out features of interest and to move between different map views (by rolling up one map and pulling down another). As McGee and colleagues have demonstrated in their study of military personnel using large paper maps in a field command center environment, paper wall-size maps affixed to a cork board or other mounting device also afford the flexible representation of events and plans through use of push pins, markers, and other tools (McGee *et al.*, 2000).

". . . wall-mounted maps are useful in presenting briefings in contexts such as a public planning meeting or emergency operations center."

Beyond their use in strategic planning, large, wall-mounted maps are useful in presenting briefings in contexts such as a public planning meeting or emergency operations center. In these cases, it is common that one or two individuals take a lead role in presenting information and steering a group discussion. As one of us observed during a hurricane briefing at a regional Emergency Operations Center (EOC), large screen displays are used currently, but they rely on keyboard-mouse interaction. This limits the potential of a map-based display to support effective question and answer interaction between the EOC chief and other personnel.

An electronic wall map/white board interface of the kind envisioned here affords the actions of walking up and pointing, drawing or writing, switching among views, and then giving way to another actor. This metaphor can also support asynchronous use in contexts such as public planning in which a map is on display for an extended period of time and the public is encouraged to add annotations that communicate their opinions about topics of debate, for example, about the proposed location of a highway.

"An electronic wall map/white board interface of the kind envisioned here affords the actions of walking up and pointing, drawing or writing, switching among views, and then giving way to another actor."

Drafting table/light table

The second metaphor considered here is the drafting/light table. A drafting table affords group activity around (rather than in front of) a large map on which collaborators might sketch their ideas. This format is typical of work by military and emergency management personnel in field command centers or urban planners in the office (where they may conduct extended work prior to its presentation with a wall display at a public meeting). Hopkins and colleagues (2001) as well as Arias, Fischer and colleagues (Arias *et al.,* 2000; Fischer, 2001) have implemented large, table-like group work displays supporting map-based planning activities. The latter research team, in their Envisionment and Discovery Collaboratory (EDC), has merged virtual and physical space in a system that allows users to create a shared model of a planning problem by manipulating 3D physical objects that provide a "language" for interacting with a computer simulation.

Arias and colleagues (2000) adopted a user-centered, participatory design approach to assess and evolve the EDC. Specifically, they worked closely with planners and interested citizens focused on community development issues in Boulder, Colorado. They report on four key insights arrived at as they developed and refined the EDC: (a) representing multiple perspectives on a problem is essential, (b) systems must support "learning as a shared, collaborative activity—particularly in the context of bridging these multiple perspectives," (c) EDC, and related environments, have the potential to support democratic and social processes, and (d) to be successful, systems should support interaction and reflection.

In some contexts, such as crisis response and military planning, large paper maps retain a distinct advantage in their combination of high resolution and portability—even in comparison to physically augmented virtual spaces such as the EDC described above. As noted in the previous section, McGee and colleagues (McGee *et al*., 2002; McGee *et al*., 2000; McGee *et al*., 2001) have studied military planners working with such maps (in both wall mounted and table top situations). Based on this research, they proposed an approach to augmenting paper maps through digital Post-it© notes (physical notes for which the position and content of the note could be sensed by the system). The goal was to create a robust system that did not require users to learn new work routines and that would continue to work even when technological failures or power outages occurred.

"In some contexts, such as crisis response and military planning, large paper maps retain a distinct advantage in their combination of high resolution and portability—even in comparison to physically augmented virtual spaces . . ."

Real world

A third metaphor used in group work environments is an activity space in which a real world (or virtual) space represents a geographic space. Activity spaces (e.g., conference rooms, computer laboratories, etc.) afford entering and behaving within them; immersive environments for group work attempt to support the same behaviors. Neves and colleagues (Neves *et al.*, 1997) developed an immersive virtual workspace based on a GIS room metaphor (a room in which maps can be mounted on the wall or placed on a digitizing tablet for encoding in the database). Their implementation supported only one user at a time. However, (conceptually) the metaphor could support multiple users.

One of the first collaborative, immersive environments using a geographic space as the underlying metaphor is the *Round Earth Project*, developed to enable children's learning about the shape and size of the earth (Johnson et al., 1999). While that effort focuses on same-place collaboration, there have been several Cave and ImmersaDesk-based demonstration projects that support collaboration within 3D, geographic-scale environments representing real and modeled spatio-temporal processes, see: (MacEachren and Brewer, 2004; MacEachren *et al.*, 1999; Wheless *et al.*, 1996). Recently, Armstrong (2001) identified teleimmersive environments (different-place, collaborative, immersive environments that rely on high performance computing and distributed geo-processing) as a grand challenge to the research communities in geographic and information sciences.

Within the category of adopting a real world metaphor for group work environments, there has also been recent progress toward collaborative technologies that support augmenting real-world space with virtual information (Billinghurst and Kato, 2002). One geospatial example is a system designed to support collaboration in outdoor navigation and information targeted at tourists exploring a city (Reitmayr and Schmalstieg, 2004). The environment augments the world with waypoints (in the form of information icons) that one user can leave for others to follow. Information icons provide shared information about cultural-historical attractions (superimposed on real world objects). Another intriguing system is one developed to support archeological prospecting (Nigay *et al.*, 2002). This environment integrates a head-mounted display (HMD) and a tablet computer to create an environment in which users can see both the world and the digital environment; the latter also includes a view of the world generated from a video camera on the HMD. Users can select real world objects displayed on the tablet screen by clicking, creating a version of what the authors term "clickable reality". They also propose a system that supports gestures in the real world (e.g., pointing at a building) as a way to select an object in the virtual scene. The latter kind of interaction has been described in a recent National Research Council Report as "point-and-click real world" functionality (National Research Council, 2003).

"Within the category of adopting a real world metaphor for group work environments, there has also been recent progress toward collaborative technologies that support augmenting real-world space with virtual information."

NATURAL, MAP-BASED INTERACTION WITH GEOSPATIAL INFORMATION

Here, we discuss two geocollaborative system development efforts, emphasizing the role of the map-based, large-screen display as a primary interface component in each. The first system uses a vertical display that functions like an electronic white board/wall map. The second system uses a horizontal display that functions much like a traditional drafting table that multiple participants in a group activity can gather around. Both differ from most other large screen environments in their use of hand gestures in place of mouse, pen, or wand as a primary interface method for specifying display location.

DAVE_G – Dialogue-Assisted Visual Environment for Geoinformation

As noted above, our DAVE_G project uses an electronic white board/wall map metaphor and puts emphasis on making interaction with the map seem "natural." DAVE_G is designed to be natural in two ways. First, users indicate what they are interested in through natural speech-gesture signification. Second, the map is interactively constructed through human-computer dialogues to ensure its relevance to the user's information needs.

DAVE_G has gone through multiple generations and we have detailed the system architecture and natural dialogue processor elsewhere (Cai *et al*., 2005b; MacEachren *et al*., 2005; Rauschert *et al*., 2002). Here we describe the system briefly, emphasizing its use of maps to mediate human-system and human-human collaboration and setting the stage for comparing experiences using the two metaphors (white board/wall map in this case and drafting table below).

Development of our initial DAVE_G prototype (figure 1) was made tractable by narrowing the potential application domain from collaborative work generally to collaborative work with geospatial data in the context of crisis management. To deal with the challenge of supporting natural human signification of the user's information needs, DAVE_G uses microphones and active cameras to capture spoken language and natural gestures as direct input that drives the system's response on the map display. To deal with the challenge of support for natural human system dialogue, an intelligent dialogue agent is employed to process ill structured, incomplete, and sometimes incorrect requests, and to facilitate task-oriented interactions and collaborations.

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DAVE_G is based on the interaction framework initially developed in *iMap* (Sharma *et al*., 1999) and enhanced in XISM (Kettebekov *et al*., 2000; Kettebekov and Sharma, 1999; Sharma *et al*., 2003). We have added substantial extensions to support human-system collaboration (through addition of a human-system collaboration manager) as well as to support multiple user interaction (by duplicating modules for speech and ges-

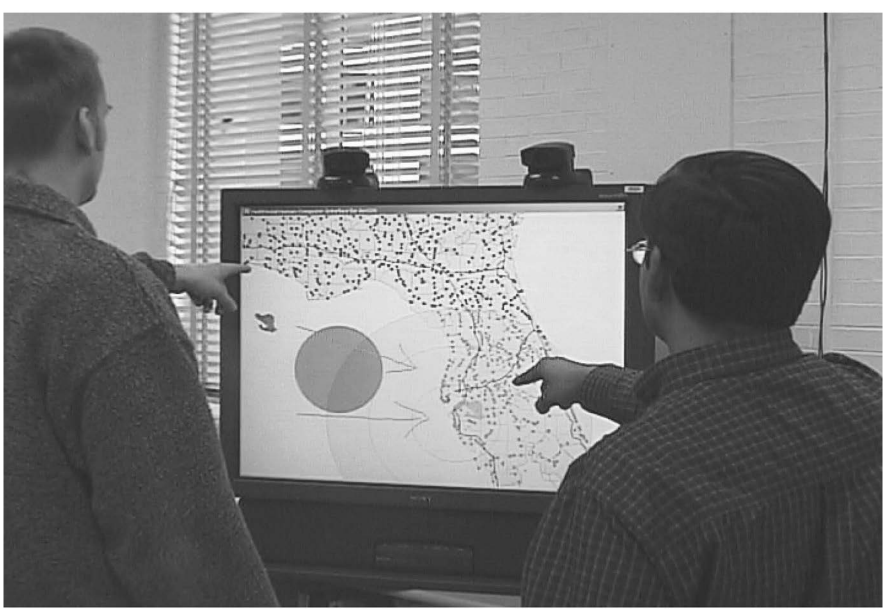

Figure 1. Two-person, gesture-speech interface to DAVE_G. Demonstration of a collaboration scenario focused on analyzing potential hurricane impacts. Figure reproduced from (Rauschert *et al*., 2002).

ture recognition for each additional participant). To capture and process speech, DAVE_G utilizes a speaker dependent voice recognition engine (ViaVoice from IBM) that allows fairly reliable speech acquisition after a short speaker training procedure. The set of all possible utterances is defined in a context-free grammar with embedded annotations. The grammar constrains the available vocabulary but retains flexibility in the formulation of speech commands.

"Hand gestures are captured using computer vision-based techniques. By capturing hand gestures, the system keeps track of the user's spatial interest and spatial attention."

Hand gestures are captured using computer vision-based techniques. By capturing hand gestures, the system keeps track of the user's spatial interest and spatial attention. For reliable recognition of hand gestures, a number of vision-related components (face detection, palm detection, head and hand tracking) are engineered to cooperate together under tight resource constraints. The results of speech recognition and gesture recognition each provide partial information for intended actions. To achieve a complete and coherent understanding of a user's request, verbal utterances from the speech recognition module have to be associated with co-occurring gestures observed by the gesture recognition module. Currently, DAVE_G can understand speech/gesture requests for most commonly used map display functions such as "show a map of the population within Pennsylvania", "zoom here{gesture}", "highlight these{gesture} features", "make a one-mile buffer around these {gesture} features", and more. It can also support more complex requests such as "Dave, show me the areas that will flood," an ambiguous request to which it will respond with a prompt such as "I have flooding data for Tropical Storms and Category 1 through 5 Hurricanes, which would you like to see?".

The user-system dialogue segments, as illustrated above, are mediated by DAVE_G's GeoDialogue subsystem (Cai *et al*., 2005b). GeoDialogue implements specific mechanisms to enable natural communications assisted by visual displays. DAVE_G's dialogue is neither user-led nor system-led, but rather is a mixed-initiative process controlled by both the system and the users in collaboration. It allows complex information needs to be incrementally specified by the user. The system can initiate dialogues anytime to request missing information for the specification of GIS queries. This dialogue-assisted human-GIS interaction approach is designed to deal with the complexity of specifying spatial information needs in crisis management (and other) applications of GIS, which often requires the synthesis of inputs from multiple people in several iterations in order to construct a fully specified and executable GIS query.

HI-SPACE

"GeoDialogue implements specific mechanisms to enable natural communications assisted by visual displays."

The HI-SPACE environment, like DAVE_G, implements a gesture-based interface developed by Richard May (May, 1999). As noted above, the HI-SPACE environment offers a drafting table (light table) metaphor that allows users to gather around a shared display and to interact with the display using gestures and placement of physical objects on the virtual map (figure 2). Our experimental unit is on loan from the Pacific Northwest National Laboratory. In its current form, the interface relies on gesture alone (i.e., it does not support speech input).

One of May's initial goals when developing the HI-SPACE environment was to promote more natural interaction among groups of users as well as between each user and the display. We have implemented modest extensions to HI-SPACE that focus on support for maps and exploratory visualization tools in the display.

The three most important features of the HI-SPACE environment in relation to group use of maps and related visualization tools are its: *hori-*

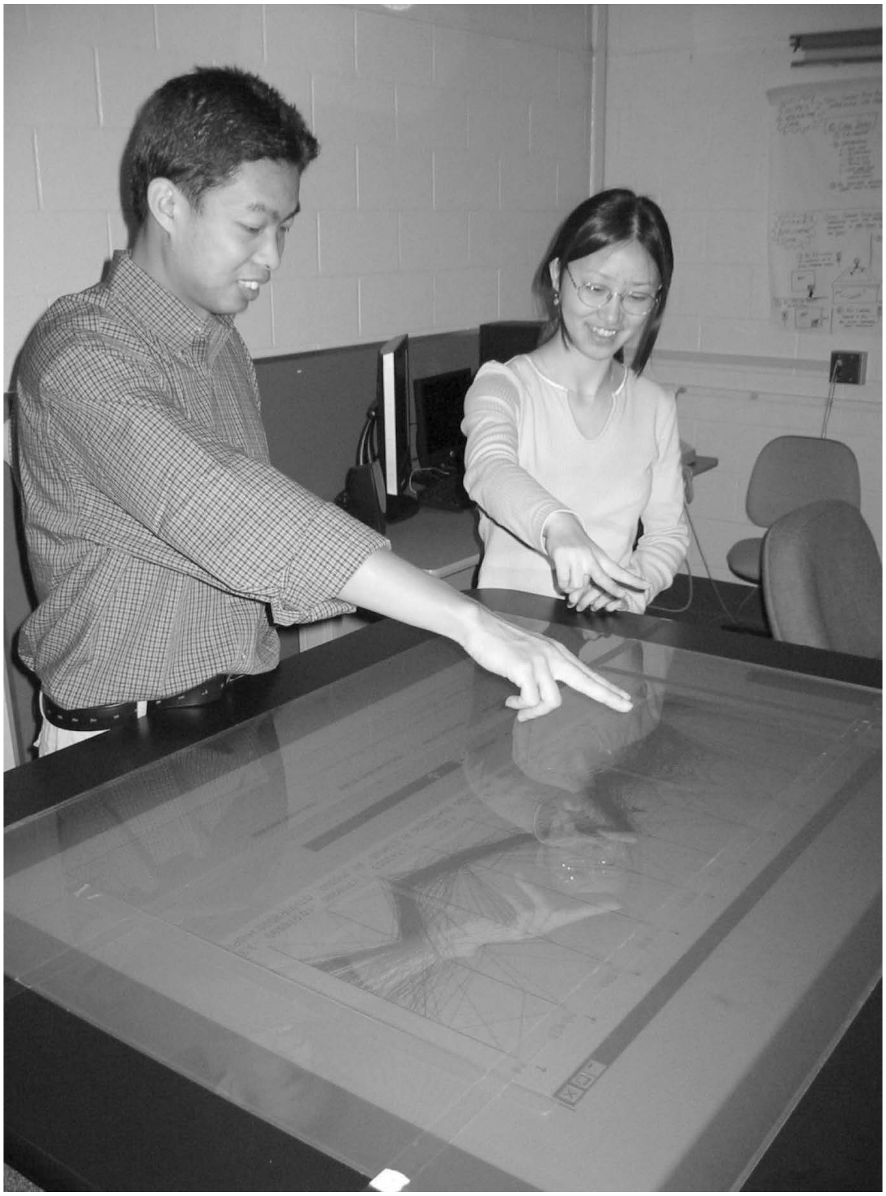

Figure 2. Gesture interface to the HI-SPACE Table. Demonstration of collaboration with interactive map component in GeoVISTA Studio. *HI-SPACE* Table developed by Richard May (May, 1999), on loan to the GeoVISTA Center from the Pacific Northwest National Laboratory.

zontal display surface, *support for multiple cursors,* and *untethered gestures*. The combination of these features enables natural forms of group communication through eye contact, gaze, and the ability of each person to interact with a map or other visualization tools through their individual cursors. Next, we provide a few more details on the implementation of these features.

Desktop metaphor

The size and horizontal orientation of the HI-SPACE display enables groups of individuals to work in a comfortable round-table fashion, rather than being dispersed on separate personal computers or clustered in front of vertical displays (where shifting attention between the display and collaborators requires more substantial head and eye movement). Besides

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viewing and sharing visual information, users can also place real world objects on the HI-SPACE table display as they would on a traditional table or desktop to augment and enhance collaborative discussions. Unlike a traditional tabletop and paper map, however, the placed objects (called phicons) are recognized by the camera system and become part of the display. For example, when a user places an object on the display, the object's attributes are determined by matching its shape (or symbols on its surface) to possible kinds of object; e.g., in an epidemiological context, a circular object placed on a map could be interpreted as the centroid of a public health region for which aggregate statistical summaries are then calculated. At this point in our work, we have not implemented the tools to take full advantage of this HI-SPACE functionality, but the developers of HI-SPACE have demonstrated the potential in a computer game application (Cowell *et al*., 2004).

". . . when a user places an object on the display, the object's attributes are determined by matching its shape (or symbols on its surface) to possible kinds of object . . ."

Multiple cursors

In order to support *geocollaboration*, in which multiple users work concurrently on a single platform (computer), a mechanism is required for multiple users to interact with the display. Myers, et al (Myers *et al.*, 2004) discussed three options for addressing this problem: (1) forcing users to take turns with one cursor, (2) having multiple simulated cursors; or (3) building applications that have an independent cursor inside the application that supports multiple customizable cursors. Our extensions to the HI-SPACE environment address this issue through the third option.

Our implementation is designed to support use of HI-SPACE with Java applications. Understanding multi-user interaction, thus, requires a brief discussion of how a single user interacts with a Java application. As shown in figure 3, a mouse click is translated by the operating system into an OS-level event. The event is sent to the Java Virtual Machine (JVM) where it is translated into a JVM mouse event. Java applications actually respond to JVM events (rather than OS events). In order to enable multiple-user interaction, virtual mouse events for each user can be generated at either the OS-level or JVM-level. In our application they are generated at the JVM level.

Gesture-based interaction

"HI-SPACE supports untethered gesture recognition . . . allowing group members to use relatively natural forms of communication to share ideas . . ."

HI-SPACE supports untethered gesture recognition (not requiring a data glove or other device), allowing group members to use relatively natural forms of communication to share ideas (such as pointing to indicate emphasis). HI-SPACE is like DAVE_G in relying on video capture of gesture to support user interaction. It differs from DAVE_G in using a ceiling mounted, non-active camera that recognizes hand position and gesture as an absence of signal from a set of vertically oriented, infrared emitters in the HI-SPACE's base. This method of gesture capture supports relatively precise recognition of hand signals.

Our extensions to HI-SPACE support recognition of multiple distinct gestures that can signify different mouse behaviors. For example, stretching out one finger indicates a mouse move action and using two fingers indicates a mouse press action. The gestures of each user are translated into virtual mouse events that are fed into the OS, sequentially. This establishes a direct link between the users and the computer through the HI-SPACE display. In practice, as JVM mouse events are generated they are recognized, processed, and fed to the Java Virtual Machine. Figure 3 shows how this procedure works.

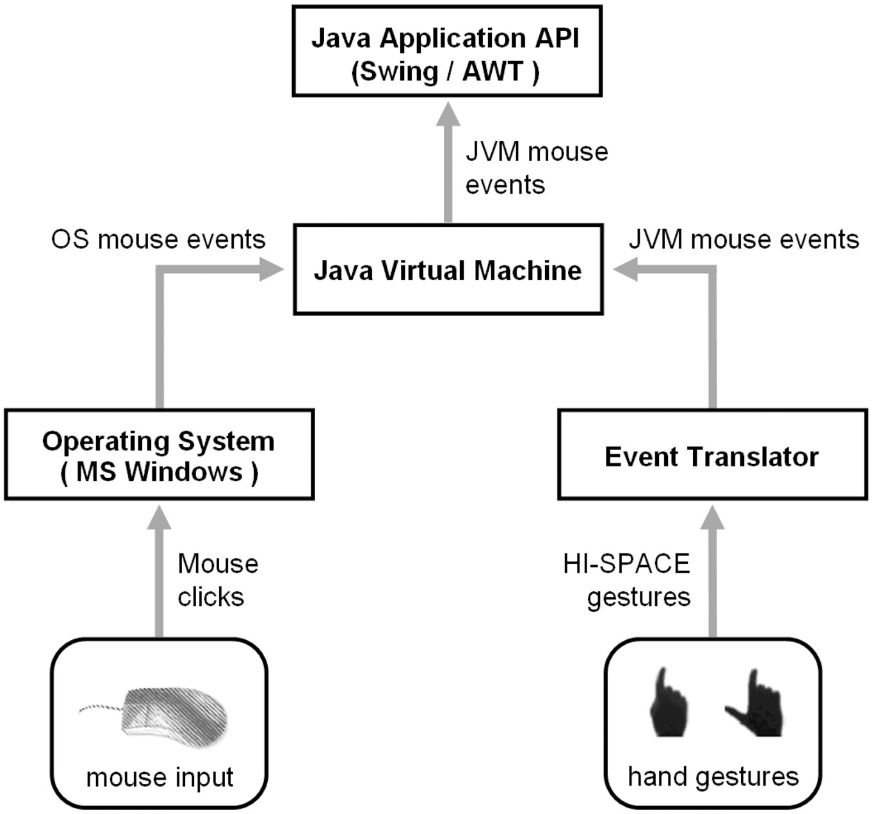

Figure 3. Implementation strategy for supporting multiple participants, using hand gestures to initiate mouse events.

Comparison and Contrast

In this section, we compare and contrast DAVE_G and HI-SPACE, drawing upon experiences gained through iteratively testing and refining the interfaces. Both DAVE_G and HI-SPACE allow a small team of collaborators to be co-located comfortably around a common large-screen display device. The large display is designed to provide a shared visual workspace (Whittaker *et al*., 1993), supports situation awareness (Endsley, 1995), and enables smooth transition between individual and collaborative actions in mixed focus collaboration (Gutwin & Greenberg, 2002). HI-SPACE enables groups of individuals to work in a round-table fashion, while DAVE_G allows multiple individuals to be clustered in front of vertical displays. Like the use of a drafting table, HI-SPACE seems to be a better fit for small team decision-making where participants are relatively equal partners in decisions. In comparison, the use of DAVE_G, like the use of wall-mounted maps, is more suited to briefings and asynchronous updating of a shared view onto evolving situations.

"HI-SPACE enables groups of individuals to work in a round-table fashion, while DAVE_G allows multiple individuals to be clustered in front of vertical displays."

Beyond their use of large-screen display, DAVE_G and HI-SPACE both allow collaborators to use natural forms of communication to interact with the visual display and to share ideas with others. We believe that support for this natural, collaborative exchange will result in significant savings in time to complete key tasks because the nature of communication and the process of work remains consistent as collaborators shift between individual and collaborative activities and between interaction with the system and with each other (Dourish & Belotti, 1992).

As shown in Figure 1, DAVE_G simultaneously captures the hand gestures of multiple users and represents them visually on the display as gesture icons. HI-SPACE implements the same function as multiple cursors, each representing a user's hand location. Such a design feature can enrich support of small-team geocollaboration because individual activities on the visual workspace are immediately visible to other members of the team, enhancing the ability of the team to maintain activity awareness (Carroll *et al.*, 2003).

"As a step toward developing geospatial information technologies that support group work in crisis management, we have conducted a range of task analysis activities focused on understanding the process of teamwork in crisis management and emphasizing how geospatial information and technologies are used."

A key feature of both HI-SPACE and DAVE_G is that they allow users to add objects to the visual display to augment and enhance collaborative discussions. The HI-SPACE table supports phicon recognition where users can place and manipulate physical objects on the display to signify the real-world entities under discussion. The complement to phicons available in DAVE_G is an ability to point to any location and ask the system to place a marker from the system's knowledge base at that location. Examples from the crisis management application domain discussed in detail below include user positioning of HAZMAT incident site markers, emergency shelters, roadblocks, or other point objects on the virtual map. We have implemented, used, and assessed this functionality; for discussion of the assessment, see: (Fuhrmann *et al*., 2005).

CONSIDERING THE CONTEXT OF CRISIS MANAGEMENT

To make near-term progress toward natural interfaces to large-screen map-based display, we have focused attention on one application domain, crisis management. This domain is likely to benefit considerably from both large screen display and natural interfaces that allow users to focus on the problem at hand (rather than how to use the system).

As a step toward developing geospatial information technologies that support group work in crisis management, we have conducted a range of task analysis activities focused on understanding the process of teamwork in crisis management and emphasizing how geospatial information and technologies are used. For discussion of the methodology and detailed results from this task analysis work, see: (Brewer, 2002; Brewer, 2005). Here we highlight selected findings and conclusions from these activities that relate specifically to large-screen, map-based display.

". . . typical computer support for crisis management teams consists of multiple desktop computers, often clustered by emergency response function or by the participating government agency. This fragmented workspace discourages tightly coordinated decision-making. "

Our task analysis work has involved off-site study of the training materials and operations plans used to prepare personnel for and guide work in crisis management activities plus on-site visits to multiple EOCs as well as observation of multiple training exercises. One finding of these activities is that typical computer support for crisis management teams consists of multiple desktop computers, often clustered by emergency response function or by the participating government agency. This fragmented workspace discourages tightly coordinated decision-making. There is a trend toward installation of large-screen displays in EOCs, but thus far they are used mostly for broadcasting updates, rather than for enabling group work.

Excerpts from an interview with the Florida Hurricane Program Manager are particularly relevant to consideration of the ways in which easy-to-use, large-format display might enable effective work in an EOC. This manager indicated that a constraint on the utility of maps in time critical situations had been the time it took to print the large maps needed to support group discussion. Also, in the planning rooms, it was sometimes difficult to clearly see the printed maps. The manager noted, specifically that:

If you have a great big map, and everyone can reasonably, clearly see it, and you're standing up there saying, these are the places where our assets are deployed. These are the areas where we need to send them into. It's much easier to do that with a map than it is to say, well, wait a minute, how close is Alachua to Brevard County. A lot of things become self-evident.

The manager went on to indicate that they were working to get large flat screen TVs in the planning and conference rooms where most of the decisions were being made. That would allow them to show the real-time displays of the multiple mapping technologies used in planning (GIS, HURREVAC, Satellite Imagery, etc).

To me, words are almost useless in a high stress, immediate decision-making contexts. Whatever we can do to map it out and make it easy for people to digest is by far the way to go.

". . . the maps were critical for making decisions because they helped eliminate speculative discussions of how close one area was to another."

Continuing on this theme, the manager suggested that large format maps (printed or digital) allow the directors to ask questions such as "why are you recommending that we evacuate starting at 7 o'clock in the morning?" and the hurricane program manager could show the map depicting the evacuation timings. Highlighting the importance of large maps during disaster planning and response, (as noted above) the participant indicated that part of the reason maps were not used more frequently in decision making contexts in the past was the length of time it took to have them plotted. He indicated that the maps were critical for making decisions because they helped eliminate speculative discussions of how close one area was to another. To help overcome the time required to plot maps, the GIS team had begun to develop an easier to use interface to allow decision makers and response personnel real-time access to the geospatial information.

