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Letter from the Editor

Dear Members of NACIS,

Welcome to *CP52*, the third issue of 2005. In case you are wondering, it's September 20…about 79 degrees out (in Duluth no less!!)…a crystal-blue sky hovering above me…the leaves are morphing into brilliant fall colors…Il Divo is spinning on the ipod…nope, not a bad day at all. I would prefer, though, to be on my bike riding the hills of Duluth instead of here in my office writing this column (note to self to revisit priorities).

With this issue we say goodbye to Ren Vasiliev as Book Review Editor. Ren has served on the editorial board for 8 years now, and has been book review editor for 5 of those years. I have truly valued Ren's staunch work as book review editor, and I am extremely grateful for her wit, sass and creativity. I have known Ren for 19 years now, and I am proud (and amazed even) to say that we are not only col-

(*continued on page 3*)

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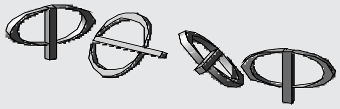
about the cover



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*)

leagues, but are friends. I will miss the delightful banter and censorable emails from her. Ren is one of those rare NACIS members who has served our community quietly for many years. Thank you Ren.

CP remained busy and prosperous this past year publishing 3 regular issues, and one non-series issue celebrating the 25th anniversary of NACIS that was distributed to attendees of the 25th Annual Meeting in Salt Lake City. Manuscript submissions have remained healthy…seventeen different manuscripts have crossed my desk so far this year…seven of those were published or will be published…several are still under review. Planning for 2006 is well underway, with two of the three issues for next year pretty much planned and moving forward.

In this issue of CP we have a brilliant mix of papers. *Mapping the Miasma* by Tom Koch demonstrates for the reader that medical mapping did not arise from with the appearance of cholera in the nineteenth century, but instead appeared as early as the sixteen hundreds as a means for showing spatial relationships between disease occurrence, and locations from whence it was believed the disease causing pathogens were borne. This paper provides fascinating accounts of early medical mapping examples, and the social implications of the decisions made and the policies that were instituted to contain the spread of infectious diseases.

Attention to Maps by Robert Lloyd introduces the reader to the notion of *consilience*, and how this concept can facilitate research in cognitive mapping across disciplines. Consilience is a concept that insists that facts and fact-based theories in any one discipline apply across all disciplines. If theories are robust across disciplines, then knowledge gained in one field can smooth the progress of discovery in other fields. This paper provides many examples of how research in psychology, cognitive science, and neuro psychology on vision and attention can inform research in map design.

Looking Closer: A Guide to Making Bird's-eye Views of National Park Service Cultural and Historical Sites by Tom Patterson takes the reader through some historical examples of bird's-eye view maps dating back to the Renaissance, and then weaves his story with current, practical examples of the National Park Service's 3D view maps. Anyone even remotely interested in producing these types of maps/ representations will find this paper incredibly useful, and the graphics awesome.

Enjoy!

As always, I welcome your ideas, comments and suggestions.

Warmest Regards,

Scott Freundschuh, Editor

Mapping the Miasma: Air, Health, and Place in Early Medical Mapping

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Medical mapping is broadly assumed to have been a nineteenth century reaction both to the appearance of cholera and the social consciousness of principally British reformers. It is however older, more embedded in the scientific enterprise than the social critique, and in the end, more central to both than researchers typically recognize. This paper argues that medical mapping was from its start in the late 1600s principally a tool for the self-conscious testing of spatial propositions, arguing a relationship between health and place, and between the locus of specific disease incidence and suspected sites of local infectious generation. Through the nineteenth century the resulting work--social and medical—typically advanced a miasmatic theory that argued that infectious diseases were generated spontaneously and diffused naturally through the air. This paper reviews the history of medical cartography as a scientific enterprise in the age of miasma, and the importance of this work to social reformers as an outcome rather than a principal impetus to mapping as a critical tool.

Keywords: Edmond Chadwick, history science, history medicine, medical mapping, miasma.

INTRODUCTION

Medical mapping, and the disease topography[1] it promotes, developed neither as an innovative response to cholera's invasion of Europe in the 1830s nor the social reformer's desire to document "the appalling living conditions of the poor" (Robinson, 1982, 156). Rather, medical mapping began in the seventeenth century as a means of administering health protection policies in the face of epidemic disease (Arrieta, 1694), and, in the eighteenth century, became a tool of disease topography (Seaman, 1796) and taxonomy (Finke, 1792). Without loosing its administrative utility, medical mapping was from the start a tool for the self-conscious testing of spatial propositions, arguing a relationship between health and place, and between the locus of specific disease incidence and suspected sites of local infectious generation. This work typically advanced a miasmatic theory that argued that infectious diseases were generated spontaneously and diffused naturally through the air.

From at least the seventeenth century onwards, therefore, medical maps served not simply to illustrate a paper or picture a situation but instead to graphically prove an argument. Some sought to prove the general thesis that bad airs caused disease, or alternately, that disease was water rather than airborne. Some argued that a specific disease was autochthonous while others insisted the same disease was, in fact, exogenous. In every case, however, maps carried the burden of proof of spatial arguments about either disease in general or a specific disease itself.

Initial submission, November 30, 2004; revised submission, February 14, 2005; final acceptance, February 16, 2005

While new to medical mapping, and to medical history (Koch, 2005), this argument is common across the broader discourse of mapping. It therefore seeks to introduce to medicine an understanding of mapping as a critical tool of thinking that others have brought to geology (Rudwick, 1976), biology (Camerini (1993), and the broader analysis of spatial phenomena in general (Wood, 1995). The result serves distinct but related functions. First, it adds depth to a limited, largely descriptive literature on historical medical mapping and its relation to medical science. It does this by simultaneously drawing upon and reconsidering the work of earlier researchers like Jarcho (1970), Stevenson (1965), and Robinson (1982), whose individual reviews of historical medical maps were written without attention to the disease theories that earlier researchers argued in their mapping. Secondly, this review emphasizes the degree to which early disease investigators were also social theorists arguing in their maps for practical, sanitarian responses to epidemic outbreaks in the evolving, mercantile and industrial city.

The argument also serves to remind contemporary researchers, medical and cartographic, of the indivisible relations among disease theory, the methods by which disease incidence are studied, and the technologies of research and reportage that are crucial to theoretical discussion and practical application. Medical mapping stands in this telling as one critical element in a complex mangle of practice that is political, social, scientific, and technological at once. It is, in Pickering's phrase, "the emergently intertwined delineation and reconfiguration of mechanic captures and human intentions, practices, and so on" (Pickering, 1995, 23). In this "mangle" early epidemiology, medical mapping, medical geography, and public health are located within the greater context of the history of science, its technologies of thought and production. What results is a disease ecologic perspective in which viral and bacterial incidence are considered from the start within social and physical contexts.

"Medical mapping stands in this telling as one critical element in a complex mangle of practice that is political, social, scientific, and technological at once."

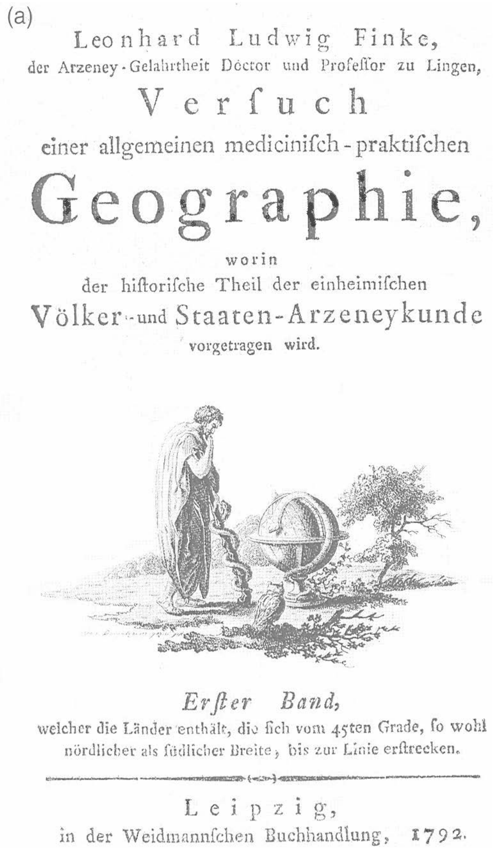
The consideration of a collection of chronologically ordered medical maps in the context of the evolution of the disease theories in whose service the maps were made results in a general paradigm shift. Maps are transformed from ephemeral additions, illustrations grafted to scientific arguments, into integral instruments of the science that is argued. The necessity for this shift is evident in the manner in which all health disciplines typically date their origins from the work of John Snow (Snow, 1849b, 1854, 1855) whose maps and writings on cholera are seen as the event after which the individual disciplines entered a modern analytic period (Richardson, 1936; Vinten-Johansen *et al.*, 2003). That perspective, this paper argues, begins the tale after it was well begun.

SEVENTEENTH CENTURY MAPPING

Few examples of seventeenth century medical mapping have survived into the modern era. While mapping for specialized purposes like navigation was rigorously pursued in the 1600s, mapping was an expensive, specialized discipline whose application to less productive, scientific enterprise was necessarily limited. Nor were the technologies of the day, relatively crude in the presentation of locational attributes, easily adapted to medical studies. When produced, the number of private and public libraries capable of archiving the maps were insufficient to secure their survival. Most of the medical maps that were made in this period have therefore been lost, surviving only in notes about their making.

In 1792, for example, Leonhard Ludwig Finke drew a "Nosological Map of the Word" for his three-volume *Versuch einer allgemeinen medicinisch-praktischen Geographie*. An abridged translation of the full title is *Notes on General Practical Medical Geography Dealing with the History of Medical*

Science and Pharmacology of the Indigenous Population of the Varying States of Germany (see figure 1).



(a)

Leonhard Ludwig Finke,
der Arzeney-Gelahrtheit Doctor und Profeſſor zu Lingen,
Verſuch
einer allgemeinen medicinifch-praktiſchen
Geographie,
worin
der hiſtoriſche Theil der einheimiſchen
Völker- und Staaten-Arzeneykunde
vorgetragen wird.

Erſter Band,
welcher die Länder enthält, die ſich vom 45ten Grade, ſo wohl
nördlicher als ſüdlicher Breite, bis zur Linie erſtrecken.

Leipzig,
in der Weidmannſchen Buchhandlung, 1792.

Figure 1.

An ambitious work, it embodied Finke's attempt to describe a broad topography relating taxonomy of observed diseases and the pharmacology of their treatment to the distribution of peoples affected by those diseases (Barrett, 2000b). This may have been the first use of the phrase "medical geography," one advanced by Finke in this way: "When one brings together all which is worth knowing with regard to the medical status of any country, then no one can deny that such a work describes the name of a 'medical geography'" (Howe, 1961, 9).

Unfortunately, the map, now lost, was not included with the printed text, Finke wrote, "because I was afraid that the work would become too expensive I do have it ready but have not sent it to be printed and I think it will not be printed soon" (Barrett, 2000, 917). The technology and expense of printed production was beyond his means, and presumably, that of other writers who excluded working from their own publications.

Fink's map reflected a general theory of disease generation and diffusion as the geographically specific outcome of uniquely local conditions. The general Hippocratic and Galenic assumption was, as the German physician Hoffman put it in 1746, that diseases were the result of "a fixed and static cause essential to the country, and that they therefore remain in the country without change and variation for many years" (Howe, 1961, 8). Those fixed causes were typically assumed to be airborne, good and bad airs that promoted or inhibited specific infectious diseases in each locality at different times of the year.

An exception to disease as static and endemic were epidemic diseases that periodically swept across regions, nations, and the continent. Influenza was recurrent, and bubonic plague, while broadly endemic, in the seventeenth century was ferociously pandemic, striking across most of Europe in mid-century. The science of the day, steeped in the work of Hippocrates and Galen, considered plague a sickness in the "pestilential atmosphere," whose precise nature while *static* was unknown; but practically, the *dynamic* nature of plague as a contagious disease was broadly recognized if not theoretically addressed. Its containment within effected areas was certainly a practical concern for local administrators even if not a subject of investigation by medical theorists.

PLAGUE: BARI, ITALY

For example, a late seventeenth century outbreak of plague in the province of Bari, Italy, was aggressively met with a sophisticated quarantine system administered by Filippo Arrieta, royal auditor for the province under the military governor of Bari and its neighboring provinces, Basilicata and Cappitanata. With his long, official report on containment efforts achieved through the deployment of troops, Arrieta included two detailed maps (Arrieta, 1694, see figures 2 and 3), one of which was described by Jarcho (1970) in his seminal paper on early medical mapping. Jarcho identified two cordons, one forty-five miles in length and composed of 360 barracks enclosing the towns of Monopoli, Conversano, and Castellano where the infection was present. Another, longer cordon separated the province from its neighbors, Capitanata, Basilica, and Otranto. "Isolation was completed on the costal side by feluccas, two of which are shown on the map" (Jarcho, 1970, 132).

The symbols (churches, hospitals, trees, boats) were drawn in childish profile while the coastline and boundaries were rotated and oblique

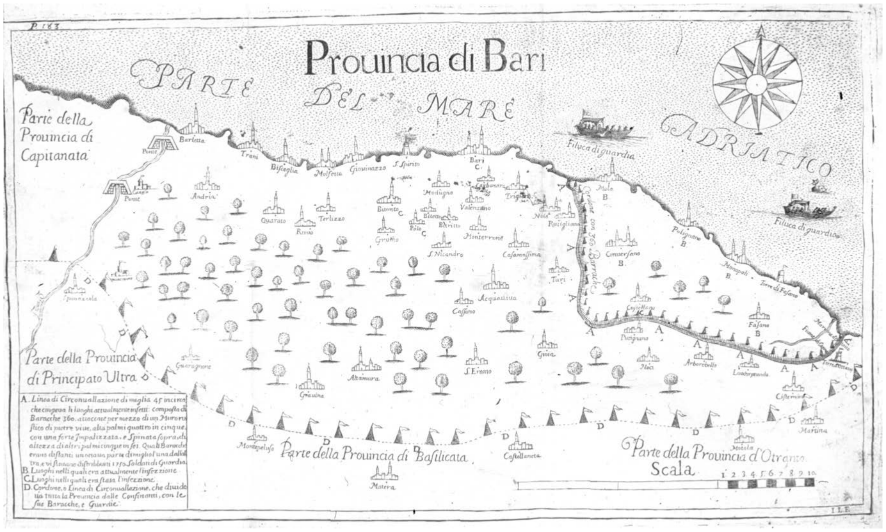


Figure 2. Map of the plague in the province of Bari, Naples, 1690-1692, by Filippo Arrieta. The map shows areas most affected and the boundaries of a military quarantine imposed to prevent its spread to neighboring towns and to other provinces. Source: the New York Academy of Medicine.

(Wood, 1992, 174-178). Towns and cities were symbolized by drawings of simplified buildings, churches (with a cross) or hospitals (without) where the ill were typically taken for isolation and, if they did not survive, eventual burial. A "C" distinguished towns where the outbreak had occurred but was past from those "B" towns where the infection was active. Between the towns, trees symbolized, if not rural, then non-urban areas of the province.

Within the map can be seen a complex series of interlocking levels of containment designed to prevent the spread of the plague. The costal patrol symbolized by the feluccas (*feluca di guardio*) served to prevent shipping and maritime travel. On land, a dark wall with the repeated letter "A" along a *"linea di circonval lazione"* separated areas of active plague from western neighbors (noted by a "C") where the plague had been active, and from southerly areas where it had yet to appear. On top of the wall are tents symbolizing the location of troops stationed at quarter-mile intervals to enforce the quarantine.

Within the area of active plague was another containment level ten miles in circumference marked with a "B" and described in the legend but not symbolized in the map.[2] These individual districts separated towns free of plague but susceptible to it (Mola, Polignano, Fasno, etc.) from others in the district where plague was active or had recently been active. These inner cordons were each enforced by the deployment of 250 soldiers from fifty barracks, troops stationed in the towns at risk and charged with their protection. Finally, the map included a general, provincial cordon "D" separating Bari province from its neighbors. Here, too, the quarantine was enforced by troops whose tents are used to symbolize their presence. The military cost of deploying 1,750 troops stationed at 350 barracks was considerable, as Arrieta's text makes clear.

The map distilled the details of a major military operation designed to halt or at least slow the spread of plague, one that reflected a sophisticated, practical understanding of what since Kendall (1957) has been understood as a pattern of hierarchical, spatial and network diffusion processes (for a discussion see Haggett, 2000, 26-29). Levels of containment separated the province from its neighbors ("D"), districts where plague had been

("C") from those where outbreaks were active, and at a third level insulated individual towns still plague free from those where it was evident ("B"). The whole presents a surprisingly modern approach to quarantine as a means of inhibiting the spread of actively epidemic disease.

This is clearer in a second map not discussed by Jarcho in which there are *two* walled areas, one around the north central area of the province where the plague was active ("D") and a second ("C"), the legend makes clear, around Bari and nearby towns where the disease had earlier appeared (see figure 3). The broader containment area ("E") is province wide, separating Bari from its provincial neighbors. Inherent in the map is a theory of plague as a progressive disease whose containment could only be achieved through the restriction of trade and citizen travel. Absent however was any effort to use this data to argue the nature of the disease, its precise agents or vectors. The luxury of scientific consideration was Finke's, not Arrieta's. In the summary of his troop deployments Arrieta presented, however, a thoroughly modern and extraordinarily sophisticated quarantine program active at the level of the city and the broad region which modern epidemiologists concerned with disease containment might applaud (Haggett, 2000, 99-103).

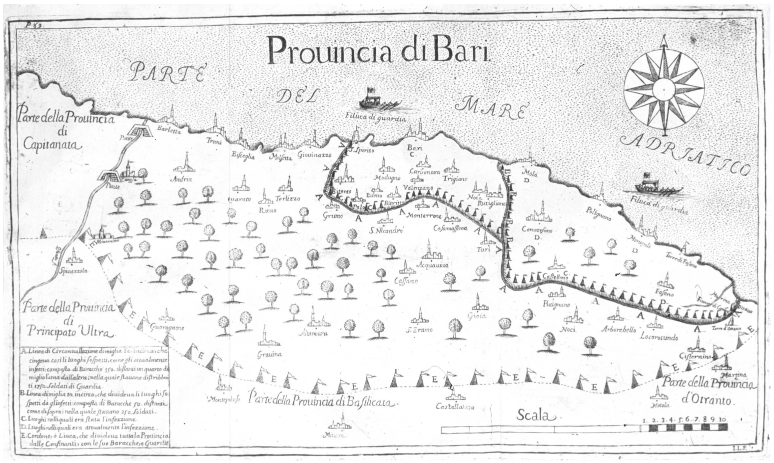


Figure 3. Map of plague containment zones in the province of Bari, Naples, 1690-1692. Tents represent troop deployments on provincial borders, zones of active plague and those where plague had already occurred. Source: New York Academy of Medicine.

EIGHTEENTH CENTURY MAPPING

By the late eighteenth century, administrative and scientific functions were combined in a body of progressively rigorous, self-consciously conceived studies designed to apply miasmatic theories to the study of specific disease outbreaks in urban environments. In this period a series of new diseases primarily effecting coastal ports of mercantile nations (typhoid and yellow fevers, for example) gave rise to the need both to understand their origins and limit their effect. This resulted in the articulation of a sanitarian thesis identifying odiferous areas of untreated urban waste as the source of specific epidemic outbreaks. These sanitarian maps advanced the simple proposition that odiferous areas of urban waste near docklands were proximate to the neighborhoods in which outbreaks occurred. This proximity implied causality. Therefore the remedy was to improve the sanitary facilities of cities, reducing the sources of the foul airs that generated disease. The argument was simultaneously miasmatic and sanitarian.

In the 1790s Valentine Seaman, a surgeon at New York Hospital and a pioneer in nursing education, investigated a yellow fever outbreak in his city as an example of a localized, miasmatic disorder (Stevenson, 1965). In this decade eastern coastal cities were struck repeatedly with a series of ferocious outbreaks that killed thousands of citizens. In 1793 approximately ten percent of Philadelphia's population perished in a yellow fever outbreak. In 1798 more than 3,000 people died from the disease in a four-month period (Shannon, 1981, 221). Thousands more succumbed in cities like Baltimore and New York City.

Because these outbreaks were concentrated in the docklands of coastal port cities, some assumed the disease somehow was imported on ships. In the language of the day "anticontagionists" believed that these diseases were the manifestation of unseen microscopic "animalculae" that mysteriously traveled in ships, infecting individual travelers who then transmitted the illness to port populations after disembarkation. Disease progression was thus the result of mobile, undetectable poisonous agents specific to each condition and responsible for its spread. To limit the unseen agents' diffusion it therefore would be necessary to increase ship and traveler quarantine at the expense of rapidly evolving trade.

Opposed to this theory of a peripatetic but undetectable agent was the miasmatic theory. Based on the theory of good and bad airs in the tradition of Hippocrates's *Airs, Waters, Places*, "contagionists" argued that static and local, odiferous airs occurring were the breeding grounds and vectors of contagious illnesses. The theory included an explanation of disease generation and a therapeutic viewpoint that considered the location of each patient within his or her physical environment (Porter, 1997, 172). Absent microscopes of sufficient power, olfactory and visual senses were the primary tools used to investigate disease generation and diffusion.

Foul humors infected populations at two scales through the processes of "exhalation and contagion" (Shannon, 1981, 222).[3] Exhalation was the product of the stench of rotting vegetables and waste inhaled at distances of 300 to 400 yards. Contagion was a more local effect occurring on a street or in a tenement building. At both scales the localized, static foul airs characterized an environment in which diseases spread spontaneously to nearby residents.