Based on our analysis of the process of work in crisis management and the current and potential use of geospatial technologies to support that process, we have developed some general working hypotheses about natural, large-screen interfaces for crisis management activities with geospatial information. These include:

- The white-board/wall map metaphor (thus a large, vertical display) is most appropriate for briefings to large groups (e.g., in an Emergency Operations Center or at a planning meeting). Here, natural gesture combined with speech should be effective – since displays are typically both large and elevated for viewing. Thus, natural pointing and other gestures (of the sort you would use to draw someone's attention to a location on a wall map) are appropriate.
- In our efforts to implement interfaces that can be experimented with in real-world situations, we have found that there is a trade off between robustness of performance and naturalness of gesture-based interaction. In order for natural, free hand gesture-based displays to support coordinated group work (thus to go beyond the case of one individual presenting results of work to a group), we believe that they must achieve a high level of naturalness. Thus, users should not have to think about interacting with a computer display (as they do when moving a cursor across the screen with either a mouse movement or hand gesture). Instead, they should be able to focus on interacting with the information represented (as they can (at least in a limited way) in DAVE_G when they say "highlight the segment of Interstate from here to here" and accompany this request with

". . . there is a trade off between robustness of performance and naturalness of gesture-based interaction."

a composite gesture that points roughly at the beginning and ending intersection intended. This functionality, however, has proved difficult to support when the system is intended to be used by many different individuals. Thus, to achieve reasonably low error rates in system interpretation of user requests, it has been necessary to limit the system to using a *hand as a mouse* metaphor in which gestures are used to guide a screen cursor (rather than the more natural *free-hand gesture* metaphor where the purpose of gesture is determined by context).

"For groups ranging from two to perhaps a dozen individuals, we anticipate that hand-held, PDA based interfaces will be an effective interface device."

- Due to the challenges of making free-hand gesture interfaces both natural and robust for a range of users, we believe that a sketch-based interface will have advantages (in the near term, perhaps the next 2-3 years) over the free-hand gesture-based displays we have experimented with. While there are sketch-based wall mountable displays available commercially, the displays tend to be modest in size and probably will not support more than 2-3 people working at one time. For groups ranging from two to perhaps a dozen individuals, we anticipate that hand-held, PDA based interfaces will be an effective interface device. With a linked PDA, users beyond practical pointing distance can add annotations and draw the attention of others to objects or places they are discussing. We have begun to experiment with the option of sketch-based interfaces to maps that use hand-held devices to control large-screen displays. Specifically, we have used tablet computers rather than PDAs because the available resolution allows essentially the same information to be displayed on the hand held device and on the large screen. This makes feature selection and annotation more practical that that with a PDA on which only a subset or schematic representation of the large screen display content is possible.
- The tabletop metaphor (thus a HI-SPACE like display) will be appropriate for situation rooms, mobile command centers, planning department offices and other applications in which small teams of people collaborate intensively. We expect the use of phicons to be particularly effective as a device for supporting human-human dialogue and idea generation in this context. Since more complex work will be done in situation rooms and mobile command centers than in a public briefing, we expect that a *gesture language* may have advantages over more natural, free hand gestures and that voice input that is command-like (rather than natural) may prove to be efficient for immediate information access.

"While sketch-based interfaces, a gesture language, and limitations on voice input have potential advantages . . . support for natural gesture and language in combination has the potential . . . to enable both human-human display-supported dialogue and mixed-initiative human-system dialogue . . ."

- While sketch-based interfaces, a gesture language, and limitations on voice input have potential advantages (particularly in the short term), support for natural gesture and language in combination (as implemented partially in DAVE_G) has the potential (particularly in the long term) to enable both human-human display-supported dialogue and mixed-initiative human-system dialogue (where the system anticipates users needs). Empirical comparison of these approaches is needed as is consideration of how they might be productively integrated.

DISCUSSION

At this stage of our work, we have implemented the two prototypes detailed above and we have also implemented a speech-pen tablet interface that supports collaboration between individuals in an EOC and in the field, see: (Cai et al., 2005a). We have applied the prototypes to a series of realistic crisis management scenarios derived from our field work with crisis management personnel in contexts that range from hurricane response at the state level, through regional response to major chemical spills, to local emergency response. Initial progress makes it clear that achieving more natural interfaces to GISystems will depend upon being able to recognize and adapt to the context of use. This will, in turn, require strategies for modeling context, which is a very challenging research problem in its own right.

"Initial progress makes it clear that achieving more natural interfaces to GISystems will depend upon being able to recognize and adapt to the context of use."

Based on our experiences with large-screen group displays and support for natural modes of interaction, we are developing more comprehensive strategies to support natural, group interaction with and through "smart" maps. A key component in our approach is to recognize that, in natural human dialogue and related collaborative activities, visual input serves at least three distinct roles (MacEachren and Brewer, 2004). *First*, visual displays (maps, images, diagrams) often represent the objects of attention – thus, they represent what the group work is about or directed to. *Second*, visual displays serve as a medium and resource for human thinking; they can support structuring of arguments and negotiation among alternatives. *Third*, visual displays can be used to provide workplace awareness, to help a user keep track of what others are doing, and of the process of activity over time. The GeoDialogue subsystem, now implemented as part of DAVE_G, includes specific mechanisms to maximize the above roles of visual displays (Cai *et al*., 2005b). In this environment, our user modeling subsystem keeps track of the mental states of collaboration and knowledge sharing and guides the process of display generation.

Maps (or other visual displays) in our GeoDialogue subsystem are not pre-determined by the system, but instead are constructed through coordinated user-system interaction. This approach differs, fundamentally, from traditional GISystem uses of maps. The map, in a dialogue-based system, is a core component of a human-system (or human-human) dialogue process (rather than being a simple information source). The goal is that maps act as dynamic facilitators to thinking and communication. In addition the map, as an externalized representation of human thinking, should 'listen' to users and share initiative with the user as appropriate. Thus, the process of generating and using map displays to address problems must be mixed-initiative. Our most recent additions to DAVE_G demonstrate the potential of mixed-initiative human-system dialogue (Cai *et al*., 2005b).

Another extension of our current work on DAVE_G and HI-SPACE is to enable geographically distributed teams to engage in geocollaborative activities. For distributed users, support for workspace awareness and activity awareness is much harder (than with co-located users) due to the lack of visual clues to monitor task and collaboration states. The strategies for coordinating among distributed users include (1) transmitting and prioritizing virtual mouse events received over the network so that multiple users' operations can be processed without interfering with one another and (2) supporting collaboration through a variety of display and interface technologies where a mix of DAVE_G, HI-SPACE, and Tablet PC-based pen-voice interfaces communicate through a collaboration agent. Extensions to the coordination mechanisms in our GeoDialogue subsystem now allow us to effectively simulate geocollaborative crisis management scenarios where individual users in the field (working with a tablet displays) can interact with a group of users in an office or command center using the HI-SPACE display or DAVE_G (Cai *et al*., 2005a).

"Overall, supporting group work with geospatial information is a challenging task, whether that work is same-place or different-place."

Overall, supporting group work with geospatial information is a challenging task, whether that work is same-place or different-place. Our broad goals in the research reported here (and in a series of complementary recent papers) are: (1) to develop a theoretical framework that supports the design, implementation, assessment, and application of technologies that support map-based geocollaboration and (2) to apply that framework to both the study of map-based geocollaboration as a process and the development of information technologies that support geocollaboration.

"Technology-enabled geocollaboration is a relatively new domain of research and practice."

Technology-enabled geocollaboration is a relatively new domain of research and practice. As such, there are many unanswered questions and the software/hardware environments detailed above provide an opportunity to investigate a subset of them. Specifically, we plan to build upon the work detailed above by focusing on: the impact of different metaphors to enable collaboration in different problem domains and with different kinds of geoinformation technologies, alternative methods for making interfaces more natural (and whether this does, in fact, make them easier to use), support for multi-lingual and multi-cultural users, and understanding how map-based (and other) visual displays enable (or might enable) human-system and human-human dialogue and joint work.

"Maps, of course, have played a substantial role in collaborative activities for centuries, but cartographers . . . seem to have given little thought to the design of maps . . . to specifically support group work."

Maps, of course, have played a substantial role in collaborative activities for centuries, but cartographers (and others) seem to have given little thought to the design of maps (or map-based interactive displays) to specifically support group work. Our own work thus far has also given limited attention to map design for group work tools. However, we see design of maps to enable group work as an important challenge for cartographers to address as collaborative maps move into the main stream with environments such as Toucan Navigate, a commercial, web-based collaborative mapping environment (Schafer *et al.*, in press). Similarly, while there has been considerable attention given to group spatial decision support (Armstrong, 1994; Jankowski and Nyerges, 2001; Nyerges and Jankowski, 1997), only limited attention has been given to maps and other visual displays as devices to enabled group work. We view this gap in our knowledge and understanding as a substantial opportunity for cartography to make an impact on GIScience and information science more generally and on the application of that science in a range of contexts for which group work with geospatial information is critical. We encourage cartographers and other GIScientists to this engage this opportunity.

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Non-Photorealistic Rendering and Terrain Representation

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In recent years, a branch of computer graphics termed non-photorealistic rendering (NPR) has defined its own niche in the computer graphics community. While photorealistic rendering attempts to render virtual objects into images that cannot be distinguished from a photograph, NPR looks at techniques designed to achieve other ends. Its goals can be as diverse as imitating an artistic style, mimicking a look comparable to images created with specific reproduction techniques, or adding highlights and details to images. In doing so, NPR has overlapped the study of cartography concerned with representing terrain in two ways. First, NPR has formulated several techniques that are similar or identical to antecedent terrain rendering techniques including inclined contours and hachures. Second, NPR efforts to highlight or add information in renderings often focus on the use of innovative and meaningful combinations of visual variables such as orientation and color. Such efforts are similar to recent terrain rendering research focused on methods to symbolize disparate areas of slope and aspect on shaded terrain representations. We compare these fields of study in an effort to increase awareness and foster collaboration between researchers with similar interests.

Keywords: Non-photorealistic rendering, terrain rendering, computer graphics

INTRODUCTION

The discipline of cartography is not an island, entire of itself. Many areas of inquiry that border on or overlap cartography, such as data classification using statistics, are well documented. Others are not as well delineated, especially with the boom in computer technology in recent years. An example is non-photorealistic rendering (NPR) in computer graphics. In this paper, we map out disjoint but similar research efforts ongoing in NPR and terrain rendering in cartography, highlighting areas of overlapping interests.

Since the earliest graphic output from computers, one goal that researchers in computer graphics strive towards either explicitly or implicitly is photorealism. A computer graphic image is said to be photorealistic if it is virtually indistinguishable from a photograph of the same object. Such a goal may be subjectively evaluated by the user with visual inspection, or objectively evaluated with such tools as light meters.

Although photorealistic images can be made in a number of ways, a typical methodology would be to represent a real world object as a virtual computer object, and then create an image of the virtual object based on characteristics such as shape, color and texture inherited from the real world object. This process is referred to as rendering (Rogers, 1997). In practice, rendering in computer graphics often refers to using information

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from a three dimensional (3-D) computer model to create a two dimensional (2-D) image.

Non-photorealistic rendering is a more exclusive term than its name may imply. Any rendering whose purpose is other than photorealism is not necessarily included in this subject area. Instead, NPR researchers have defined a number of alternative goals for their rendering. These include: scientific curiosity, similarity to handmade graphics, communication of specific information, hypothesis of a language of pictures, and a better understanding of the mechanism of meaning transfer (Strothotte and Schlechtweg, 2002). These diverse goals can be thought of as a categorization of non-photorealistic computer graphics research within the last 15+ years. Some early works focused on NPR techniques restricted to image space; a 2-D image is manipulated to create a different 2-D image. A seminal work that discussed NPR techniques applied to 3-D objects and displayed in 2-D image space is Saito and Takahashi's 1990 article entitled *Comprehensible Rendering of 3-D Shapes*. This work was important in its discussion of geometric buffers to define the object in 3-D space, and comprehensible rendering—techniques with a focus on the effect the rendering has on the viewer. This article also included digital terrain (and building) data that were rendered with shading, contours, oblique profile lines, and height data (elevation layer tinting). This is one of the few uses of terrain data reported in the NPR literature.

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In the 1990's, a sense of identity began to develop among NPR researchers. Computer graphics research published in journals, such as the *Institute of Electrical and Electronics Engineers' Computer Graphics and Applications* (IEEE CG&A), explicitly defined goals other than photorealism. The Association for Computing Machinery's (ACM) Special Interest Group for Computer Graphics (SIGGRAPH) conference began sessions on research in non-photorealistic rendering later in the decade.

"Topics are diverse and include recreating artistic styles (from watercolor paintings to sumi-e art), the rendering of mechanical drawings, medical imaging, and cartoon animation."

The beginning of the 21st century brought a flurry of activity that helped to shape the field of NPR. Now a biennial event, the first International Symposium on Non-Photorealistic Animation and Rendering was held in 2000 in Annecy, France. Two important books were also published during this time, Gooch and Gooch's *Non-Photorealistic Rendering* (2001) and Strothotte and Schlechtweg's *Non-Photorealistic Computer Graphics* (2002). These entities helped to shape NPR's identity and categorize its research in a broad range of topics. Topics are diverse and include recreating artistic styles (from watercolor paintings to sumi-e art), the rendering of mechanical drawings, medical imaging, and cartoon animation.

Strothotte and Schlechtweg (2002) assign NPR literature to a number of "points of view." Most of these have direct counterparts in the field of cartography. As examples, "the freedom not to have to reproduce the appearance of objects precisely as they are" would include cartographic generalization, and "the possible deformations of images" would include map projections. Our primary interest is in NPR techniques that are similar to methods used for terrain rendering. These include specific drawing styles and the effect a rendering has on a viewer-comprehensible rendering.

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In a general sense, many current software applications for computer graphics may be considered photorealistic-neutral. The user may render a virtual office building with textures of glass and steel, but could also render the same building with a paisley pattern. The focus in computer graphics, as with cartography, is often the purpose of the rendering and the perceived user. For example, a land use/land cover map with hill shading may look less like realistic terrain than a layer tinted map, but may better communicate important patterns to the user.

In this article, we explore the connections between techniques of terrain rendering and NPR. We hope to raise awareness with both cartographic and NPR researchers about the shared areas of research. We also hope that this knowledge may lead to cross fertilization of ideas and collaboration among those doing research in these two fields. Additionally, in reviewing historical and recent stylized techniques for terrain representation, we illustrate that multiple techniques of depiction has always been an important consideration for terrain representation in particular and cartography in general.

". . . we illustrate that multiple techniques of depiction has always been an important consideration for terrain representation in particular and cartography in general."

DRAWING STYLES IN TERRAIN RENDERING AND NPR

Hatching lines

To introduce drawing styles in NPR, we look first at hatching lines. Hatching lines can be drawn in 3-D object space to show the curvature of the surface. 3-D objects in computer graphics are described with different criteria than those we use for terrain. Beginning with a datum such as mean sea level, cartographers can define the orientation of any surface element using slope and aspect. Most computer graphics objects, however, have no such datum. Thus they are often described by a series of geometric buffers (g-buffers).

Figure 1 compares geometric components used in NPR (and more generally in computer graphics) and those used in terrain representation. **Figure 1a** includes a 3-D virtual model to be represented as a 2-D image on some viewing plane. The rendering will be based on a number of g-buffers, including an identifier of the object within the virtual scene (id-buffer), the distance from the object to the viewing plane (z-buffer), and the surface normal vector (n-buffer) (terminology from Strothotte and Schlechtweg, 2002).

"3-D objects in computer graphics are described with different criteria than those we use for terrain."

Figure 1b includes a 2.5-D virtual model to be represented as a 2-D planimetrically correct map (planimetric view). Elevation is measured from a datum plane parallel to the planimetric map, unlike the z-buffer, which is measured from the viewing plane. We also use slope and aspect as a surrogate for the n-buffer to uniquely define the orientation of a surface element in object space.

If the viewing plane in **Figure 1a** were to be moved, all z-buffers would need to be recalculated to re-render the image, a common practice in NPR. This is not an issue for planimetrically correct maps, as the viewing plane is always set parallel to the datum plane, and elevation values are invariant with a fixed datum. Those working with terrain rendering have often chosen to work within this planimetric construct that simplifies rendering, but at the same time limits the variability of resulting displays.

"Those working with terrain rendering have often chosen to work within this planimetric construct that simplifies rendering, but at the same time limits the variability of resulting displays."

The more flexible and less globally consistent nature of NPR rendering is exemplified in Saito and Takahashi's (1990) torus with hatching lines and shading (**Figure 2**). The torus has no datum, so a (u,v,z) coordinate system needs to be defined for this particular object. If the torus were lying flat on a table, **Figure 2a** would correspond to a series of radial planes perpendicular to the table and intersecting at the torus' central axis, and **Figure 2b** would represent traces resulting from intersecting the torus with a series of planes parallel to the table. **Figure 2c** combines shades of gray with these hatching lines over part of the image, using the two hatching line patterns independently or in combination to create a crosshatched pattern.

Figure 2 reveals that hatching lines would fit into a cartographic classification system as a hybrid between short, discontinuous hachures (note

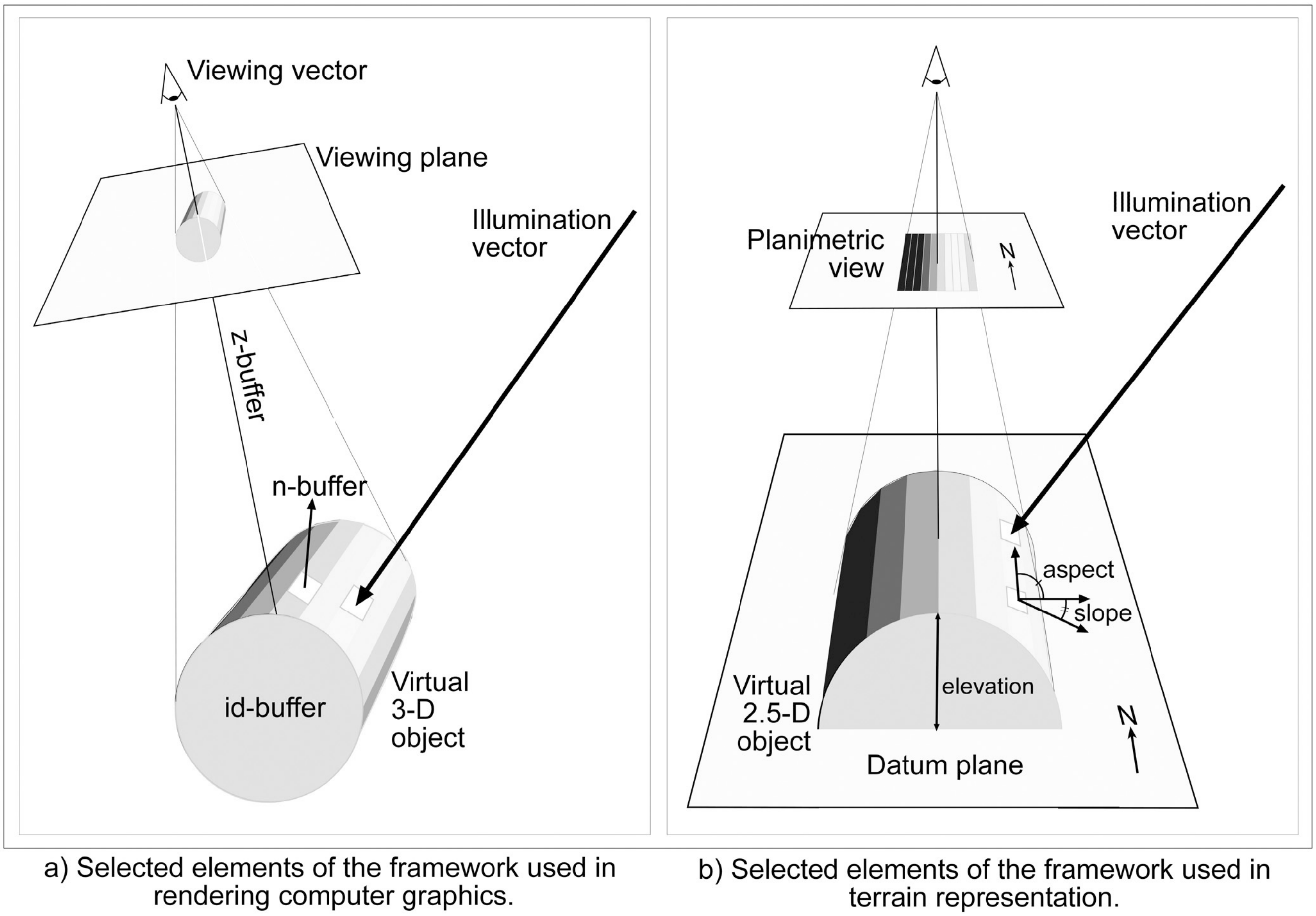


Figure 1. Selected elements of the frameworks used for rendering computer graphics and terrain. a) The geometric buffers used for rendering, including the z-buffer, n-buffer, and id-buffer. Also shown are the relationships among the viewing vector and plane, the 3-D virtual object, and the illumination vector. b) The metrics used for representing terrain, including elevation, slope and aspect. Also shown are the relationships among the planimetrically correct map, the datum plane, and the illumination vector. (see page 84 for color version)

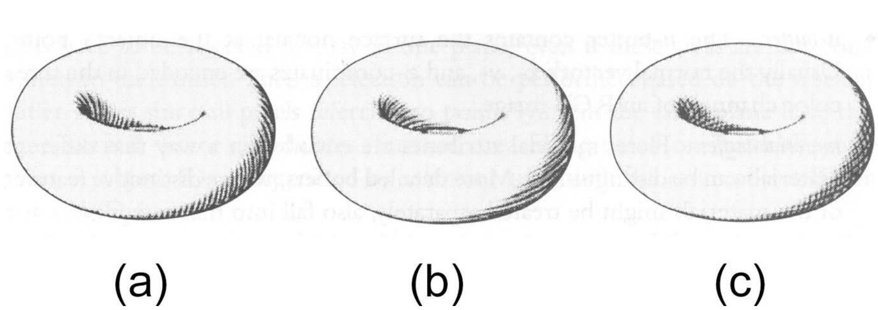


Figure 2. A torus rendered with hatching and shading. Methods include a) hatching lines similar to cartographic hachures, b) hatching lines similar to cartographic isarithmic lines, and c) cross hatching (a combination of the first two) (Reprinted from Saito and Takahashi (1990) with permission from ACM SIGGRAPH)

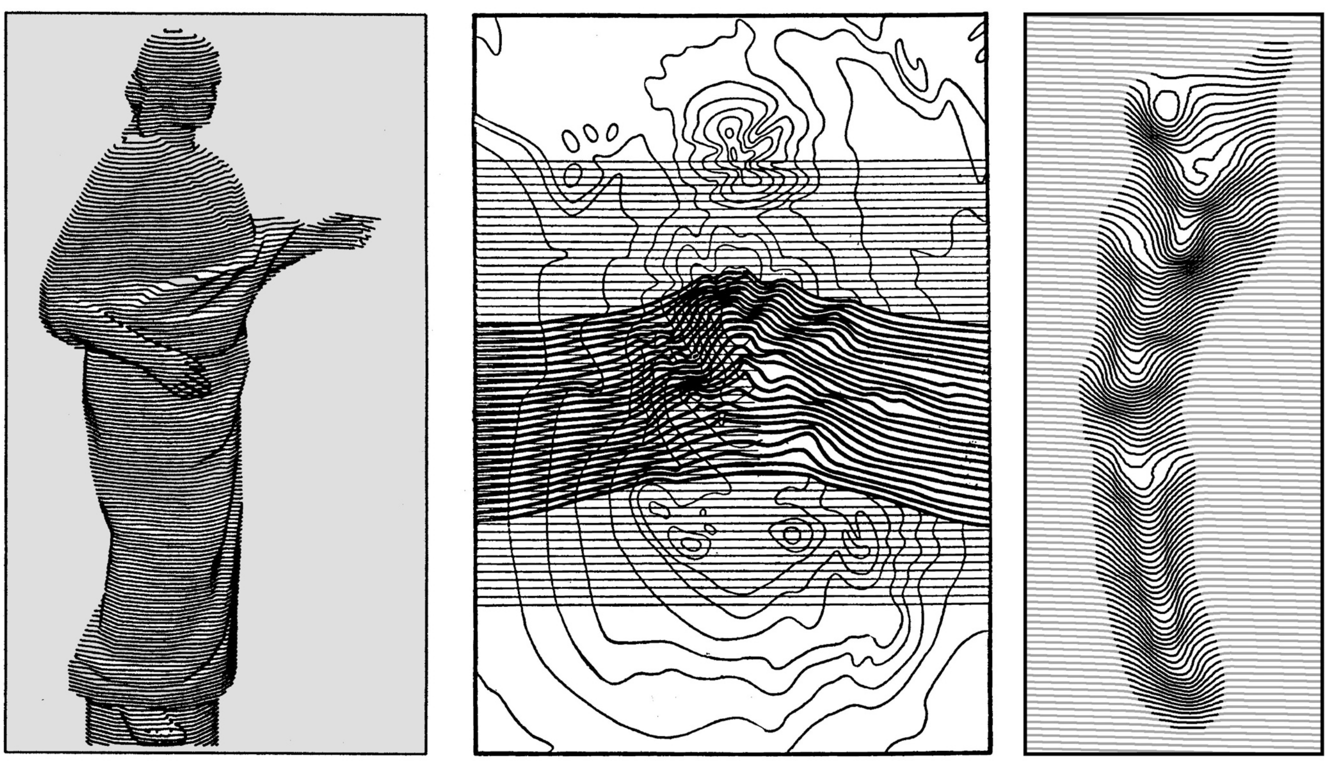
difference in spelling) and long, continuous isarithmic lines or contours. Both cartographic techniques are based not on a (u,v,z) coordinate system specific to a particular object, but on a global datum that locally approximates a flat surface. In this construct, discontinuous hachure strokes are oriented in the direction of steepest slope and continuous contour lines are oriented parallel to the datum with no change in slope. Thus if the torus in

Figure 2 were lying flat on the table as datum, the hatching lines of Saito and Takahashi (1990) in **Figure 2a and 2b** would approximate cartographic hachure strokes and contours respectively.

In the field of NPR, Deussen (1998) and Deussen *et al*. (1999) devised a method for generating continuous hatching lines of uniform thickness by intersecting a 3-D virtual object with parallel planes. The technique extracted traces on boundaries defined by a number of parallel, evenly spaced clipping planes. **Figure 3a** shows a 3-D virtual statue rendered with such a technique. No datum is, or need be associated with such a 3-D object, but the parallel planes used in rendering can be said to be tilted up and dipping towards the top of the page. This rendering technique is nearly identical to the inclined contour method devised by Tanaka (1932) 66 years earlier.

"This rendering technique is nearly identical to the inclined contour method devised by Tanaka 66 years earlier."

Tanaka's first method of rendering landforms was the orthographic relief method, although it is commonly called the inclined contour method (Tanaka, 1932). Instead of using planes parallel or perpendicular to the datum to create contours or profiles respectively, Tanaka intersected the topography with evenly spaced parallel planes at an oblique orientation to the datum. Although these traces have no intuitive meaning, each trace is in its proper planimetric location. Assuming north to the top of the page, parallel planes dipping directly to the south will result in a trace that appears as a hybrid between a contour and a profile. The resulting shading effect gives the appearance of illumination from the south, with



a) NPR rendering by Deussen (1998) b) Terrain rendering by Tanaka (1932) c) Terrain rendering using the GIS method of Peuker et al. (1974)

Figure 3. Three examples rendered from traces resulting from the intersection of a series of parallel planes and a virtual object. The first shows lines resulting from the intersecting a geometric model of a statue and a series of evenly spaced parallel planes. (From Deussen (1998) with permission from Springer-Verlag Publishers).The second illustrates Tanaka's inclined contour method (from Tanaka (1932) with permission from The Geographical Journal). The third is a map created from a generalized digital elevation model of the Newfoundland mountains of northwestern Utah. Planes dipping to the north are used with Tanaka's inclined contour method as computer automated by Peucker et al. (1974).

the unfortunate consequence of perceptually inverting the topography for most users (**Figure 3b**).

In **Figure 3b**, Tanaka began with a contour map, then drew parallel lines oriented east-west. The constant spacing of the lines determined the steepness of the oblique, intersecting plane. Contours were then redrawn on the oblique plane. Beginning with the lowest topographic contour, inclined contour traces move to subsequent contour levels each time a higher landform contour intersects a higher contour on the oblique plane. The resulting spacing of lines results in oblique illumination of the terrain.

"The simplest methodology takes the terrain surface, adds it to a dipping plane surface, and then contours the new surface in the traditional manner."

Early geographic information system (GIS) technology automated the inclined contour technique (Peucker *et al.*, 1974). The simplest methodology takes the terrain surface, adds it to a dipping plane surface, and then contours the new surface in the traditional manner. **Figure 3c** is an inclined contour map of the Newfoundland Mountains of northwestern Utah, rendered using a generalized digital elevation model and parallel planes dipping to the north, which is to the top of the page. The rendering is similar to Deussen's NPR image in **Figure 3a**.

Inclined planes used to create the rendering can have any orientation, but planes that do not slope down to the south will not result in traces resembling pseudo-profiles for a map with north to the top of the page. Robinson and Thrower (1957) used planes dipping to the south, and refined Tanaka's technique by adding lines to the shaded side of terrain to give the impression of northwest illumination (**Figure 4a**).

"These simplified sketches mimic landscape drawings and were inspired by the inclined contour renderings of Robinson and Thrower."

More recently, Visvalingam and Whelan (1998) and Visvalingam and Dowson (1998) devised the profile-stroke (P-stroke) method. This sketch-based method is a filtered subset of profile plots of concave and convex surfaces presented as an oblique view of the terrain (**Figure 4b**). These simplified sketches mimic landscape drawings and were inspired by the inclined contour renderings of Robinson and Thrower (1957). This work is the only research in cartographic visualization widely cited within the NPR literature.

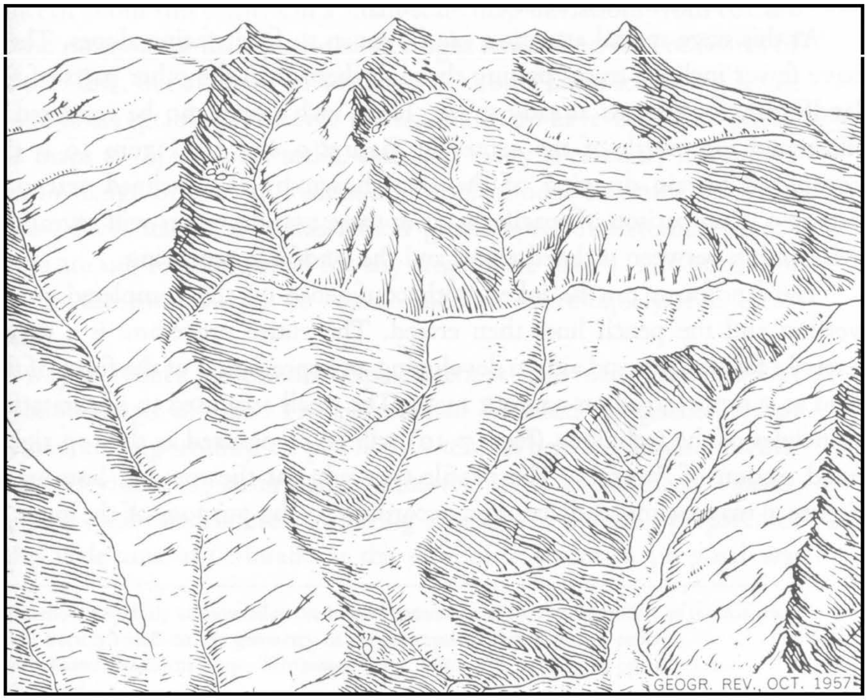
Stroke-Based Illustrations

One research focus in NPR is creating images based on individual line segments that simulate the style associated with pen-and-ink illustrations. This stroke-based illustration method, which resulted from NPR research on artistic form, compiling rules and computer automation of the process, depicts both tone and texture simultaneously (Gooch and Gooch, 2001). In some cases, these methods were based solely in image space; the user would begin with an image, use brush tools to define the orientation of strokes throughout the image, and apply stroke textures provided by the application (Salisbury *et al.*, 1994, Salisbury *et al.*, 1996, and Salisbury *et al.*, 1997). **Figure 5a** shows detail of a pen and ink rendering of a raccoon's face created from an image.

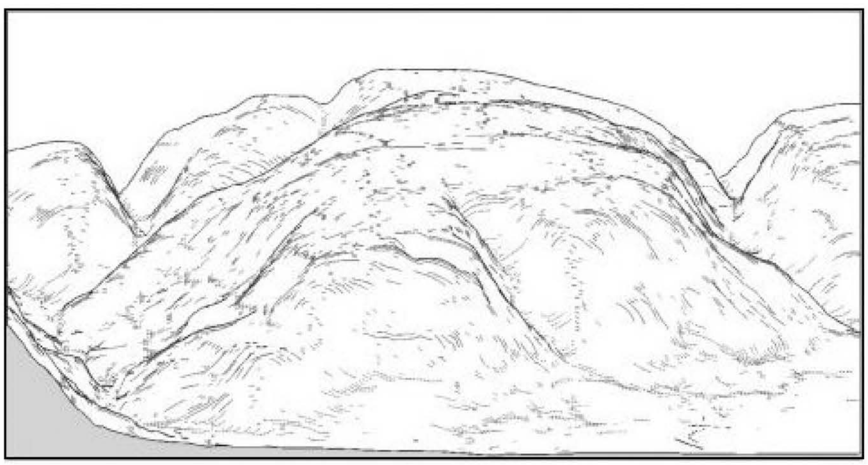
"Similar to the procedure of NPR researchers, early mapmakers defined rules and automated the resulting steps in creating hachures."

Similar to the procedure of NPR researchers, early mapmakers defined rules and automated the resulting steps in creating hachures. Swiss Major J.G. Lehmann in 1799 was the first to quantitatively represent the terrain with hachures. He used black lines oriented in the aspect direction with the thickness of the line proportional to the slope (Robinson *et al.*, 1995). Imhof (1982) and Slocum *et al.* (2005) include a list of all rules for hachuring. An example of a slope hachure map created by Lehmann (1843) and reproduced in Imhof (1982) is shown in **Figure 5b**.

Quantitative rendering with hachures began with a contour framework, with the spacing and orientation of contours determining orientation and thickness of hachures. Strictly applied, however, hachures render



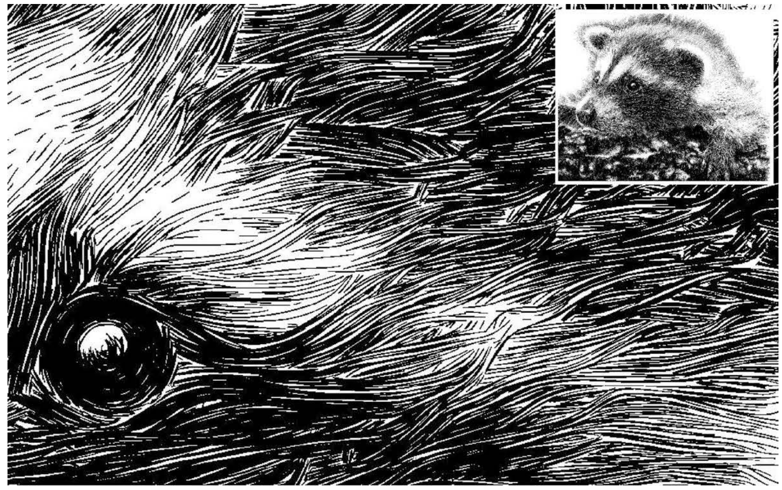
a) Hand rendering by Robinson and Thrower (1957)



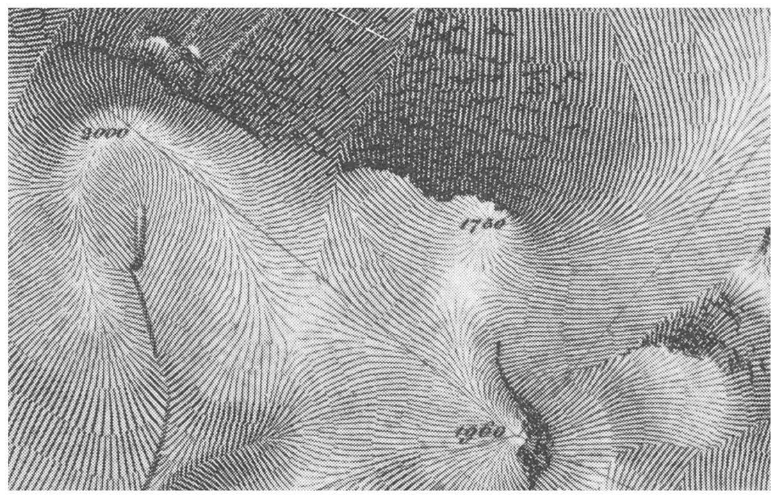
b) Computer rendering by Visvalingam and Whelan (1998)

Figure 4. Two examples of stroke based renderings of terrain. The top is a planimetrically correct map of the Camp Hale area of Colorado based on Tanaka's inclined contour method. Additional strokes have been added on the more shaded side of the terrain to enhance the 3-D appearance (From Thrower and Robinson (1957) with permission from the Geographic Review). The bottom is an oblique view of a terrain rendered with the profile stroke (P-stroke) method. (From Visvalingam and Whelan (1998) with permission from Eurographics UK).

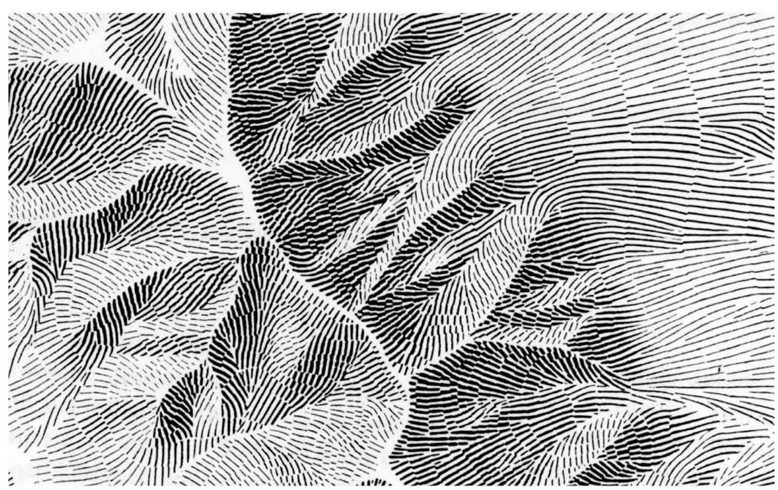
landforms as if illuminated from a vertical source. To simulate oblique illumination, cartographers used aspect, slope and illumination direction to adjust variations in thickness of black hachures on a white background. This permitted illuminated and non-illuminated surfaces to be more easily distinguished. An example of a portion of such a shadow hachure map of Üetliberg (near Zürich) from Imhof (1982) is presented in **Figure 5c**.



a) NPR rendering using a pen-and-ink method (Salisbury et al., 1997)



b) Terrain rendering using slope hachuring (Lehmann, 1843)



c) Terrain rendering using shadow hachuring (Imhof, 1982)

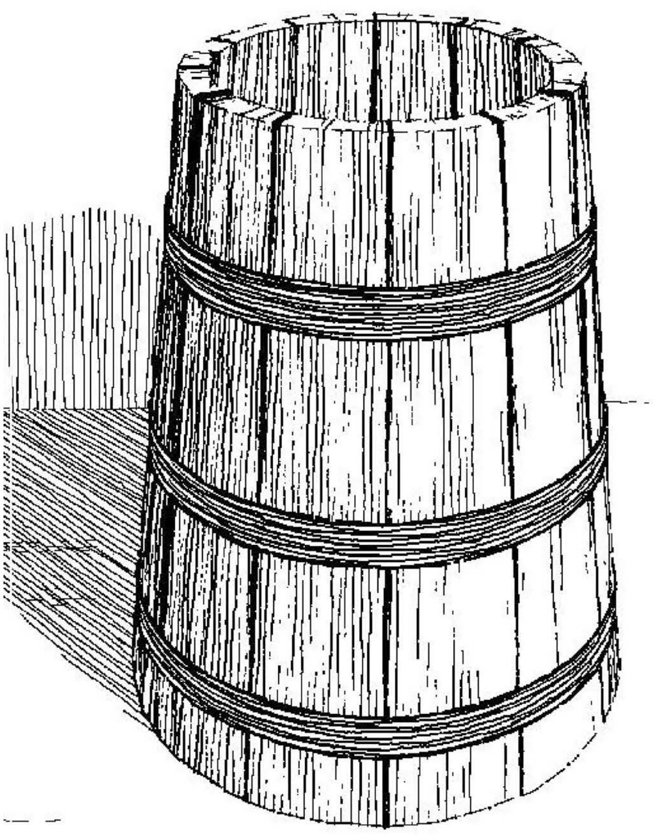
Figure 5. Examples of a pen-and-ink rendering and two hachure maps. The top is a pen-and-ink rendering of an image of a raccoon (From Salisbury et al., 1997).The middle is a planimetrically correct slope hachure map of a steep mountain region drawn by Lehmann and originally published in 1843 (Reproduced in Imhof (1982), Chapter 1, Figure 13, p. 10). (Reprinted with permission from Walter de Gruyter). The bottom is a planimetrically correct shadow hachure map of Üetliberg near Zurich (From Imhof (1982), Chapter 10, Figure 150, p. 223. Reprinted with permission from Walter de Gruyter).

All images from **Figure 5** show fine detail, with tone and texture working together to create a shading effect. Hachure maps, however, are usually created from an object space model of the topography. In the case of **Figures 5b** and **5c**, the model is an elevation contour map of the area. NPR research has also identified methods to create pen-and-ink illustrations directly from object space (Winkenbach and Salesin, 1994 and Winkenbach and Salesin, 1996). Objects are represented by parametric surfaces, and strokes are drawn in directions related to the 3-D geometry of the object. **Figure 6a** is an example of a wooden bucket rendered from object space.

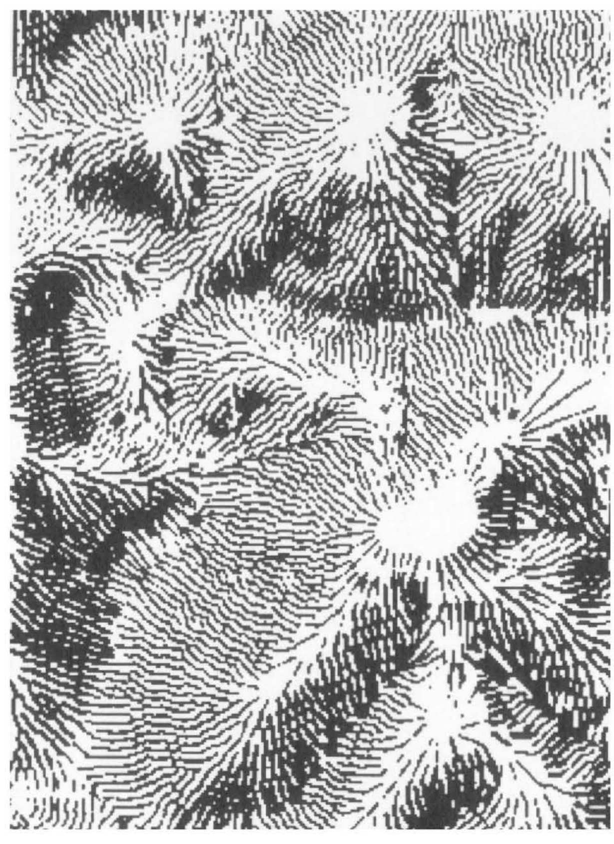
Yoeli (1985) was the first to computer automate rule-based hachuring. An example of his results is presented as **Figure 6b**. He began with a contour framework and applied Imhof's (1982) rules for shadow hachuring. Lines tend to have a wavy appearance as individual straight hachure lines vary slightly in aspect direction between sequential contours.

"Yoeli was the first to computer automate rule-based hachuring."

Portions of the two renderings in **Figure 6** have a similar appearance but reflect important differences between techniques. The wavy strokes in Winkenbach and Salesin's (1996) illustration are not the result of minor variations in orientation. Instead, they are customized strokes to mimic the texture of wood. Additionally, longer strokes of varying thickness were used in the same direction to represent gaps between the individual



a) Pen-and-ink rendering of a 3D parametric surface (Winkenbach & Salesin, 1996)



b) GIS rendering of a terrain (Yoeli, 1985)

Figure 6. Computer automated renderings from virtual 2.5-D and 3-D objects using hachure mapping and pen-and-ink drawing methods. The left is a pen-and-ink rendering of a wooden bucket (From Winkenbach and Salesin (1996) with permission from ACM). The right is a planimetrically correct shadow hachure map created from a framework of isarithmic lines (From Yoeli (1985) with permission from the Cartographic Journal).

boards. Finally, straps were drawn with strokes that were based on the geometry of the virtual object, but at an orientation orthogonal to that of the wood texture and gaps. This NPR rendering began with a smooth 3-D object, used enhancement techniques to apply textures, and thus depicted textures associated with naturally occurring terrain perturbations.

Buchin *et al*. (2004) extended the use of hachure lines into 3-D. They used slope lines to render landscape illustrations with oblique illumination techniques by calculating stroke density. They also used a textured based approach, moving away from the uniform lines used by Yoeli (1985) in his hachure maps. They applied these line drawings on oblique views of terrains.

"Two issues associated with such losses listed by Strothotte and Schlechtweg are (1) lack of contrast between adjacent objects of the same color, and (2) a clear indication of surface shape or curvature."

ADDING HIGHLIGHTS AND DETAILS FROM OBJECT SPACE

Comprehensible rendering recognizes that shading can result in lost information in the transition from 3-D object space to 2-D image space. Two issues associated with such losses listed by Strothotte and Schlechtweg (2002) are (1) lack of contrast between adjacent objects of the same color, and (2) a clear indication of surface shape or curvature. We will discuss current NPR and terrain rendering research that addresses these issues.

Silhouette, Crease and Boundary Lines

Objects rendered with NPR can be complex 3-D models with significant changes in orientation at edges between adjacent faces. The resulting feature edges are of particular concern in the rendering process. Feature edges include silhouettes and creases. A silhouette is defined from the viewing vector (Gooch and Gooch, 2001). At a silhouette point, the surface normal vector would be perpendicular to the viewing vector. In other words, it acts as an edge between the portion of the 3-D model facing towards and away from the viewer. A crease is an edge defined by an abrupt change in the orientation of the surface normal (Gooch and Gooch, 2001). The user can define a threshold angle; if the angular difference between two surface normal vectors exceeds the threshold, then a line representing a crease is included in the rendering. Creases are defined by the 3-D object and thus view invariant, while silhouettes vary with the orientation of the viewer.

"Creases are defined by the 3-D object and thus view invariant, while silhouettes vary with the orientation of the viewer."

Gooch *et al*. (1999) used black silhouette lines and white crease lines with shaded facets to render technical illustrations (**Figure 7a**). Using an illumination source for shading on the visible portion of the 3-D model, white creases tend to highlight the shading. Black silhouette lines also highlight shading, indicating areas where a portion of the 3-D model is hidden from view.

Cartographers creating planimetrically correct maps have had no strong motivation to explore silhouettes or creases in terrain rendering. They generally use 2.5-Dimensional (2.5-D) data models to represent topography, in which any (x,y) location has one and only one z value (Weibel and Heller, 1991). This format ensures the absence of silhouette lines on planimetrically correct maps. Creases in terrain appear to be unexplored, but may be trivial compared with the related but more geographically meaningful topographic features such as stream valleys and drainage divides.

"Creases in terrain appear to be unexplored, but may be trivial compared with the related but more geographically meaningful topographic features such as stream valleys and drainage divides."

Tanaka's (1950) cartographic technique for planimetrically correct representation of terrain caused some discussion of representing edges. Tanaka's relief contour or illuminated contour method was a procedure for drawing black and white contours of variable thickness to represent

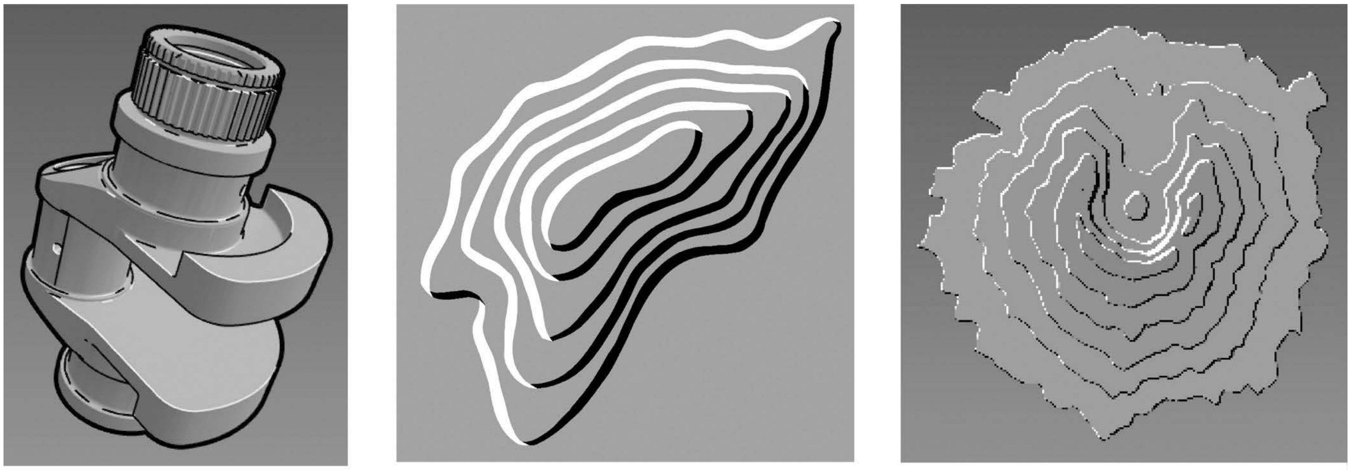


Figure 7. A comparison of illuminated contours with crease and silhouette lines. The right shows silhouette lines in black and crease lines in white designed to communicate the shape and structure of a complex mechanical model (Reprinted from A.A. Gooch and B. Gooch, 1999 with permission from ACM SIGGRAPH). The middle is a hand-rendered illuminated contour map (Modified from the cover of Imhof (1982)). The left is a computer automated illuminated contour map of Mt. St. Helens in Washington state (modified from Kennelly and Kimerling (2001) with permission from Cartography and Geographic Information Science). (see page 85 for color version)

non-illuminated and illuminated areas. Black contours approximated a shadow cast by a flat, stepped surface and white contours approximated similar features cast in negative from a light source 180° from the true direction of illumination. In essence, the topography was being approximately rendered as if it were a stack of cardboard layers cut from contour outlines.

Imhof (1982) discusses Tanaka's (1950) technique, and includes an example of such a map on the cover of his book (modified as **Figure 7b**). He criticized the technique saying that it gives an unnatural impression of steps. Kennellly and Kimerling (2001) attempted to mitigate this effect by using surface normal orientation instead of the aspect direction used by Tanaka to vary line thickness. The resulting illuminated contours are thinner in areas of gentle slope, and thicker in areas of steeper slope (**Figure 7c**). Regardless, illuminated contour techniques can be thought of as rendering topography by representing contours as a vertical step between otherwise flat areas. In NPR terminology, this method creates creases where none naturally exist.

To see the relationship between illuminated contours and silhouette lines, we would have to move away from the planimetrically correct map. Imagine a virtual model based on the contour cutout model. If the viewer (as represented by the viewing vector) were to look at the model from the same direction as the illumination vector, all silhouette lines would correspond with black contours. The remaining crease lines would correspond with white contours.

"In essence, the topography was being approximately rendered as if it were a stack of cardboard layers cut from contour outlines."

"To see the relationship between illuminated contours and silhouette lines, we would have to move away from the planimetrically correct map."

Halftones in Object Space

Computer graphics have always expressed a strong interest in the method by which images are displayed and reproduced. Computer graphics research has delved extensively into the arena of digital halftoning or dithering (for example Ulichney, 1987). For grayscale images, this involves using black and white pixels for display on a computer monitor. Cartography has shown similar interest in halftoning (for example Robinson *et al*., 1995, pp. 367-370). It seems fair to say the primary interest of cartographers has been similar to computer graphic researchers seeking photorealistic results; both want to create continuous tones of gray for more realistic displays. This is accomplished primarily by using patterns of black and white pixels that are as difficult to detect as possible. The result is an image or map with smoothly varying shades of gray, and completely lacking in texture from the black and white pixels used to create the shade of gray.

"It seems fair to say the primary interest of cartographers has been similar to computer graphic researchers seeking photorealistic results; both want to create continuous tones of gray for more realistic displays."

NPR researchers have taken the dithering process from a procedure traditionally done in 2-D image space to a process that takes information from 3-D object space and use this information for orienting halftones in the rendering. Veryovka and Buchanan (1999) used such comprehensible rendering to orient halftones on an image of three objects of variable shape and orientation. **Figure 8a** shows the results of using the surface normal vector to define halftone orientation. A close-up of the sphere reveals that elongate black pixel patterns follow the orientation of the 3-D object.

Kennelly (2002) used halftones oriented in the aspect direction to create a similar effect (**Figure 8b)**. These orientations are determined using aspect information from the 2.5-D digital elevation model and classified into 12 categories. The resulting display allows 16 shades of gray based on classifying hill shade values. The resulting map adds surface orientation information to the hill shading as a halftone-based texture.

Obvious differences are evident between **Figure 8a** and **8b**. One difference is Veryovka and Buchanan (1999) assigned a different texture to each object (cylinder, sphere and box) for better visual separation. They also developed an error diffusion algorithm to vary texture contrasts and tones throughout the image. The result of the error diffusion step is that their image looks smoothed; the GIS rendering looks stark by comparison. Finally, the GIS rendering orients all halftones in the aspect direction. The NPR rendering varies orientation with a surface normal defined by a g-buffer, but this does not uniquely define the orientation of the halftone pattern. For example, halftones are oriented around the curved side of the cylinder (direction of maximum curvature), but they could just as easily been oriented in a parallel manner from the cylinder's base to its top (direction of no curvature).

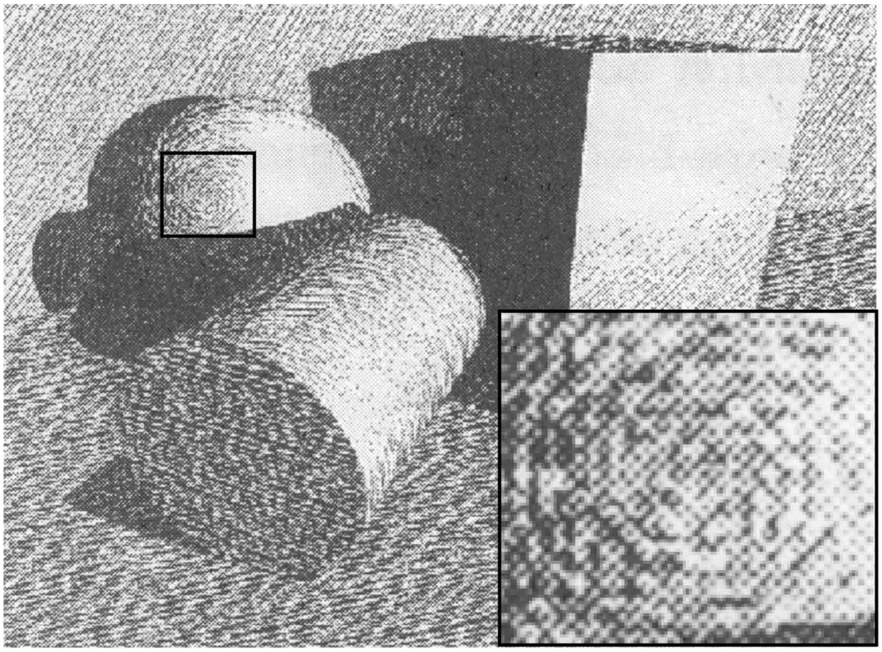
"Veryovka and Buchanan (1999) used such comprehensible rendering to orient halftones on an image of three objects of variable shape and orientation."