In an attempt to prove the contagionist argument, Valentine Seaman studied the yellow fever outbreak in New York City's docklands. His results were reported in a fifty-two-page monograph (1796), an article in the then new journal, *Medical Repository* (1798), and another in a book on "bilious fevers" by Noah Webster (Seaman, 1796b). In each text Seaman argued the origin of the outbreak was the smell that arose from the city's garbage and sewage that accumulated in the harbor area and that "no Yellow Fever can spread, but by the influence of putrid effluvia" (Seaman, 1798, 316). He mapped this argument in the *Medical Repository* article that remains the most frequently cited and perhaps most concise of his statements. Seaman's maps splendidly distilled the miasmatic theory of disease contagion in his attempt to prove yellow fever was static, not dynamic; a creature of the foul smells generated by urban waste.

In his first map Seaman located ten fatal cases of yellow fever occurring in a 1797 outbreak in an area where "most of the patients infected with dangerous fevers, were either such as resided in the neighborhood of slips (which were or lately had been cleaning out) or whose employment led them to frequent such places" (Seaman, 1798, 317, see figure 4). The map included the index case of the outbreak, a seaman taken sick in East George Street who had recently arrived from South Carolina in the sloop *Polly* on which one crewman had died on the passage northward. Seaman

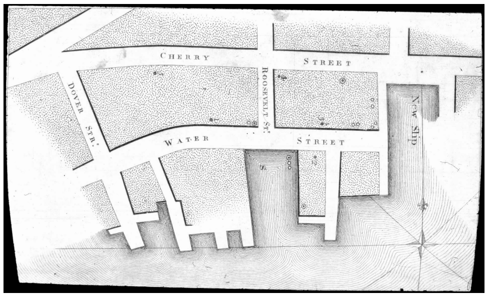


Figure 4. Seaman's 1798 map of yellow fever deaths in the Roosevelt Street basin area, New York. Fatalities are number sequentially. Near-fatal deaths are symbolized by an E, cases whose diagnosis was uncertain were symbolized by an "o". Source: the National Library of Medicine. (see page 90 for color version)

considered and then rejected the ship as a possible source of the infection. While it was possible, Seaman admitted, that the *Polly* seaman somehow brought the disease with him to New York it was clearly local conditions that gave the fever its deadly affect: "It may be, that a partial principle of death lurked in his [the seaman's] system, during the whole time after the death of his comrade, and most likely, never would have seriously acted upon him, had he not immersed himself in this or some such like furry-fostering miasmata."

The real culprit, Seaman concluded, was the urban environment itself, the fetid air in the vicinity of the dockland terminus of the Roosevelt Street drain (not shown on the map) into which city waste poured, "in addition to the other putrid matters that such places are always collecting." Daily, ebb tide exposed perhaps eight hundred square yards of rotting, perishable materials (everything that a household or small business would throw out) and "putrid matters," human and animal waste. The smell *was* foul and the proximity of this odiferous waste area to the yellow fever outbreak was plain to see.

In a second map whose focus was the urban effluvia Seaman continued the proposition that the proximity of the homes of persons with yellow fever and the location of odiferous sites of urban refuse were positively correlated (see figure 5). To do this he included an "S" to symbolize "slips, puddles, filth, and garbage," and an "x" to locate areas of "convenience," places he described as "being open and so contiguous to the Market, {that they had become} the common convenience to a multitude of people" (Seaman, 1798, 13). Wastes from these sites washed down the city's streets to ferment on the tidal flatland of the docklands. What resulted was a map of odor sites that with the map of fever incidence, Seaman believed, proved a cause and effect relationship. Together, the maps demonstrated, Seaman argued, to "every unprejudiced mind that in the city there appears to be an intimate and inseparable connection between the prevalence of Yellow Fever and the existence of putrid effluvia" (Seaman, 1798, 324-25).

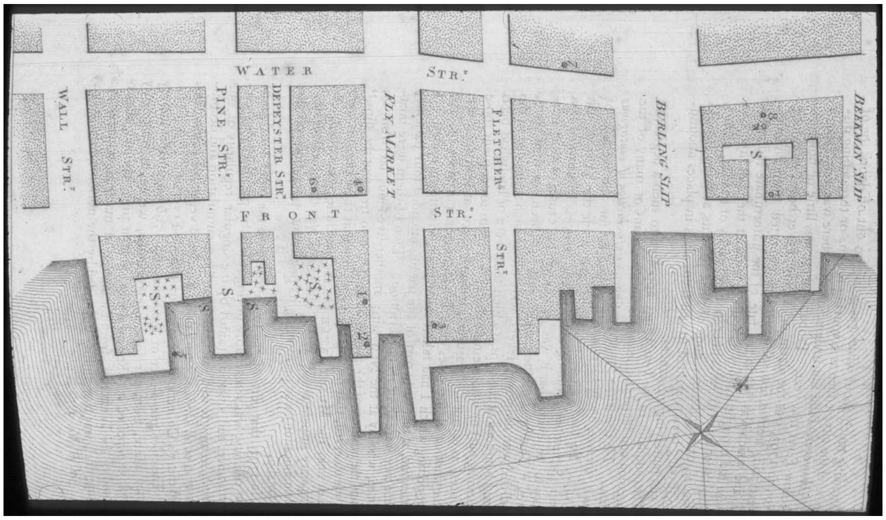


Figure 5. Seaman's map of the sources of the 1795 yellow fever outbreak in New York City. Fatal cases are numbered sequentially. An "S" symbolized "slips, puddles, filth, and garbage". An "x" was used to indicate "common convenience." Source, the National Library of Medicine. (see page 90 for color version)

There *was* a relationship between the foul odors and the disease. The odiferous dockside area was also a breeding ground for mosquitoes "never before known, by the oldest inhabitants, to have been so numerous as at this season," wrote Seaman, who assumed that the fouled, urban air spontaneously generated *both* yellow fever and a plague of mosquitoes: "The rise of putrid miasmata equally favor the generation of these insects." The mosquitoes were not perceived as a disease vector carrying the unseen animalculae but as a secondary effect of the miasma that was the cause of the fever.

Seaman did not draw the maps he made. Rather, he drew or had drawn symbols of disease incidence and effluvial sites onto an existing copperplate map of the city. The process of etching a copperplate was complex, expensive, and time consuming. Nor was there a need for a new plate to be made; in 1789 and again in the 1790s copperplate city maps were being commercially produced in New York City: "in the late eighteenth century the city of New York was frequently charted for the benefit of its citizens, its visitors, and its government" (Stevenson, 1965, 237).

While the commercial maps made Seaman's maps possible, the limitations of copperplate frustrated his attempt at a more comprehensive graphic. He lamented, for example, "the want of proper marks to identify it [the disease] where it is slight" (Seaman, 1798, 317). Nor was he able to include on his map all the identified cases without diminishing the legibility of the map. Nevertheless, Seaman's map admirably advanced his argument that the epicenter of the outbreak was proximate to foul odiferous airs generated whose foul stench the science of the day "knew" to be generative of disease. To prevent future outbreaks a program of urban waste treatment and control was the logical, necessary conclusion.

PASCALIS

A generation later the technology of printing had improved sufficiently to permit better maps of an 1819 yellow fever outbreak in New York City. Accompanying a detailed study of that outbreak, Felix Pascalis mapped fatal incidents of yellow fever at the level of city blocks in a manner similar to early urban tax maps of residential location. Each death was numbered to reflect its order of occurrence. The result looks like a land parcel or taxation map. Here, too, mapping showed that mortality was concentrated in an area that was overflowing with "perishing and fermenting materials," producing "an offensive smell and, no doubt also, deleterious miasmata" (Pascalis, 1819, 19).

Advances in mapping technology and production permitted Pascalis a denser level of case reportage than Seaman. Here, perhaps for the first time, a relatively accurate density of occurrence was used to argue about the locus of an infectious disease in relation to environmental contaminants. "It will be seen, by the annexed diagram, that in the vicinity of Old Slip, out of 57 cases, the enormous proportion of 34 or 35 originated from that single block . . . ten persons, out of the number of 83 sent to Fort Richmond, the greater part from that block, shortly after sickened with the malignant fever, and three of them died in the Marine Hospital" (Pascalis, 1819, 241, see figure 6).

Pascalis described but did not map the effluvial sites detailed in his text. The sheer density of cases, and the general description of nearby odiferous sites encouraged, however, the conclusion that "yellow fever is produced by impure and deleterious exhalations from putrid substances" (Pascalis, 1819, 17).

The relationship between the density of clustered cases and the proximate waste sites not only proved that the disease was "engendered by domestic causes," foul airs that pervaded certain areas, but *disproved*, he

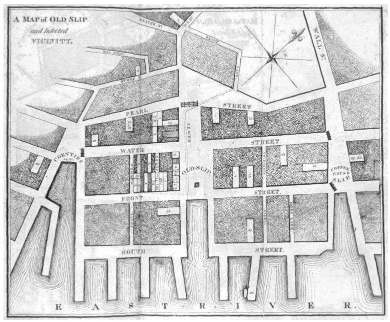


Figure 6. Pascalis's map of yellow fever cases near Old Slip, New York, 1819. Fatal cases are numbered sequentially by time of death. Source: the New York Academy of Medicine. (see page 90 for color version)

hoped, the contagionist argument that yellow fever was "communicated by human contagion from foreign ports." As the final clause of his monograph's long title made clear, his work was self-consciously crafted with both goals in mind. His mapped study was undertaken "*with a view of ascertaining, by comparative arguments, whether the distemper was engendered by domestic causes, or communicated by human contagion from foreign ports*" (Pascalis, 1819).

"If the miasmatic theory of disease missed the intervening vector it nonetheless caught a critical aspect of the epidemiological problem."

Issues of disease theory and generation had very practical consequences. Miasmatists assumed that control of future outbreaks would require sanitarian attention to accumulations of waste washed from the city to the river's edge, the assumed locus of disease generation and aerial diffusion. Unnecessary, however, would be any effort that might impede growing regional and international ship traffic through stricter quarantine procedures. And, of course, Pascalis was correct: The odiferous waste sites, breeding grounds for mosquitoes, were complicit in the yellow fever outbreak. If the miasmatic theory of disease missed the intervening vector it nonetheless caught a critical aspect of the epidemiological problem.

CHOLERA

Epidemic cholera, also called "*cholera morbus,*" or more popularly, "Asiatic cholera," became by the 1830s the epidemic disease on which many researchers focused. First identified in Calcutta in 1781-2, it was the cause of death of approximately 20,000 pilgrims at Hurdwar in 1783-4. The first outbreak among British troops occurred in Jessor, India, in August 1817 when 3,000 members of the 10,000-man British army then stationed in India under the Marquis of Hastings died of the disease (Morris, 1976, 23). In 1830, the disease had spread to St. Petersburg, Russia, and in the fall of 1831 arrived in Sunderland, England, where keelman William Sproat was the first of more than 50,000 English to die in the first pandemic (Morris, 1976, 11). Between the first and second pandemics, a number of researchers studied the 1831-33 epidemic, arguing in their work for a correspondence between the "good airs" of higher altitudes and the "bad airs" of the odiferous, densely inhabited riverbanks of British maritime cities.

An example is Thomas Shapter's frontispiece map of *The History of Cholera in 1832*. Published on the eve of the second pandemic in 1849, the map "showing the location where the deaths caused by pestilential cholera occurred in 1832-34" sought to describe, in the words of a *Lancet* reviewer (*Lancet*, 1849, 317), a "city close, confined, badly drained, and still worse supplied with water" (see, Vinten-Johansen et al. 2003, 324, see figure 7). In its careful attention both to the incidence of the disease and the environment in which it proliferated, the map carried, for Shapter and his contemporaries, a powerful proof of the miasmatic theory of cholera's generation and diffusion.

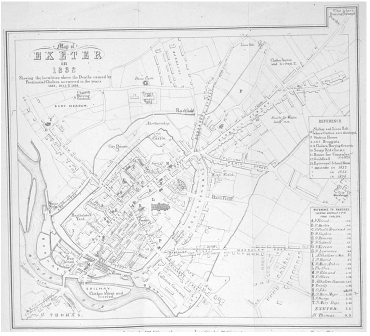


Figure 7. Map of cholera in Exeter, 1832, published by Shapter in 1849. The map includes a statistical table of deaths by parish population and incidence of disease by parish in the years 1832-4. Source: the New York Academy of Medicine. (see page 91 for color version)

Despite its attention to water sources in the city, a focus that gained currency in the 1850s, Shapter's map served primarily an airborne, miasmatic argument in several ways. Not the least of them was a descriptive function familiarizing late 1840s readers with 1830s Exeter: convalescent homes, burial grounds, soup kitchens, and sites for the disposal of the clothes of the infected, etc. are all marked. During the bubonic plague of the 1600s special burial pits for the victims of epidemics had been created; special locations for the cleansing of the clothes of the afflicted were instituted. In the cholera epidemic of 1831 these protocols returned, the evidence of them embedded in the map (see figure 8).

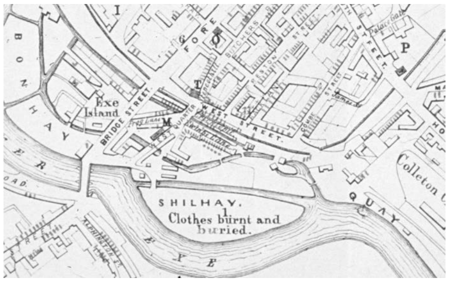


Figure 8. (see page 91 for color version)

At another level the map was a self-conscious topography of the relationship between the city's geography and the incidence of disease over time, one that linked bad air in lowland, riverside areas near effluvial sites with the most intense areas of disease incidence in the years 1832, 1833, and 1834. Deaths occurring in each year were distinguished in the map by both symbol shape and color. As well, mortality data was aggregated in the legend at the scale of the individual parishes, each parish symbolized in the map by a capital letter. Like Seaman's and Pascalis's, Shapter's map again presented a miasmatic argument based on proximity. It differed in the depth of data, the extent of the mapped detail, and the level of aggregation. The resulting map identified "a few isolated spots in which a remarkable and undue amount of mortality took place" (Shapter, 224) in relatively low-lying areas of dense habitation near the river where effluvial build-up resulted in the odiferous, miasmatic airs Shapter blamed for the epidemic.

GRAINGER

Richard Grainger's 1849 *Cholera Map of the Metropolis* (Grainger, 1850, Appendix B) presented a similar argument at a different scale. Here altitude was related to location odiferous sites that correlated positively with cholera. The hypothesis was that an inverse correlation existed between increasing altitude and disease incidence. Inked by hand on an existing lithograph of Greater London's parish jurisdictions, the map boldly displayed occurrence based on data reported by parish districts and the physical domain of the city's political districts. Its focus was not the neighborhood but the whole metropolis (see figure 9). In this Grainger followed the 1830s initiatives of the "Paris School" (Porter, 1997, 406-8) medico-statisticians whose approach involved numerical and graphical analysis of ever more broadly constituted regional and national datasets (Jarcho, 1970, 1974).

On Grainger's map three different densities of disease occurrence can be seen. Small numerals designating elevation above sea level are included in the map to support of the theory that generative, miasmatic airs tended to settle around low-lying riverbanks. And there *was* a correspon-

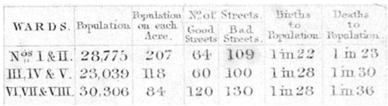
Figure 9. Grainger's density map of the 1849 cholera epidemic in London showing intensity by political district and sub-district. Source: the College of Physicians of Philadelphia Library, Philadelphia, PA. (see page 91 for color version)

dence. Incidence of cholera *was* highest in those areas nearest the Thames riverbank where elevation was lowest. Where cholera did occur at higher elevations, Grainger carefully mapped local circumstances that might have contributed to the anomaly. Thus in Islington (number 8) “Bad ventilation and no drainage” is written near a darkly colored, localized outbreak. And in Westminster, “over-crowding” was noted in the area of Fennings Buildings where a dense outbreak’s epicenter is surrounded by a pattern of moderate occurrence. “Open sewers” are mapped near an outbreak at Barrington Crescent in Lambeth (number 30), and “putrid water” near Lambeth Church sub-district (number 28). These were riverside areas into which the city’s sewage flowed and from which much of the city’s water was drawn. Famously odiferous into the 1860s, it was as much the overpowering stench of the Thames River as much as the health problems that might result from them that argued for the river’s rehabilitation through an expensive embankment (Porter, 1998).

CHADWICK

While the general correspondence of altitude and relative health might be explained by “exhalation” it did not explain the typically uneven spatial distribution of disease in areas of equal altitude. Variation in disease rates in neighborhoods was assumed to result from the processes of “contagion,” the close quartered contact with foul airs in a single building or apartment. Social reformers concerned with the living conditions and the health status of lower class, working populations carefully described the correlation between disease incidence and economic status. Living conditions, resulting in fearfully dense housing without sufficient ventilation or sanitation, provided the precise environment for foul airs to generate within tenement apartments and between tenant neighbors, creating a demonstrably increased severity of disease.

Among those whose work advanced this argument was Edmund Chadwick, whose famous *Report on the Sanitary Conditions of the Labouring Population* (Chadwick: 1842, 160) offered a “forceful indictment of unsanitary living conditions in the industrial slums, as well as a severe criticism of physicians ignorant of the causes of contagion and of the moribund local health boards” (Melosi, 2000, 46). Well researched and well argued, the report included a host of tables (see figure 10) and “A Sanitary Map of the Town of Leeds.” (see figure 11)



WARDS.	Population.	Population on each Acre.	No. of Streets.		Births to Population.	Deaths to Population.
			Good Streets	Bad Streets.		
Nos I & II.	28,775	207	64	109	1 in 22	1 in 23
III, IV & V.	23,039	118	60	100	1 in 28	1 in 30
VI, VII & VIII.	30,306	84	120	130	1 in 28	1 in 36

Figure 10. Data legend from Chadwick’s map of Leeds with population and health statistics aggregated at the ward level.

On it cholera and other communicable diseases are located at the homes of the deceased. Statistics of healthier and less healthy populations are summarized in the map legend. Across the city the “less cleansed” areas are shaded a darker brown and these, not surprisingly, are areas largely inhabited by working rather than more moneyed families. Blue spots are hand inked onto the map to indicate “localities in which cholera prevailed,” while red spots are used to identify residences from which the victims of “contagious disease have been sent to the House of Recovery from 1834 to 1839.” Using the evolving statistical approaches of the day, the ratio of “good” (healthy) to “bad” streets by parish district was calculated based on deaths and births by area population. The message was clear: irrespective of altitude, increasing density of population correlated negatively with income, positively with mortality, and negatively with rate of birth. In the map, increasing density of population also correlated with the blue and red dots.

The choice of color schemes was unfortunate. Over time the map has faded and with it the distinction between shades of brown and red. On a different but related black and white map, Chadwick mapped the relationship between health and socioeconomic class in Bethal Green. Here the absence of color and the relative simplicity of the symbols promoted

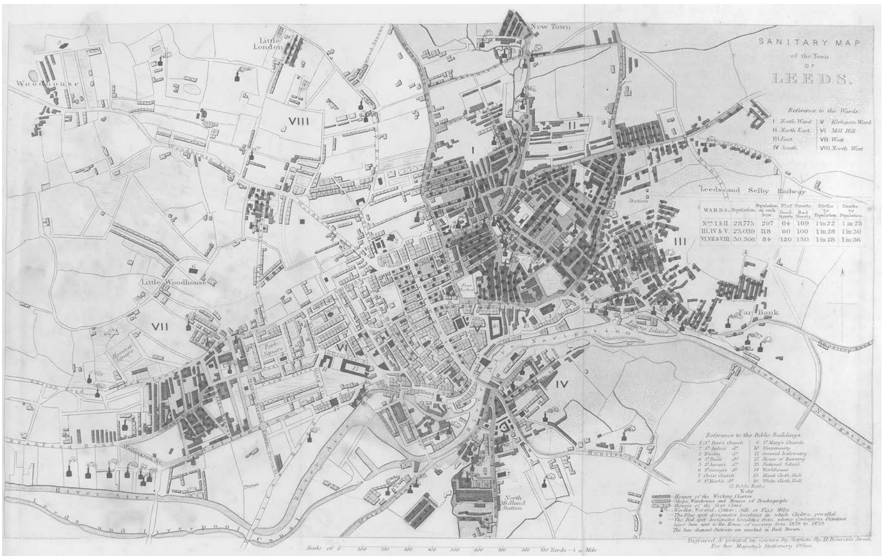


Figure 11. Chadwick's map of Leeds in which increasing incidence of contagious disease is correlated graphically with declining income. Map courtesy of Wellcome Trust. (see page 92 for color version)

clarity (see figure 12). Again, disease incidence is located at the homes of decedents. Intensity of incidence correlates positively with the lower socioeconomic and densely settled neighborhoods. Taken for granted was that such neighborhoods, without adequate sanitation, also had fouler airs in streets and home, promoting disease generation by general exhalation and by inhalation at the household scale.

JOHN SNOW

London physician and anesthesiologist John Snow argued a very different theory of cholera as a water rather than airborne disease. Snow believed that the disease was passed interpersonally through contact with the waste products of those who were already ill and through drinking contaminated water drawn from the polluted riverbanks of the industrializing city. As Snow put it: "The water works that supply the south of London take water from the Thames mostly at places near which the chief sewers run into it. Moreover, the wells in this part of London are very liable to be contaminated by the contents of cesspools . . . these are the chief sources of the high mortality on the south of the Thames, and where they are not in operation there has been comparative immunity from the disease" (Snow, 1849a, 749).