Color for Detailed Rendering

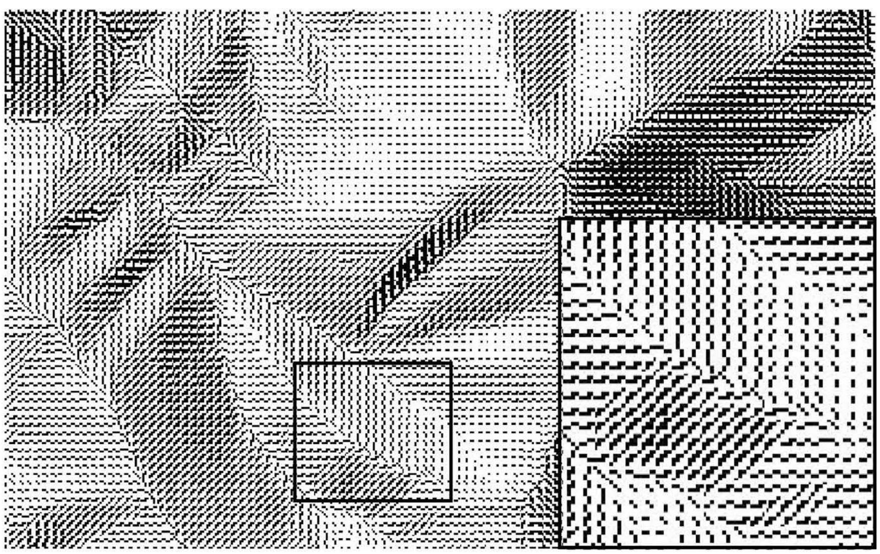
Colors can also be applied to images based on information from 3-D object space. NPR research has specifically looked at the use of color to enhance shading. Gooch *et al*. (1998) vary colors by modifying the classic diffuse and specular shading models, the latter shown on sample hemispheres at the top of the left side of **Figure 9**. They combined two color properties into their scheme as illustrated at center left. First, they assigned a color to an object, and then modulate it through a scaled range of grayness based on shading. Next, they used warm to cool color variations, such as pure blue to yellow. The changes in temperature created the illusion that cool colors recede and warm colors advance. Additionally, Gooch *et al*. (1999) note this change in color temperature is associated with a shift in luminosity. The bottom left of **Figure 9** shows a mechanical drawing using three object colors based on id-buffer. Each color is a linear blend of two tonal variations, with a Phong shading model used to create specular shading.

"The changes in temperature created the illusion that cool colors recede and warm colors advance."

Color techniques have also been used for terrain rendering. Moellering and Kimerling (1990) devised the MKS-ASPECT™ color scheme using the Hue-Lightness-Saturation (HLS) color space. The HLS color model is represented as a two cones with hexagonal bases fitted together base to base. Lightness varies along the central axis, with all fully saturated



a) Oriented halftones of 3D shapes
(after Veryovka and Buchanan, 1999)



a) Oriented halftones of 2.5D terrain model
(after Kennelly, 2002)

Figure 8. Two examples of images with oriented halftones. The top shows geometric objects whose texture is based in part on halftones whose orientation is controlled with information stored in geometric buffers (g-buffers) (Modified from Veryovka and Buchanan, 1999 with permission from NCC Blackwell Ltd.). The bottom shows a planimetrically correct map of the Sweet Grass Hills of north-central Montana using halftones oriented in the aspect direction. (From Kennelly, 2002, with permission from Cartographic Perspectives).

colors having a lightness of 50%. The 50% lightness slice of the HLS color model forms a hexagon similar in appearance to a color circle of all hues. Selecting colors around the slice, they sought easily discriminated colors. Additionally, the relative luminance of the selected colors as measured on

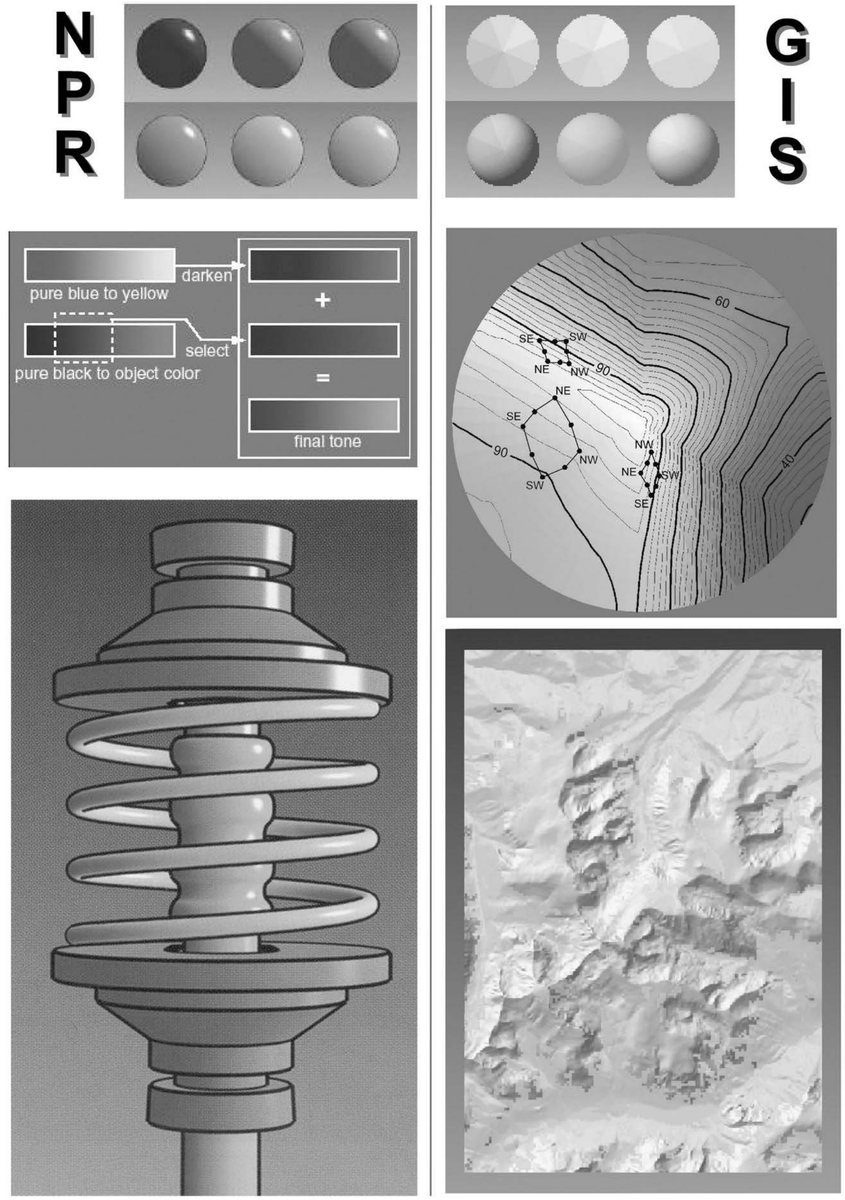


Figure 9. These two coloring schemes add color details and highlights to conventional shading techniques. The NPR technique on the left uses cool to warm undertones to add subtle tonal variations to object colors (From Gooch et al., 1998 with permission from ACM SIGGRAPH). The terrain rendering scheme on the right of a portion of the Absaroka mountains of southwestern Montana uses aspect-variant colors that add luminous highlights and enhance shading of surface elements (Modified from Kennelly and Kimerling (2004) with permission of Cartography and Geographic Information Science). (see page 86 for color version)

the computer screen with a spectrophotometer matched a modified cosine illumination intensity function. The resulting rendering replaced ambiguous shades of gray with unique colors, while approximating traditional hill shading effects.

Brewer and Marlow (1993) devised a scheme based on aspect and slope using the Hue-Value-Chroma (HVC) color model. In the HVC color model, differences in each variable are perceptually equidistant. As with the previous technique, colors were selected around the entire color circle. They did not, however, try to match a theoretical cosine curve, but rather used this color model to maximize lightness differences among hues. Additionally, they varied chroma, which is similar to saturation, with slope, using more saturated colors for steeper land forms.

Kennelly and Kimerling (2004) introduced the idea of applying colors with aspect-variant luminosity using the Hue-Saturation-Value (HSV) color model, and then hill shading in a traditional manner. HSV is a popular color model for software that includes color pickers. With such color model, it is easy to see the relationship among colors to be picked or modified. For example, users can begin with a green, and then see other shades of green nearby that can be described by such terms as richer, paler, more yellowish-green, or more blueish-green. HSV, however, is distorted with respect to the luminance of colors. Colors of 100% value (the V of HSV) can have very different luminosity. Kennelly and Kimerling (2004) mapped the luminosity for all colors on the 100% V slice of this color model to use with an aspect variant color scheme.

"HSV, however, is distorted with respect to the luminance of colors."

Examples of such GIS-based shading applied to sample hemispheres are presented for comparison with those of Gooch *et al*. (1999) at the top of the right side of **Figure 9**. Unlike previous aspect based methods designed as alternatives to traditional hill shading, this color scheme is to be used in combination with hill shading.

This aspect-variant color scheme selects eight colors in a diamond pattern in HSV color space, with luminosity increasing from northeast to southwest, and saturation increasing from northwest to southeast. Examples using a variety of green, tan and blue colors are represented in the middle right of **Figure 9** with black dots plotted on top of the HSV color cone. The bottom right of **Figure 9** shows these three object colors applied to different land uses in a terrain model with hill shading of a portion of the Absaroka Mountains, Montana. Areas of snowfields/ice are displayed in blue, exposed rock is in tan, and vegetated areas are in green. Luminosity between northeast and southwest facing surface elements varies with color luminosity, while brightness values between northwest and southeast facing surface elements varies with shading. The resulting display creates or increases contrast between some adjacent surface elements by uniquely assigning color by aspect, increasing brightness value and decreasing saturation to the northwest, and increasing luminosity to the northeast.

"Unlike previous aspect based methods designed as alternatives to traditional hill shading, this color scheme is to be used in combination with hill shading."

The techniques of Gooch *et al*. (1998) and Kennelly and Kimerling (2004) have important differences (See **Figure 9**). Gooch *et al*. (1998) calculated colors from a lighting model, with the goal of rendering tone-scaled object colors with cool-to-warm undertones. The resulting rendering offers subtle color changes consistent with traditional shading models. Colors are symmetric across a plane parallel to the illumination vector. Kennelly and Kimerling (2004) focused on quantifying luminosity in color space, then varying luminosity with aspect and hill shading from two different directions. The resulting map is not intended to match an optically based shading model. It also lacks radial symmetry of color, an intentional attempt by the authors to vary color for each aspect direction.

"The techniques of Gooch et al. and Kennelly and Kimerling have important differences."

DISCUSSION

The ability of mapmakers to create accurate renderings of terrain with a 3-D appearance hundreds of years before the advent of computers resulted primarily from two unique aspects of their early trade. First, data for quantitative models of real world objects were collected and represented in a systematic and intuitive manner. Second, common geographic methods of representing this data resulted in renderings, or could be used as a framework (such as contours) to create new renderings.

Elevation data are measured from vertical datum, such as mean sea level. Terrain measurements at different points can be related by such intuitive concepts as higher or lower. The general behavior of the terrain as a smooth, continuously varying field also contributes to a simple model. If each point has one and only one elevation value, a 2.5-D model can accurately represent the surface.

"Terrain measurements at different points can be related by such intuitive concepts as higher or lower."

Virtual models used in computer graphics differ significantly, as illustrated in **Figure 1**. There is no defined datum for objects, such as the statue, the bucket, or the mechanical part rendered in **Figures 3, 6, and 7** respectively. Whether a point on a bucket is higher or lower than another is only meaningful if a z-coordinate related to a datum were used to define its 3-D shape. If a z-value is used, whether a point on the bucket is higher, lower, or at the same z-value depends on how the coordinate system was defined with respect to the bucket. Additionally, the nature of these discrete objects implores a 3-D instead of a 2.5-D model for accurate representation.

Mapmakers often create images of their virtual models using the methodology shown in **Figure 1b**, which is a simplifying convention often used to create planimetrically correct maps. With such maps, the viewing vector is defined perpendicular to the datum, with the viewing plane or map consequently being parallel to the datum. NPR researchers working with terrain would describe planimetrically correct maps as seen from an orthographic viewpoint directly above the terrain model. In essence, this view fixes some g-buffers necessary for NPR rendering as constants for a particular terrain (See **Figure 1**). The elevation is inversely related to an invariant z-buffer. The orientation of any surface element can be uniquely represented by two intuitive angles: slope and the aspect.

"In essence, this view fixes some g-buffers necessary for NPR rendering as constants for a particular terrain."

The earliest efforts to graphically render terrain used isarithmic or contour lines. These were drawn based on elevation data only, but their orientation and spacing represent aspect and slope respectively. As long as contour lines are darker than the background, contours themselves shade terrain so that steeper areas appear darker. This rendering of the terrain is similar to shading resulting from a light source shining perpendicular to the datum. It is generally called vertical illumination and judged as inferior to illumination at some intermediate angle between vertical and horizontal, called oblique illumination (Imhof, 1982).

To create better renderings, mapmakers typically began with the contour framework. and used slope and aspect information to create oblique shading effects. This included changing the relative brightness of contours with respect to the background (Tanaka's methods), or changing thickness and spacing of hachures drawn between contours with respect to slope and aspect (as described by Imhof (1982)). All of the maps presented here are obliquely illuminated, with the exception of Lehmann's hachure map (**Figure 5a**).

Researchers in NPR—or computer graphics in general—have no need for the concept of vertical illumination. They can, nonetheless, achieve a similar rendering of poor quality if the illumination vector is oriented in the same direction as the viewing vector. Additionally, NPR researchers have no need for slope or aspect. Without a widespread datum and with 3-D models constantly changing orientation in 3-D space, they are primarily concerned with how a surface normal vector orientation is changing with respect to the illumination vector.

"Additionally, NPR researchers have no need for slope or aspect."

In practice, researchers working with terrain rendering can and do work directly with the surface normal vector and illumination vector for rendering. Still, discussing the most recent cartographic methods for rendering terrain without using terminology such as slope and aspect would be a challenge. For example, all of the color methods cited above vary colors with slope, aspect, or both. Mapmakers representing terrain adopted a useful tradition and terminology hundreds of years before and continue to look for effective techniques within this construct.

Procedures for defining and rendering virtual models in 3-D space is a more inclusive approach, but one that is also more complex in its implementation. Terrain rendering has created many striking representations of oblique views of terrain, from the block diagrams of William Morris Davis to the P-stroke sketches of Visvalingam and Whelan (1998). Additionally, the technical challenges of such displays have been long documented in terrain rendering literature, from the detailed techniques of Lobeck (1924) to more recent discussions of GIS-based perspective displays (for example Weibel and Heller, 1991).

"Terrain rendering has created many striking representations of oblique views of terrain, from the block diagrams of William Morris Davis to the P-stroke sketches of Visvalingam and Whelan."

CONCLUSIONS

Mapmakers hundreds of years ago were able to use well defined data structures and innovative display procedures to render terrain. With few exceptions (such as architectural renderings and engineering drawings), terrain maps would remain some of the only non-computer based images quantitatively rendered from models constructed from careful measurements of real world objects. The challenges of measuring and relating terrain data were facilitated by the use of a datum and a 2.5-D data model. The challenges of representing these quantitative models with a systematic procedure lent itself to the use of planimetrically correct maps. The challenge of drawing terrain maps with the appearance of 3-D rendering led to the development of procedures that would match shading from an oblique illumination source.

"With few exceptions (such as architectural renderings and engineering drawings), terrain maps would remain some of the only non-computer based images quantitatively rendered from models constructed from careful measurements of real world objects."

Many of these techniques met the challenges of creating realistic renderings. Other examples provided oblique shading while at the same time creating very unique and stylized renderings. Two examples of these would be physiographic diagrams and rock drawings. Physiographic diagrams such as those of Erwin Raisz (1931) use standard, easily recognized black and white symbols to represent landforms. These symbols also render the terrain through tonal variations in the individual symbols. Rock drawings are striking and stylized representations of steep and complex rocky areas (Imhof, 1982). These renderings are achieved by artistically combining a number of rendering components, including contours with local variations in interval, skeletal or edge lines, rock hachures (a variety of shadow hachures), color and shading (Imhof, 1982).

Despite the fact that more realistic maps can now be made of the same areas mapped with these techniques, these renderings remain much revered and often cited. Cartographers have always been interested in multiple methodologies for depicting similar data. These less realistic techniques are simply examples of a variety of methods to represent terrain.

"Other examples provided oblique shading while at the same time creating very unique and stylized renderings."

Since the advent of computer models, display and rendering, there has been a proliferation of images created from virtual objects. NPR offers an interesting example of such work, because many such renderings are quite stylized. As such, it is easy to recognize methods or procedures that are similar to antecedent terrain rendering techniques. It is also possible to identify NPR techniques that may be interesting to apply to terrain renderings.

Newly developing NPR methodologies give those of us with an interest in the history and practice of terrain rendering two unique and important opportunities. The first is the opportunity to raise awareness with

NPR researchers of the rich and important heritage of terrain rendering techniques. Second, identifying areas of overlapping interest with respect to current research seems rich in opportunity. Possibilities include 1) increased collaboration with NPR research, 2) applications of NPR techniques within the terrain rendering construct, and 3) advancing methods for cartographic renderings of 3-D objects.

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From Afghanistan to Iraq in Media Maps: Journalistic Construction of Geographic Knowledge

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Professor Robert Churchill passed away as this article underwent publication. Though Bob was formally trained as a physical geographer, he eventually became the backbone of Middlebury College's GIS and cartography program, and an irreplaceable member of the geography department. Family, colleagues, students, and the entire Middlebury College Community miss Bob's anecdotes, his kindness, and his easy laughter.

The last two decades have seen a marked rise in the number of maps in the popular media, yet academic interest in journalistic cartography remains low, though the bulk of the public relies on the media for its geographic knowledge. Because they invoke a sense of belonging, identity, and allegiance, the number of media maps, like flags and other patriotic icons, increases during conflict. From the U.S. invasion of Afghanistan until the proclamation of victory in Iraq almost two years later, three major American news magazines published nearly 200 related maps. Early maps of Afghanistan affirmed U.S. military prowess and promised quick retribution, but with the failure of this promise, pointed to obstacles from terrain to climate. As interest in Afghanistan cooled and rhetoric over Iraq heated up, cartographic attention shifted accordingly. Initial maps of Iraq were provocative, focusing especially on the state's supposed possession of weapons of mass destruction. Maps again depicted American military might, and as the invasion progressed seemingly unimpeded, Baghdad came into cartographic focus. In these compositions the melding of artwork, remotely sensed images, and photography lends even greater veracity to the maps themselves, which not only convey but also construct both political and geographic knowledge.

KEYWORDS: media maps, journalistic cartography, political cartography, war on terrorism

INTRODUCTION

After weeks of posturing and ultimatums, the United States invaded Iraq on March 19, 2003. Although the most visible and rehearsed justification for this action was Iraq's alleged and much publicized possession of weapons of mass destruction, some of the earliest rationalization for military action was based on the assertion that Iraq was harboring members of Al Qaeda and the more general allegation that Iraq was a sponsor of terrorism against the United States. Ironically, Iraq escaped notice almost entirely in discussions of global terrorism following September 11, 2001, and in the search for perpetrators of the attacks on the World Trade Center and the Pentagon. That search instead quickly narrowed in on Afghanistan when it seemed certain that Osama bin Laden and high ranking members of Al Qaeda had taken refuge there. Afghanistan continued to receive headline attention in the months that followed until the

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threat posed by Saddam Hussein—whether or not that threat was real and imminent—reached a crescendo, drawing attention away from Afghanistan and shifting the story to Iraq. A public who had become familiar with Afghanistan was now compelled to learn a new geography.

For the majority of people, this geography was undoubtedly learned (if at all) from the media, most emphatically and effectively through maps (Monmonier, 1989; Vujakovic, 1999a). Media maps define place in the mind of the public, but maps impart far more than location, size, shape, place names, and other lessons of rudimentary geography. Because they are, in a very real sense, creations of prevailing society, maps present a view of the world that is conditioned by social norms and the values and ideologies of their makers (Kosonen, 1999). For the war in Iraq, media maps offer an alternative form of discourse, one that may provide insight into those norms, values, and ideologies and how they change through time, as well as some sense of the function of the map itself in molding and mirroring public perception and beliefs. Our purpose is to examine cartographic representation of the conflict in Iraq and the period preceding the conflict, and to consider what messages were being conveyed, how those messages may have been assimilated and understood by readers, and how and why the messages changed through time.

"Media maps define place in the mind of the public, but maps impart far more than location, size, shape, place names, and other lessons of rudimentary geography."

Maps, Media, Message

In response to the increased appearance of maps in the popular media that followed the innovations in cartographic production and design of World War II, Ristow initiated an academic dialogue on the role of journalistic cartography (1957). Similar to the increase documented by Ristow in the middle of the last century, the number of maps appearing in the print media has increased profoundly in recent years largely as the consequence of desktop mapping and related computer technologies (Monmonier, 1989; 2001). As these technologies continue to evolve, the sophistication as well as the quantity of media maps continues to increase (Herzog, 2003). Some anticipated that the growing number of maps resulting from technological innovation would stimulate greater academic interest in journalistic cartography (Gilmartin, 1985). Two decades later, however, research has failed to keep pace with the proliferation of media maps (Perkins and Barry, 1996).

"For the war in Iraq, media maps offer an alternative form of discourse . . ."

This lack of interest is curious and not easily explained. Certainly in the past, academic cartographers were quick to exorcise maps that did not adhere to the prevailing rules of expressiveness (Harley, 1989). Academic cartographers may show little interest in journalistic maps for fear that these non-academically trained mapmakers will ignore their ideas and input (Gilmartin, 1997). The limited study of journalistic maps, in some part, may also be a consequence of the intellectual privileging of text at the expense of image. The historic paucity of maps in newspapers has been attributed to the opportunity costs they exact. Printing a map means sacrificing text, and Ferris (1993) maintained that above all, editors are word people. Momentarily accepting this argument to explain the dearth of media maps in the past, and perhaps the lack of research interest in journalistic cartography as well, it is not clear whether the profusion of maps in recent years reflects an increasingly visual society or an emerging recognition by the media of the power and authority that maps hold.

". . . the number of maps appearing in the print media has increased profoundly in recent years largely as the consequence of desktop mapping and related computer technologies (Monmonier, 1989; 2001) . . . the sophistication as well as the quantity of media maps continues to increase (Herzog, 2003)."

To the extent that media maps have received any attention, it has usually been to critique their design and effectiveness (Balchin, 1985; Gauthier, 1988). No doubt the choice of projection or how a map is centered or how data are generalized are important questions that influence public perception of geography, but what may be implicit in these concerns, and of greater, overarching importance, are the messages conveyed by journalistic maps, especially given the acknowledged role of the media in the geographic education of the public at large. Like all maps, those that appear in the media are potent and readily recognizable emblems, icons that can assert territorial dominance and define geopolitical perceptions (Anderson, 1991; Kosonen, 1999). Moreover, because they articulate both a sense of place as well as relations among people and place, maps are instrumental not just in the representation or even the interpretation of geographical knowledge but in its construction (Crampton, 2002).

Based on these arguments, a dramatic increase in the number of maps of Afghanistan following the terrorist attacks of September 11 is not surprising. In spite of the fact that 15 of the terrorists directly involved in the September 11 attacks were Saudis, the responsibility for those attacks was attributed almost solely to Afghanistan by geographical association both with Osama bin Laden and with global terrorism more generally. Media maps provided not only an important geographical frame of reference for this story but, by articulating the enemy, reasserted and perhaps redefined the identity of the United States which momentarily had assumed the role of victim (Churchill and Slarsky, 2004). But as the action in Afghanistan wore on with the failure to find bin Laden, what story did the maps tell? With escalating tensions in Iraq and increasingly bellicose rhetoric, the ostensible importance of Afghanistan began to diminish. As a consequence, a shift in cartographic focus and a corresponding increase in the number of maps of Iraq might well be expected. What may be less obvious and predictable, however, are the arguments embedded in the shifting cartographic representations of Afghanistan and Iraq.

"Media maps provided not only an important geographical frame of reference for this story but, by articulating the enemy, reasserted and perhaps redefined the identity of the United States . . ."

Maps in News Weeklies

To better understand the dialectic between media maps and society, we examined all maps that appeared in three major news magazines, *Newsweek*, *Time*, and *U.S. News and World Report*, from October 15, 2001 through September 30, 2003. We elected to focus on these publications for several reasons. First, we were concerned that the sheer number of maps appearing in newspapers of record during this period of time would be too voluminous to permit close scrutiny. Second, while newspaper maps have increased markedly both in quantity and quality (Ferris, 1993), the greater lead time of news magazines, as well as higher print quality, accommodate compositions that are graphically sophisticated and rich in content. Maps displayed on television are disadvantaged by brief exposure time, and although this is not true for the Internet, the comparatively low resolution of display devices continues to limit the content of maps both on the Internet and on television. Furthermore, maps in news magazines are intended not only to provide geographic reference and to draw people into the story but, increasingly, to tell the story as stand-alone compositions (Ohlsson, 1988). Indeed, there is some indication that people often do study the maps without reading the accompanying story (Perkins and Barry, 1996). Finally, even though these magazines may have different editorial perspectives, they are intended to appeal to a broad national readership rather than regional markets, and hence may offer a more comprehensive reflection than newspapers of the interrelations between maps and society.

". . . the greater lead time of news magazines, as well as higher print quality, accommodate compositions that are graphically sophisticated and rich in content."

In all we examined 189 maps that related to global terrorism, the pursuit of terrorists in Afghanistan, and the emerging military engagement in Iraq. Because actions in both Afghanistan and Iraq were predicated on the attacks on the World Trade Center and the Pentagon, we also included maps that involved the events and the aftermath of September 11. Nearly all these maps were printed in color; 54 were double-page spreads; and 19 more occupied full-page layouts. Although no map can be wholly neutral in position, the great majority of those we examined were clearly expository in nature. Many relied on symbols such as flashpoints, targets, and encircling arrows, for example, while many more were embellished with photographs, satellite imagery, and artistic renderings of aircraft, weapons, and soldiers. Only about one-fifth of the maps were sufficiently free of such obvious symbology and imagery that they could be considered simple reference or locator maps. There was not great disparity in the number of maps of Afghanistan and Iraq that appeared over the period of study, but predictably, the geographical focus changed through time, as did the character and tone of the maps themselves, albeit in more subtle fashion.

". . . Afghanistan is surrounded, if not pinned down, by callouts and contained by a distinct orange line which . . . provide cartographic assurance of inevitable and rapid defeat of the enemy."

Obstacles in Afghanistan

Although terrorism defies geographic boundaries, the demand for retribution for the attacks of September 11, 2001 necessitated the clear definition of an enemy and conjunctively, the identification of a place on the map—a set of boundaries to geographically define and contain that enemy. With Osama bin Laden reportedly holed up there, Afghanistan filled that need quite effectively, and within a matter of days, media maps made the transition from depicting domestic attack sites and global terrorism in general to representation of Afghanistan and military actions against terrorists harbored within its borders.

Like the composition in *Time* from October 22, 2001 (Figure 1), the maps that appeared initially in the news weeklies were consistently aggressive in tone. Here Afghanistan is surrounded, if not pinned down, by callouts

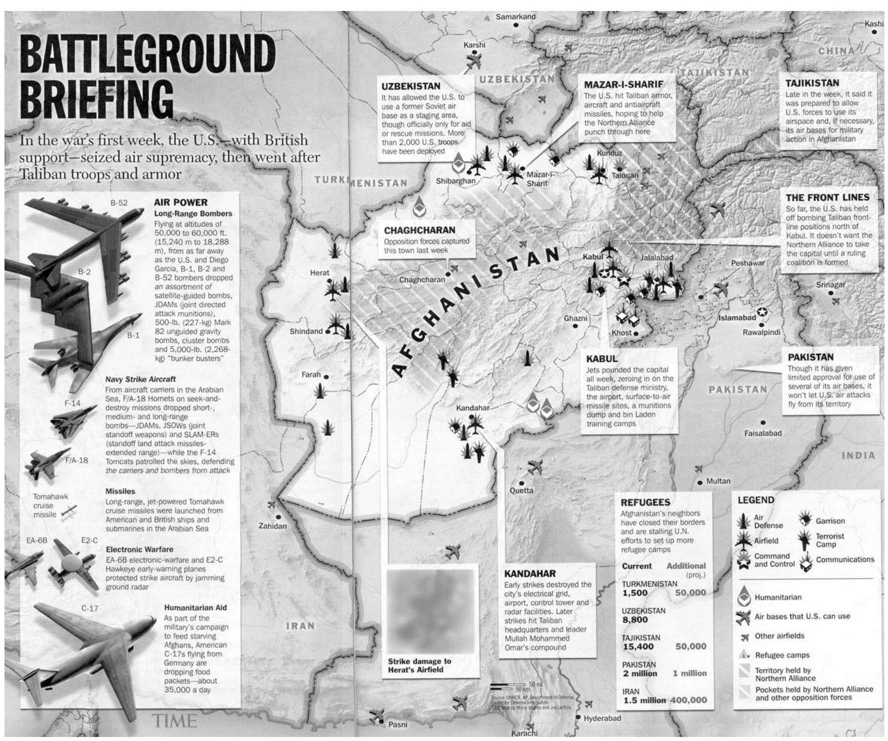

Figure 1. "Battleground Briefing." Time*, 22 October, 2001.* Reprinted from **Time Magazine** ® with permission. *Cartography by Missy Adams and Joe Lertola.(see page 87 for color version)*

and contained by a distinct orange line which, together with images of aircraft, a photograph highlighting damage with yellow arrows, and flashpoint symbols, attest to the strength of the U.S. military and provide cartographic assurance of inevitable and rapid defeat of the enemy.

As actions in Afghanistan continued with failure to find bin Laden, the message shifted in subtle but purposeful fashion. Maps began to focus on the physical environment with emphasis on rugged terrain, lack of the most basic infrastructure, and inhospitable conditions. Of 55 maps of Afghanistan included in our study, 48 used shaded-relief or three-dimensional perspectives to depict the terrain, and of the few maps that did not use these techniques, nearly all appeared before the end of 2001. The use of relief shading and three-dimensional perspectives is surely due in part to the fact that off-the-shelf data and sophisticated software make these techniques easy to use. Yet the consistent and often dramatic use of these effects also goes far to explain any failures in the pursuit of bin Laden and Al Qaeda. In spite of the obvious and profound superiority in weapons technology, shown prominently in the offering from *US News and World Report* (Figure 2), intensely rugged terrain devoid of roads, settlements,

"Maps began to focus on the physical environment with emphasis on rugged terrain, lack of the most basic infrastructure, and inhospitable conditions."

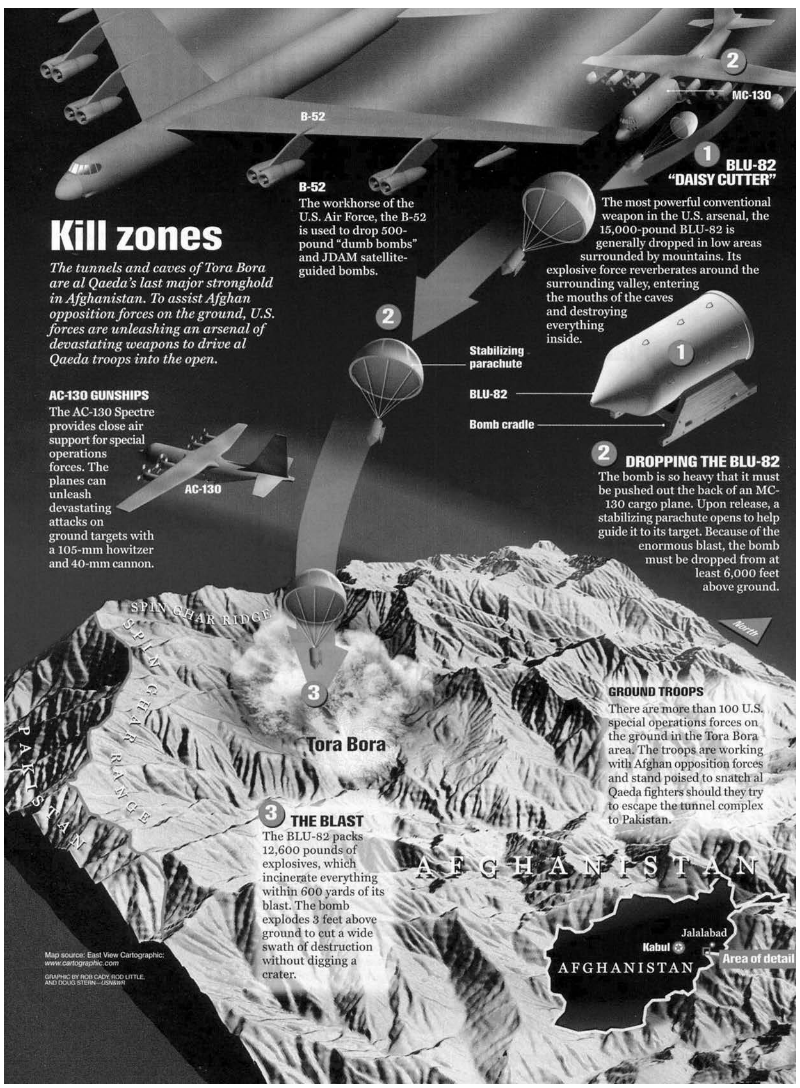

Figure 2. "Kill Zones." U.S. News & World Report*, 24 December, 2001.* Copyright 2001 U.S. News & World Report, L.P. Reprinted with permission*. Cartography by Rob Cady, Rod Little, and Doug Stern. (see page 88 for color version)*

and people suggests that actually effecting that damage against the enemy may be difficult given the physical environment.

Barren and bleak terrain, however, was not the only impediment to rapid and unequivocal success. Although readers are not allowed to disregard the rugged, mountainous landscape, climate was dramatically added to the mix in another map from *Time*, "When Winter Comes" (Figure 3). If the title alone is not sufficient to cause a chill, the juxtaposition of blue tones and call-outs with the white-clad soldier erases any doubt that winter conditions will make pursuit of the enemy even more difficult. The reader does not have to look at the caption to surmise that the Taliban can readily tolerate these conditions, even in the face of well equipped and well trained U.S. special forces (although one might question the training of a soldier who would consider firing a weapon with its flash suppressor and barrel plugged with ice and snow). Clearly, superiority in weapons, technology, training, and tactics may not be enough to insure quick and complete success in Afghanistan.

"By the summer of 2002, however, the agenda of the Bush Administration turned from Afghanistan toward Iraq. Maps of Iraq began to appear regularly and in greater numbers, while already dwindling cartographic interest in Afghanistan became negligible . . ."

Turning Toward Iraq

Although they declined in number, maps of Afghanistan continued to appear in the news weeklies on a regular basis through the opening months of 2002. By the summer of 2002, however, the agenda of the Bush Administration turned from Afghanistan toward Iraq. Maps of Iraq began to appear regularly and in greater numbers, while already dwindling cartographic interest in Afghanistan became negligible with maps appearing only occasionally after the summer of 2002 (Figure 4).

Although the regime of Saddam Hussein would be linked with terrorism soon enough, at least rhetorically, the maps that explored the Iraqi terrorist threat through the summer of 2002 seemed to present somewhat mixed messages. One world map, for example, includes Iraq among states

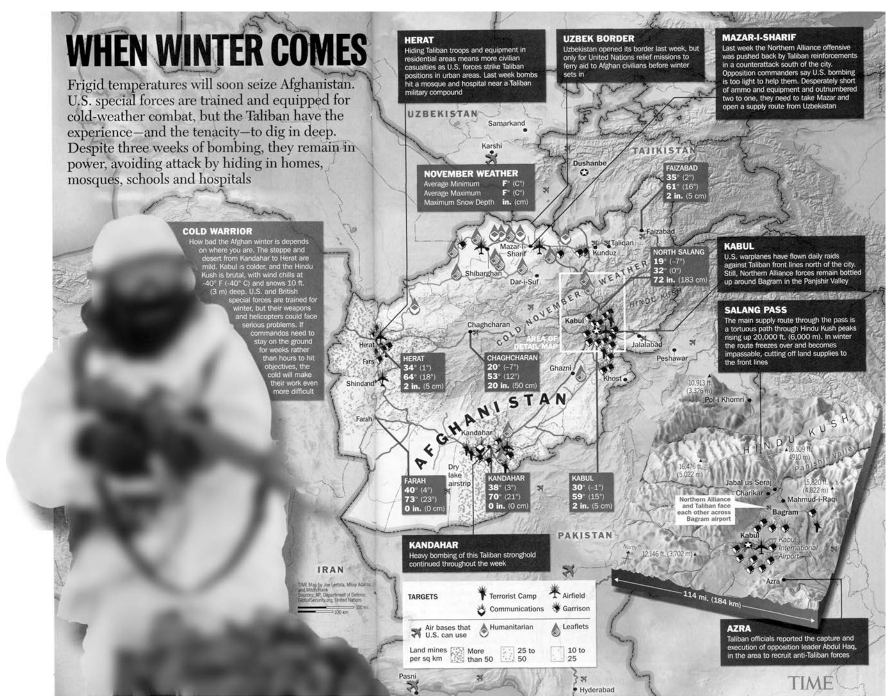

Figure 3. "When Winter Comes." Time, *5 November, 2001. Satellite images courtesy of Space Imaging.* *Cartography by Joe Lertola, Missy Adams, and Mitch Frank.* *(see page 89 for color version)*

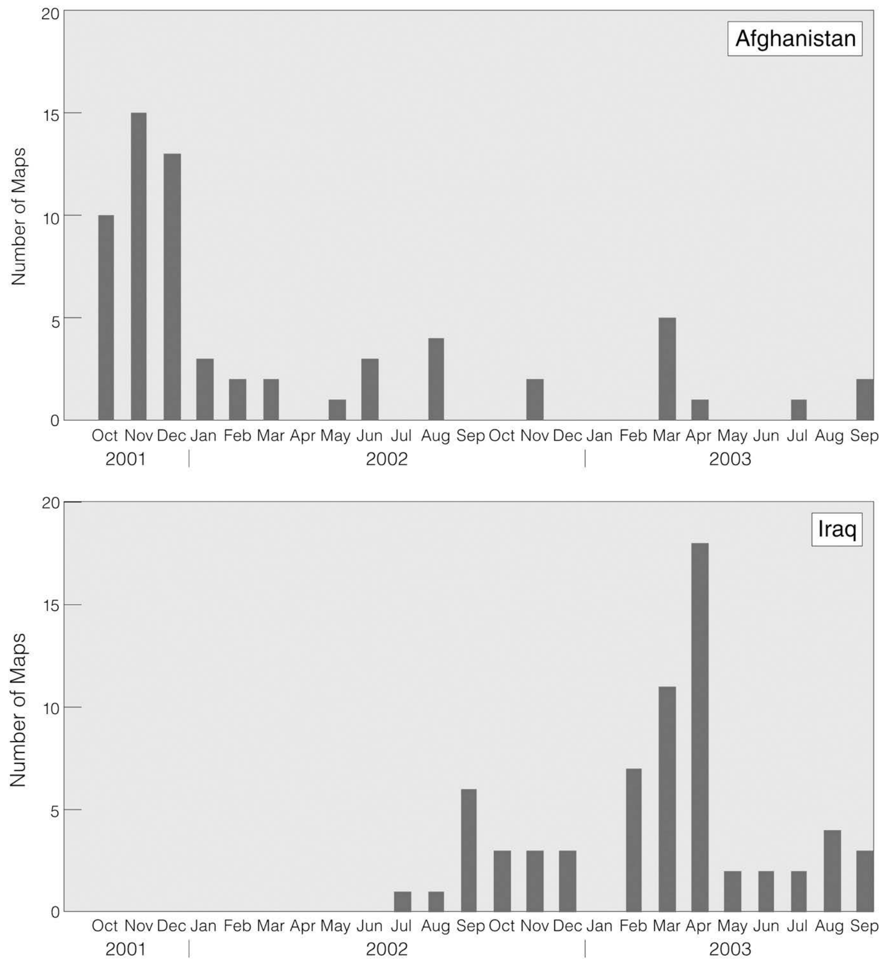

*Figure 4. Number of maps of Afghanistan versus Iraq that appeared in three domestic news weeklies—*Time, Newsweek, *and* US News and World Report*—from 15 October, 2001 through 30 September, 2003.*

where Al Qaeda has operated but visually downplays its significance relative to a number of other countries. Another composition, which explores Osama bin Laden's whereabouts, links Afghanistan and Iraq with a bright, sweeping arrow but, in the accompanying text, concludes it doubtful that Iraq would provide sanctuary to terrorists. By the fall of 2002, however, these ambiguities seem to have been resolved as illustrated by a map published in the September 2 issue of *Time* (Figure 5). The map not only indicates that members of Al Qaeda may be taking refuge within the Iraq's borders but also shows a training camp for Iraqi terrorists and "foreign extremist Arabs". If the association with terrorism is not clear enough from the content and symbology — the red dripping from the Kurdish region at the top of the state, for example — Hussein stands in front of the map with hand across his heart yet looking away with an untrustworthy squint and a sardonic grin. One inescapable irony here, of course, is that fact that alleged Al Qaeda refugees are shown in the Kurdish region of the state, but in spite of Saddam Hussein's contempt for the Kurds, the mere presence of Al Qaeda within its borders may be enough to suggest Iraq's culpability in terrorism against the United States.

"If the association with terrorism is not clear enough from the content and symbology—the red dripping from the Kurdish region at the top of the state, for example—Hussein stands in front of the map with a hand across his heart yet looking away with an untrustworthy squint and a sardonic grin."

In light of the message proffered by this map, it bears repeating that Iraq escaped attention in the search for global terrorists in the aftermath of September 11. Nonetheless, the connection with terrorism was presented

Figure 5. "Saddam's Game." Time, *2 September, 2002.* © 2006 Time Inc. All rights reserved. Reprinted from **Time Magazine** ® with permission. *Cartography by Jackson Dykman. (see page 90 for color version)*

as one of the first transgressions by Iraq, at least cartographically, and one of the fundamental provocations in fabricating a rationale for U.S. attack. Other arguments followed quickly.

"... the connection with terrorism was presented as one of the first transgressions by Iraq, at least cartographically, and one of the fundamental provocations in fabricating a rationale for U.S. attack."

Oil was discussed often enough in the public discourse, but only two of nearly 200 maps noted U.S. interest in Iraqi petroleum. Weapons of mass destruction attracted far greater attention and were mentioned so frequently, in fact, that WMD became a familiar acronym. Of the numerous maps that took weapons of mass destruction as a principal theme, the one that appeared in *Newsweek* on September 16, 2002 (Figure 6) is representative of the tone and message yet interesting in its own right. Red symbols are used to show the location of nuclear, biological, and chemical installations, as well as sites of ballistic missile production, while military installations and Saddam's palaces are depicted in similar black symbols. Arrows bring the eye back to the large and menacing cluster around Baghdad. The character of the arrows themselves, giving the impression of having been hastily drawn with grease pencil or marker, creates a complementary dynamic, as if the map was taking shape like a chalk talk or a football play, a formative plan of action based on emerging revelation.

"The character of the arrows themselves ... creates a complementary dynamic, as if the map was taking shape like a chalk talk or a football play, a formative plan of action based on emerging revelation."

Although stylistically distinct, a map that appeared later in *Time* (Figure 7) imparts much the same message. Relying on a substantially larger scale, this map presents a three-dimensional perspective limited to the area around Baghdad, with brightly colored pushpin symbols to suggest an alarming concentration of potential weapons sites. This map includes

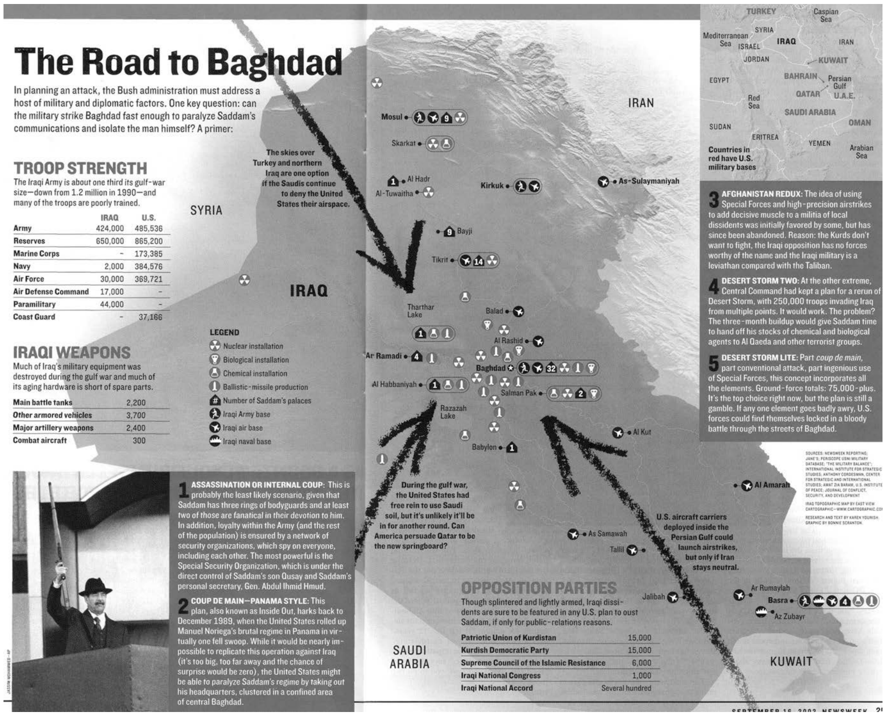

Figure 6. "The Road to Baghdad." Newsweek*, 16 September, 2002. Newsweek—Bonnie Scranton. © 2002 Newsweek, Inc. All rights reserved. Reprinted by permission. Cartography by Bonnie Scranton. (see page 91 for color version)*

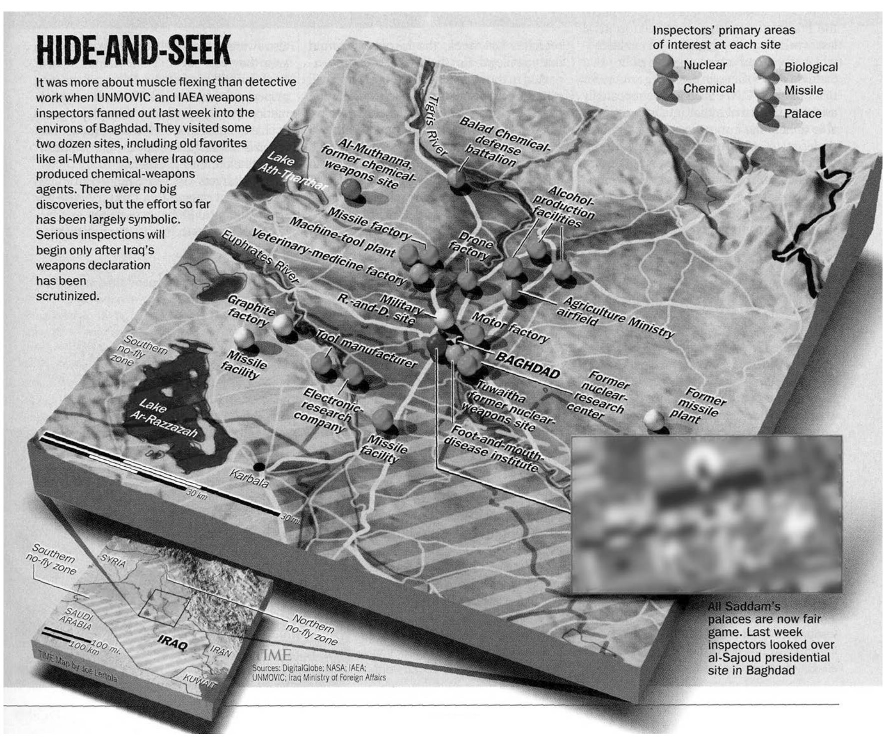

Figure 7. "Hide-And-Seek." Time*, 16 December, 2002.* © 2006 Time Inc. All rights reserved. Reprinted from **Time Magazine** ® with permission*. Cartography by Joe Lertola. (see page 92 for color version)*

Saddam's palaces with the suggestion that these facilities too may harbor weapons. An inset photograph of the al-Sajoud Palace not only confirms the strategic significance of the presidential compounds but offers implicit assurance of the sophistication and reliability of U.S. surveillance and intelligence technologies and goes some distance to assuage any lingering reservations that the threat posed by Iraqi weapons of mass destruction is real.

Like the picture of the al-Sajoud Palace, photographs are often blended with maps, yet it is doubtful that readers could independently identify what is being depicted. Immediately following the Chernobyl disaster, an image of an Italian concrete factory was passed off as the nuclear complex to American television networks (Mitchell, 1992). Like the concrete plant, few readers may be able to identify a presidential palace with certainty, but given the veracity of the visual image, even fewer are likely to question its authenticity. Instead, and especially when used in conjunction with a map, photographs and images emphatically underscore the integrity of the entire composition.

". . . when used in conjunction with a map, photographs and images emphatically underscore the integrity of the entire composition."

The public stance of the Bush Administration, as well as much of the public dialogue, on both the war in Iraq and the actions in Afghanistan, involved a distinct dualism. On the one hand, these were military actions that targeted enemies, which were well articulated, both ideologically and geographically. On the other hand, a purported objective of these actions was to liberate the peoples who had been oppressed by these common enemies within. This dualism, however, is not reflected in the maps that we examined. Instead, the enemy is most often delineated by geographic boundaries through maps like that shown in Figure 8. A U.S. soldier equipped with the latest technology literally dwarfs Iraq, which might fit conveniently under the trooper's boot. If this visual metaphor does not portray adequately Iraq's hopeless position, the country is encircled by air, navy, and army bases. Text boxes with flags of neighboring states that surround Iraq further tighten the noose, even if the role of some of these states remains ambiguous.

With Iraq quickly overpowered, at least in the maps on the pages of the country's news weeklies, and with what appeared to be early success

Figure 8. "Strike Force." Time, 17 March, 2003. © 2006 Time Inc. All rights reserved. Reprinted from **Time Magazine** ® with permission*. Cartography by Jackson Dykman. (see page 93 for color version)*

of the invasion, cartographic emphasis shifted to Baghdad, an important symbolic target and, presumably, the principal strategic objective. Maps with titles like "Targeting Baghdad" (2003), "Inside Baghdad" (2003), "Battle for Baghdad" (2003), and "Pinpointing Baghdad" (2003) speak to the importance of the capital, while assuring rapid and successful occupation of the city. Nearly all these map compositions use satellite imagery of the city in some fashion. Like the photograph, this imagery makes an implicit but strong statement about the United States' technological sophistication, its detailed understanding of the city's geography and crucial infrastructure. In "Pinpointing Baghdad" (Figure 9), these messages are reinforced by ubiquitous flashpoint symbols as well as photographic evidence of the effects of technological and military superiority. Like Iraq as a whole, Baghdad has been occupied and conquered by maps.

"Like the photograph, this imagery makes an implicit but strong statement about the United States' technological sophistication, its detailed understanding of the city's geography and crucial infrastructure."

Constructing Geographic Knowledge

No matter how any particular map is interpreted or deconstructed, a distinct pattern is unmistakable in the news-weekly maps that appeared from the beginning of military action in Afghanistan through the Second Gulf War in Iraq. The earliest maps of Afghanistan boasted visually of U.S. superiority and seemed to promise quick and complete retribution against Osama bin Laden and Al Qaeda. As the action wore on with, at best, limited success, the maps offered up apologies in the form of hostile physical environment and absence of infrastructure. With little breaking news in Afghanistan, attention began to dwindle as the Bush Administration looked toward Iraq. Maps now provided justification for an inevitable U.S. attack, and although one or two maps explored the possible connections with international terrorism, the real focus was on weapons of mass destruction. The cartographic evidence of these weapons alone offered ample justification for military invasion, and with the invasion, once again, came maps that demonstrated military might of the United States, not unlike those maps that illustrated actions in Afghanistan. Rapid troop movement with seemingly few obstacles redirected cartographic attention

"Like Iraq as a whole, Baghdad has been occupied and conquered by maps."

"Maps now provided justification for an inevitable U.S. attack . . . The cartographic evidence of these weapons alone offered ample justification for military invasion."

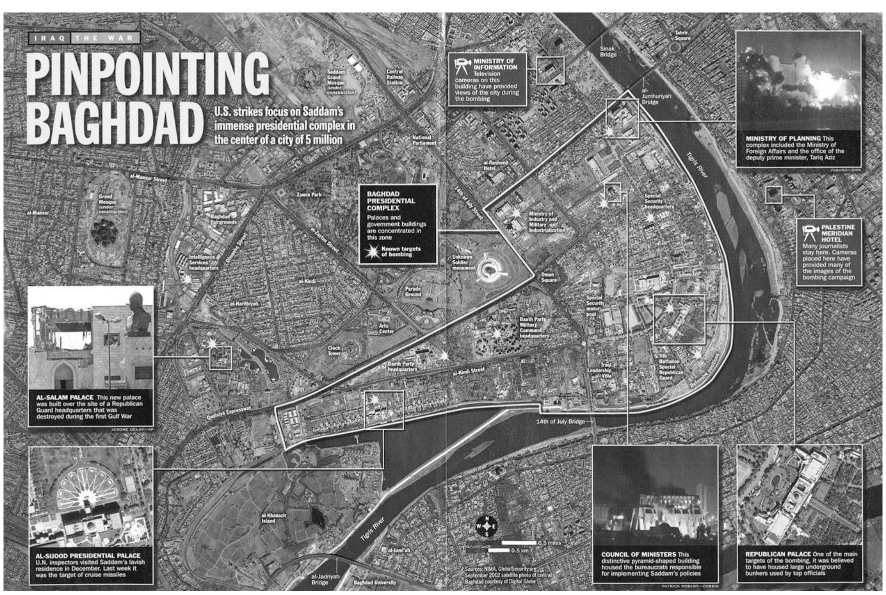

Figure 9. "Pinpointing Baghdad." Time*, 31 March, 2003.* © 2006 Time Inc. All rights reserved. Reprinted from **Time Magazine** ® with permission. *Satellite image courtesy of DigitalGlobe. (see page 94 for color version)*

to the acquisition of Baghdad, surely an important trophy, if not as significant as Saddam Hussein himself. Within days of the invasion, until its conclusion some three weeks later, maps of Baghdad became the cartographic lingua franca in reporting the war.