In the 1850s Snow advanced his argument through two famous studies. The larger and more ambitious South London study (Snow, 1855) was detailed and complex. Its mapping suffered from the limitations of a printing technology that muddied and made near unintelligible its colors (see figure 13). In a separate but related neighborhood-scale study Snow considered a cholera outbreak in the Broad Street, Soho, area near his home (Snow, 1855, 1855a). These most famous of nineteenth century medical maps failed, however, to convince Snow's contemporaries of his waterborne thesis. "Is this evidence scientific?" the *Lancet* asked in an 1855 editorial (Vinten-Johansen et al, 2003, 344). "Is it in accordance with the experience of men who have studied the question without being blinded by theories?" The answer was no. Snow was respected as the leading authority on clinical anesthesiology but not for his work in this area. "The truth is, that the well whence Dr. Snow draws all sanitary truth is the main sewer. His *specus*, or den, is a drain. In riding his hobby very hard, he has

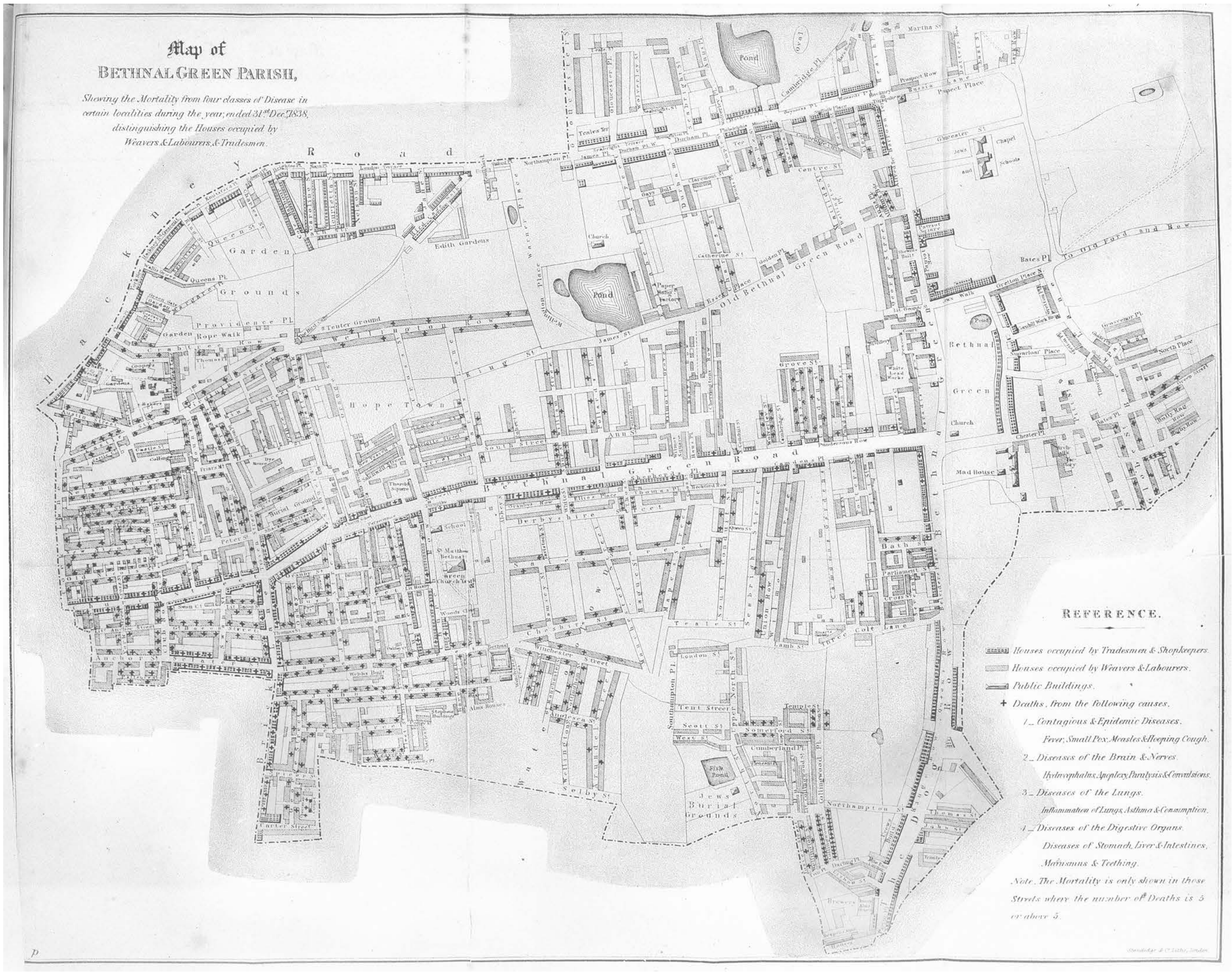


Figure 12. Chadwick's map of Bethel Green correlating class and neighborhood in the incidence of disease. The map was part of a greater attempt to locate disease within specific physical and socioeconomic environments in which disease incidence was promoted or inhibited. Source: British Library.

Figure 13. Detail of John Snow's map of Cholera in the Broad Street outbreak in 1854. Each bar represents one death in a topography that attempted to relate the water source ("Pump") to pattern of cases in the neighborhood outbreak. Source: College of Physicians of Philadelphia.

fallen down a gully-hole and has never been able to get out again" (*Lancet*, 1855). Far from being lauded as an exponent of modern research methods, many believed, in the words of the *Lancet*, that "Snow had deviated from his usual scientific practice. He had presented conclusions without experimental evidence or statistics to back them up."

The problem was not that Snow advocated a new general theory of disease but that he argued a limited theory of a single disease—cholera—that questioned prevailing disease theory. In effect Snow, argued for a specific exception to the miasmatic theory without a theoretical justification that would explain that exception. As importantly, at least to skeptics, Snow's data was ambiguous. His maps easily could be read as supporting a theory correlating a greater incidence of cholera in riverside parishes with the bad airs of lowland riverbanks where noxious waste collected. Edmund Parks, for example, argued that the centralized pattern of the outbreak centered on the Broad Street pump was exactly what one might expect if a noxious miasma was in fact the cause of the disease (exhalation) that then spread by contagion among the area's habitations. Furthermore, Parks pointed out, there were so many pumps in the area that no matter where the epidemic had its center one would surely be close by (Parks, 1855).

It is worth pausing to note parenthetically the importance of Snow's mapped work to modern epidemiology (Rothman, 2002), medical cartography, medical geography, and public health (Vinten-Johansen et al. 2003, 392-399). While rejected in Snow's day, his studies of both the Broad Street outbreak and the South London epidemic remain first cases in the teaching of each discipline's approach to disease. In medical cartography this is especially true of the iconic Broad Street map (McLeod, 2000) whose presentation is graphically clear and whose focused database even today is easy to manipulate.

As importantly, it presents a clear example of a type of graphic "map thinking" (Brody *et al*. 2000) characterized by a topographic approach to a local area study of disease (Koch and Denike, 2004). Its simplicity makes the conclusion, to us, sufficiently obvious that it is virtually an advertisement for medical cartography advanced reflexively by a slew of twentieth century writers (Vinten Johansen et al. 2003, 396-399; McLeod, 2000). Over the last 160 years, however, its appearance has been changed with the context of its presentation. It's database has been truncated—fewer wells and fewer deaths presented—to advance graphic simplicity. The symbolization has been changed. Today it stands not simply as testimony to Snow's work and thinking but to the manner in which datasets are manipulated—cartographically and statistically—in service of an author's focus, theories, and personal attentions (Koch, 2004).

VIENNA CONFERENCE 1874

Over the next twenty years Snow's special theory of cholera transmission was accommodated within a generally miasmatic theory of disease generation. In effect, the argument became a thesis in which at one scale, cholera was a miasmatic condition that, at another, was transported on ships between countries. At a third scale the argument became that the disease could also be transmitted interpersonally. All three scales were discussed and described at the end of the third pandemic, which began in the 1860s, at an 1874 an international congress on cholera held in Vienna.

At the end of the Congress the researchers agreed on a general set of "facts." First, it was "unanimous affirmed 'that the Asiatic cholera, susceptible of epidemic extension, is not developed spontaneously, except in India, and when it appears in other countries it is invariably by introduction from without" (Woodworth, 1874, 54). The assumption remained, however, that "the surrounding air is the principal vehicle of the generative agent of cholera; but the transmission of the malady by the atmosphere, in the immense majority of cases, is restricted to the close vicinity of the focus of emission. As to facts asserted of transportation to a distance of one or many miles, they are not conclusive" (Christie, 1876, 476). Finally, researchers also agreed "cholera can be transmitted by personal effects coming from an infected place, especially such as have served for the sick from cholera; and certain facts show that the disease can be carried to a distance by these effects " (Woodworth, 1875, 47).

A number of studies presented at the Vienna conference considered evidence mapped at various scales based on data collected during the first pandemics and the one that began in the 1860s. Perhaps the greatest study of the third pandemic, one owing much to the conference itself, was a thousand page report, *The Cholera Epidemic of 1873 in the United States,* by army captain Dr. Ely McClellan. McClellan served under the U.S. Surgeon General, Dr. John M. Woodworth, who had been ordered by the U.S. Congress to investigate and then report on the U.S. epidemic. Woodworth assigned McClellan to investigate the progress of cholera as it marched from New Orleans up the Mississippi through more than 10 states. To gather data McClellan, with the assistance of Dr. John C. Peters relied on local health officials in effected cities.

McClellan's goal was to prove that cholera was introduced at the port of New Orleans and then spread up the Mississippi by riverboat and train. He favored the idea that cholera was transmitted interpersonally by the wastes of contaminated humans but remained open to a theory of contagion that assumed the close, dank air of overcrowded riverboat quarters was also complicit in the spread of the disease. With other members of the Vienna conference he believed the disease was endemic only in India and differed fundamentally from the "summer cholera," or food poisoning, that often caused diarrheic disease in nineteenth century cities.

The report he prepared for Dr. Woodworth was extraordinarily map rich. It included maps from the Vienna conference drawn by British and French researchers who had mapped the progress of cholera internationally and nationally in its two earlier pandemics. With earlier U.S. maps of previous epidemics these maps provided the context in which McClellan located his study of the third pandemic's epidemic progress. For each of the cities whose health experts submitted a report, McClellan either modified maps of disease incidence his respondents had submitted or personally drew (or had drawn) maps that together would argue a general pattern of diffusion. Together these maps presented a pattern of disease spread based on riverboat and train networks in the then western U.S. that resulted in localized outbreaks resulting from interpersonal contact with persons infected by exposure to river or secondarily rail traffic and commerce.

"McClellan's goal was to prove that cholera was introduced at the port of New Orleans and then spread up the Mississippi by riverboat and train."

McClellan built a powerful argument based on the reports of local respondents. For example, the New Orleans report McClellan received from Dr. C. R. White, president of the Louisiana Board of Health, insisted that most Louisiana physicians "warrant the belief that it was not Asiatic cholera" that struck their state but only an unusually severe occurrence of endemic diarrhea, also called cholera. "The prevalence of cholera at the same period of 1873 may be viewed as the natural tendency of that portion of the year, exaggerated into serious, and deadly, and somewhat general disease, by the presence of local poison, engendered by filth and magnified by unusual meteorological conditions" (Woodworth, 1875, 101). In short, summer heat and rains combined with local filth to generate foul airs causing endemic summer diarrhea that in 1874 was unusual in its intensity but normal in its occurrence. White's was an argument both Seaman and Pascalis would have understood and applauded.

McClellan first complimented the "admirable and exhaustive report of Dr. White," and then rejected conclusively "the theory that the cholera epidemic of 1873 originated *de novo* at New Orleans." He made his case on the back of White's own data with a two-step mapped analysis that remains today a useful model of mapped, epidemiological thinking. He first located on a map of the city the cases that White identified, numbering them sequentially on the basis of chronology. After plotting the location of the homes of these first deaths, McClellan drew lines connecting the homes of the deceased to the steamboat levee where they worked, numbering the vectors based on the date of diagnosis. They may *live* here, and here, and here, McClellan's map said, but all the cholera victims *worked* on the levee where the disease was introduced by ship. Where cholera victims lived elsewhere, places where either another line would be illegible or a blackened city square would be hard to read, he marked the house with an "**x**". That most of these homes were on or near the river, or clearly vectored from it, added weight to the map's argument.

McClellan then drew an incomplete circle centered on the steamship levee to define a "cholera area" of greatest incidence (see figure 14). The circle served several functions. First, it defined an area of greatest intensity to refute Dr. White's insistence upon a diffuse urban outbreak of miasmatic origin. The uniform pattern of occurrence expected of an airborne disease was replaced here by a pattern of disease clusters whose individual cases all were decedents with intimate connection to the local docklands. Secondly, the circle localized disease occurrence within an area centered on the steamship levee, advancing a geographic proposition in which relation to the docklands correlated with incidence of disease. In McClellan's treatment, the steamships and riverboats were the assumed carriers of the disease. Their docks were the center of the circle around which the homes of the decedents swirled. Third, McClellan's circle served as a signature technique McClellan used to link the maps of cholera, one to another, in all the affected cities. In this way he created a consistent graphic that implicitly argued his case for all cities rather than for any one city uniquely.

"Upon the accompanying map a circle has been described, the center of which rests upon the river-front of Canal streets. The diameter of this circle is long enough to include the locality at which case No. 15 died. It will be observed that the circle embraces but the heart of the city of New Orleans, and that a large portion of the city is without its limits...it will be found that the vast majority of the cholera-deaths in 1873 occurred within

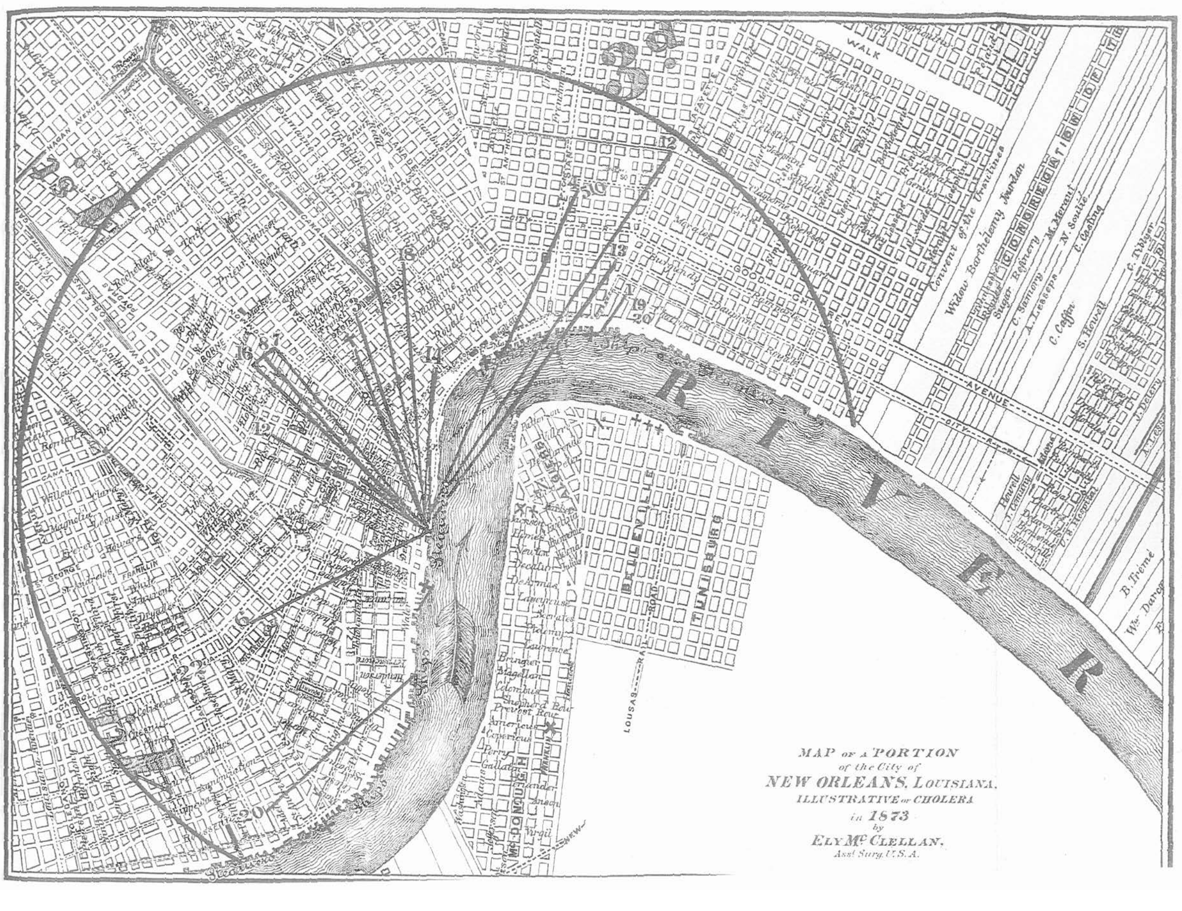


Figure 14. McClellan's map of the New Orleans cholera outbreak in 1873. Source: Rare Books and Special Collections: University of British Columbia.

the area of this circle" (Woodworth, 1875, 106). Like John Snow with his map of cholera cases clustered near the Broad Street pump, McClellan argued that were the epidemic local and miasmatic, another less irregular pattern of disease occurrence would have appeared.

The conclusion was clear: "Dr. White's doctrine of 'non-importation' will not stand." Up and down the river, "the unfortunate individuals who contracted cholera upon or near the steamboat levee came in contact with the poison which had been imported in the effects of emigrants from the cholera-infected districts of Europe" (Woodworth, 1875, 111). McClellan was of course aware of the important arguments for urban hygiene and cleanliness as disease prevention polices which were founded on the theory of exhalation. He quoted extensively from correspondents in those Mississippi cities who accepted the thesis of cholera's general importation without abandoning a belief in exhalation and contagion as generative forces in the propagation of cholera in the densely habited quarters of the poor. Whether the disease was air or waterborne, the unsanitary city was everywhere complicit.

In Memphis, Tenn., for example, Drs. H.H. Erskin and J.C. Peters, the latter from New York City, argued the city's foul airs and its unsanitary ways made it a prime candidate for an epidemic outbreak (see figure 15). "The place was rife with the elements of a great plague, and only needed the specific germ to diffuse it widely and fatal," they reported. The city's "sanitary condition was shameful and a disgrace When cholera was announced the streets were unclean, the alleys reeking with filth, the back yards even in the case of our prominent citizens, who blushed to be made the subjects of public exposure, were full of slops and garbage privies had remained unemptied for years and were in many places running over with the foul accumulations" (Woodworth, 1875, 139).

"It was McClellan's genius to build a series of case studies showing the disease's diffusion while permitting, through local respondents, different theories of the environmental determinants . . ."

It was McClellan's genius to build a series of case studies showing the disease's diffusion while permitting, through local respondents, different theories of the environmental determinants of cholera to have full exposition. While the maps did not include the locus of wastes described in the text, or in earlier maps, it did not need them. The text carried that theme and nineteenth century readers would have assumed the working class nature of docklands and the socioeconomic conditions that prevailed there.

GERM THEORY: LATE 1800s

The cholera question was definitively settled when improvements in microscopy permitted the identification of *Vibrio cholerae* by Robert Koch in 1883. The discovery was enfolded in the exposition of Pasteur's germ theory of disease, one that paid less attention to the *medium* of disease agency, water or air, to focus on the agent itself. This did not end the concern with the condition of urban air or its relationship to disease, however. Instead it transposed that concern from one that was causal to one that was contextual. Odiferous areas of urban waste continued to be constructed as potential sites of disease generation and transmission. In the then emerging field of public health, odor was symptomatic of unimproved urban infrastructure—specifically the handling water and waste—that was not simply unaesthetic but a hazard to health as well.

In a number of cities it became common practice for public health officials to map the odiferous sewer outlets and areas of stagnant water as a way of identifying unhealthy locations whose airs, while no longer perceived as generative, were assumed to be symptomatic. An 1878 map of offensive odors in Boston serves here as an example of this class of maps whose purpose was primarily sanitarian and health-related[4] (see figure 16). As the city expanded, landfill extended the urban base across shallow

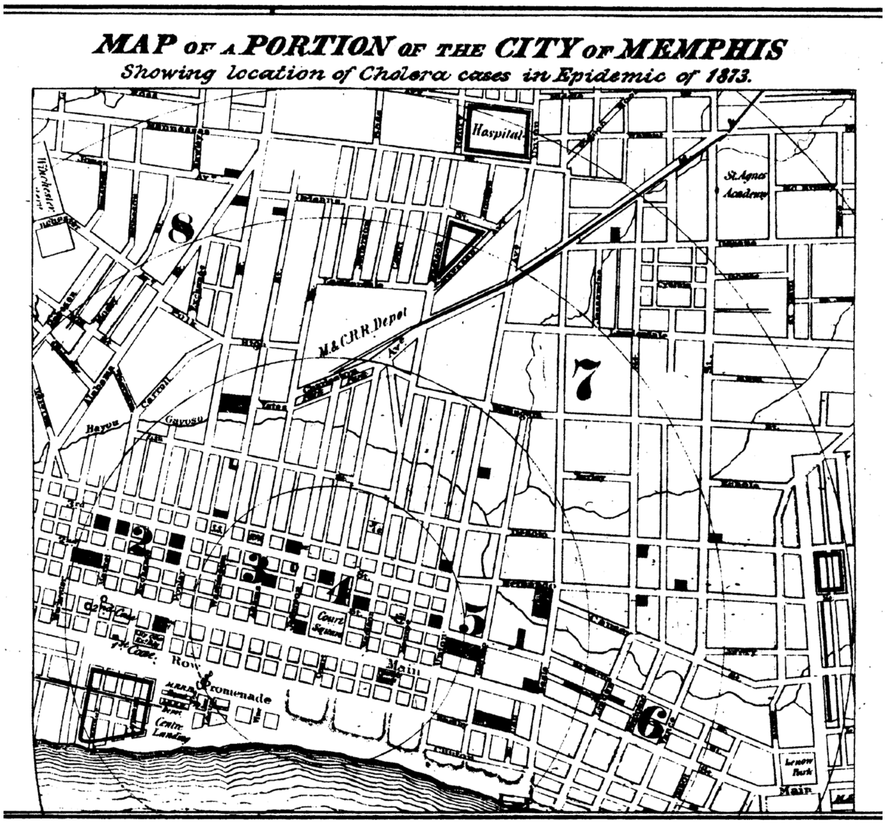


Figure 15. Map of cholera in Memphis, Tenn., showing the pattern of intense occurrence in the area nearest the Mississippi docklands. Source: Rare Books and Special Collections: University of British Columbia.

marshes and statuaries. Sewer and water piping were then laid to provide basic sanitation and water services.