Although the maps in the news magazines that we examined exhibited some distinctive design characteristics and varied significantly in total volume among publications, we observed little significant difference in cartographic perspective and voice. Compare, for example, the representations of actions in Afghanistan that appeared in *Time* (Figure 1) and *US News and World Report* (Figure 2); or contrast the map from *Time* (Figure 5) and *Newsweek* (Figure 6), both of which impugn the intentions of Saddam Hussein. Because collectively these maps are the creations of private commercial entities, they almost certainly are affected by, and to some degree reflect, a larger social context. There seems even less question that these maps affect the perspectives of their readers, yet any effort to precisely and unequivocally associate these perspectives with journalistic maps is faced with difficulty at several levels.

"Because collectively these maps are the creations of private commercial entities, they almost certainly are affected by, and to some degree reflect, a larger social context."

From a methodological point of view alone, assessing empirically how these maps shape and transform geographic knowledge for their audience seems a daunting task, the more so when photographs and images add color, dimension, and veracity to the cartographic message. A credibly designed study that might conclude 'Such and such a percentage of the public believes that failure to root out Osama bin Laden is due to impediments depicted on media maps' is clearly impracticable. Because Americans are exposed to an almost countless number of maps and map images daily, because ours is a map immersed society, much of the message conveyed by media maps may be subtle if not entirely subliminal (Vujakovic, 1999b; Gilmartin, 1988). And since the makers of these maps are immersed in the same social fabric and subject to the same values and dialogues, it can not be tacitly assumed that the display of power or strength or technical superiority in their maps is a deliberate and conscious act. Most often, we suspect there is no such deliberate intent (Pugliese, 1988). Some members of the *Geopolitik* school, for example, implored each other to be scrupulously objective in constructing their maps for fear of losing credibility, yet in contemporary context, the resulting maps appear markedly subjective if not blatantly propagandistic (Herb, 1997).

". . . the impact and importance of media maps are undeniable. From print to television to the Internet, maps have become an integral and ubiquitous element of the social dialect."

That media maps are likely not conceived to advertently advance a particular point of view but rather are inadvertently influenced by the social context and ideological values of their makers may confound rather than clarify efforts to understand the role of these maps in the public discourse. But the greater irony here is that for the same reasons their effects are difficult to measure, the impact and importance of media maps are undeniable. From print to television to the Internet, maps have become an integral and ubiquitous element of the social dialectic. Because the public accepts these maps as the first line of geographic knowledge, coupled perhaps with a lack of cartographic understanding, maps speak with unquestioned authority, an authority that is almost certainly reinforced by the sophisticated and complexly layered confections in which these maps are often presented.

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cartographic techniques

Shape Types for Labeling Natural Polygon Features with Maplex

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INTRODUCTION

Automated label or text placement has made great strides in recent years, particularly with respect to labeling point and line features. However, the same cannot be said for polygon features. One of the main difficulties is determining whether the text should be inside or outside the polygon's perimeter, and whether the text should follow the general trend of the polygon or just flow horizontally within the polygon. The problem is relatively easy to solve when the polygon is substantially larger than the text, or if the text is substantially larger than the polygon. However, for many natural features such as smaller lakes, rivers, canyons, valleys, ridges, or mountain ranges, the text will occupy an area that is not substantially larger or smaller. Also, many of these kinds of features are not simple shapes, but instead have prongs, blobs, or bottlenecks; or are simply splotchy. Each of these kinds of shapes should be approached differently when it comes to cartographic text placement. This article describes a methodology for automatically describing such shapes in order to have Maplex, ESRI's cartographic label placement extension automatically place their names on a map.

OVERVIEW

This paper is about a method for describing polygons that represent natural features, so that feature label placement rules can be derived for Maplex, a cartographic label placement extension for ArcGIS. These label placement rules must take into account preferred placement style (curved, horizontal, etc.), options for type placement (for example character spacing), and coping strategies to deal with contextual circumstances that impinge on the space available for text placement.

The main issue here is that all kinds of polygon shapes can exist in polygon datasets for hydrography or physiographic features. For some of these shapes the best rule would be to curve the text, inside the polygon, along its major trending axis, provided the polygon is large enough. If that polygon is too small, then the text could be curved outside the polygon, along the edge (if the polygon is large enough. If not, then the label could be placed horizontally, and if need be, with a leader line connecting the text and the feature. For round-ish polygons, it makes sense to place the text horizontally inside the features, and if absolutely necessary overrun the feature's edges by a small amount; otherwise if the text is too large, place it outside of the feature. The task here is how to tell Maplex what the general shape of the feature is so that the correct placement rule can be applied.

METHODOLOGY

To accomplish this goal two pieces of information are needed. First is to find the shape of the polygon: is it relatively long, oblong, or round? Second, is to find out how large the polygon is within the context of the space needed to place text. To do this, the polygon's minimum bounding rectangle (MBR) is used. The ratio of the length to the width of the MBR gives a good indication of how long or round the polygon is. Then the percentage of the MBR's area that the polygon occupies indicates whether the polygon is substantial.

The term, minimum bounding rectangle has been used extensively in many computational contexts, and therefore means different things to different people. In this case, it is the smallest rectangle that can be fitted around the polygon, often requiring the rectangle be rotated away from alignment with the x and y axis of the coordinate system used to define the polygon. Figure 1 shows an example of a MBR, and Figure 2 shows, for the sake of this discussion, a minimum bounding envelope (although such has been called a MBR in many other contexts, such as Zhou, *et.al,* 1999).

MBRs have been used extensively in selection and spatial indexing in GIS, to describe shapes and text in rough but efficient terms for conflict detection, and in many other computational and analytical contexts (Examples include Abdelmoty and El-Geresy, 2004; Papadias, *et. al.,* 1995). MBRs have also been used as a rudimentary basis for automated text placement

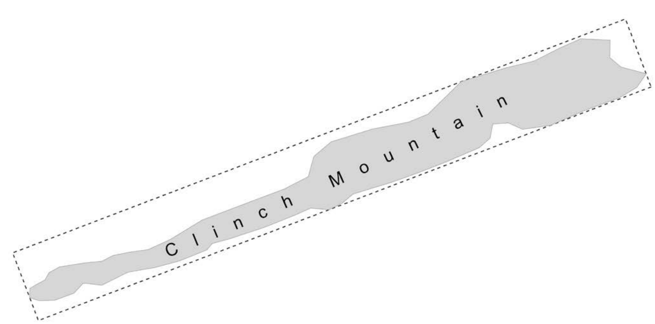

Figure 1. Example of a minimum bounding rectangle.

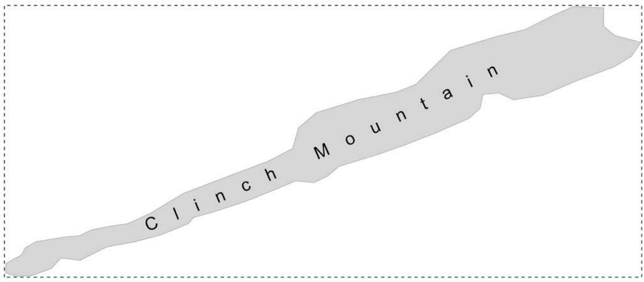

Figure 2. Example of a minimum bounding envelope.

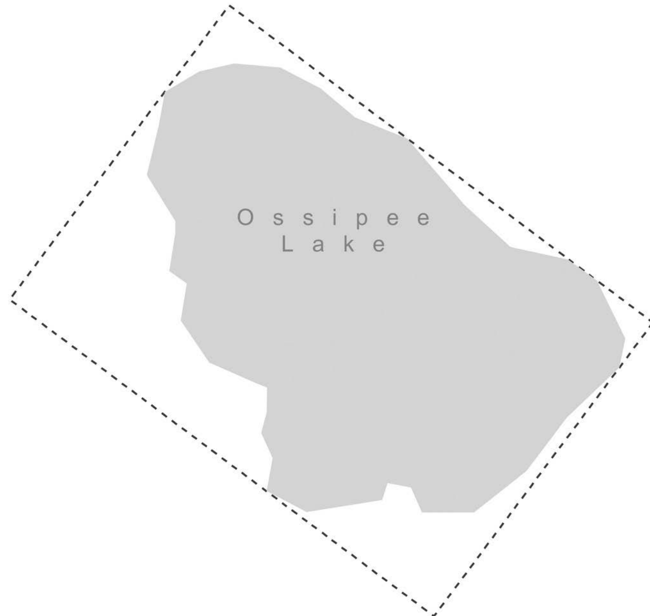

Figure 3. Example of round-ish polygon.

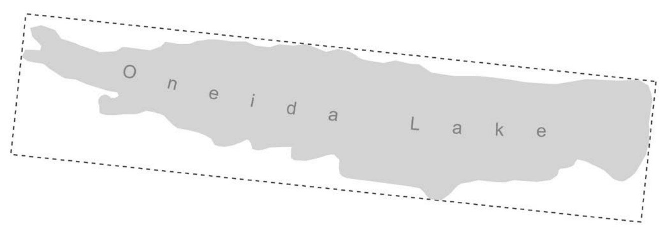

Figure 4. Example of an oblong polygon.

algorithms. This paper formalizes a more refined use of MBRs for text placement.

In order to use this method on a polygon data set, four additional fields that contain information that enables label placement are needed in the attribute table. These four fields would contain information on:

- RatioL2W: double/float. This will contain the ratio of the MBRs length to its width for each feature; it is for analysis and evaluation of results
- MBRArea: double/float. This will contain the percentage of the MBR's area that the polygon occupies; it is for analysis and evaluation of results
- LabelSize: short integer. This is optional, but useful if the range between the size of the smallest polygon and the size of the largest polygon is more than two orders of magnitude.
- LabelType: short integer. This is required and contains values ranging from 1 to 7, describing the seven types of shapes will be the basis for Maplex rules. The seven shape types are:

1. Round-ish: (see figure 3)
2. Oblong (see figure 4)
3. Long (see figure 5)
4. Long and Skinny (see figure 6)
5. Splotchy (see figure 7)
6. Snaky or Pronged (see figure 8)
7. Snaky or Pronged and Skinny (see figure 9)

In order to create the information that is stored in these fields, a Python script was written and uses an ArcGIS 9.2 geoprocessing command called "GEOMETRY:HULLRECTANGLE". This command returns a string containing the eight coordinates of the MBR. With these coordinates the RatioL2W and MBRArea field values can be set. The values for the LabelType field are set based on the following pseudo-code logic:

```
If RatioL2W < 4 and MBRArea > 60%
    Label Type = "Roundish"
Elseif RatioL2W < 8 and MBRArea > 25%
    LabelType = "Oblong"
Elseif RatioL2W >= 8 and MBRArea > 10%
    LabelType = "Long"
Elseif RatioL2W >= 8 and MBRArea <= 10%
    LabelType = "Long and Skinny"
Else
    If RatioL2W < 4 and MBRArea >= 20%
        Label type = "Splotch"
    Elseif RatioL2W < 8 and MBRArea > 12%
        Label Type = "Snaky or Pronged"
    Elseif RatioL2W < 8 and MBRArea <=12%
    Label Type = "Snaky or Pronged and Skinny"
```

This logic is essentially first determining whether the shape is round-ish, and if not, if it is oblong or long, and if not, if it is a splotch, or snaky or pronged. The specific thresholds may need to be tuned to specific cartographic requirements.

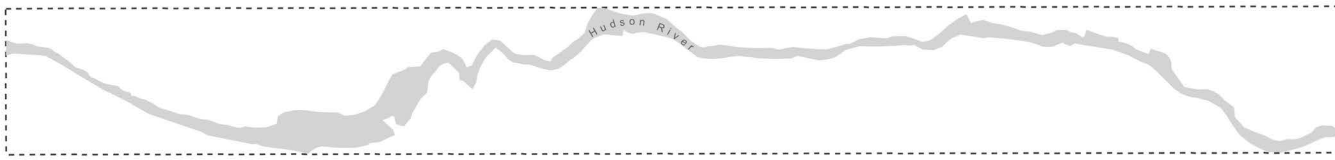

Figure 5. Example of long polygon.

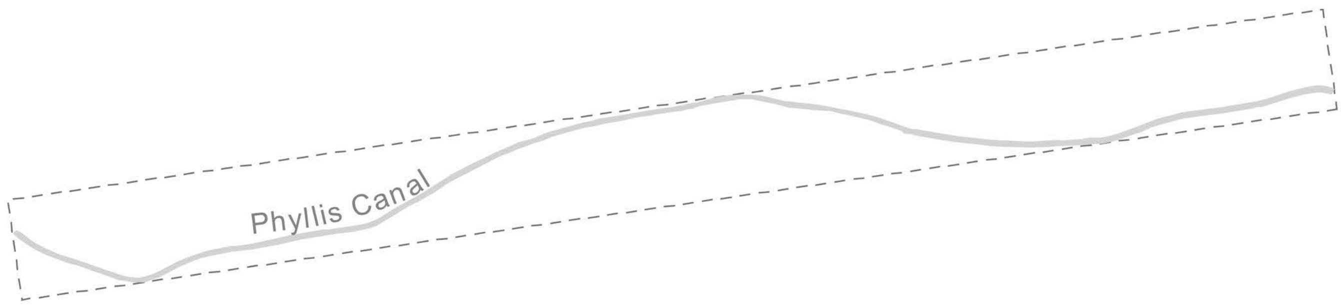

Figure 6. Example of a long and skinny polygon.

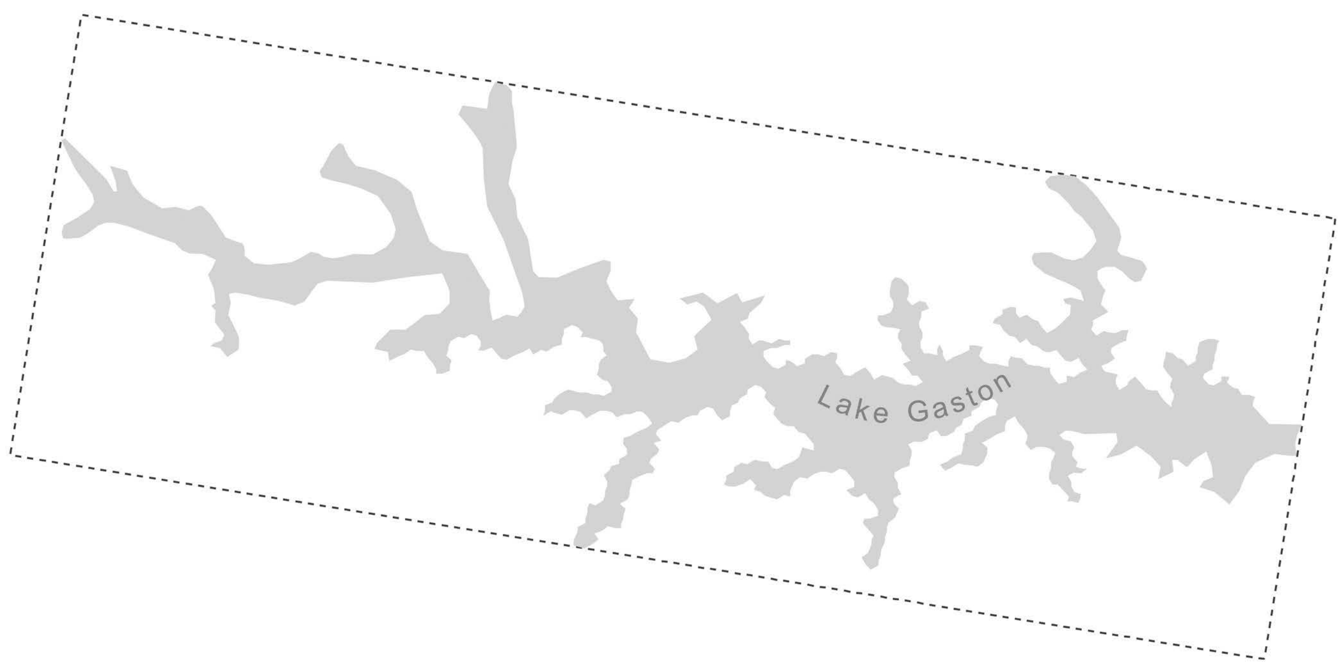

Figure 7. Example of a splotch polygon.

The final field, LabelSize, is based on a binary regression classification. That is, size classes are determined based on the range area between the smallest polygon and the largest polygon. The classes are determined by initially cutting the range in half and the upper portion becomes the first class (for the largest features). Then the lower half is cut in half and its upper portion becomes the next class. This is repeated until the desired set of size classes is codified.

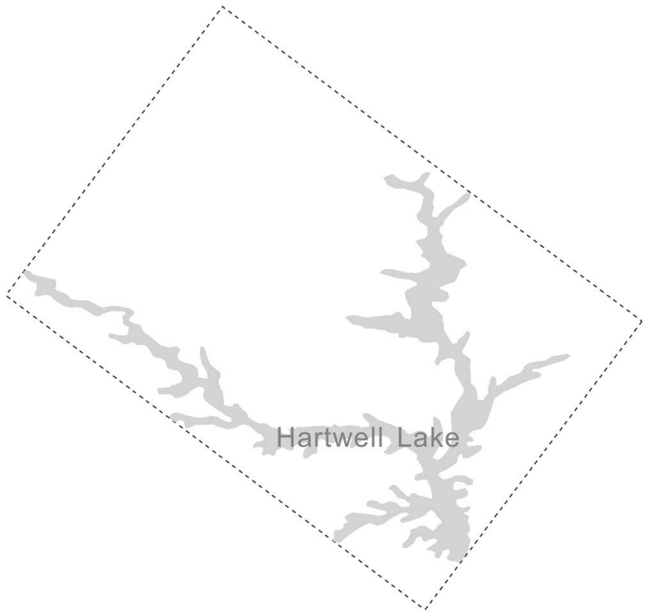

Figure 8. Example of a snaky or pronged polygon.

Figure 9. Example of a snaky or pronged and skinny polygon.

To use the result in ArcMap with Maplex, the polygon data is added as a layer and the following steps are implemented:

1. In the label properties dialog's symbology tab, choose to symbolize with the data using Categories: Unique Values Many Fields option.
2. Choose the LabelType and LabelSize fields and click the "Add All Values" button; then click the OK button to close the layer properties dialog box.
3. Open the Label Manager dialog (on the labeling toolbar) and click on your layer's uppermost line in the Label Classes list.
4. In the "Add label classes from symbology categories" section click the "Add" button. Click yes in the resulting message box to overwrite any existing label classes. (Note at this point you can close the Label Manager dialog and go back and set the layer's symbology to any desired method and symbols.)
5. In the label manager the following Maplex rules can be applied. These rules are described in general for just one size class; typically the size class would dictate the size or size range of the text symbol.

   a. Round-ish
      i. Placement: Curved
      ii. Try Horizontal First = true
      iii. May Stack = true
      iv. Character Spacing = up to 200%
   b. Oblong
      i. Placement: Curved
      ii. May overrun by 36 pts
      iii. Allow asymmetric overrun = true
      iv. Char. Space = up to 200%
      v. Reduce font from 14 pts. to 10 pts. by 1 pt. increments
   c. Long
      i. Placement: Curved
      ii. May overrun by 12 pts
      iii. Char. Space = up to 300%
   d. Long and Skinny
      i. Placement: Boundary
      ii. May Place Outside = true
      iii. Offset = 4 pts
      iv. Char. Space = up to 240%
      v. Background Label = true
   e. Splotch
      i. Placement: Curved
      ii. Char. Space = up to 300%
      iii. Reduce Font from 14 pts. to 10 pts. by 1 pt. increments
   f. Snaky or Pronged
      i. Placement: Curved
      ii. May overrun by 12 pts
      iii. Char. Space = up to 400%
   g. Snaky or Pronged and Skinny
      i. Placement: Boundary
      ii. May Place Outside = true
      iii. Offset = 4 pts
      iv. Char. Space = up to 240%
      v. Background Label = true

The above placement rules often work very well, but in the skinny cases (cases d. and g.), the orientation of the label with respect to the feature on the page does not work well; however, this is the best option currently available.

Finally it is worth noting the distribution of these shape types in terms of their frequency of occurrence in a variety of datasets. Table 1 shows that in each of these datasets there are many shapes in the round-ish category, which require different Maplex rules than the oblong and long shapes, which are also well represented. Thus, by using this method the amount of effort, particularly manual editing of text, is roughly cut in half.

	Data				
Shape Type	**Hydro 1M**	**Physio-graphic**	**Soils 25K**	**Hydro 5K**	**Vegetation 5K**
Round-ish	364	278	445	1786	14380
Oblong	592	211	1261	950	870
Long	11	14	8	931	70
Long & Skinny	0	0	0	157	0
Splotch	35	2	30	26	14
Snaky or Pronged	33	7	39	135	17
Snaky or Pronged & Skinny	2	1	2	489	5

Table 1. Feature counts for each type for five data sets. The datasets are: (1) Hydro 1M: Hydrography for 1:1,000,000 of the northeastern United States, (2) Physiographic features of North America, (3) Soils for Ada County, Idaho, (4) Hydro Areas for Ada County, Idaho for 1:5,000 scale maps, and (5) Vegetation for Ada County, Idaho for 1:5,000 scale maps.

CONCLUSIONS & FUTURE WORK

This method of identifying shape types for labeling has worked well in creating general reference maps at scales ranging from 1:5,000 to 1:1,200,000, on natural and built hydrographic polygons, and on physiographic features. This method could also be very useful in labeling vegetation type, soil type, surface geology type, and many other such features. A more complicated adaptation of this method is also being tested as a basis for identifying features to be eliminated or generalized on maps at scales smaller than the data was originally intended. Initial results of this work are quite promising.

In general, the ability to enhance GIS data that were not captured with the intent of creating higher quality cartography in a highly automated fashion is valuable. Many cartographic operations in GIS are conducted by attempting to directly and often simplistically translate GIS features that were captured independently of any cartographic product requirements into a product-specific semantic and graphical context. The result, not surprisingly, is an awkward mix that defies stylistic and semantic expectations. The method described in this article successfully adds additional meaning to the GIS features before attempting a requirements-based transformation into a cartographic solution.

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reviews

Applied Environmental Economics: A GIS Approach to Cost-Benefit Analysis

Ian J. Bateman, Andrew A. Lovett and Julii S. Brainard
2005; Paperback edition, 335 pages, $43
New York: Cambridge University Press
ISBN-13 978-0-521-67158-3

Reviewed by Grace Wong
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Conservation International

In a decision-making process, economics plays a role to finding the most efficient and cost-effective solution amongst various options. The efficient solution is typically one where resources will be properly allocated based on their economic value in markets. This very basic economic assumption has proven to be a thorn, particularly in decisions relating to land use and land cover change, as these changes impact the natural landscape and have wide ranging environmental consequences that often cannot be adequately measured nor traded in markets.

The book by Ian Bateman and his colleagues from the University of East Anglia seeks to address this issue by incorporating the non-market environmental values of land use and land cover change into standard cost-benefit analysis (CBA) to support decision-making. In addition, they push the analytical boundaries further by incorporating Geographic Information Systems (GIS) in the analysis to account for spatial and geophysical differences that are likely to impact on those values. This book demonstrates a number of ways that GIS can be employed to improve the way in which real world complexities are incorporated into CBA, thus reducing the need for simplifying assumptions.

The use of GIS is well established in the field of land and natural resource management. It provides a powerful tool that can integrate and overlay spatial data from a range of sources, undertake a wide range of analytical operations, and produce results in mapped, graphed or tabular form. While its application in traditional economic analysis is less common, the flexibility and benefits of GIS are becoming readily apparent to many environmental and resource economists who are tackling land, resource and conservation issues.

The review and analyses presented in the book is based around a UK study that examines the economic potential for conversion of land from conventional agriculture to multi-purpose woodland in Wales, with the assumption that multi-purpose woodland is a more desirable land use from an environmental viewpoint. The book examines the possible economic returns from woodland and agriculture using a range of environmental, resource and agricultural economic methodologies, and it undertakes a cost-benefit analysis (CBA) that aims to incorporate a full range of economic values and the spatial element of those values. In this case, the total value of woodland is comprised of its recreation and timber values, and carbon sequestration potential.

The book is arranged into 10 chapters. The first four chapters are related to non-market valuation methods and their application to the recreational value of woodlands. The book begins by describing the basic economic theory underlying concepts of valuation and how ethical considerations may influence incorporation of non-use values in the analysis (Chapter 1). Having explored the question of ethics and sustainability, the authors ended up to using a methodology that is neoclassically utilitarian in its ethical basis. A brief introduction to GIS is also included. The next chapter (Chapter 2) reviews the different non-market methods for estimating recreation benefits; focusing in particular on the contingent valuation (CV) and travel cost (TC) methodologies. For readers who are unfamiliar with these techniques, the authors provide a useful critique of each method and highlight where their application is most appropriate. Chapter 3 reviews previous CV and TC valuation studies of woodland recreation in the UK, including those by the authors of this book, and identifies a number of problems with these studies in terms of methodology, data analysis and reporting. In their own applications of these valuation techniques, the authors improve upon the standard CV and TC techniques by using GIS mapping capabilities to standardize and improve the derivation of key variables such as travel distance and duration, but they are still unable to overcome some of their earlier concerns as their analysis generated large variations in the valuation estimates. These results are, nonetheless, transferred to the case study area and used to generate predictions of latent demand for visits (Chapter 4). GIS is used to manipulate the travel data to provide further accuracy of travel costs, and to generate a transferable arrivals function in order to predict the number of visitors to a particular woodland site. This information can then be extrapolated to other sites. The results from studies reviewed in the previous chapter are used to obtain the value of potential demand for recreation.

The book then turns to tree growth and the timber industry in its next three chapters. Chapter 5 provides a useful overview of the industry for those unfamiliar with the history and policy structure of the commercial timber industry in the UK. This information provides the basis for construction of a timber valuation model to assess the current social and private value of timber production. Costs and revenues are then determined for a softwood (sitka spruce) and a hardwood (beech) species, and a review of the appropriate discount rates for the various decision-makers are also considered. Timber yields are then estimated using yield class models and are mapped using GIS (Chapter 6). The strengths of GIS lie in its ability to incorporate bio-geophysical and environmental information such as elevation, soil type, temperature and rainfall, and its ability to display the results spatially. The analysis of woodland values also includes the net benefits of carbon sequestration (to offset the global warming effects of carbon dioxide emissions) provided by forests by extending the timber yield model to estimate net carbon storage (or emissions where appropriate) in live biomass, wood products, waste and soils (Chapter 7). The analysis is undertaken for both tree species to quantify their carbon sequestering potential in the land use change scenario from agricultural to multipurpose woodland.

The subsequent chapters look at the opportunity cost of converting existing agricultural land to woodland in the case study area of Wales. The authors developed models to calculate farm-gate (financial) and social values for the two dominant agricultural production activities in the area: sheep and dairy farming (Chapter 8). Following a review of UK agricultural policy, the market and shadow values of sheep and dairy enterprises are estimated. It would appear that the low and declining levels of farm profitability during the study period would suggest that there are likely to be significant potential for efficiency gains in a change of land use from farming to woodland.

This intuition is confirmed in the CBA which assesses the net benefits of converting land from agriculture into woodland (Chapter 9). While current level of woodland grants and subsidies is still insufficient to catalyze land use conversion from the farmers' perspective, the authors suggest that a relatively modest increase in grants and subsidies would generate substantially higher net social benefits to the broader society. The various strands of analyses from previous chapters relating to recreation, timber values, carbon sequestration and agriculture are synthesized and overlaid using GIS value maps. These maps illustrate that there is large spatial variation in net present values (NPV), which would not have been evident if a global NPV had been produced for the entire study area as in traditional CBA techniques. Both the market and social-environmental assessments are presented and, as can be predicted, the results demonstrate sensitivity to whether the analyses are restricted to market prices or extended to include the various non-market values. In addition to the spatial factors, the choice of discount rate, choice of woodland tree species to be planted, and other policy variables also impact the sensitivity of the results.