At another scale the belief that good air promoted health, and bad air disease, became part of a broader climatic determinism. Systematized in the late 1880s, the promise was of a "historical-geographical pathology," eventually shortened to "medical geography." The focus was, as Hirsch explained in his 1881 *Handbuch der Historisch-Geographischen Pathologie*, translated into English as a *Handbook of Geographical and Historical Pathology* (Cliff and Haggett, 2003, 11-12), "the geographically dependent factors (such as race, nationality, soil conditions, climate, social factors, etc.) that have to be considered essential for the occurrence and distribution of individual diseases" (Hirsch, 1883, Vol.1, 2).

The result was a period of geographic determinism in which illness was assumed to be largely the effect of the air, climate, soils, wind, temperature, and other physical characteristics of an environment inhabited by specific, at risk populations. These factors explained both different patterns of disease incidence and, some believed, the basic nature of disease itself. "We must no longer be contented with the mere statement that certain geographical facts in the distribution of disease are coincident with certain other facts connected with the soil and atmosphere," Alfred Haviland insisted in the 1892 preface to the second edition of his *Geographical Distribution of Disease in Great Britain*. "The time has arrived when the cause of the disease itself must be thoroughly investigated, and its relation to the soil and the atmosphere ascertained" (Haviland, 1892, viii). This determinism was fundamentally different from the environmental argu-

"The result was a period of geographic determinism in which illness was assumed to be largely the effect of the air, climate, soils, wind, temperature, and other physical characteristics . . ."

Figure 16. Board of Health Map of offensive odors in Boston, Massachusetts, 1878. Red hatching shows the location of mud flats and marshes, large dots of sewer gratings, from which foul odors were carried across the city by prevailing winds marked with separate arrows. Boston Board of Health, 1878. Source: City of Boston Archives. Source: City of Boston archives. (see page 93 for color version)

ments of Hippocrates, Galen, and the other classicists. It argued not the generative cause of good and bad airs but that specific characteristics in local ecologies created environments conducive to different disease agents. The nature of ecological relationships promoting or inhibiting different disease agents would be a recurrent theme over the next century (Koch, 2005, Chapter 9).

Haviland and his contemporaries mapped a positive correlation between the incidence of disease and local geographies in which local airs were assumed to be generative of disease (see figure 17). Like others before them, the data was right but the explanation was wrong, missing intervening vectors that tied specific diseases to local environments. For example, respiratory diseases were more common in mining districts but not because of the chill, valley airs but because of the living and working conditions of low paid and ill-housed coal miners. Tuberculosis could be found in dense settlements in industrial cities where the transmission of the bacillus was favored not by "dank airs" in overcrowded tenements but by the ease with which the disease was transferred interpersonally in those dwellings.

CONCLUSION

The arguments made in the maps reviewed in this paper emphasize the relationship perceived by generations of health researchers over the last three hundred years. Together they assert the ecological perspective in which disease incidence is necessarily considered within a broad context of social and physical variables. To these are added issues of the technolo-

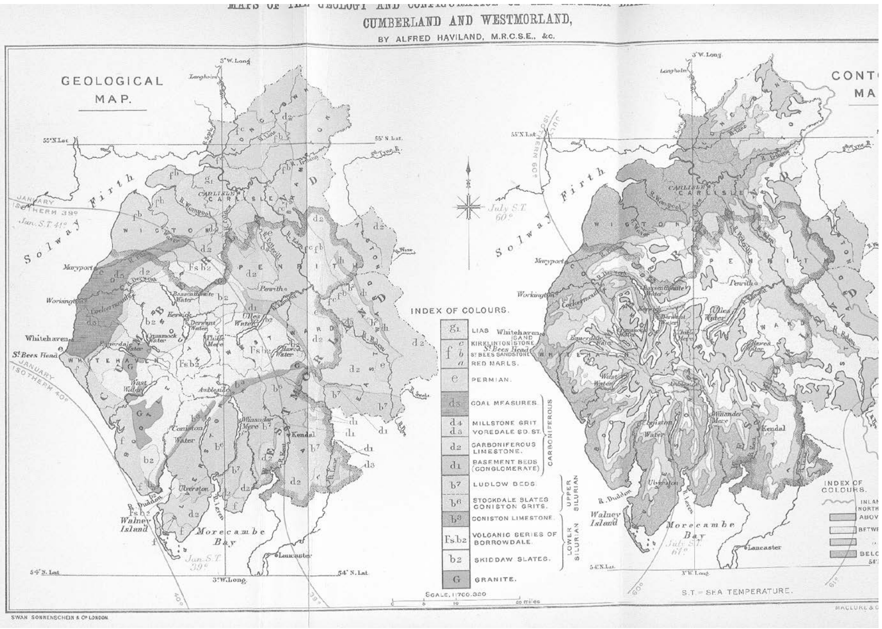


Figure 17. A. Haviland's map of geology of select British districts as part of an explanatory thesis in medical geography. Local soils and airs were used to explain patterns of greater and lesser disease incidence. Source: Rare Books and Special Collections: University of British Columbia. (see page 94 for color version)

gies of production and distribution that generally affect not simply the use of maps but more generally scientific research and publication.

The primary focus of this work has been the period in which epidemic disease was considered within the context of two theories of disease, both existing in the period before modern bacteriology and virology permitted their decisive development and eventual conjunction. Air and water are recognized today as important media for a range of infectious agents. In the end it was not either or. It was both and. That said, the broader perspective offered in this historical review has contemporary as well as antiquarian significance. The entwined importance of health, place and air remains a critical concern of contemporary investigators. Modern researchers, like their predecessors, regularly consider the relation between air quality and disease incidence (bronchitis, influenza, etc.). Of at least equal importance is the potential for airborne transmission of diseases like multi-drug resistant tuberculosis in communities that are at once poor and overcrowded. These interests coexists with intense concern over waterborne viruses and issues of urban water supply in developed as well as developing regions. Understanding the history of these concerns historically is relevant to our perception of them in the modern age.

In considering relationships between infectious agents and their modern environments mapping remains a critical tool. Today that mapping typically is carried out on a GIS platform using electronic data in a medium facilitating digital data collection and electronic as well as print dissemination of graphic and statistical results. While these technological changes have been transforming, the essential idea of a spatial proposition that equates patterns of incidence with environmental influences remains fundamentally unchanged. The modern perspective of disease ecology, mapped and statistical, is the direct inheritor of the tradition here traced to Arrieta, Seaman, and Pascal. Perhaps the greatest lesson this history teaches, therefore, is the importance of "map thinking" (Brody *et al.*, 2000) of framing a spatial proposition to consider rigorously possible cause and real relations within complex and rich environments. That has not changed. It remains the way we do business, the basic argument of map thinking itself.

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ENDNOTES

[1] "endnote reference"

[2] endnote text

[3] endnote text

[4] endnote textta. The map shows areas most affected and the boundaries of

Attention on Maps

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Wilson's (1998) notion of consilience among disciplines should be a goal for cartographers. Consilience requires important facts and fact-based theories to apply across disciplines. This paper reviews research on visual attention as an example of a topic shared by information science disciplines. Attention is considered as a competition between neural processes that allow information to be selected and emphasized for perceptual processing. Visual attention has been modeled as a spotlight, zoom lens, gradient, and multiple spotlights. It is argued that visual attention can impact multiple map reading processes and that cartographers can use knowledge about the effects of attention on map reading to design more effective maps. Attention can be directed to locations, objects, and features in the visual field and impacts performance on a variety of map reading tasks. Important general questions relating visual attention and map reading are stated and the literature providing answers discussed. The "dark side" of attention is also discussed and linked to the concepts of *inhibition of return*, *visual marking*, *inattentional blindness*, *change blindness*, and the *attentional blink*. Specific map-reading processes affected by visual attention are considered that include figure-ground segregation, visual search, and object selection and grouping. Research trends related to cartographic design and map reading are considered for these processes. Future cartographic studies are considered in four categories—vision before attention, vision with attention, vision after attention, and vision without attention. Understanding the role of visual attention in map reading should be a goal of cartographers interested in producing effective maps.

Key words: visual attention, map reading, figure-ground, visual search, perceptual grouping

INTRODUCTION

> *A united system of knowledge is the surest means of identifying the still unexplored domains of reality. It provides a clear map of what is known, and it frames the most productive questions for future inquiry* (Wilson, 1998, 326).

Consilience is the word Edward O. Wilson used to describe the unity of knowledge. His basic argument was that science should seek a unified knowledge "by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation" (Wilson, 1998, 8). If Geographic Information Science (GIScience) is to contribute knowledge to a united system of knowledge, we must understand our place within the larger system and know what common ground we share with sister information science disciplines. For example, information processing by humans can occur at various scales in space and time. Geographers tend to focus on certain scales and be less interested, or completely ignore other scales. Our distances are more likely to be measured in miles than in mil-

"If Geographic Information Science (GIScience) is to contribute knowledge to a united system of knowledge, we must understand our place within the larger system and know what common ground we share with sister information science disciplines."

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limeters or light years. Our times are more likely to be measured in years than in milliseconds or eons. We also have a focused interest in methods for acquiring knowledge. Geographers are not the exclusive users of maps and the techniques of cartography, but "we" should feel responsible for their scientific advancement. Achieving the goal of consilience will require cartographers to rethink old ideas and explore new ideas. Visual attention is an important established concept in map design and map reading that is also a fundamental and extensively researched topic in other disciplines. A review of research on visual attention across disciplines can provide cartographers a current perspective on this important topic and make a small initial step toward consilience.

The trilateral relationships illustrated in figure 1 shows the flow of information in a communication process between the maker (cartographer) and map on the left side of the triangle. Maps are designed and produced by professional cartographers using conventional wisdom.[1] Medyckyj-Scott and Board (1991, 91) suggested this conventional wisdom has primarily been based on the practice of a craft in the sense that cartography "solves its problems of map design by carrying out design and evaluation, the latter generally informally." Evaluations of productions can be done using any number of criteria.[2] The criterion appropriate for the current discussion is based on whether or not a map reader will be able to process the information on the map efficiently. The information flow between the map and map reader on the right side of figure 1 represents this process. If efficiency is achieved, the map reader should be able to acquire informa-

"Visual attention is an important established concept in map design and map reading that is also a fundamental and extensively researched topic in other disciplines."

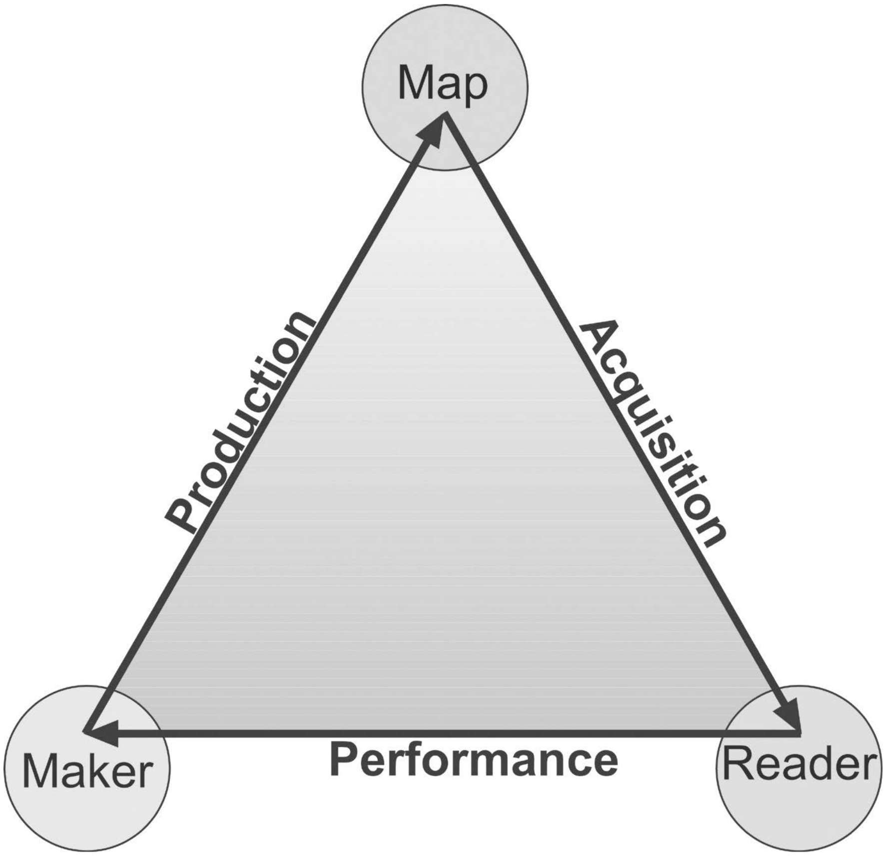

Figure 1. Trilateral relationships involving makers of maps, maps, and readers of maps.

tion from the map quickly, accurately, and confidently (Lloyd and Bunch, 2003).

Most of the time, the production and acquisition processes are done independently. In these cases, the makers of maps will not know if their productions have resulted in efficient or inefficient acquisitions. Trial maps, however, can be produced as part of a planned experimental research design that would allow hypothesis testing. For example, two animation productions might be compared. Map readers might do a vigilance task that required them to respond by clicking a mouse every time a target map symbol appeared during an animation. If animation x has target map symbols with unique colors and shapes that provides a contrast with non-target map symbols and animation y has target symbols that share colors and shapes with non-target symbols, it might be hypothesized that the performance (reaction time, accuracy, and confidence) of map readers would be better with animation x. This is because objects with unique characteristics are more likely to attract the map reader's attention. The performance results are represented as the flow of information between the map reader and map maker in figure 1. The map-maker can use significant patterns in the performance information to refine the subsequent and final productions of the animation. A new round of experiments might determine which unique colors or shapes allow the map reader to acquire information most efficiently.

"If efficiency is achieved, the map reader should be able to acquire information from the map quickly, accurately, and confidently."

There is a shared interest by cartographic researchers and researchers in cognitive neuroscience and psychology in how humans process spatial information. If consilience is to be achieved for the information sciences, then compelling facts and theories developed in one discipline should also apply in sister disciplines.[3] I believe that cartographers could contribute to a greater degree of consilience if experiments leading to map readers acquiring mapped information with optimal efficiency were based on accepted facts and theories from these sister information sciences. Consilience, however, is not an easily achieved goal. A compromise must always be made between controlling the independent variables of a cognitive experiment, and the more complex realistic map. Cartographers who wish to do experimental research encounter a paradoxical situation, a "Catch-22", so to speak. Conducting meaningful experiments requires the researcher to control the spatial information displayed on the map, while real maps frequently have a large number of characteristics affecting efficient processing that cannot be controlled easily. The Catch-22 is that strong experimental controls and realistic maps are extremely difficult to be used at the same time in research designs. The choice would appear to be between studying controlled simplified situations that do not represent actual maps, or conducting experiments with real maps without being able to control or even identify many important variables that affect the acquisition of information from maps. Since most psychology studies that have used maps have tended to favor strong controls and sacrifice realism, it may be up to cartographers to draw the line of compromise. If the line is drawn nearer to the use of realistic maps, the loss of experimental control may result in meaningless experimental results. If the line is drawn nearer to complete control and oversimplified visual displays, the experimental results may say nothing about performance with realistic maps. Consilience progress from a cognitive cartographic perspective depends on doing experiments with as much control as possible with maps that are as realistic as possible.

"The Catch-22 is that strong experimental controls and realistic maps are extremely difficult to be used at the same time in research designs."

"Consilience progress from a cognitive cartographic perspective depends on doing experiments with as much control as possible with maps that are as realistic as possible."

Visual attention is intuitively an important process related to map reading, but reviews of research in cognitive cartography suggest that researchers have not routinely considered attention directly in their studies (Lloyd, 2000; Montello, 2002). Although cartographers have discussed how graphic variables might interact with map readers' attention processes, relatively few hypotheses have actually been tested (Bertin, 1983; Shortridge, 1982; MacEachren 1995; Nelson, 2000a). The primary purpose of this paper is to review current literature related to visual attention and discuss how visual attention is connected to map reading processes. Attention can be directed to locations, objects, or specific types of features in the visual field that can potentially provide important information (Fernandez-Duque and Johnson, 2002; Itti and Koch, 2001). Attention might be directed by information already in memory (top-down processes) or by information being encoded from the map (bottom-up processes) (Miyashita and Hayashi, 2000; Sarter *et al.,* 2001). In most cases some combination of these two sources of direction are used to select information during a map reading task.

"Attention can be directed to locations, objects, or specific types of features in the visual field that can potentially provide important information."

Figure 2 illustrates some processes that might be involved in identifying a target map symbol on a map (Lloyd 1997). A person is given the task of determining if map symbol **X** is on the novel map they are about to view, and making a response of either present or absent. When the map appears, the person first must segregate the figure of the map from the background. The global patterns might be accessible for processing first followed by local objects and their features. If the target is known to have certain features that might be useful for identification, objects with these features might be grouped for further consideration and objects without these features might be grouped and suppressed. If the target has a unique

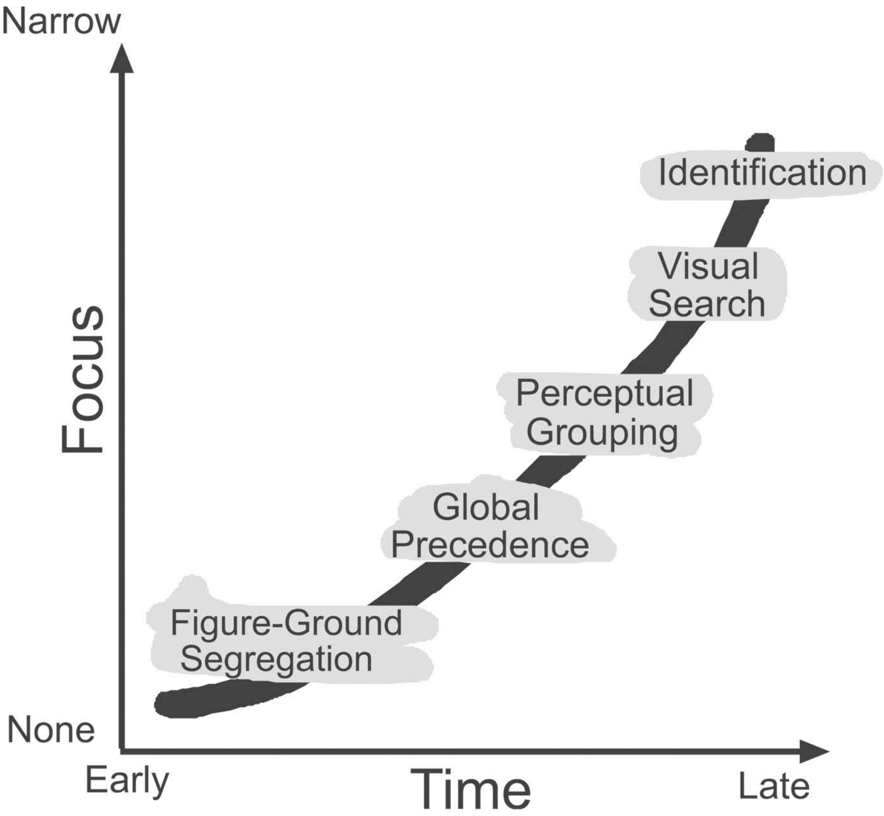

Figure 2. Processes the might be used to identify a target map symbol on a novel map.

feature, it might be identified quickly because it can easily be separated from all other objects. If the target shares one or more features with distractor objects, those grouped for further consideration can be selected for focused attention, one at a time, until the target is identified as present or absent. Information on the map and in a person's memory can contribute to visual attention as it might impact the various cognitive processes that occur between the onset of the map and the final decision.

SPATIAL ASPECTS OF VISUAL ATTENTION

A number of relevant questions emerge when considering attention's role in map reading. First, *what Is visual attention?* Attention can be related to any sensory input, but, for map reading, vision is paramount (Posner, 1994; Treue, 2003; Djordjevic *et al*., 2004; Tatham, 2004). Visual attention is a limited resource controlled by a number of distributed brain activities stimulated by visual input. "The term *attention* has been used for many different psychological, behavioral, and physiological acts and states, such as focused awareness and certain activated conditions of the nervous system. In this context, it may be expedient to define attention as a set of those neural functions by which sensory information is selected and emphasized for perception" (Kohonen, 2002, 9813). The human brain is a biological neural network with approximately a hundred billion neurons and a million billion connections between neurons (Damasio, 1999). Systems of neurons become activated as needed as we process visual information (Martindale, 1991). Although some cognitive processes operate outside our conscious awareness, at any moment in time we have a conscious awareness of information related to neurons activated above a threshold value (Posner 1994). Attention relates to a subset of our most highly activated neurons and the stimuli that inspired the high activation.

"Visual attention is a limited resource controlled by a number of distributed brain activities stimulated by visual input."

What directs attention during map reading? Visual attention is directed in two basic ways. Sometimes attention can be directed consciously by the map reader using information already stored as prior knowledge in memory. This would be considered a top-down process because the critical information directing attention is coming from the map reader's memory. Vecera (2000) suggested it might be useful to think of top-down processes as driven by the goals of a person. For example, if a person is interested in finding names of capital cities among other cities on a map, she could direct attention only to star-shaped symbols on the map. Other times visual attention is directed by information found on the map. For example, a person viewing a map of a space to identify sight-seeing opportunities might attend novel locations specifically because they were unfamiliar. Vecera (2000) indicated bottom-up attention processes are driven by the stimulus. These are considered bottom-up processes because the critical information is the novel information being perceived at that moment in time by the map reader. Map reading frequently involves both types of processes that interact to achieve a specific goal. Unless the map being considered is a cognitive map that is completely stored in memory, some bottom-up processes are part of any map reading experience. Most top-down visual search processes are assisted by bottom-up information (Hodsoll and Humphreys, 2001) and most bottom-up visual search processes are assisted by top-down information (Turatto and Galfano, 2000). Even when a person is looking at a map of a novel space, he may be aided by memories of previous map-reading experiences, or previously learned knowledge of cartographic conventions.

". . . top-down processes as driven by the goals of a person. . . bottom-up attention processes are driven by the stimulus."

Visual attention impacts the efficiency of some very basic map reading processes. A map is easier to process if it has been designed so the figure and background are clearly defined (Dent, 1972; MacEachren, 1995). Cartographers have considered bottom-up principles when designing maps, but recent studies have suggested top-down processes may also affect figure-ground assignments (Vecera, 2000; Peterson, 2003).

Attention processes can affect what spatial information is considered and when it is considered. Sometimes a highly salient feature that pops out of the map captures our attention automatically. Objects having a unique shape, size, color, orientation, or texture on a static map can cause a pop-out effect (Johnson *et al*., 2001; Lloyd, 1997). Objects that suddenly appear or have a unique motion can cause a pop-out effect on animated maps (Peterson *et al*., 2002; Weidner *et al*., 2002).

"Attention processes can affect what spatial information is considered and when it is considered."

When does attention affect the processing of spatial information? Early theories of visual search argued for an initial stage of visual processing that would complete substantial parallel processing of the entire map and do pre-attentive processing of map features (Treisman and Gelade, 1980; Cave and Wolfe, 1990). Features here are defined as characteristics of objects, for example, a map symbol might be large, round, and red. In a later stage, focused attention would be used to inspect locations that were most likely to have a target object. This conforms to the *late selection* view of attention (Kanwisher and Wojciulik, 2000). A contrary view argues for *early selection*. This view argues that relatively little perceptual processing is carried out pre-attentively. It is thought that systems driven by top-down information can affect processing relatively early. For example, neuroimaging techniques have identified regions of the brain that operate on preferred stimuli such as faces (Eimer, 2000), places (Epstein *et al*., 1999) and houses (Aguirre *et al*., 1998a). These are examples of object-based attention (Sholl, 2001).

Downing *et al*. (2001) had subjects perform a number of tasks using pictures of faces and houses while monitoring these specialized regions of the brain using neuroimaging techniques. The authors were able to demonstrate that these specialized brain regions have an early contribution to both location-based and object-based attention. The most convincing evidence for *early selection* comes from neuroimaging studies that have indicated specialize areas of the brain activate in preparation for an expected, but yet unseen stimulus, when they are cued by top-down information (Hopfinger, 2000 & 2001; Shulman *et al*., 2002).

On what mapping units do attention processes operate? Early studies of attention used a spotlight model (Figure 3a) to describe attention (Posner *et al*. 1980). Any objects inside the spotlight were selected for attention and any outside the spotlight were suppressed. A variation on this model was the zoom lens model (Figure 3b) that allowed spatial resolution to be adjusted (Eriksen and St. James, 1986). The zoom lens model also implies there is a trade off between the intensity of the focus and the efficiency, i.e., processing time and accuracy, of the visual processing. One can focus attention on a small area with higher resolving power or on a large area with lower resolving power. Gradient metaphors (Figure 3c) have also been suggested where processing efficiency is high near the target location and gradually declines away from that point (Anderson and Kramer, 1993; Handy *et al*. 1996). Some studies have suggested the spotlight does not always apply because we sometimes do not attend to all the objects at the same location (Most *et al*., 2001; Simons and Chabris, 1999). Multiple spotlights that that can split attention have also been suggested as another model (Figure 3d) for visual attention (Hahn and Kramer, 1998; Awh and Pashler, 2000). Other studies have shown it is possible to attend to groups of objects spread across space based on their common features (Driver and Baylis, 1989; Kastner and Ungerleider, 2002). Recent research has also argued that discrete whole objects rather than locations or features sometimes capture attention (Driver *et al*., 2001; Sholl, 2001).

"Other studies have shown it is possible to attend to groups of objects spread across space based on their common features. Recent research has also argued that discrete whole objects rather than locations or features sometimes capture attention."

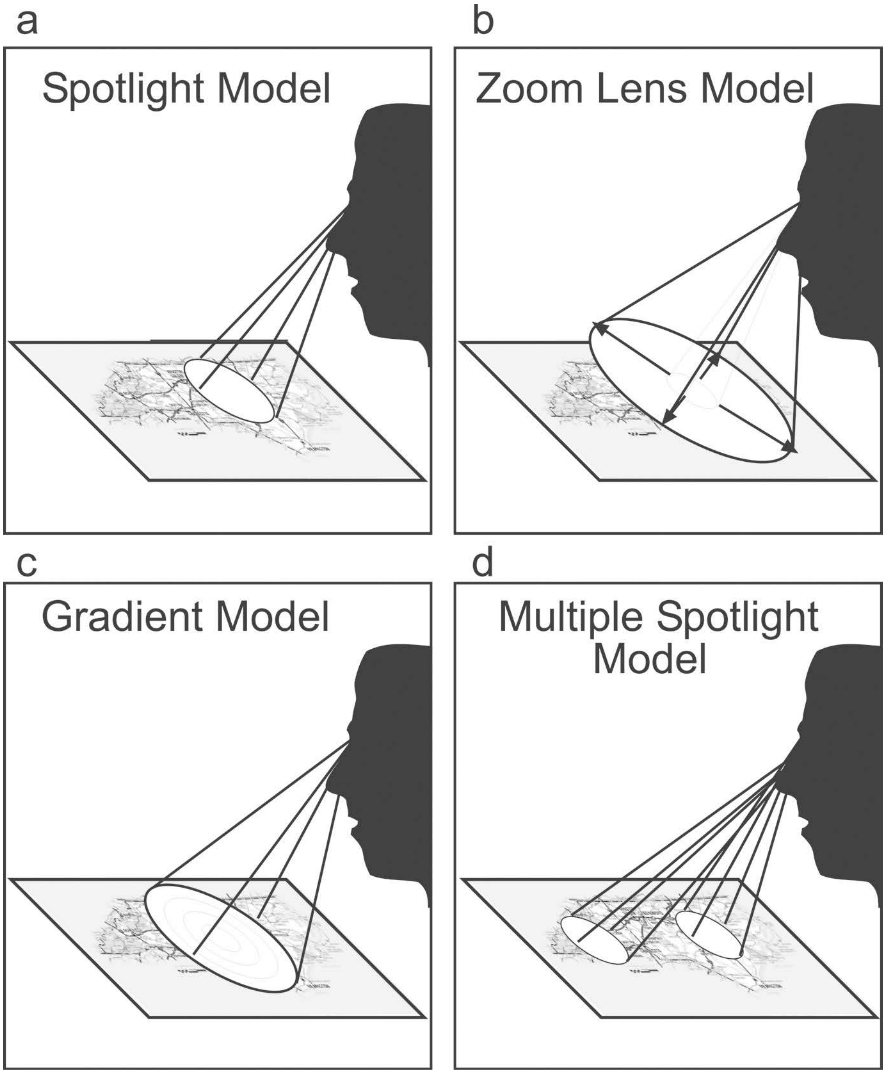

Figure 3. The spotlight (a), zoom lens (b), gradient (c), and multiple spotlight (d) models that have been suggested to represent possible allocations of visual attention.

> *"This* biased competition *approach argues that many different brain systems compete to capture attention and the winners emerge to direct attention."*

Studies that have considered the neural mechanisms of attention suggest, "attention is an emergent property of many neural mechanisms working to resolve competition for visual processing and control of behavior" (Desimone and Duncan, 1995, 194). This *biased competition* approach argues that many different brain systems compete to capture attention and the winners emerge to direct attention. A review of neruroimaging studies has supported the notion that "competition may be biased in advance of stimulus presentation, by preparatory states that 'prime' representation of the target stimulus" (Driver and Frackowiak, 2001, 1259). Another review of neuroimaging studies concluded, "attention can under different conditions select locations, features, objects or a combination thereof" (Kanwisher and Wojciulik, 2000, 98). For a map-reading task, the competition among neural processes related to both top-down and bottom-up information should be biased by information related to the current task. Attention is directed to items that have characteristics processed by the winning systems and away from the items processed by the losing systems. The *biased competition* model has been applied to both selective attention for locations, objects, and features (Desimone and Duncan, 1995) and to the segregation of figure and background (Vecera and O'Reilly, 1998; Vecera 2000).

On what spatial locations can attention operate? Eriksen and St. James (1986) argued selected regions could be scaled like a zoom lens. The region selected for attention might be made relatively large to encompass a single large target or made relatively small to surround a very small target. Intriligator and Cavanagh (2001) investigated the spatial resolution of visual attention. Their experiments measured the smallest distance between objects that still allowed individual objects to be attended. Results suggested that the selection of attention has a coarser grain than visual resolution. At a fixed scale, you can see individual small objects, but cannot attend to them as individuals when they are located too near each other. This same study also reported the limits of selection increase away from a central fixation point, and that selection limits are less below the fixation point than above the point. This suggests one's ability to select attention is not uniformly distributed away from a central point of focus.

"This suggests one's ability to select attention is not uniformly distributed away from a central point of focus."

Recent studies have suggested it is possible to divide attention and direct it as multiple spotlights under some circumstances. Hahan and Kramer (1998) conducted experiments with linear arrangements of stimuli that suggested multiple foci could be maintained as long as new distractors did not appear between the attended locations. They further considered if this was possible because the two spotlights were in different hemifields and, therefore, controlled by different hemispheres of the brain. Another experiment demonstrated subjects could maintain two spotlights within one hemifield. Awh and Pashler (2000) considered the possibility of multiple spotlights within a 5 X 5 array that was represented as a two-dimensional space. Each trial briefly displayed an array filled with 23 letters and 2 numbers. Numbers appeared at two pre-cued positions in the array on either side of a fixation point for valid cues. Numbers appeared at positions between the two pre-cued positions and on the other side of the fixation point for invalid cues. Subjects simply identified what numbers were displayed. The authors concluded, "it is possible for observers to achieve multiple foci of attention in the visual field" that had "a bimodal distribution of processing quality, in which accuracy was highest at two noncontiguous locations and markedly lower directly in between those locations" (Awh and Pashler, 2000, 845).

"Chun and Marois argued that visual attention has a bright side and a dark side."

McMains and Somers (2004) conducted functional magnetic resonance imagery studies that monitored brain activity while subjects performed tasks involving spatially separated stimuli. They found neural activation patterns that suggested subjects could maintain attention spotlights both across hemispheres and within hemispheres. They argued, "this provides direct evidence that spatial attention can select, in parallel, multiple low-level perceptual representations" (McMains and Somers, 2004, 677).

It has also been suggested that individual differences in allocation patterns are related to the amount of available working memory (Kane *et al.*, 2001). Bleckley *et al.* (2003) presented results suggesting that individuals with a low working memory capacity allocated attention as a spotlight while individuals with a high working memory capacity showed a more flexible allocation of attention.

THE DARK SIDE OF ATTENTION

Chun and Marois (2002) argued that visual attention has a bright side and a dark side. The bright side is that attention improves access to important information that can be used to complete a task or solve a problem. The dark side is that the selection of a part of the total information available in a visual field such as a map may result in other potentially important information being missed. A number of research categories are briefly reviewed here that considers the dark side of visual information processing.

Inhibition of Return: As the focus of attention is shifted on a map the effect of that attention may still influence how one processes information. A large number of studies have reported on the inhibition of return effect (Klein, 2000; Samuel and Kat, 2003, Los, 2004). Wright and Richard (2000, 2351) indicate, "Inhibition-of-return is the process by which visual search for an object positioned among others is biased toward novel rather than previously inspected items. It is thought to occur automatically and to increase search efficiency." This suggests map readers should have a natural inclination not to return to locations they have already considered with focused attention. This bias toward novel information may have a dark side if previously considered locations or objects on a dynamic map later happen to contain important information. Cartographers could perform an experimental study that would test the hypothesis that new target objects on a dynamic map would be found more quickly if it occupied a previously unoccupied location rather than a location previously occupied by a non-target map symbol.

"This suggests map readers should have a natural inclination not to return to locations they have already considered with focused attention."

Visual Marking: A concept related to inhibition of return has been called *visual marking* (Watson and Humphreys, 1997; 1998). Watson and Humphreys (2000) found that probes falling on old locations were more difficult to detect than probes falling on new locations. They concluded there was an intentional rather than an automatic bias against old items. Olivers and Humphreys (2003) considered if the inhibition of old locations could carry over from trial to trial. They used a preview task that had the old items differ in color from new items. Later trials presented without the preview were faster when the trials had items with the same color represented in earlier preview trials. Cartographers might be able to determine if visual marking is an automatic bias or a learned strategy using a search task on a dynamic map. An automatic bias should have the same effect on early and late trails, while a learned strategy should affect early trials less than late trials.

Inattentional Blindness: When salient and distinctive objects unexpectedly appear on a dynamic map, studies have shown such objects may frequently be missed when an observer is focusing attention on some other object or event (Simons and Charbis, 1999; Simons, 2000; Mack, 2003). These studies make a distinction between explicit attention and implicit attention capture. In a dynamic map reading context, studies of explicit attention could consider the likelihood that potentially relevant, but unexpected map symbols will be noticed, while studies of implicit attention could consider the likelihood that expected, but irrelevant map symbols can be ignored. An explicit attention capture would imply an awareness of the map symbol, while an implicit attention capture would imply an impact on the performance of a task without explicit awareness. Lavie (1995) argued the cognitive load associated with a perceptual task determines the amount of implicit processing associated with unattended objects. Only attended objects are processed with higher cognitive loads, but unattended objects are also processed with lower cognitive loads. Most *et al.* (2001) reported the likelihood of attentional capture for a suddenly appearing object was increased if its luminance was similar to attended objects and dissimilar from ignored objects. It was argued that subjects developed an attentional set for luminance and were able to ignore other dimensions, e.g., shape, that might also distinguish the suddenly appearing object from other objects.

"Only attended objects are processed with higher cognitive loads, but unattended objects are also processed with lower cognitive loads."

Contextual Cueing: Another example of implicit spatial learning related to map reading has been called *contextual cueing* and demonstrated by Chun and Jiang (1998; 1999; 2003). The basic argument is that a consistent spatial context can be implicitly learned, and having this knowledge will make visual search more efficient. Chun (2000, 171) suggested, "contextual information provides useful constraints on the range of possible objects that can be expected to occur with that context" and "contextual information allows perceivers to benefit from the fact that the visual world is highly structured and stable over time." Jiang and Wagner (2004) argued the memory of individual distractor locations and configurations of distractor locations are learned in *contextual cueing*. They reported the search for shape targets could be improved by *contextual cueing*, the relative locations of objects were learned, and the knowledge transferred to rescaled, displaced, and perceptually regrouped displays. Other research has strongly suggested spatial contextual information is implicitly learned during the performance of search tasks and that these long-term memories can persist for some time (Chun and Jiang, 2003). Olson and Chun (2002) reported evidence that the implicit learning of spatial context information is constrained by perceptual grouping. They indicated that grouping by spatial proximity significantly reduced search times, but grouping by non-spatial features such as color did not produce a similar benefit.

"The basic argument is that a consistent spatial context can be implicitly learned, and having this knowledge will make visual search more efficient."

Change Blindness: Map readers are likely to fail to detect changes in dynamic maps for a number of reasons. Changes on a dynamic map might occur during eye-movements, blinks, and blank screens or in locations away from focused attention (Simons, 2000). Simons and Levin (1997, 261) defined *change blindness* as, "the inability to detect changes to an object or scene." Their review of the *change blindness* literature suggested the visual system encodes the many details of perceptual experiences for an instant, but does not integrate more than the gist of the details from view to view. This is done to provide the viewer with stable impressions over time rather than chaos, but causes viewers to miss many changes. Changes to centrally attended objects are more likely to be noticed, but are also often missed. Simons and Levin (1997, 267) suggested, "attention is necessary, but not sufficient, for change detection." Cartographers might use a dynamic map that featured potential change blindness situations to consider if specific changes were missed while accurate general impressions were being learned.

On the bright side, Thornton and Fernandez-Duque (2002, 99) reviewed converging evidence and concluded, "that changes can be registered by the visual system and can influence behavior even in the absence of conscious awareness." This suggests map readers viewing dynamic spatial displays may implicitly learn information from the experiences that could influence decision making even though they were not conscious of the learned information.

"This suggests map readers viewing dynamic spatial displays may implicitly learn information from the experiences that could influence decision making even though they were not conscious of the learned information."

Attentional Blink: Map readers may also fail to attend to information on dynamic maps when information comes in rapid succession. In a map-reading context, a second target map symbol that is presented at the same location within half a second of a first target map symbol is likely to be missed because of an *attentional blink* (Raymond *et al.* 1992; Shapiro *et al.* 1997; Kellie and Shapiro, 2004). The typical experimental design used to study *attentional blink* is called rapid serial visual presentation (RSVP). A sequence of frames is presented as a continuous series that contains one or two frames with targets and blank frames (masks) or other non-target objects. Subjects are required to view the sequence and determine if the target or targets are present or absent. A review of explanations for this effect found a common theme indicating the second target was missed because a limit resource was not available to process the second target (Shapiro *et al.* 1997). Awh *et al.*(2004) reviewed literature that reported the *attentional blink* effect for a variety of target types that included letters, numbers words, shapes, colors, and orientations. They conducted a number of *attentional blink* experiments that used faces as targets and reported faces sometimes could be identified accurately as second targets without the *attentional blink* effect. It was argued that stimuli with spatial patterns such as faces are processed using both holistic configural information and individual feature information. If the feature channels were occupied processing the first target, the configural channel would still be available to identify the second target. Cartographers could easily study this notion because maps and some map symbols also have both spatial patterns and features.

Folk *et al*. (2002) were able to demonstrate what they called a *spatial blink.* Their results indicated that even when one is certain that a target will appear in a specific location in a dynamic display, the appearance of a distractor stimulus at a peripheral location captures attention if the distractor stimulus shares a feature such as color with the target. If someone is set to consider the presence or absence of a red target at a particular location, the shift of attention to another location having a red stimulus increases the likelihood a briefly presented target will be missed.

"Kahneman et al.'s *object file theory argued that when a new object appears and captures our attention, we create a temporary object file in working memory to keep track of the object."*

Kahneman *et al.'s* (1992) object file theory argued that when a new object appears and captures our attention, we create a temporary object file in working memory to keep track of the object. When this viewed object appears to change locations, as in an apparent motion animation, or changes features over time, the data associated with the file is reviewed. This could result in the data encoded about the object being updated if changes are appropriately small, or a new object file being created for a second object if the changes are sufficiently large.

Raymond (2003) claimed that new objects not new features trigger the *attentional blink*. Her experimental results indicated that an *attentional blink* occurred when the first and second targets were different objects, but not when they were the same object with different features. This would be the expected result if the resources needed to create a new object file in working memory were significantly greater than the resources needed to update the data for one object file. Cartographers could easily test this expectation with object files representing map symbols on a dynamic map.

Kellie and Shapiro (2004) morphed one object (smoking pipe) into another object (cooking pot) to test the hypothesis that this process would give the impression of a single object being smoothly transformed and, therefore, not create an *attentional blink*. This was verified and explained by the notion that only one object file needed to be created and updated when viewing the morph animation. When the same frames created for the morph were presented in a scrambled order, this created a demand for more object files, and created an *attentional blink* effect. An inverse relationship was reported between object file contiguity and the magnitude of the *attentional blink* effect.

VISUAL ATTENTION RELATED TO MAP-READING PROCESSESS

Cartographers have considered visual attention as part of processes such as the discrimination between figure and ground, spatial search for map symbols, and object selection processes (Dent, 1972; Lloyd, 1988; Nelson, 1999). Such processes generally reflect hierarchical organizations in both space and time. An early temporal and broad spatial process is the discrimination of the figure (the important area or areas on the map that need to be viewed) from the background (the unimportant area or areas on the map the do not need to be viewed). A serial search for a target map symbol is a middle-level process in space and time. A serial search process would occur after figure-ground segregation and throughout the area of the map that is considered the figure. Objects such as map symbols are selected during later stages of processing, grouped, and narrowly viewed to access meaningful information.

Figure and Ground: The earliest visual processes generally used when reading maps are discriminations of figures from backgrounds. "These visual processes are important because figures form the basis of much visual processing — humans are more likely to recognize and act upon figures than backgrounds" (Vecera *et al*. 2004, 20). Cartographers have discussed the importance of their responsibility to help map readers quickly and accurately distinguish figure from ground. Earlier discussions by cartographers have emphasized both the importance of creating visual hierarchies on maps, and the effects of principles argued by *Gestalt* psychologists (Ellis 1955; Wood, 1968; Dent, 1972). For a discussion of specific *Gestalt* principles related to map reading see MacEachren (1995). A number of early studies noted that figure-ground ambiguity on maps might occur when there is competition between effects, such as value and texture, that differentiate one area on a map from another (Dent, 1972, Head, 1972, Lindenberg, 1975). MacEachren and Mistrick (1992, 91) considered the role of brightness in figure-ground assignments and reported, "neither light nor dark areas are seen as figure if all other things are equal, and that knowledge of which area is land does not dictate that land will be seen as figure." The inability of labels to affect figure-ground segregation would seem to support models that postulate figure-ground assignments precede the focused attention required to read labels.