The final chapter (Chapter 10) summarizes the research findings, identifies some of the limitations of the analysis, and highlights the omission of certain critical non-market values (such as biodiversity and habitat values of woodlands) from the overall CBA.

Readers who are familiar with GIS methodologies and with expectations of substantial advancement and innovation in the application of GIS to applied economic analysis might be slightly disappointed, given the title of this book. While the overall application of an integrated environmental and economic CBA in this study is very sound and provides some interesting results, GIS is largely used only as a supporting tool to integrate multiple data layers for the economic analyses. A natural next step would be to build upon the book's current approach and use GIS as a scenario building tool to examine the potential levels of land use change under the different policy options, and to map their resulting social, economic and environmental consequences.

Nonetheless, the authors have provided extremely useful insights into some of the capabilities of this tool, and their comprehensive documentation of the study methodology allows for this approach to be readily adapted to other regions and contexts when considering land use change options at a regional scale, whether for development or conservation objectives. The authors should be lauded for their very strong, creative and expansive efforts.

Maps and the Internet, with CD insert
Edited by Michael P. Peterson
Oxford, United Kingdom: Elsevier, 2003.
ISBN 0-08-044201-3

Reviewed by Daniel G. Cole
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This multi-authored work, which was published three years before this review, addresses the issues and developments of internet-focused cartography at the start of the 21st century. Books of this type are often out-of-date relatively soon after going to print. While that can certainly be said for portions of this book, this reviewer can state at the start that this or a newer edition should still be on the shelf of most cartographers. The book is divided into four parts with 28 chapters written by 35 authors. The organization is logical, and, while some of the chapters could have been combined, the book is well-indexed, and progresses with the individual chapters usually able to stand on their own.

Part One (six chapters) provides the introduction and covers contemporary issues. The age of the book becomes evident with Peterson's introductory discussion on the historical background of maps on the web and their associated file types (PDF and JPEG). Had the book been published more recently, the JPEG2000 format would have certainly been included. He notes the University of Texas website as being popular, but now he would have to promote David Rumsey's website as well. His discussion of the popularity of MapQuest would now likely have been supplanted by Google Maps with Google Earth.

The second chapter [Krygier, Peoples] on geographic literacy addresses "the issue of map education in a world transformed by the WWW" (p. 17). The web enables students "to engage in diverse, active mapping" but "requires more than teaching about the latest WWW mapping sites" (p. 18). Indeed, since maps are often viewed uncritically, whether on paper or over the web, getting students and others to question what they see when maps are displayed is of prominent importance. Krygier routinely has his students check out the static historical map sites such as the Library of Congress and the University of Texas map collection sites, as well as five commercial websites. Krygier and Peoples bemoan that maps and graphics are rarely properly cited , and that a standard bibliographic guide for digital images and maps did not exist (although one can now check the Library of Congress for such a guide: http://memory.loc.gov/learn/start/cite#maps). The authors promote the Census Bureau's American Factfinder site as being very good for learning to use and produce choropleth techniques, classing systems, and map design. They also voice worries about post 9/11 access problems to property records, photos and databases.

Chapter three [Cartwright] focuses on designing web maps since they require a different design and production approach as compared to paper maps, Cartwright points out the considerations that must be taken regarding not only web design, but also concerning the device upon which the maps will appear. As he states, maps on the web are sometimes constrained by the old rules suited to printed maps. Writing today, he might have discussed maps destined to appear on an iPod or Blackberry. Obviously, contrast becomes a primary design component for tiny screens, and compression becomes imperative as well in order to illustrate most map details. He discusses currently available mapping services such as National Geographic's Map Machine, the Alexandria Digital Library Project, downloadable data from USGS, and web atlases including the National Atlas of Canada.

The fourth chapter [van Elzakker, Ormerling, Kobben, Cusi] deals with dissemination of census data with examples from the Netherlands and the Philippines. The four authors built a five-page table of website functionalities for 126 UN countries (expanded to 187 on their updated website). Most allow retrieval of static maps, charts, text and tables, and some allow users to customize individual maps without needing any installation or knowledge of GIS software. Household data is normally withheld, but block data was found to be more than adequate for studying geographic/ethnic/gender/age/income spatial data. One complaint about this chapter concerns the poor figure reproduction of the Philippine website (p.69).

Chapter five [Richmond, Keller] covers internet cartography and official tourism sites. This chapter had copy editing problems. For example, Richmond and Keller state that they examined a sample of 181 maps from 40 official national tourism destination websites, but only list 30 destinations on p. 81. Further, the list is broken down into two tables of 20 and 10 locales with the title of the first table stating 30 rather than 20. The second table repeats the entry id number 2 twice so that a reader not paying close attention might assume that this table contains only nine, rather than ten, sites. Nonetheless, the authors do a good job critiquing the various static and interactive tourist websites and thus how well the sites guide prospective tourists to planned vacation spots. This reviewer wonders if any of these critiques were delivered back to the respective tourist boards.

The sixth chapter [Monmonier] addresses cartographic surveillance and locational privacy. Monmonier notes the concerns regarding location based services: mapping for commercial purposes versus ex-offender mapping during probationary periods, and from the tracking of children and pets to monitoring non-criminals through cell phone use. Traffic mapping, crime mapping and on-line cadastres allow for planning by local governments, while at the same time permit individuals to actively participate in community affairs.

Part Two (ten chapters) deals with technical developments in the field. In chapter seven, Herzog investigates developing cartographic applets. He complains that most maps on the internet "concentrate only on location and routing" (p. 117). His objective was "(1) to make the method of thematic cartography more popular; and (2) to bring specific content - maps of the spatial distributions of socio-economic phenomena - to a broader audience" (p. 118). Speaking of a broader audience, chapter eight's authors [Andrienko, Andrienko, Voss] discuss the CommonGIS Project, a cartographic expert system designed to provide GIS for everyone. That goal, the authors admit, requires an intelligent (knowledge-based) graphic user interface and functionality. They profess success by stating that "First, it assists users to represent data on maps and other graphical displays in accord with principles of cartography and graphic design. Second, it suggests exploratory instruments suitable to the goals of analysis. Third, it assists in utilizing these instruments by context-specific instructions about how to operate them" (p. 145).

The ninth chapter [Jiang] gives a critical methodological discussion of serving GIS internet functionality. Jiang divides the topic into surveys of a server/client model, a peer-to-peer model (P2P), and mobile agents. Chapter ten [Li] presents P2P sharing of cartographic data and software where there is no client or server; rather, everyone is a client *and* server with dynamic IP addresses. Li writes about issues surrounding data sharing and acquisition. While he expresses frustration in dealing with the Federal Geographic Data Committee (FGDC), an appreciation of the data downloads available from various government and commercial sources is made, especially the Geography Network, although neither the FGDC Clearinghouse nor the Geography Network "are easily accessible to individuals who want to publish their data (p. 163)." Li finishes with a discussion of a prototype P2P system.

Chapter 11 [Zaslavsky] is concerned with online cartography using eXtensible Markup Language (XML). Zaslavsky covers the emerging XML standard for encoding spatial data, XML-based languages for 2D rendering, and the use of XML for managing, browsing and harvesting cartographic metadata. The author discusses Geographic Markup Language (GML) and other XML vocabularies, and delves into an extensive treatment of AxioMap, which is an application of XML for interactive online mapping.

The 12th chapter [Neumann, Winter] outlines the use of scalable vector graphics (SVG). Neumann and Winter express the importance and constraints of the SVG open-source standard that allows integration of text, 2D vector and raster files, scripting interactivity, animation, and other special effects. They wisely remind us that "vectors are fully scalable, to the point where [they] can reveal shortcomings in the data (after all, the cartographic data is only scalable within a certain scale range)" (p.199).

Chapter 13 [Lehto] reviews the standards-based architecture for multi-purpose and multi-channel geodata publishing. Lehto addresses a four-tiered architecture encompassing spatial data, information, portal, and mobile terminal services, along with the access interfaces and data encoding between the tiers. Chapter 14 [Tsou] covers the development of intelligent software agent architecture for distributing databases and mapping services. Tsou points out that combining layers from different sources is easy, but making sure that intelligent cartographic design gets implemented is the challenge for cartographers. As a result, he gives three goals: "the ability to search, carry and apply cartographic rules for web mapping applications"; to "provide a dynamic framework to combine different cartographic rules for different mapping tasks"; and to "facilitate the establishment of distributed cartographic knowledge bases (CKB) which can help map users to access/distribute/exchange different cartographic rules, map symbols, color schemes, design layouts, via the Internet" (p.233).

The 15th chapter [Ottoson] deals with 3D visualization through Georeferenced Virtual Reality Modeling Language (GeoVRML). Ottoson reviews the basics of 3D visualization, rendering, and virtual reality, and discusses the current and future trends regarding GML, SVG, X3D, Java 3D, and Mpeg-4 and -7. Chapter 16 [Fuhrmann] concerns supporting wayfinding in desktop geovirtual environments. Fuhrmann describes active tracking through the internet from the observer's position and orientation, noting the relatively easy possibility of getting 'lost' in a virtual environment. He also discusses the development of a prototype; detailing the drawbacks such as lack of realistic rendering, narrow field-of-view, poor spatial resolution and optical distortion.

Part Three (nine chapters) deals with applications and user issues. Chapter 17 [Mooney, Winstanle] is concerned with public transportation information systems and journey planning. Mooney and Winstanley state that while route planning over the internet can be easily and quickly achieved, "producing maps of the same quality as that of human expert mapmakers is still an unsolved task in the area of computer-aided cartography" (p. 291). They further note that building a journey planner, based on public transport (bus, subway and train) can be a daunting task. They provide a critical comparison of public transit websites from Chicago, New York, and Dublin, and two from London.

Chapter 18 [Torguson, Blinnikov] covers an Atlas of Russia created by and for college students as an active learning tool. Combining Russian studies with cartography, Torguson and Blinnikov provided an active learning tool that was flexible, timely, and cost efficient. Chapter 19 [Giordano] concerns an historical geoinformation project in New Bedford, Massachusetts. The author points out that the licensing and permitting process for protecting waterway environments and private property has been in place in Massachusetts since 1866. From this long-term database, Giordano was able, in what is referred to as a 'Chapter 91 Pilot Project', to compile shoreline changes over time while integrating traditional GIS and cartographic tools with multimedia for public education. In the 20th chapter, Hu describes a web-based multimedia GIS project with a case study in the Florida Everglades. He discusses the use of a web server, map server, and data server in a multimedia environment involving digital video, sound, text, and graphics.

Chapter 21 [Caquard] deals with the contemporary possibilities of internet maps and public participation. Caquard argues that thematic maps have traditionally been "designed by experts for the use by experts in centralized top-down management systems" (p.345). He expresses the possibility of the internet offsetting the above statement; indeed, over the past decade a flurry of papers and projects have appeared in forums ranging from NCGIA to URISA promoting public participation GIS. The author warns about three deficiencies in thematic cartography: first, map data may be difficult to understand by the non-expert public; second, map information may not meet the needs of the stakeholders; and third, the appearance of the map as "objective, neutral and precise" (p.348) may, in fact, hide embedded biases. For his study, 12 types of map were analyzed against 12 criteria, examining the differences between static maps (which, like paper, do not invite participation), dynamic GIS maps (where a somewhat partial potential of public participation exists at the end where GIS becomes both the medium and the message), and dynamic maps without a specific relation to a GIS (where spatial communication is more dynamic and interactive, but less analytical). Caquard stresses the importance of qualitative data versus quantitative data for increasing the public participation of internet users accessing raw data to make their own maps suited to their needs. Lastly, Caquard poses the following query: "how can the combination of public participation and the Internet be used to fundamentally be used to rethink thematic cartography?" (p.355)

Chapter 22 [Cammack] is concerned with integrating abstract models of the environment via the internet. In his text, Cammack promotes developing public awareness of environmental issues by integrating abstract map models within virtual reality. He conducted a case study of the Little Sac River basin in southwest Missouri using Quick Time Virtual Reality (QTVR) (Apple) together with ArcIMS using hyperlinks between the two. More research was deemed to be needed. Chapter 23 [Schwertley] deals with QTVR maps for the web. As a pilot study, Schwertley made virtual landscapes of Magnolia, Iowa. He also critiqued existing virtual reality/map combinations of Yellowstone Park, University of Oregon campus, and the Island of Porquerolles, France.

Chapter 24 [Gartner] addresses the concept of telecartography for the mobile internet: "the distribution of cartographic presentation forms via wireless air data transfer interfaces and mobile devices" (p. 386). Gartner predicts that this will be a leapfrog technology, as graphics-capable cell phones, PDAs, PocketPCs, and now Blackberries, become ubiquitous. Chapter 25 [*authors*] describes the use of PDAs with TeleAtlas. Screen resolution, menus, font issues, and overall readability are reviewed.

Part Four (three chapters) concludes with theoretical developments. Taylor, in Chapter 26, covers the concept of cybercartography as a multisensory/multimedia interactive format. But he cautions that "we do not know whether or not a multimedia, multisensory approach is more effective for communication, teaching and learning"…indeed…"merely presenting the same information in several modes does not necessarily facilitate learning" (p.409). Cybercartography is apparently still in its infancy since both the cyberatlases that he cites (Latin America and Antarctica) are still under construction. In chapter 27, Brodersen discusses modeling the visualization of internet maps as a form of cartographic communication. Peterson's Chapter 28 finishes the book by setting the foundations for present and future research in internet cartography. As he notes, the vast majority of maps are now distributed over the internet, and he complains that current research is mostly devoted to the technology. Researchers, largely, are not relying on theory to guide research but are instead chasing technical developments. Like most of the authors in the book, he sees that much work is needed; but at the same time he sees a promising future for the discipline.

The accompanying CD is a mixed bag. Some authors merely reproduce the figures and some internet links from their text. Others more generously provide scripts, bibliographies, slide shows, class notes and exercises, and additional internet resources not noted in the manuscripts. As to be expected after three years, a scattering of sites are no longer active: notably, none of the links worked with Chapter 24. Ideally, the entire text of this book could have been produced on a CD with numerous maps, graphics, videos, and links, and this reviewer would encourage that avenue (moving up to a DVD if necessary) for any future ventures of this type.

color figures

"False Truths": Ethics and Mapping as a Profession

Tom Koch

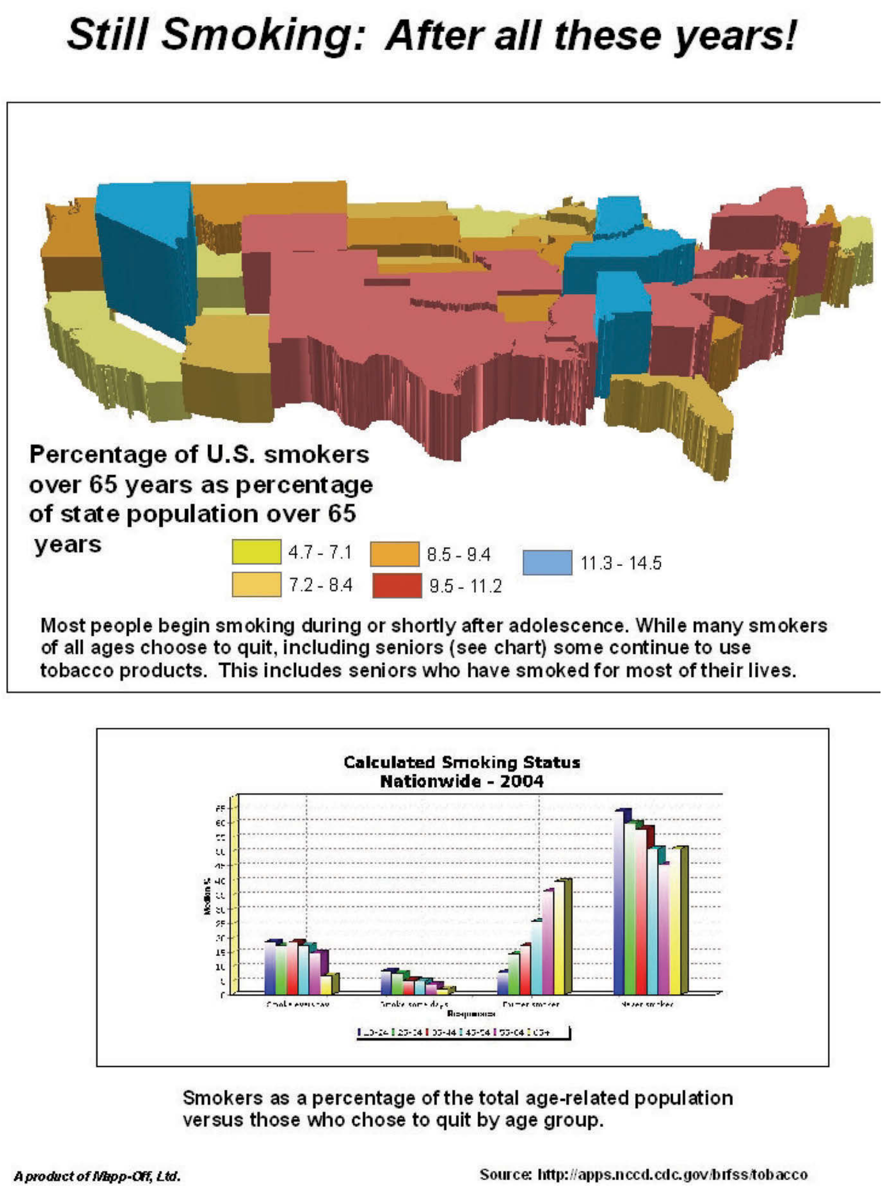


Figure 1. Long-lived smokers is a potential response to the hypothetical ATT contract for a map of data on smokers over 70 years of age in the United States. Map by author.

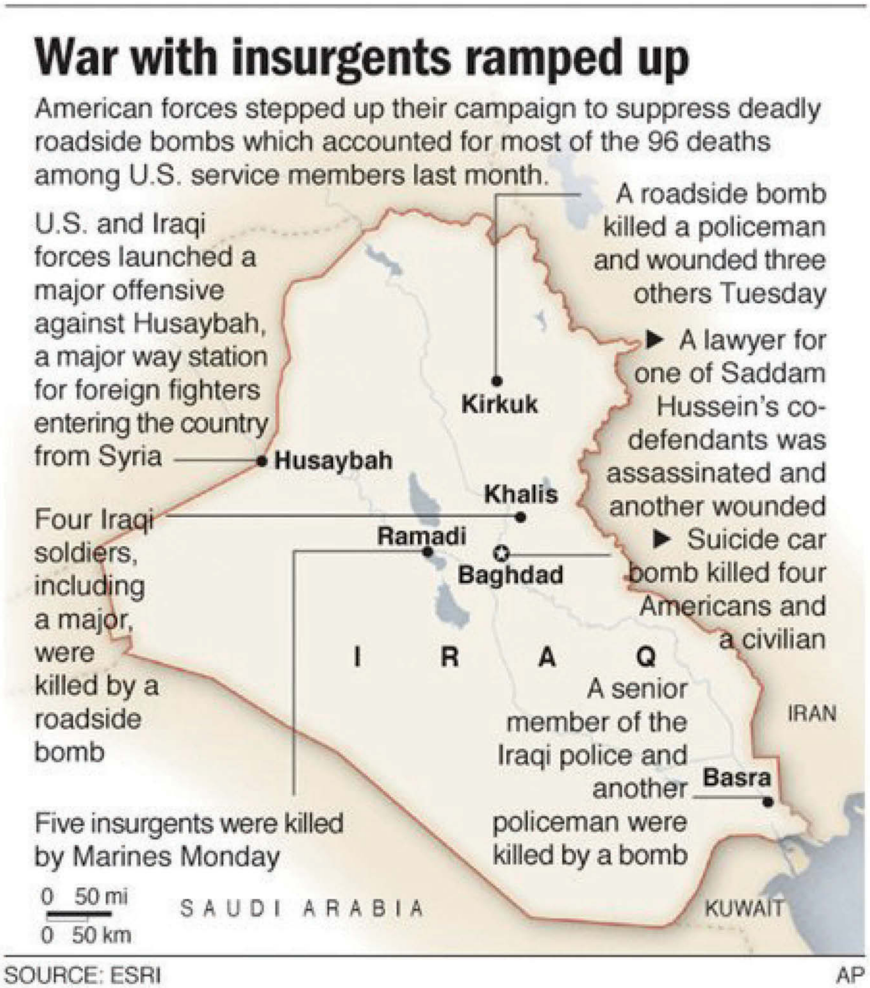


Figure 2. This map-story by the Associated Press of military events in Iraq argued for increased US military activity in response to "foreign" insurgents. (AP Graphic). Accessed 8 Nov. 2005 at http://global.net/.

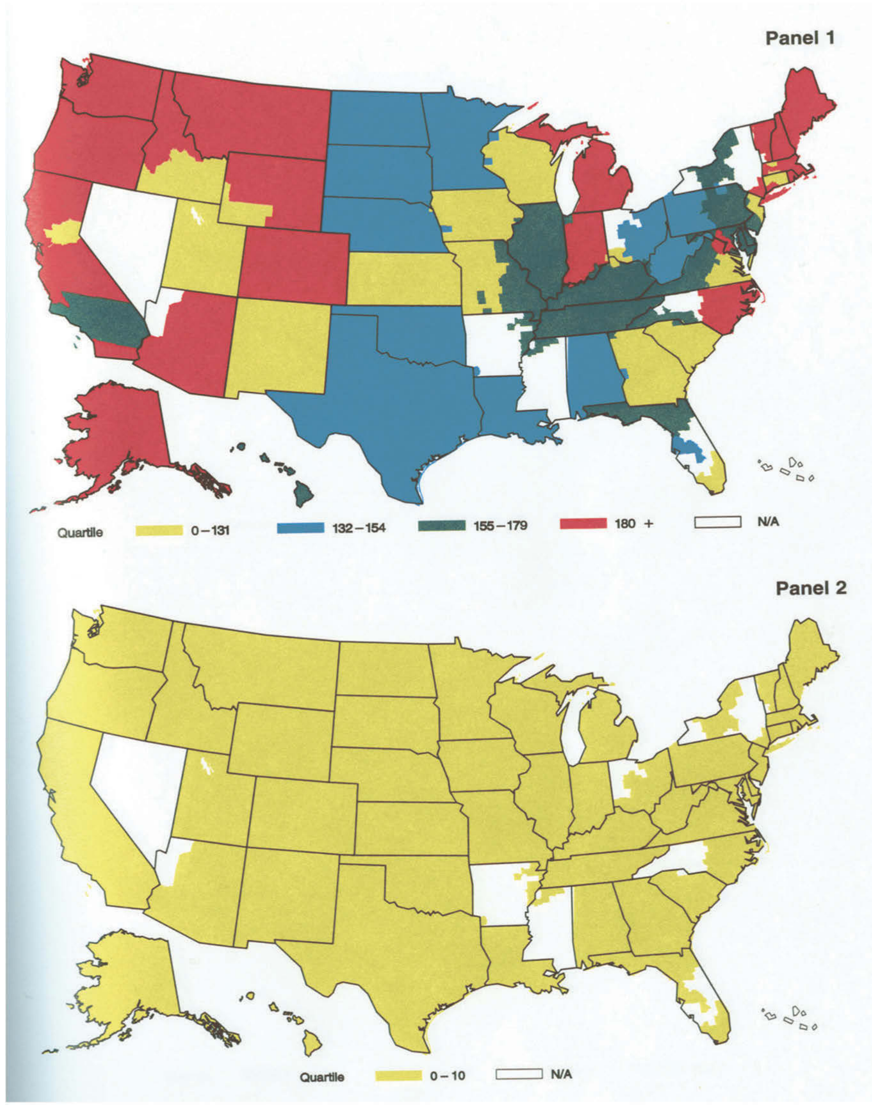


Figure 3. The map of liver transplant candidate waiting times for all those with liver disease (top) and those in urgent need of a liver transplant argued equality of service for critical patients but variable waiting times in some places for non-urgent patients. Source: National Institute of Medicine. Organ Procurement and Transplantation, 58a.

Non-Photorealistic Rendering and Terrain Representation

Patrick J. Kennelly and A. Jon Kimerling

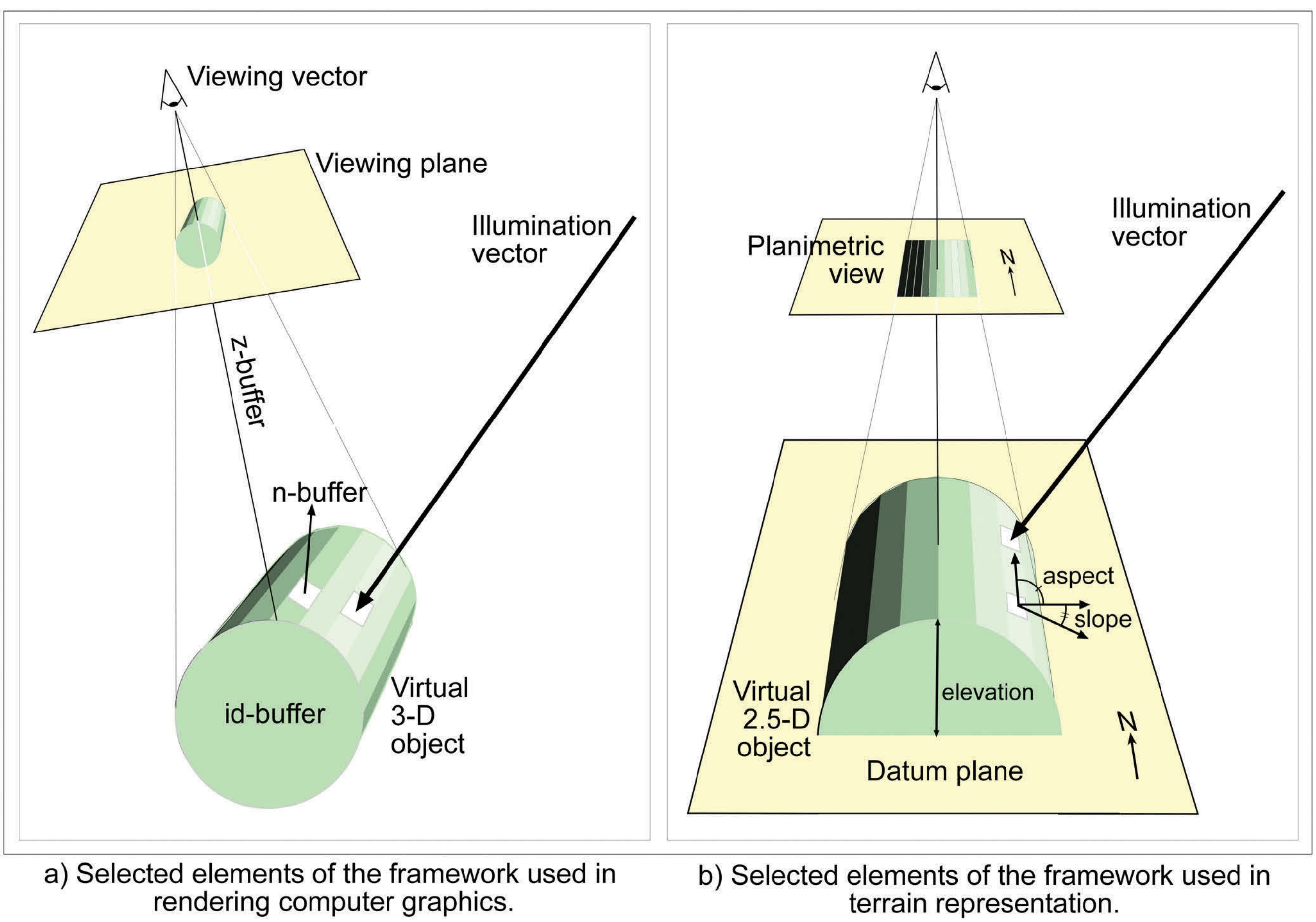


Figure 1. Selected elements of the frameworks used for rendering computer graphics and terrain. a) The geometric buffers used for rendering, including the z-buffer, n-buffer, and id-buffer. Also shown are the relationships among the viewing vector and plane, the 3-D virtual object, and the illumination vector. b) The metrics used for representing terrain, including elevation, slope and aspect. Also shown are the relationships among the planimetrically correct map, the datum plane, and the illumination vector.