"The earliest visual processes generally used when reading maps are discriminations of figures from backgrounds."

Theories that argue for hierarchical stages in vision support the notion that the assignment of figure and ground is completed in parallel across the entire visual field before higher-order processes such as focused attention or object identification are initiated (Neisser, 1967; Marr, 1982; Biederman, 1987). Peterson and Skow-Grant (2003) referred to the notion that figure-ground assignment always precedes access to object memories as the *figure-ground first assumption*. The *figure-ground first assumption* leads to two important predictions. First, memory for a shape should not affect a figure-ground assignment because the assignment is assumed to precede any visual attention processes that could be used to match objects in memory. Studies, however, have produced results that indicate object memories are accessed before the assignment of figure and ground is completed (Peterson, 1994; Vecera and O'Reilly, 1998). Peterson (1999) argued object recognition occurs prior to figure-ground segregation. It was hypothesized that pre-figural processes operate on edges to recognize objects, and that this recognition then affects the assignment of figure and ground. Vecera and O'Reilly's (1998) computational model based on parallel distributed processing is slightly different. The model hypothesizes top-down information from internally stored object memories and bottom-up information from the edges present in the visual field are simultaneously processed to affect figure-ground assignments. This view argues for a biased competition between the "bottom-up information carried by the physical stimulus and top-down information based on observer's goals" (Vecera, 2000, 353).

"Theories that argue for hierarchical stages in vision support the notion that the assignment of figure and ground is completed in parallel across the entire visual field before higher-order processes such as focused attention or object identification are initiated."

"Studies, however, have produced results that indicate object memories are accessed before the assignment of figure and ground is completed."

If figure-ground assignments are assumed to precede object processing, it is also predicted that exogenous cues directing visual attention would not influence the initial figure-ground assignment on a map when it first appears to be viewed. For example, if an area on a map has a built in figure bias cause by a *Gestalt* principle such as *good continuation* or *closure,* precueing a background location on the map as the map initially appears on a Web page should have no influence on the initial figure-ground assignments. In other words, precueing the ocean could not shift the initial figure assignment from a continent to the ocean if the map was designed using *Gestalt* principles to show the continent as figure and ocean as background.

Vecera and O'Reilly's (1998) alternate theory suggests original *Gestalt* principles biasing figure-ground assignment can interact with visual attention to affect the initial figure assignment. An experiment to test the theory showed a display with convex and concave shapes that had different colors and a common boundary (Vecera *et al.*, 2004). *Gestalt* principles would predict the convex shape would appear as the figure and the concave shape would appear as the background. A significant interaction effect indicated that the biased response for the convex shape as figure was reduced when the concave shape was precued. This result was interpreted to mean that "exogenous spatial attention can compete with image-base *Gestalt* cues in figure-ground assignment (Vecera *et al.*, 2004, 25). This indicates that a cartographer presenting a map on a Web page could enhance the likelihood that subjects would segregate the region intended as the figure by marking it with a precue as the page loads.

> *"This indicates that a cartographer presenting a map on a Web page could enhance the likelihood that subjects would segregate the region intended as the figure by marking it with a precue as the page loads."*

Global Precedence: Another interesting hierarchical effect has been called *global precedence* (Navon, 1977). See Kimchi (1992) or Navon (2003) for reviews of the *global precedence* literature. The original hypothesis was that global information is available earlier than local information. The basic issue was whether one sees the forest before one sees the trees. Compound stimuli were typically used in these studies. Examples could be large letters made from small letters or a large state made from small states (Figure 4). Other designs have considered global information in photographs as low-frequency information and local information in photographs as high-frequency information (Loftus and Hartley, 2004). For example, an original aerial photograph (Figure 5b) of an orchard might be separated into global information that shows broad homogeneous regions (Figure 5a) and local information (Figure 5c) that shows the details of linear features.

The general finding was that letters could be identified faster at the global level than at the local level (Navon, 1977). Distracting information related to global shapes also was found to affect the processing of local shapes, but distracting information related to local shapes did not affect the processing of global shapes (Miller and Navon, 2002). Navon (2003) suggested two issues are important. He called one the *disposition issue* and the other the *prevalence issue*. He suggested the *global precedence* effect is a competition between two constituents. The *disposition issue* is concerned with whether or not human perceptual systems have an inherent predisposition to favor global constituents. The *prevalence issue* is concerned with whether or not most real world global patterns are able to win biased competitions with local constituents.

> *"Global precedence should be particularly interesting for those who make and use real world graphics such as maps."*

Global precedence should be particularly interesting for those who make and use real world graphics such as maps. If the human perceptual system has an inherent predisposition to process global information first, then map readers should process the patterns on maps made by the cartographic symbols before they process the individual symbols *ceteris paribus*. The *prevalence issue* is somewhat in doubt for map reading because cartographers cannot control the nature of global patterns on maps as well as they can control the nature of local map symbols. Similar to processes that segregate a figure from the background, the biased competition between the global pattern and local objects in the figure has been argued by some to take place before attention is focused, and by others as directed by attention (Navon and Pearl, 1985; Rock and Mack, 1994). Since the degree to which the global configuration is well organized and matches a familiar pattern in memory seems to affect the advantage of the global pattern,

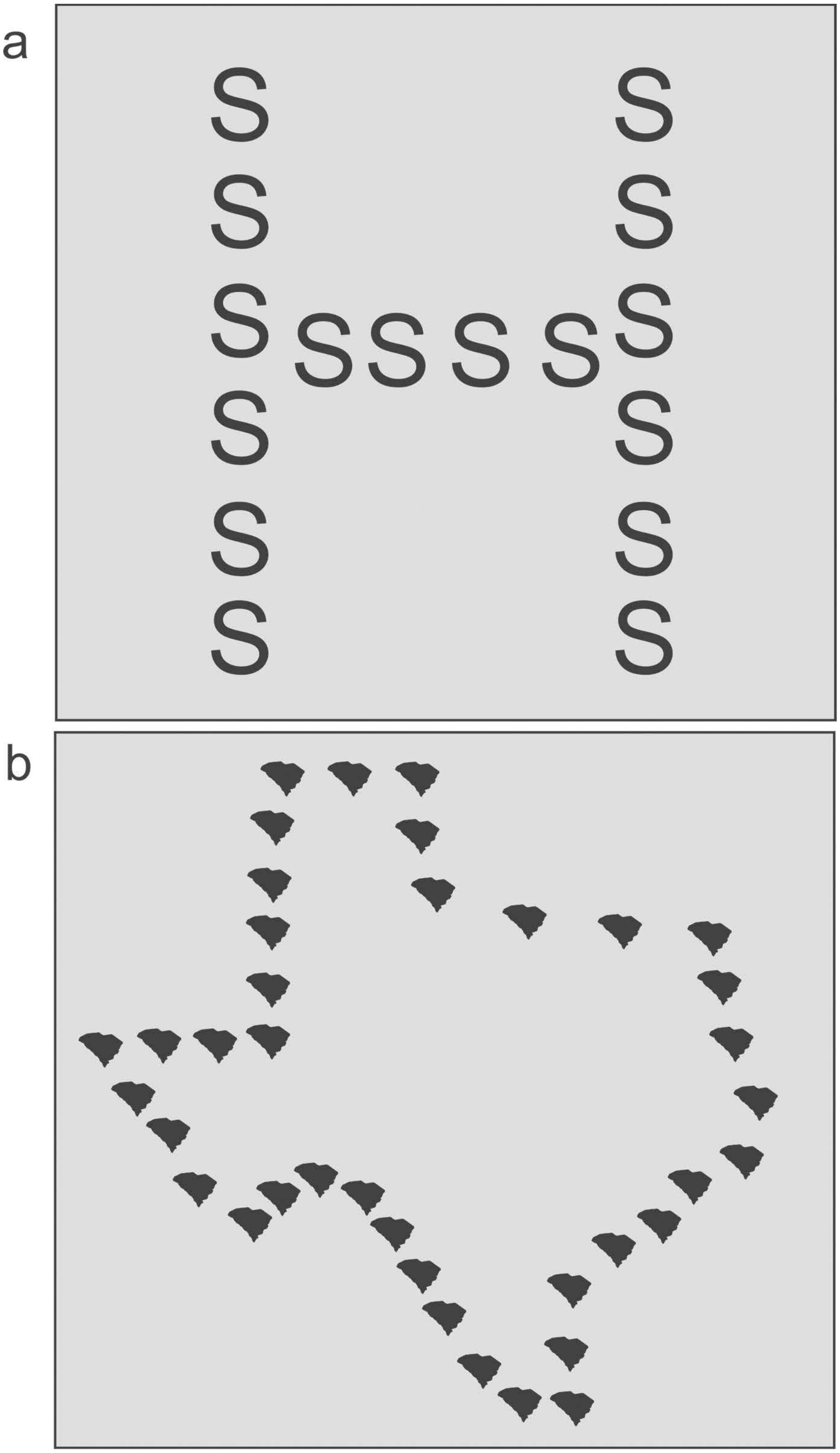

Figure 4. Compound figures showing a large letter pattern made from small letter objects (a) and a large state pattern made from a small state objects (b).

both bottom-up information (*Gestalt* principles) and top-down information (templates in memory) appear to impact the competition (Navon, 2003).

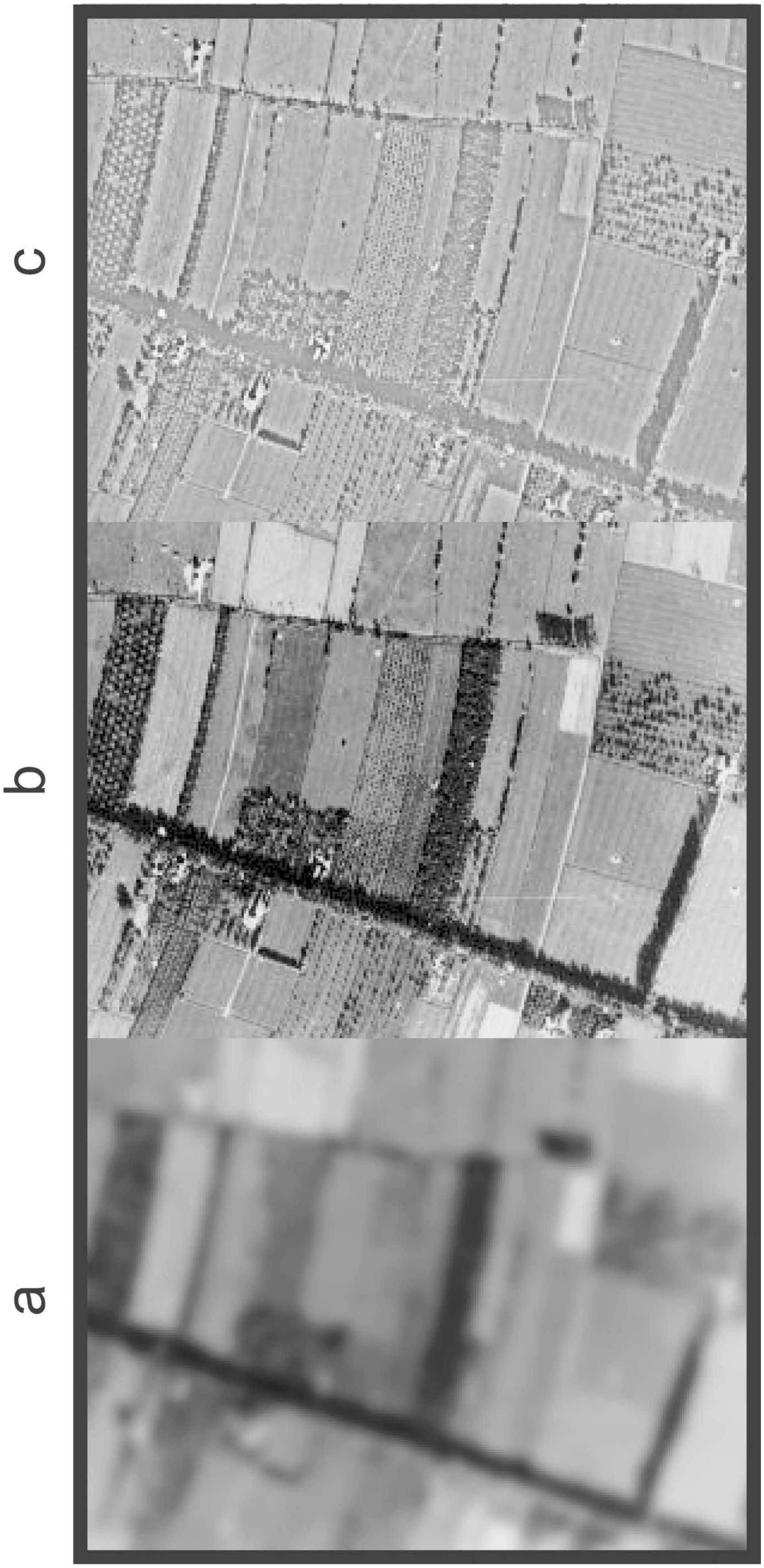

Figure 5. Aerial photograph of an orchard with images showing low-frequency (a), all (b), and high-frequency (c) information.

Loftus and Hartley (2004, 104) identified studies that offered different theoretical perspectives for "the relations between global and local information — the relative time courses over which they are acquired and the means by which they combine into overall perception of the scene." Studies that argue for an *independence theory* take the position that both global and local information can be acquired from a stimulus, such as a map, after it appears and that the order of acquisition is not important (Parker *et al*., 1996). An *independence theory* is distinguished from *global-to-local* theories in that the latter argue for an order to the processing. Sanocki (2001) distinguished between *global precedence* theories that argue the processing of global information precedes the processing of local information, and *interactive* theories that argue that global processing not only precedes but also affects the processing of local information. Morrison and Schyns (2001) have also pointed out that global and local processing have been referred to in two ways that may not be the same (Figures 4 and 5). Some studies have defined global and local scales in terms of the sizes of areas or objects (Sanocki, 1993) while others have used low and high spatial frequency and defined global and local scales in terms of course and fine textures (Olds and Engle, 1998). Studies defining spatial scale using these methods have supported different processing theories. Those defining scale by spatial frequency generally have supported the *global precedence* theory while those defining scale by size have generally supported the *interactive* theory (Loftus and Harley 2004).

> *"Studies defining spatial scale using these methods have supported different processing theories. Those defining scale by spatial frequency generally have supported the* global precedence *theory while those defining scale by size have generally supported the* interactive *theory."*

Visual Search: Cartographers have considered many ideas related to visual search in their discussions of map reading. Dobson (1985) made a distinction between search processes driven by the map, which he call *visual search guidance*, and searches driven by higher level cognitive processes, which he called *cognitive search guidance*. The former can be impacted through the map design decisions made by the cartographer and the latter can be impacted through education processed related to map reading.

Based on a number of theories proposed by cognitive scientists, cartographers have conducted experiments on the visual search processes used with maps (Treisman and Gelade, 1980; Duncan and Humphreys, 1989; Cave and Wolfe, 1990). These theories have considered the role that attention plays in visual search in different ways. For the current discussion, consider a base map with a number of map symbols on it. One of the symbols may be the target symbol and the target may have unique features or share features with distractor symbols. The person searching the map is shown the target symbol before seeing the trial map, and must respond as to whether the target is present or absent. Treisman's (1988) *feature integration theory* argued for two distinct stages in a visual search process. An initial pre-attentive parallel stage provided an initial processing of the available information into separate feature maps. Features are locations on dimensions such as red on the color dimension or horizontal on the orientation dimension. If a target map symbol has a unique feature, its presence can be detected quickly during this initial stage without focused attention. When this happens the target is said to pop-out of the map. If the target map symbol does not have a unique feature that distinguishes it from distractor map symbols, a second stage uses focused attention to consider each possible map symbol until the target is found or all possible distractor map symbols have been eliminated from matching the target.

> *"If a target map symbol has a unique feature, its presence can be detected quickly during this initial stage without focused attention. When this happens the target is said to pop-out of the map."*

Other theories for visual search make different assumptions. Duncan and Humphreys' (1989; 1992) *attention engagement theory* made no distinction between parallel and serial stages of processing and argued the similarity between the target and distractors and the similarity among the distractors dictated the difficulty of the task. The search was easy when there was a great contrast between the target and distractors and when distractors were homogeneous. A search should be very difficult when the target was very similar with distractors and the distractors were very dissimilar from each other.

Nelson (1994) tested the predictions of the *attention engagement theory* in a map-reading context by having subjects search for a target color among distractor colors on bivariate choropleth maps. Results indicated that some colors (red and yellow) could be detected significantly faster than other colors. A larger contrast between the target and distractor colors also produced significantly faster reaction times, but the contrast among the distractor colors did not significantly affect reaction times. It was also noted that it was impossible to create maps that have both a small contrast between the target color and distractor colors and a large contrast among distractor colors.

"The search was easy when there was a great contrast between the target and distractors and when distractors were homogeneous. A search should be very difficult when the target was very similar with distractors and the distractors were very dissimilar from each other."

Guided search theory considered visual attention the critical factor in explaining visual search processes and proposed attention was guided by a combination of bottom-up information from a stimulus like a map and top-down information in the searcher's memory (Wolfe, Cave, and Franzel, 1989; Cave and Wolfe, 1990; Wolfe, 1994; Wolfe and Gancarnz, 1996). Cartographers should be interested in what features can guide attention and their relative strengths (Wolfe and Horowitz, 2004). Lloyd (1997) reported parallel searches that produce a pop-out effect for target map symbols with a unique color, shape, size, or orientation when targets were present, but only color produced a pop-out effect when the target was absent. Conjunctive searches that had targets sharing color or shape with distractors also produced a pop-out effect. Conjuntive searches that had targets sharing color and orientation, however, produced a classic serial self-terminating pattern with reaction times increasing with number of distractors.

A number of studies have performed search experiments with choropleth maps that required map readers to search for targets that were adjacent polygons filled with specific colors (Brennan and Lloyd, 1993; Bunch, 1999; Bunch and Lloyd, 2000). It was generally reported that both top-down and bottom-up information influenced search efficiency. With complex choropleth maps, the search for color boundaries was relatively difficult and pop-out effects were not the typical result. Targets with higher luminance red and yellow colors generally resulted in significantly faster search times. Processing time significantly increased with the similarity of the target colors and distractor colors and significantly decreased with the similarity among the distractor colors on test maps (Bunch and Lloyd, 2000).

"Targets with higher luminance red and yellow colors generally resulted in significantly faster search times."

Other studies have also considered the processes used to search for point symbols on maps. Lloyd (1988) examined reaction time patterns to determine if map readers used similar search processes when they determined if a pair of pictographic symbols were present or absent on cartographic and cognitive maps. Subjects who were presented the target symbols first and searched for them on a visible map appeared to use a serial self-terminating process. This was indicated by a pattern showing reaction times increasing linearly as the number of symbols on maps increased. The slope of the relationship between reaction time and number of symbols was approximately twice as steep for absent responses than it was for present responses. Other subjects were presented the map to learn first, the map was then removed, and then the two target symbols were presented. Subjects determined if the symbols were present or absent on the map they had memorized. These subjects appeared to use a parallel search process when considering cognitive maps they had encoded into memory. This was indicated by a pattern of reaction times that did not increase for either present or absent responses as the number of symbols on maps increased. The qualitatively different patterns for the two groups of subjects clearly indicated different search processes were being used to search visible cartographic maps and memories of these same maps.

Nelson *et al*. (1997, 30) considered the search for multivariate point symbols represented as Chernoff Faces and concluded, "research results demonstrated that hierarchical relationships could be manipulated within these types of symbol to increase search efficiency." Visual searches with these complex point symbols proved to be relatively difficult. Subjects appeared to use serial searches in some cases even when the target had some unique feature that should have promoted a pop-effect. It was also reported that search efficiency varied by the type of feature involved in the search. The searches for targets were most efficient when head size was the unique feature and least efficient when mouth orientation was the unique feature. Conjunctive searches that involved a search for a whole and a part, for example head and eyes, were more efficient than conjunctive searches that involved a part and another part, for example nose and mouth.

"The qualitatively different patterns for the two groups of subjects clearly indicated different search processes were being used to search visible cartographic maps and memories of these same maps."

Selection and Grouping of Objects: As Palmer *et al*. (2003, 311) defined it, "perceptual grouping refers to the processes that are responsible for determining how the part-whole structure of experienced perceptual objects (such as people, cars, trees, and houses) are derived from the unstructured data in retinal images." Groups of symbols on maps could be added to the examples above. Cartographers represent symbols on maps so their characteristics suggest to viewers they belong in groups. Without organizational clues, the symbols would not appear to be differentiated or appear to be part of a single group (Figure 6a). Basic *Gestalt* principles based on common colors (Figure 6b), sizes (Figure 6c), orientations (Figure 6d), or motions (Figure 6e) could be used to assign individual symbols into separate groups.

Cognitive research has also been done on familiar cartographic situations such as grouping based on symbols being in a common region (Figure 6g) or having common connections (Figure 6h) (Palmer, 1992; Palmer and Rock, 1994). Palmer and Brooks (2004) discuss common fate principles involving point and line symbols that affect the selection of figure and ground. Examples can be shown for a map with two regions separated by a common boundary. If the boundary shares some key feature with the symbols in one of the region, such as color (Figure 6i) or orientation (Figure 6k) most people select that region as the figure. If the color (Figure 6j) or orientation (Figure 6l) of the boundary is not shared by the symbols in either region, then neither region has an advantage for figure selection.

"The perceptual grouping of map symbols can have an important effect on map reading. Efficiencies can be accomplished in visual processing if objects having similar features can be considered all together as a group rather than as many individuals."

The perceptual grouping of map symbols can have an important effect on map reading. Efficiencies can be accomplished in visual processing if objects having similar features can be considered all together as a group rather than as many individuals. For example, if one is searching for a red map symbol, all the green map symbols can be put into one category that can be suppressed as a group (Duncan and Humphreys, 1992).

Nelson (1999; 2000a; 2000b) conducted studies based on selective attention theory that documented how map readers responded to bivariate point symbols. She focused on ideas related to the measurement of the perceptual grouping of features on an image, and how map readers acquire information from multiple dimensional map symbols. Symbols that are defined on two dimensions such as size/shape or hue/value, can be categorized according to how the dimensions interact. *Separable* dimensions can be attended to independently of other dimensions. *Integral*

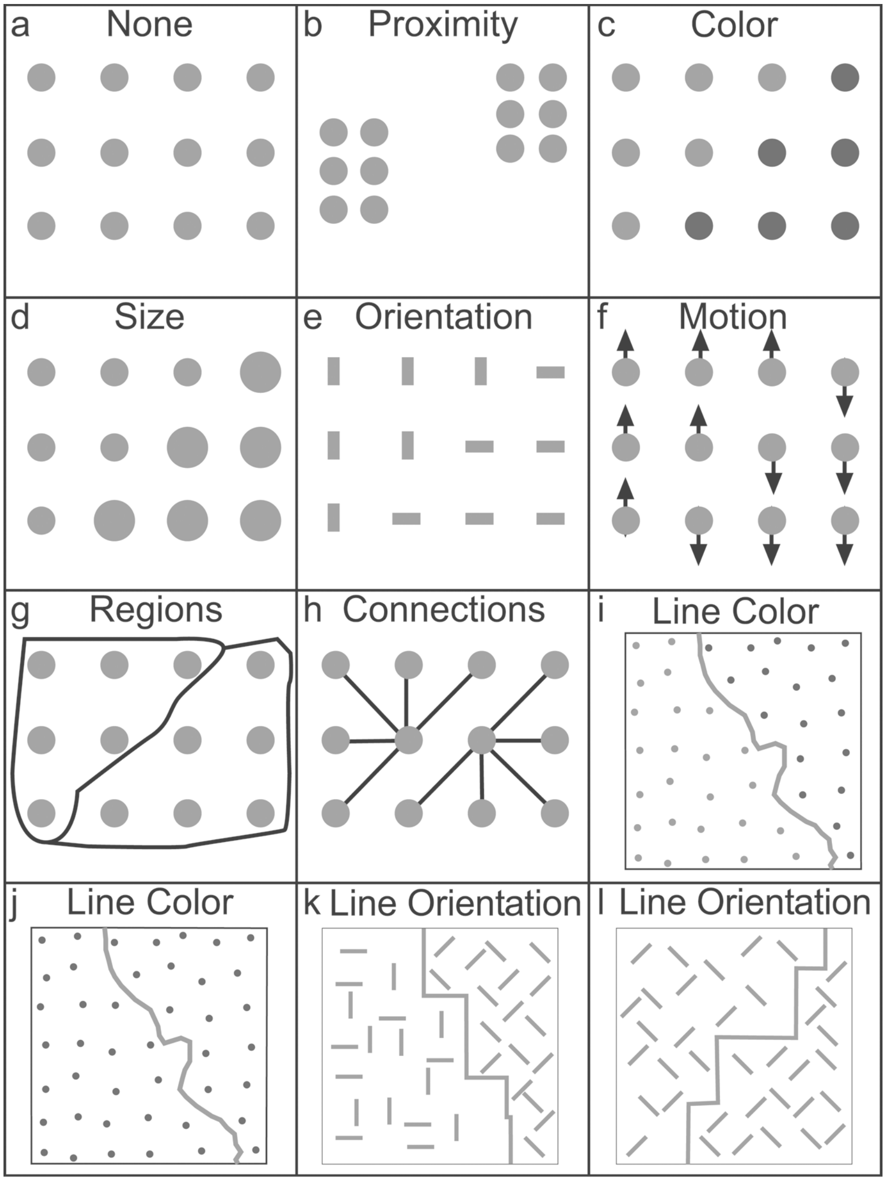

Figure 6. Visual grouping with map symbols. Simple examples show no differentiation (a), and two groups based on proximity (b), color (c), size (d), orientation (e), and motion (f). More complex examples show two groups based on common regions (g) and connections (h). Figure selection (i) and no figure selection (j) based on common line and texture color and figure selection (k) and no figure selection (l) based on common line and texture orientation. (see page 95 for color version)

dimensions cannot be attended to without processing other dimensions. *Configural* dimensions can be attended to independently, but they can also interact to form an emergent property that takes precedence over the original dimensions. Speeded-classification tasks were designed to make subjects classify symbols according to stated rules. The rules required subjects to attend to one, either, or both dimensions while filtering out an irrelevant dimension. The results of the experiments were then applied to the design of bivariate thematic maps. These three studies serve as the best example of how cartographers can use knowledge of the visual attention processes used by map readers to design more effective maps (Nelson, 1999; 2000a; 2000b).

> “Configural *dimensions can be attended to independently, but they can also interact to form an emergent property that takes precedence over the original dimensions.”*

ATTENTION ON FUTURE MAPS

Wolfe (2000) reviewed the visual attention literature and identified four ways attention relates with vision. These relationships can be expressed as questions related to cartographic design and map reading and serve as a structure for discussing some possible future map reading studies related to attention. The first relationship considered is *vision before attention.* An important question is, "what information is available for processing before attention selects a location or object?" This issue is related to design decisions that cartographers can make that affect the map reader's selection of figure and ground, or processes that can help the map reader quickly select a layer of information of particular interest in a hierarchy, for example a global pattern or a local object. A series of experiments could consider alternate design choices for maximizing the segregation of figure from ground, or causing global or local information to be processed first. *Gestalt* principles are known to be useful bottom-up methods for affecting figure-ground selection with traditional paper maps, but other methods might be available with electronic map viewed on a monitor. A region, map symbol, or feature could be marked pre-attentively before, or as a map appears on the monitor (Peterson, 1994; Vecera and O'Reilly, 1998). It might also be possible to use high-frequency or low-frequency signals to prime the selection of global or local information on a map (Loftus and Hartley, 2004). Experimental methods could be used to determine effective methods for directing attention to one or more locations that need to be considered quickly in a dynamic presentation.

> "Gestalt *principles are known to be useful bottom-up methods for affecting figure-ground selection with traditional paper maps, but other methods might be available with electronic map viewed on a monitor."*

The second relationship is *vision with attention.* The important question here is, "how does focusing attention affect the information selected for processing?" Attention for most map reading tasks can be directed by information on the map and information in the map reader's memory. Competitions may be taking place among locations, features, and objects on the map, and between bottom-up and top down information. The construction of animated maps offers a bigger challenge to cartographers, but there are more resources available to influence the direction of attention on dynamic maps. Studies of efficient processing could test specific hypotheses related to the best methods for directing attention to appropriate locations, features, or objects on a dynamic map. Visual search studies done by cartographers have been restricted to static maps and have considered searches for point symbols and polygons. The dynamic maps that appear on automobile navigation systems need to be searched quickly and accurately so the map reader can acquire important navigation information. Interactive maps may require one to process information quickly and make choices that affect the nature of the next view of the map. Cartographers designing these maps are required to respond to new attention phenomena, for example *inattention blindness*, *change blindness*, or *attention blink*, with these maps.

> *"Interactive maps may require one to process information quickly and make choices that affect the nature of the next view of the map."*

The third relationship is *vision after attention.* An important question is, "does attention leave any lasting effects after it has been directed away from a stimulus?" Map reading studies related to the *inhibition of return* and *visual marking* would fit into this category. Both of these effects suggest map readers should have a bias against attending to previously attended information. This bias for novel information, whether it is automatic or intentional, could impact the visual processing of animated maps. Studies should consider both the positive and negative impacts of these effects. A bias toward novel information might increase or decrease performance for a vigilance task. If a subject were to monitor a dynamic map and report when a particular map symbol appeared, target symbols at new locations or having new features should be more likely to capture attention. The same map reader may find it more difficult to notice target symbols that appear at previously attended and rejected locations or with previously attended and rejected features.

The fourth relationship is *vision without attention.* The important question is, "what is the fate of stimuli that are never selected for attention?" This is a very intriguing question. One possibility is that this information has absolutely no effect on map-reading processes. This, however, is not the only possibility. Unattended information may be learned implicitly without conscious effort and it may influence the processing of the information being processed with focused attention. *Contextual cueing* could prove to be a promising technique for cartographers interested in studying the lasting effects of spatial patterns on their maps. Chun and Nakayama (2000, 77) argued, "Implicit memory traces, not available to conscious awareness, are laid down during visual processing. Visual processing benefits from the accumulation of information provided by the spatial and temporal context of past views." Any spatial patterns that are repeated during map reading and explicitly learned could prove to enhance performances on map-reading tasks. Most *contextual cueing* studies have used a visual search task, but other types of tasks may show an enhanced performance if done in a familiar context rather than a novel context. Studies could be done that present one layer of mapped information as a consistent or inconsistent context and consider a task being completed with another layer of information.

"Contextual cueing *could prove to be a promising technique for cartographers interested in studying the lasting effects of spatial patterns on their maps."*

A simple example could be a map that illustrated rivers in one layer and cities in another layer. The task could be to determine if a city map symbol with particular features were present on the map. The target city might be a red circle and distractor cities might be red squares and blue circles. The city locations would be fixed, but the target and distractor symbols would be randomly assigned to the locations. If half the trials had a river layer that was the same and the other half had novel river patterns, trials with the repeated context should have a faster mean reaction time than trials with the ever-changing context.

This paper has reviewed a number effects related to visual attention that cartographers should consider as they design their maps. These effects have been studied in non-mapping contexts, but need initial studies to establish if the effect on performance extends into a map-reading context. An understanding of how map readers direct attention and how visual attention impacts the performance of map reading tasks should be an important goal for those who wish to produce effective maps. Cognitive experiments conducted within the context of real cartographic maps that test hypotheses related to visual attention should provide the knowledge needed to accomplish this goal. The results of such studies can demonstrate consilience in the information sciences and frame productive questions for future research.

"An understanding of how map readers direct attention and how visual attention impacts the performance of map reading tasks should be an important goal for those who wish to produce effective maps."

NOTES

[1] Non-professionals using mapping software also make many maps. Although these are maps, the people who have access to the conventional wisdom of professional cartographers and who may be motivated by consilience research agendas did not design them.

[2] If the map is considered as a work of art, it should be produced to be aesthetically pleasing. If economic efficiency is the main concern, the map should be produced quickly and inexpensively.

[3] Wilson (1998) argued the physical sciences and biology in particular have achieved a high degree of consilience. He also argued that progress in the

social sciences has been much slower. Wilson does not discuss geography as part of either the physical or social sciences. Because of the disciplines diverse nature, geography should be able to contribute to greater consilience in physical, social, and information sciences.

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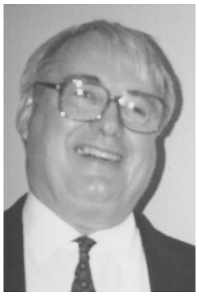
Remembering Ron Bolton (1933-2005)



Ron Bolton became involved with NACIS early on in the Society's history. He was not at the organizational meeting in Milwaukee in 1980, but submitted an abstract for a paper on "Cartographic Information Systems" for the 1981 Gatlinburg meeting. Although he didn't present his paper and apparently didn't attend the meeting, he was involved in the 1982 Alexandria meeting, where he became Vice President.

It was at this time that I really got to know and appreciate Ron. Since Milwaukee was chosen as the site for the 1983 meeting, I ended up being heavily involved with the conference. I well remember a phone conversation with the then NACIS president (who shall go un-named), in which he expressed the negative sentiment "I don't know about this guy Bolton." Well, that guy Bolton was soon the acting president when the afore-mentioned jumped ship in mid-stream. Ron turned out to be a tireless program manager who was on top of every detail, conversing with me by phone several times a week, and, making it to Milwaukee for at least one site visit before the meeting.

After his presidency, Ron was recruited to be the first executive director of NACIS. It was during Ron's tenure as president and then executive director that NACIS became the strong, vital organization that it is today. At the annual meetings, as well as the semi-annual board meetings, you could always count on Ron to be there and to be involved.

Shortly after I became executive director, NACIS planned to hold its annual meeting in Silver Spring, and once again, Ron was called into service to assist with local arrangements. On March 13, 1993 the board met at the conference hotel. On that day, what came to be called the "storm of the century" hit the East Coast, closing airports and paralyzing traffic. Therefore, for the most part, the participants at the meeting were those who had managed to arrive the day before. Only two people from the DC area were able to attend, Susan Nelson, the local arrangements chair, who lived relatively close by, and Ron. Ron's office was nearby, but he lived way down in Virginia and always had a long commute. But, determined to make the meeting, he started out super early to be with us that day. The details of that meeting are long forgotten, but the weather and the return home were memorable for all involved.

Ron was for years the head of NOAA's Aeronautical Charting Division, responsible for the charts and other navigational data used by pilots. Accuracy and currency were of vital importance to him because an error could, literally, mean life or death. Ron was always very proud of his division's safety record, and was eager to point out that in all the times that he was required to testify in cases against the government, he had never lost a case for them due to charting inaccuracy or error.

Ron's tenure at NOAA was a period of great change in the cartographic arena. It was his mandate to automate his division—a task stressful enough in itself, but to do that while maintaining accuracy and a demanding revision schedule was a formidable undertaking indeed.

Somehow, in addition, he managed to find time to be a NACIS officer, or executive director, to present professional papers at nearly every meeting and to teach cartography at the college level. Furthermore, Ron always had time to sit and chat, or to go to lunch. From my point of view, NACIS will never be the same without him.

Chris Baruth, AGS Collection, University of Wisconsin-Milwaukee

Ron Bolton passed away September 3, 2005, in an untimely accident. I worked for him and with him during the 15 years I spent in Aeronautical Charting at NOAA, now a part of FAA. I remember that he fought tirelessly for his employees (300 cartographers), and in ways that were frequently transparent to them. He was instrumental in raising the salary level of those in the cartography series at NOAA from GS 9 to GS 11. He protected us from the A76 process that would have opened options for contracting our jobs. He encouraged attendance and participation in NACIS activities and generously approved leave for his employees in that respect. I am sure that the high percentage of NACIS members in government in those early days was due to his support. He also promoted fun at NOAA and, I suspect, encouraged fun at the early NACIS meetings. After work at NOAA, we held annual and sometimes biannual potluck parties with a DJ and dancing. It promoted cohesiveness among colleagues and allowed us to meet our colleagues' significant others. I didn't realize that was unusual until I left the organization. I left Aeronatical Charting at NOAA 10 years ago but still remember Ron's laugh.

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cartographic techniques

Looking Closer: A Guide to Making Bird's-eye Views of National Park Service Cultural and Historical Sites

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For an online gallery of NPS bird's-eye views and QuickTime VR scenes visit: www.shadedrelief.com/birds_eye/gallery.html

ABSTRACT
The US National Park Service (NPS) has long used large-scale panoramas, also known as bird's-eye views, to portray park sites where buildings and other human-made features are plentiful. This paper examines these bird's-eye views, most of which were produced by nationally renowned contract illustrators in a wide range of artistic styles. Both their traditional and digital work receive attention. A brief historical review looks at the antecedents of current NPS products dating back to the Renaissance. The practical second half of the paper focuses on how the NPS now designs these bird's-eye views with 3D software, with an eye toward cost savings. Topics include viewing parameters in a 3D scene, preparing DEMs, modeling buildings, designing trees, and creating environmental special effects. Two dozen full-color illustrations supplement the text.

INTRODUCTION

On the afternoon of May 31, 1889, following a night of torrential rain and years of poor maintenance, South Fork Dam reached its breaking point. The earthen structure gave way releasing three-kilometer long Lake Conemaugh in a deadly surge of water and debris—trees, houses, barbed wire, and livestock—that swept through Johnstown, Pennsylvania. More than 2,200 people died in the disaster, which ranks as the worst inland flood in US history. The former dam site is now a national memorial managed by the US National Park Service (NPS). To explain to visitors how the flood occurred, the NPS uses a sequence of bird's-eye views showing the dam deteriorating over time, ending with its failure (figure 1). Bird's-eye views such as these are commonly a part of the presentations that the NPS prepares for visitor use. They vividly depict historical events and settings, and give a panoramic yet intimate view of places in a way that no other graphic, including a traditional map, can. In our fast-paced, distraction-filled modern world, bird's-eye views are a rare commodity for being able to "connect" with park visitors.

Figure 1. Johnstown Flood National Memorial, Pennsylvania. The South Fork Dam as it appeared when newly constructed (left), in a state of disrepair (middle), and breaching (right). Art by L. Kenneth Townsend. (see page 96 for full color version)

In this paper I examine how the NPS designs and produces bird's-eye views for the depiction of cultural and historical sites. The range of products includes artistic illustrations, such as Johnstown Flood—most of the other views deal with cheerier topics—and products with lines and labels that fall within the cartographic fold. The primary emphasis is on the digital 3D design and production methods developed by the NPS in collaboration with our contract illustrators. In the hands of a talented 3D artist, digital production methods yield bird's-eye views every bit as visually appealing as those produced traditionally. How we reached this level of refinement is a story worth telling.

The making of bird's-eye views is a difficult and poorly understood enterprise. Although they portray spatial relationships just as any proper map should, they nevertheless are a niche product on the margins of mainstream cartography. Art, architecture, computer gaming, movie animation, and the new field of urban simulation all have a stake, perhaps more deservedly than cartography, in the ownership of this genre. The conventions that guide cartographers in the making of traditional maps simply do not exist yet for bird's-eye views, although research has begun in this area (Haeberling, 2004). It should come as no surprise then that the people who make NPS bird's-eye views, regardless of their professional backgrounds, are by necessity self-taught.

To begin bridging this knowledge gap, the aim of this paper is to provide practical ideas for those making bird's-eye views, and to serve as a reference for clients needing to have them made. Knowing basic concepts and the right questions to ask is essential for all parties concerned. After beginning with a general discussion of bird's-eye views, the pages that follow look at the many design and production issues that go into the making of a successful view.

BACKGROUND

The somewhat quaint term bird's-eye view, first coined circa 1600, is apt for describing the obliquely viewed perspective scenes that I discuss in this paper. They are a variant of the landscape panoramas painted by the late Heinrich Berann and others, but with the emphasis on the human environment rather than the natural (Patterson, 2000). Human-made structures on the surface of the land, such as buildings, fences, and dams, appear with three-dimensionality and dominate the scene.

Extremely large-scale depiction is another key trait of bird's-eye views. Notwithstanding an unfortunate Ruppell's Griffon Vulture that once collided with an aircraft 11,278 meters over Africa, most birds fly at altitudes less than 1,000 meters, and usually they stay within a few dozen meters of the ground (Whiteman, see references for URL). This altitude range is similar to the viewing elevation found on NPS bird's-eye views, a point much closer to the ground than that of a typical map. For example, cities and towns often appear on maps as small dots; the sites depicted on a typical bird's-eye view would take up at most a mere pinprick of the area within these dots. At these much larger scales even tiny details, including people and animals, become visible. Keen-eyed readers may have noticed the horse and carriage crossing the South Fork Dam (Figure 1, middle).

The ease in which readers can identify all features on a bird's-eye view is one of their chief advantages over traditional maps. At extremely close range in a scene we recognize the depicted objects based on observations in our everyday lives rather than the learned skill of map reading. As the virtual camera moves closer to the ground and the scale becomes increasingly large, you reach a point where realistic 3D depiction of surface objects becomes the preferred solution rather than abstract 2D depiction. In some cases 2D depiction is never feasible, for showing a horse and carriage on a dam, for instance. Most of the visual cues needed for identifying large objects (things that are bigger than we are) can be found in profile view in the vertical (z) dimension. We identify buildings by the windows, doors, siding, etc, observed on their exterior walls. How many of us know what the roof of the building we are currently in looks like from above? More difficult still, what does the building's footprint look like on a large-scale plan map?

Bird's-eye views also can reveal things that are difficult for a contemporary park visitor to see, such as how a place looked in the past. Possible examples include a crumbling archeological site portrayed as the vital place that it once was, a historic battle recreated on a field that today looks more park-like than bloody, and, as we have seen, simulating a dam break. A special use for NPS bird's-eye views is showing readers the otherwise hidden interiors of buildings (figure 2). Finally, bird's-eye views go by many names. Among the words commonly mixed and matched together, often only according to whim, are aero, oblique, panoramas, perspective, three-dimensional (3D), renderings, scenes, simulations, views, visualizations, and, last but not least, maps. All are appropriate. In this paper I will attempt to stick with the term bird's-eye views. However, for the sake of variety and brevity I occasionally use the other terms.

Figure 2. Building visualization. (left) The Castillo de San Marcos, St. Augustine, Florida, lifted off its foundation. (middle) Buildings at Appomattox Court House, Virginia, that no longer exist, shown in ghosted form. (right) The interior of a barracks at Manzanar, California, revealed in an "X-ray" or cutaway view. From left to right, art by L. Kenneth Townsend, Chris Casady, and Don Foley, respectively. (see page 96 for full color version)

Historical perspective

Bird's-eye views have a long history in mapmaking, and those produced by the NPS are a part of this continuum. Despite the predominance of planimetric maps today, up until two centuries ago oblique views were far more common, and the depiction of terrain and cities often revealed the three-dimensional nature of these features. It is only natural that early mapmakers drew cities in this manner; that is what the buildings in which they lived looked like. Perhaps the most famous early bird's-eye view is a 1502 map of Tuscany and the Chiana Valley by Leonardo da Vinci. On this oblique map the hills appear in profile topped with fortified towns. The city maps created in Europe during the Renaissance are the direct stylistic forebears of some bird's-eye views made by the NPS today (figure 3).