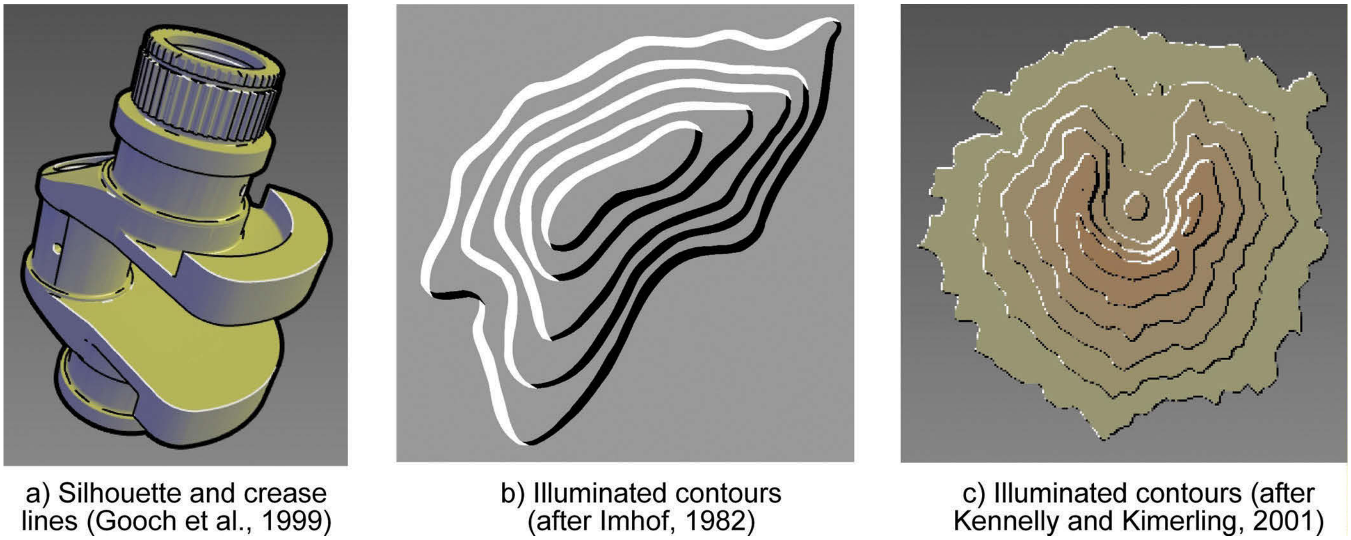


Figure 7. A comparison of illuminated contours with crease and silhouette lines. The right shows silhouette lines in black and crease lines in white designed to communicate the shape and structure of a complex mechanical model (Reprinted from A.A. Gooch and B. Gooch, 1999 with permission from ACM SIGGRAPH). The middle is a hand-rendered illuminated contour map (Modified from the cover of Imhof (1982)). The left is a computer automated illuminated contour map of Mt. St. Helens in Washington state (modified from Kennelly and Kimerling (2001) with permission from Cartography and Geographic Information Science).

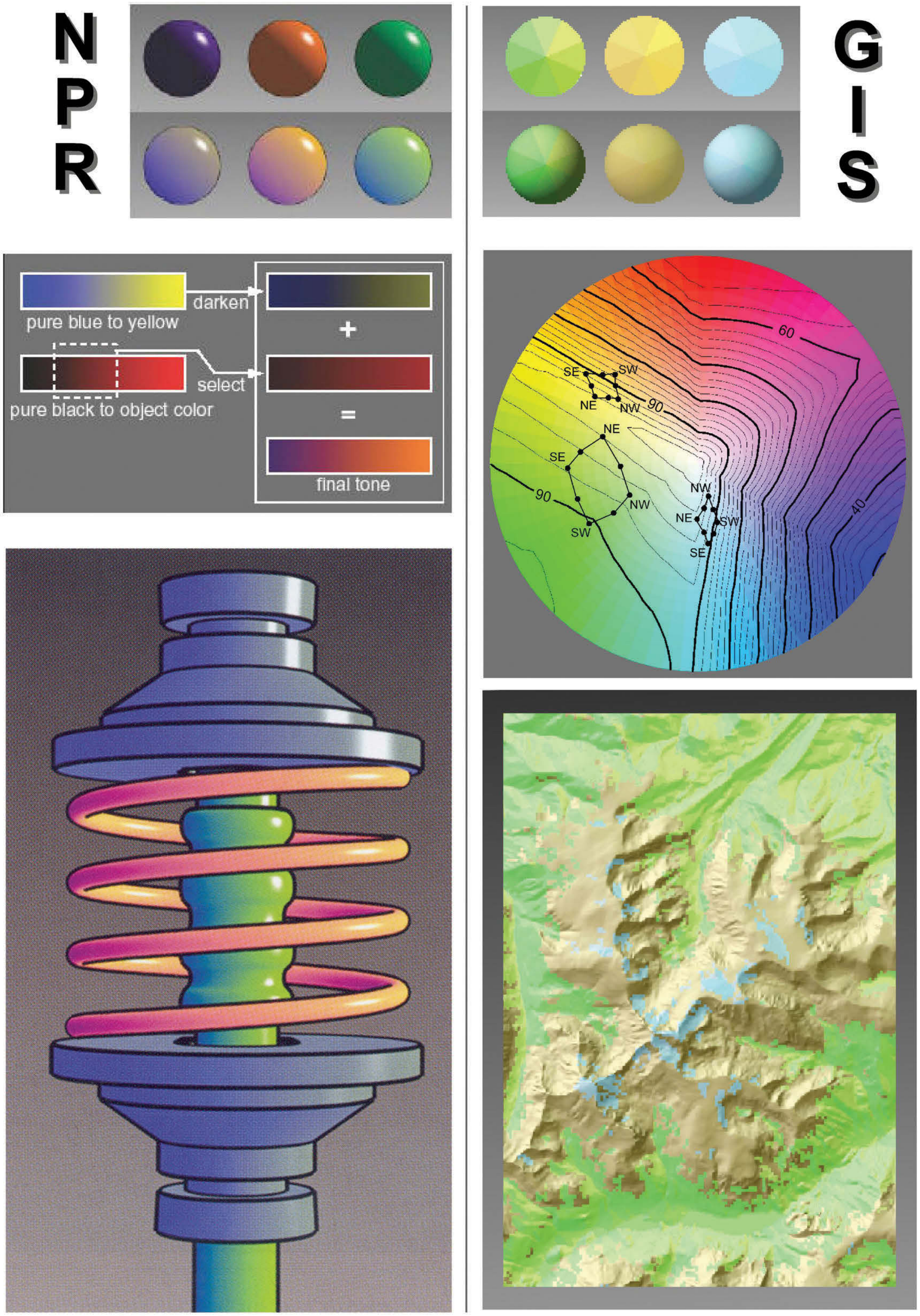


Figure 9. These two coloring schemes add color details and highlights to conventional shading techniques. The NPR technique on the left uses cool to warm undertones to add subtle tonal variations to object colors (From Gooch et al., 1998 with permission from ACM SIGGRAPH). The terrain rendering scheme on the right of a portion of the Absaroka mountains of southwestern Montana uses aspect-variant colors that add luminous highlights and enhance shading of surface elements (Modified from Kennelly and Kimerling (2004) with permission of Cartography and Geographic Information Science).

From Afghanistan to Iraq in Media Maps: Journalistic Construction of Geographic Knowledge

Robert R. Churchill and E. Hope Stege

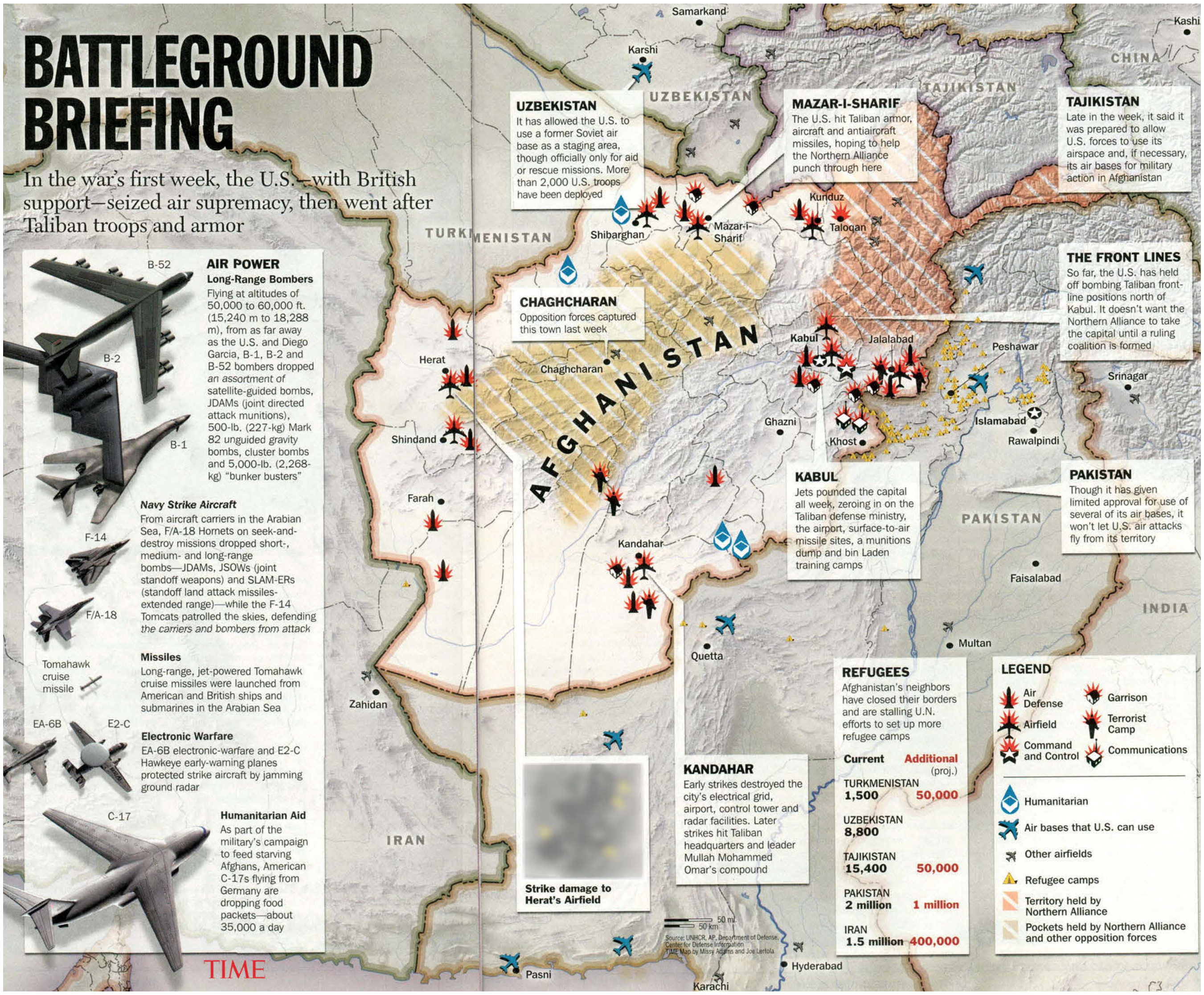


Figure 1. "Battleground Briefing." Time*, 22 October, 2001.* *Cartography by Missy Adams and Joe Lertola.*

Figure 2. "Kill Zones." U.S. News & World Report, *24 December, 2001.* Copyright 2001 U.S. News & World Report, L.P. Reprinted with permission. *Cartography by Rob Cady, Rod Little, and Doug Stern.*

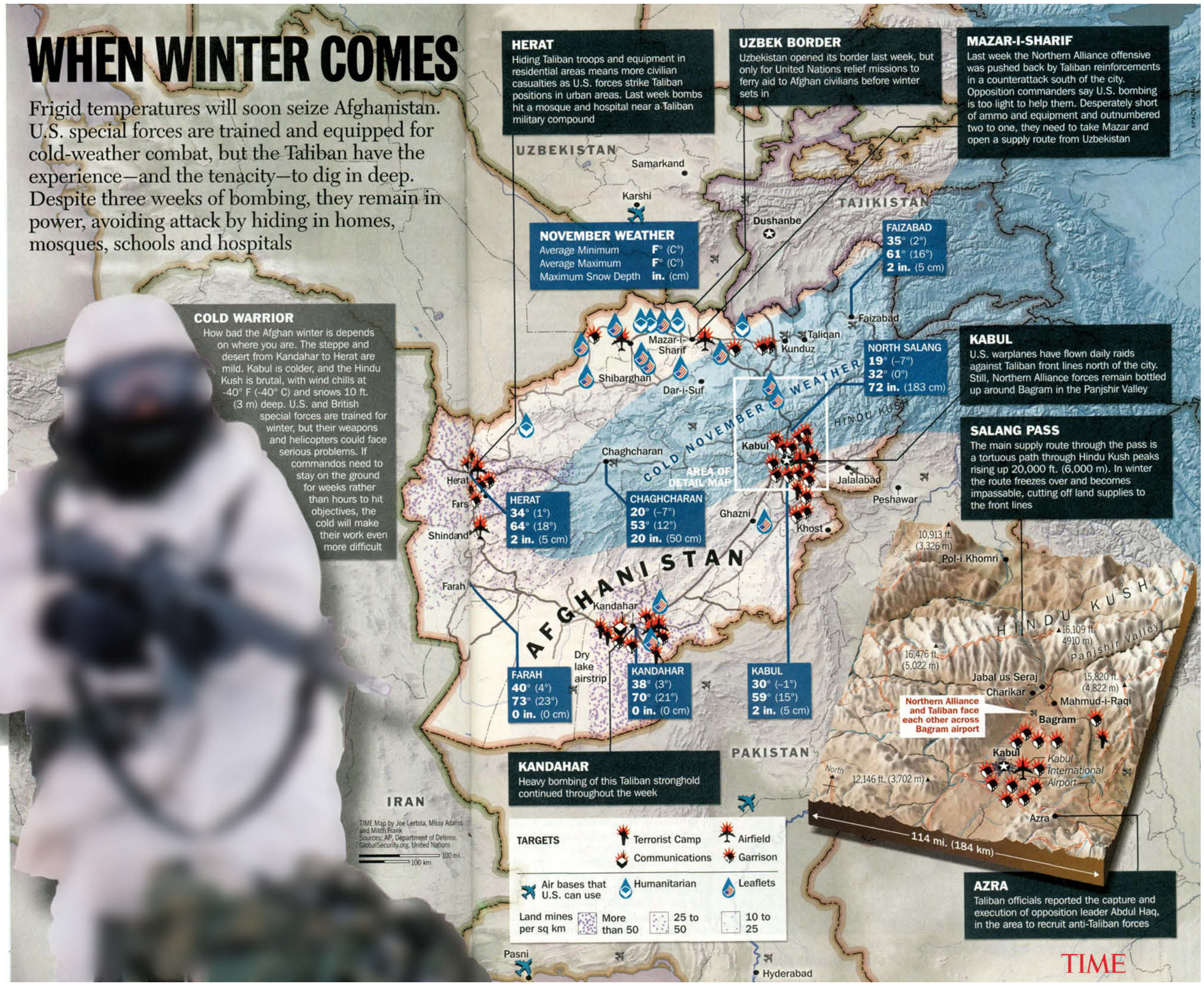
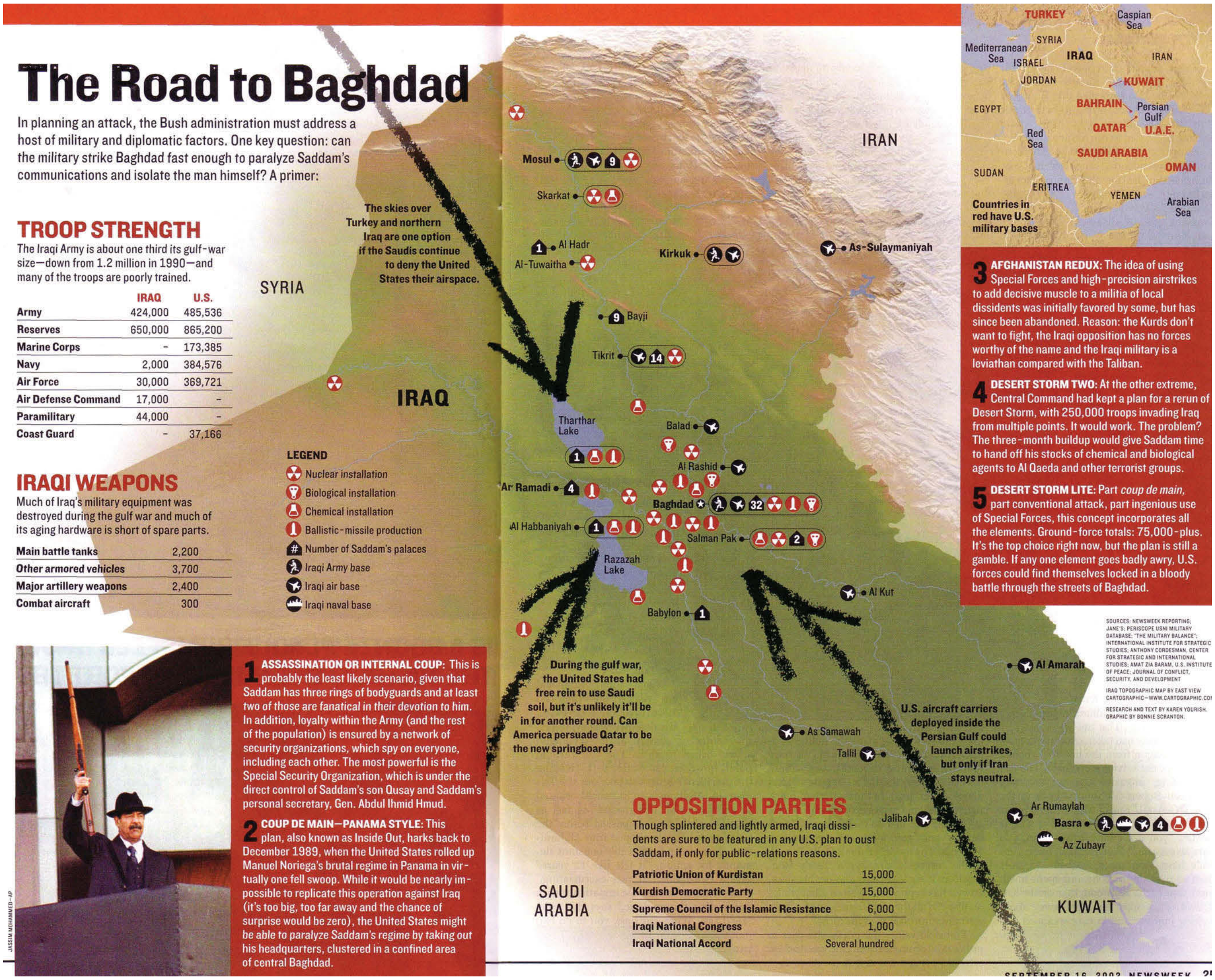


Figure 3. "When Winter Comes." Time, *5 November, 2001. Satellite images courtesy of Space Imaging.* © 2006 Time Inc. All rights reserved. Reprinted from **Time Magazine** ® with permission*. Cartography by Joe Lertola, Missy Adams, and Mitch Frank.*

Figure 5. "Saddam's Game." Time, *2 September, 2002.* © 2006 Time Inc. All rights reserved. Reprinted from **Time Magazine** ® with permission. *Cartography by Jackson Dykman.*



The Road to Baghdad

In planning an attack, the Bush administration must address a host of military and diplomatic factors. One key question: can the military strike Baghdad fast enough to paralyze Saddam's communications and isolate the man himself? A primer:

TROOP STRENGTH

The Iraqi Army is about one third its gulf-war size—down from 1.2 million in 1990—and many of the troops are poorly trained.

	IRAQ	U.S.
Army	424,000	485,536
Reserves	650,000	865,200
Marine Corps	-	173,385
Navy	2,000	384,576
Air Force	30,000	369,721
Air Defense Command	17,000	-
Paramilitary	44,000	-
Coast Guard	-	37,166

IRAQI WEAPONS

Much of Iraq's military equipment was destroyed during the gulf war and much of its aging hardware is short of spare parts.

Main battle tanks	2,200
Other armored vehicles	3,700
Major artillery weapons	2,400
Combat aircraft	300

1 ASSASSINATION OR INTERNAL COUP: This is probably the least likely scenario, given that Saddam has three rings of bodyguards and at least two of those are fanatical in their devotion to him. In addition, loyalty within the Army (and the rest of the population) is ensured by a network of security organizations, which spy on everyone, including each other. The most powerful is the Special Security Organization, which is under the direct control of Saddam's son Qusay and Saddam's personal secretary, Gen. Abdul Ihmid Hmud.

2 COUP DE MAIN—PANAMA STYLE: This plan, also known as Inside Out, harks back to December 1989, when the United States rolled up Manuel Noriega's brutal regime in Panama in virtually one fell swoop. While it would be nearly impossible to replicate this operation against Iraq (it's too big, too far away and the chance of surprise would be zero), the United States might be able to paralyze Saddam's regime by taking out his headquarters, clustered in a confined area of central Baghdad.

3 AFGHANISTAN REDUX: The idea of using Special Forces and high-precision airstrikes to add decisive muscle to a militia of local dissidents was initially favored by some, but has since been abandoned. Reason: the Kurds don't want to fight, the Iraqi opposition has no forces worthy of the name and the Iraqi military is a leviathan compared with the Taliban.

4 DESERT STORM TWO: At the other extreme, Central Command had kept a plan for a rerun of Desert Storm, with 250,000 troops invading Iraq from multiple points. It would work. The problem? The three-month buildup would give Saddam time to hand off his stocks of chemical and biological agents to Al Qaeda and other terrorist groups.

5 DESERT STORM LITE: Part *coup de main,* part conventional attack, part ingenious use of Special Forces, this concept incorporates all the elements. Ground-force totals: 75,000-plus. It's the top choice right now, but the plan is still a gamble. If any one element goes badly awry, U.S. forces could find themselves locked in a bloody battle through the streets of Baghdad.

OPPOSITION PARTIES

Though splintered and lightly armed, Iraqi dissidents are sure to be featured in any U.S. plan to oust Saddam, if only for public-relations reasons.

Patriotic Union of Kurdistan	15,000
Kurdish Democratic Party	15,000
Supreme Council of the Islamic Resistance	6,000
Iraqi National Congress	1,000
Iraqi National Accord	Several hundred

Figure 6. "The Road to Baghdad." Newsweek*, 16 September, 2002. Newsweek—Bonnie Scranton.* *Cartography by Bonnie Scranton.*

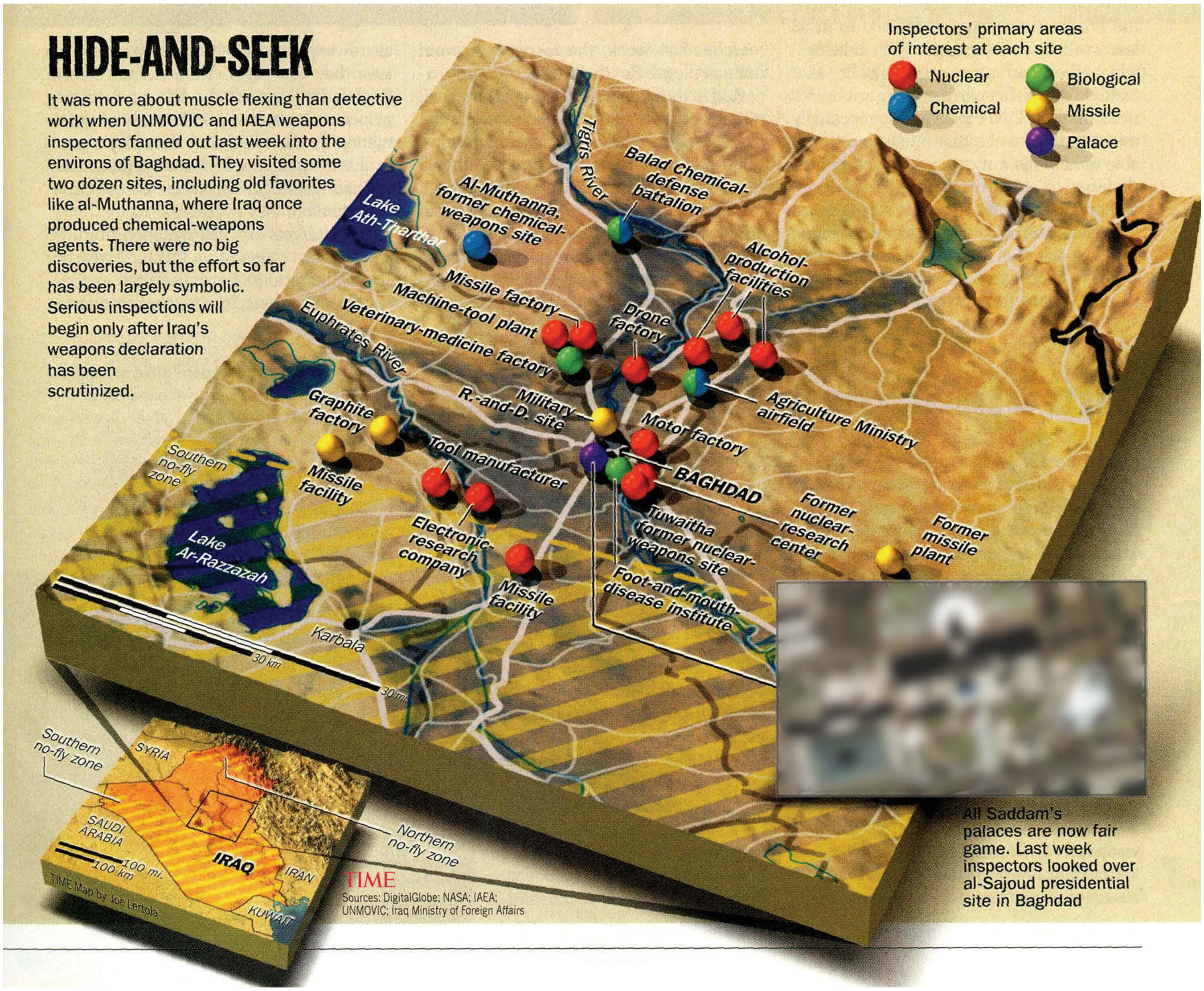


Figure 7. "Hide-And-Seek." Time*, 16 December, 2002.* © 2006 Time Inc. All rights reserved. Reprinted from Time Magazine ® with permission. *Cartography by Joe Lertola.*

Figure 8. "Strike Force." Time, *17 March, 2003.* © 2006 Time Inc. All rights reserved. Reprinted from **Time Magazine** ® with permission. *Cartography by Jackson Dykman.*

Figure 9. "Pinpointing Baghdad." Time, 31 March, 2003. © 2006 Time Inc. All rights reserved. Reprinted from **Time Magazine** ® with permission. *Satellite image courtesy of DigitalGlobe.*

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