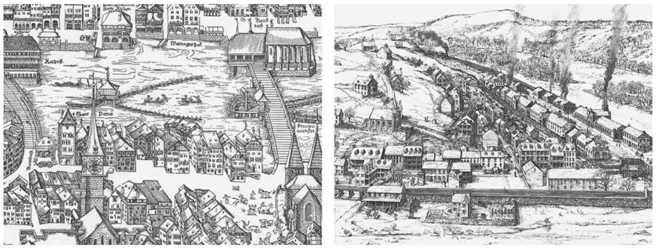

Figure 3. (left) A 1576 map of Zurich, Switzerland, by Jos Murer. (right) A map showing Harpers Ferry, West Virginia in 1860, drawn by Richard Schlect circa 1980. Zurich map source: Imhof, 1963. (see page 96 for full color version)

The decades from the late 19th to early 20th century were the golden era of bird's-eye views in the US. As towns and cities grew and became prosperous thanks to industrialization, it became fashionable and a matter of civic pride to advertise this newfound economic vitality in the form of oblique panoramic maps. Itinerant panoramists traveled from town to town primarily in the Northeast and northern Midwest mapping furiously as they went. Notable panoramists include Thaddeus Mortimer Fowler, who in his 54-year career generated more than 400 views, and Albert Ruger who published 60 views in 1869 alone (Hébert, 1984).

Fowler and Ruger did not go up in hot air balloons or strap miniature cameras to pigeons or kites to gather information for their panoramas. Instead, they stayed firmly on the ground drafting a street map in perspective based on a grid. Next, they walked through the town sketching the facades of buildings that would appear from the viewing direction that they had chosen. Finally, they drafted the final panorama, filling in detail from the building sketches they made in the field. As we shall see later in this paper, the techniques used by Mssrs. Fowler and Ruger, overlooking the primitive technology of the day, have similarities to those of the NPS today. The US Library of Congress maintains an online collection containing some 1,500 bird's-eye views of cities in the US and Canada made during the Victorian and Edwardian eras (see references for URL).

As industry in the American heartland waned in the mid-20th century, so too did the making of classic bird's-eye views. This relatively quiet period of time, however, did see the publication of several notable pieces, including an axonometric view of Manhattan published in 1962 by Bollmann Bildkarten of Germany (see references for URL); David Greenspan's detailed battle maps for the American Heritage Picture History of the Civil War (Catton, 1960); and, artistic illustrations appearing in National Geographic magazine. The pieces by Greenspan and various National Geographic artists, which depicted past events and thematic subjects in oblique views, point toward the type of bird's-eye views that the NPS would produce in the coming decades.

Today, bird's-eye views are once again in vogue. If the industrial economy spurred their production a century ago, the burgeoning tourist economy drives it now. The prevalence of 3D maps of ski areas and summer resorts highlights this trend. Just as 19th-century bird's-eye views were a tool for economic boosterism, we find today that many chambers of commerce distribute 3D maps (ranging in appearance from cartoonish to glitzy to elegantly refined) of downtown restaurant and entertainment districts in a bid to attract more tourist dollars. Bird's-eye views are also growing in popularity online. The recent launch of Google Earth now allows users to interactively explore 25 major cities in the US from any direction and viewing elevation with buildings appearing as blocky 3D forms. Rival online mapping service MSN Virtual Earth has plans to depict buildings in urban areas with oblique aerial photographs taken from multiple directions (see references for URLs).

Whether 3D maps are really better than 2D maps for helping people find things and get around is not certain and is a topic of current cartographic research (Freundschuh, 2001). Marketers, however, are more decided about the usefulness of bird's-eye views. When selling things, looking good matters. The NPS uses bird's-eye views for promotion of a different sort: to foster appreciation of the cultural and historical heritage of the United States.

TRADITIONAL NPS BIRD'S-EYE VIEWS

The Harpers Ferry Center (see references for URL) is the NPS facility responsible for making bird's-eye views, a side product of a much broader mission. The Center creates interpretive media—a catchall term that includes brochures, indoor and outdoor exhibits, movies, and multi-media—for the 388 units of the National Park System. Art plays an important role in this effort. Since its creation in 1970, Harpers Ferry Center has commissioned nearly 10,000 pieces from hundreds of commercial artists and illustrators, many with national reputations. The subject matter portrayed by this commissioned art is as broad as the National Park System itself. In the art collection at Harpers Ferry Center you can find ink sketches of prehistoric artifacts, a watercolor of a determined John Brown holding a pike, and an acrylic collage of the plants and animals found in the Everglades. It is amidst this visual bounty that one also finds the 200 or so pieces that qualify as bird's-eye views.

Traditional art

Many of these artistic works strain even the broadest "big tent" definitions of what a map is. On some pieces the viewing angle is high and map-like, but on most the angle is considerably shallower, making spatial relationships difficult to judge. Not that it matters much. Views of this type are not intended to help visitors get around but to convey an impression of how a place looked in the past. Non-spatial issues—who, what, and how— take precedence over where. The most successful of the illustrative views recreate historical events with vibrant realism. For example, the view of Fort McHenry, Maryland, depicts the familiar battle imagery contained in the lyrics of the US national anthem (figure 4, left). A comparison with a stirring martial tune is a tall order for any graphic, which the bird's-eye view by L. Kenneth Townsend manages to accomplish, notably.

Figure 4. Some of the varying artistic styles found in illustrative NPS bird's-eye views. (left) Fort McHenry, Maryland, by L. Kenneth Townsend. (middle) Fort Bowie, Arizona, by Richard Schlect. (right) Oxon Hill Farm, Maryland, by Greg Harlin. (see page 97 for full color version)

Depending on the artist and the type of medium used, the style of a bird's-eye view can vary considerably, a choice that the NPS makes carefully. Often these styles relate to a particular genre of art. For example, the luminous and detailed quality of Townsend's "Fort McHenry" is reminiscent of countless paintings of heroic battles hanging in museums throughout the world (figure 4, left). In the muted ink and watercolor renderings of Richard Schlect it is not too difficult to see parallels with the 19th-century expeditionary art (figure 4, middle). And the soft watercolors of Greg Harlin strike a chord of nostalgia for our simpler arcadian past (figure 4, right). We see this style of art on the cover of catalogues issued by a vendor of outdoor apparel and gear based at latitude 43° 51′ N, longitude 70° 06′ W.

The staff at Harpers Ferry Center provides art direction to the artists who transform a blank sheet of paper into a lavishly rendered bird's-eye view. To learn more about how this is done I visited Wood Ronsaville Harlin, Inc. in Annapolis, Maryland, an illustration studio which does contract work for the NPS (see references for URL). There I met with Pam Ronsaville, president of the firm, and senior illustrators Rob Wood and Greg Harlin. Like our other contract illustrators, they do not specialize exclusively in the making of bird's-eye views but create a range of products that includes natural science, historical, infographic, and children's illustrations. Recently they have also begun creating cover art for popular fiction. Belying these pieces that stir the reader's imagination, however, careful research and preparation goes into all of the art that they create with little left to their own imagination. For example, even an artistic book cover derives from direct visual references, typically photographs taken in the controlled environment of their studio and composited as a mosaic in Adobe Photoshop. It should come as no surprise then that when making bird's-eye views the need for good visual references is even more important.

Oblique aerial photography is the reference material of choice for making bird's-eye views. Greg Harlin photographed Oxon Hill Farm, Maryland, from a helicopter to obtain the base map he needed to paint the final art (figure 4, right). He supplemented the aerial photographs with others taken from the ground. When Rob Wood painted a view of Herbert Hoover National Historic Site, Iowa, obtaining helicopter photography was not possible so he had to rely instead on an aerial photograph draped on a DEM and viewed obliquely in a 3D application. Because buildings in 2D aerial photographs do not appear with three-dimensionality when viewed in a 3D application, Wood had difficulty visualizing how the final scene should look. He nevertheless managed to pull this off in the end in his usual polished style.

The actual rendering of the bird's-eye view takes place in three steps: a rough pencil sketch, a final pencil sketch, and, finally, the painted art. At all stages of production the art undergoes review by staff at Harpers Ferry and at the park portrayed in the art. The entire process progresses in fits and starts and can take more than a year to complete. Both Harlin and Wood emphasized the importance of visiting a site to "absorb the natural beauty and history of the area" as an important factor in producing top-notch views. Deciding just how much or, more importantly, how little texture to put in a scene is key to a successful project. According to Harlin "I spend a lot of time making it look like I didn't spend a lot of time painting the illustration." Both artists try to imagine themselves "in the scene" as they paint. When rendering final art they also pay considerable attention to lighting to accentuate small details and give the overall scene interest and drama.

Map-like views

In addition to this commercial art, over the past 35 years the NPS staff has made about one dozen map-like bird's-eye views that are utilitarian in appearance and function. They serve primarily as devices for orienting visitors and site navigation—where is the visitor center and how do I get there. To produce these views we traced over oblique aerial photographs in ink, leaving a framework of casing lines for roads, pathways, trees, and buildings that were filled with flat colors photomechanically. They look similar to the 3D maps of college campuses that are so common today. Depending on the availability of suitable oblique aerial photographs, these products were relatively inexpensive and quick to make. Moving now to the digital part of this paper, we will see that they are no longer made with ink at the NPS.

DIGITAL NPS BIRD'S-EYE VIEWS

As elsewhere in the cartographic community, at the NPS the transition from traditional to digital mapping has been our focus for much of the past dozen years. Having started with small inset maps first, we now make all of our products digitally, including large visitor-use maps, shaded relief, and even landscape panoramas. We also make map-like bird's-eye views—like the inked versions discussed above—digitally. Using Adobe Illustrator software instead of Rapidograph pens, the NPS has replaced all of these inked pieces with vector files, also comprised of lines and flat tones. I discuss a variant of this technique in the upcoming section on budget bird's-eye views.

Making artistic bird's-eye views with digital tools that are comparable in quality to our best traditional pieces has proven to be a difficult challenge. Vector drawing applications like Adobe Illustrator can take you only so far in depicting scenes with artistic refinement and natural realism. For these we have turned to 3D software, the same tools used to create blockbuster animated movies and popular computer games. Scenes created with 3D software can contain dappled lighting, soft shadows, reflective water bodies, atmospheric haze, and organic textures that appear, for some types of work, completely real to all but the most discriminating viewers. Nevertheless, 3D software has a major downside compared with other digital techniques; it is an order of magnitude more difficult to use. Big and complex, these are not the sorts of applications with which you can occasionally dabble and expect to gain proficiency. Consider Maya, the 3D application used to create many of the special effects in Hollywood movies. In the large production shops it is common for the animation professionals who use Maya to have a single specialty, like modeling, texturing, lighting, motion, etc (Casady, 2004). Creating 3D special effects is a collaborative effort, as long film credits show.

As though using difficult-to-use software were not enough, the creation of a bird's-eye view in 3D software requires the user literally to build a virtual model of the entire site in painstaking detail. If you want to see it, you have to model it: scratch beneath any surface in a 3D scene and you will find a wireframe object. The effort is similar in scope to the elaborate sound stages built for filming movies or the museum dioramas with displays of wild animals (of the stuffed variety) placed in front of painted natural backdrops. On a bird's-eye view, to distinguish between two buildings—one, say, with a gable roof and the other with a hip roof—requires building separate models of each building. Depending on the complexity of the buildings, each may take anywhere from 15 minutes to several hours to create. Multiply this by perhaps dozens of buildings in a given scene, and the production quickly becomes arduous.

The creation of bird's-eye views at the NPS with 3D software occurs both in-house, mostly for simpler projects, and with the assistance of outside contractors whom we art direct for larger and more complex projects. Our contractors include notables like Chuck Carter, best known for his work on the computer game *Myst*; Don Foley, author of two books on 3D animation and a frequent contributor to National Geographic; and, Chris Casady, who worked on the movie *Star Wars* (see references for URLs). If the output from 3D software has a visual fault it is the tendency for it to look hyper-realistic—too smooth, shiny, and simulated. Although this look is desirable for depicting space stations and sleek new automobiles, it is out of character for historic park sites. Of the NPS contractors, the work of Chris Casady, despite, or maybe because of his impeccable credentials on science fiction movies, achieves the painterly look that the NPS seeks in bird's-eye views. Through patient hard work, mastery of his preferred software (Bryce), and an artistic eye, Casady manages to combine human-made and natural features into thoroughly convincing final scenes. You will see many examples of his work throughout this paper.

Today one finds many 3D software applications sold to a relatively small pool of users. Consequently the prices of these applications are generally high, although not as expensive as they were a few years ago. Nevertheless, Maya Unlimited, a product of Alias, and one of the pricier 3D applications, will cost you US $6,999. The artists who provide services to the NPS use a variety of 3D modeling and rendering applications. If the need arises, sometimes they will use multiple applications on the same project. Subscribing to the belief that using software creatively is as important as what brand (or price) it is, I use Bryce 5.0, a $100 application from Daz Productions. There is, however one software application used by everyone. The raster art rendered by all 3D programs inevitably finds its way into Adobe Photoshop for final image enhancement. Additionally, at the outset of a project, data are prepared in Photoshop for later use in 3D applications. For the rest of this paper I attempt to be software agnostic as much as possible. If you should happen to prefer a software application other than the one that I am discussing, I invite you to make a mental substitution.

Planning

The design of bird's-eye views requires considerably more care and interaction with clients than does the design of a traditional 2D map. A point is reached soon after production begins at which making even a small change to the basic scene parameters, for example, shifting the direction of view 10 degrees to the west, means much wasted work. An analogous situation would be for an architect to give new plans to a builder after construction has begun. To safeguard against this, the Harpers Ferry Center provides the park staff with several mockups of a bird's-eye view to review. A base map loaded into a 3D application allows easy changes to the viewing parameters should the need arise. The park staff then decides, with coaching from

Harpers Ferry Center, which preliminary scene best meets their needs—consensus is essential. Work on the final scene begins only after Harpers Ferry receives written approval to proceed from a person in authority at the park (figure 5). Occasionally I encounter a park site that for a variety of reasons is not ideally suited for depiction as a bird's-eye view. My advice based on hard-learned experience is not to force the issue but instead to use conventional 2D mapping. In fact, some projects are undeserving of any type of cartographic depiction—for example, showing the path from a parking lot to a nearby visitor center. In this case, people can more easily follow signs on the ground pointing to the visitor center.

Figure 5. A portion of Eisenhower National Historic Site, Pennsylvania. (left) A plan map draped on a DEM and viewed obliquely in Bryce. The park approved this view as the basis for final production. (right) The final bird's-eye view. Art at right by Chris Casady. (see page 97 for full color version)

Budget bird's-eye views

A few words are in order about the fiscal realities of making bird's-eye views. Although 3D modeling software creates the most elegant bird's-eye views, the downsides are production times and costs that are significantly higher than other digital options. Hollywood studios can afford the expense of 3D production because of the potentially enormous revenues that films generate. The same applies to computer games. In late 2004 the release of the computer game *Halo2* generated US $124 million in sales for Microsoft in 24 hours. Because production budgets at the taxpayer-funded NPS are smaller by a factor of several zeros compared to these commercial entertainment ventures, we use 3D techniques with any eye toward both quality and cost management. A complex bird's-eye view created by 3D software costs about the same as an equivalent view painted traditionally, somewhere between $12,000 and $20,000. One advantage of 3D modeling is the potential for repurposing work as animations or QuickTime Virtual Reality (QTVR) scenes, which spreads costs over several projects. Nevertheless, until more economical 3D production methods become available, as they undoubtedly will, for much of our work we will continue to seek less expensive alternatives, including simply tracing vector art from oblique aerial photographs. Two less expensive methods of producing bird's-eye views deserve mention here.

Hybrid method

This involves combining 3D modeling with vector drawing software for production. The "flying carpet" view of Marsh-Billings-Rockefeller National Historical Park, Vermont, is an example of such a merger of methods (figure 6, middle). The foundation of the scene was a square-shaped digital elevation model (DEM) representing terrain viewed obliquely with 3D software. A rasterized map draped on the DEM, much like a decal on an automobile bumper, shows roads, trails, and building footprints. The next steps include rendering the oblique 3D scene, saving it as a 2D Photoshop file, and placing it as background art in Illustrator. Finally, in Illustrator, the trickiest step was drafting simulated 3D buildings on top of the building footprints visible on the raster art placed on the layer below. Even with the aid of reference photographs and perspective grids as a guide, drawing angled rooflines presents visualization challenges. Ultimately, one must rely on intuition to accomplish the task.

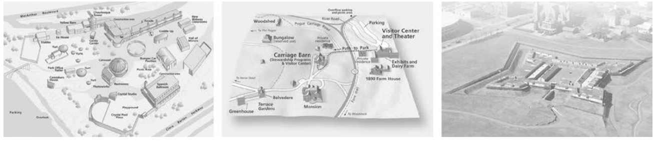

Figure 6. (left) Glen Echo, Maryland, was sketched in Adobe Illustrator using an older inked map as a guide. (middle) Marsh-Billings-Rockefeller National Historical Park, Vermont, was made from a 3D terrain base upon which buildings were drawn in 2D in Adobe Illustrator to appear three-dimensional. (right) Fort Stanwix National Monument, New York, derives from an oblique aerial photograph artistically filtered in Adobe Photoshop. (see page 97 for full color version)

Photo method

Occasionally an oblique aerial photograph by itself can serve as the final art. The NPS used this method for making the bird's-eye views of Fort Stanwix National Monument, New York (figure 6, right). Faced with spending $15,000 and waiting several months to have the scene developed using 3D software, we instead hired a photographer and helicopter to take dozens of high-resolution digital photographs from the air. One of these shots had the viewing direction, viewing angle, and illumination that we sought. Including the in-house time spent planning the project, writing contracts, and applying watercolor artistic filters to the image in Photoshop, the job took only days to complete and cost just $1,400.

Not every park site lends itself to this production method, however. Fort Stanwix, which sits in an open field, is not obscured by the large numbers of trees that are typically found in parks and, more troublesome still, often grow next to buildings. Wintertime photography when the leaves are off the trees helps but only so much. The decision to use aerial photography depends on the suitability of the site, access to oblique aerial photographs, and tolerance for image editing in Photoshop. On the plus side performing touchups in Photoshop is much faster than modeling 3D scenes completely from scratch. In the case of Fort Stanwix the NPS was fortunate and only had to remove a few lingering snow drifts (the photograph was taken in early April) with the Clone (rubber stamp) Tool in Photoshop.

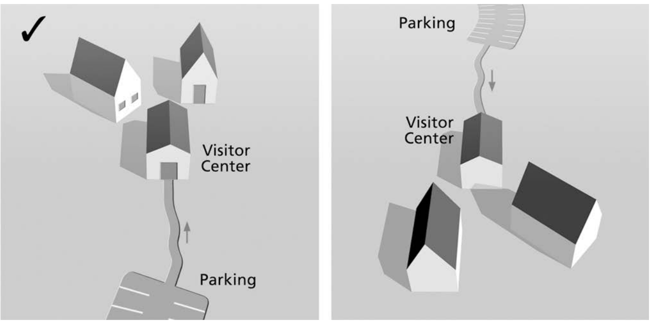

Figure 7. Direction of view. (left) A bird's-eye view should approximate, from a raised vantage point, what a visitor sees when entering a site. (right) A view from the opposing direction makes it harder for visitors to orient themselves because left and right, and, front and back, no longer corresponds to what they see on the ground. (see page 98 for full color version)

3D DESIGN AND PRODUCTION

This final section covers some of the many design and production factors influencing the making of bird's-eye views in a 3D software application. Given the great variety of software used for creating 3D scenes, and how generally difficult they are to use, the discussion that follows gives an overview of the issues—what you should be doing, more so than the particulars of how you might do it. I introduce subjects generally in the same order in which they come up when building a 3D scene. Several of the illustrations compare examples of good and bad design—a check mark at the top indicates the good examples.

I will begin this section with a discussion of the viewing parameters that determine the basic appearance of a 3D scene. Appropriately enough the first step in designing a successful bird's-eye view is choosing a good view.

View direction (orientation)

All bird's-eye views look at sites from a certain direction, for example from southwest to northeast. Picking the best view direction is a critical concern because, compared to planimetric maps, bird's-eye views are less flexible for on-site navigation. As you walk the winding paths of a park with a printed bird's-eye view to guide you, the piece cannot be rotated to the direction you are facing as is possible with a plan map. Try turning upside down any of the illustrations of a bird's-eye view that accompany this article. They just don't work. What this tells us is that whatever view direction you choose for a bird's-eye view—the possible choices span 360 degrees—had better meet the orientation needs of most park visitors most of the time.

For maps of large-scale sites the NPS has a longstanding convention of using an orientation that matches the direction from which visitors enter the site (figure 7). For example, when Metro riders emerge squinting from underground onto The Mall in Washington, DC, they see an outdoor map exhibit oriented in the direction that they are facing. People glance at the map, get their bearings, and then set off. Knowing which way is north is less important than the immediate concern of getting from point A to B quickly. This same user-centric orientation also applies to large-scale bird's-eye views.

For park sites with a single point of entry and a primary visitor destination, determining the best viewing direction is simple. In these cases the alignment of the view direction should generally follow the path that a visitor takes into the site. However, not all park sites are so simple, and choosing the best direction of view is less obvious. For bird's-eye views at smaller scales, with multiple points of entry, and with multiple visitor destinations, conventional orientation from south to north may be the best option. In addition, the view direction should show the front facades of important buildings—visitors do not care about the delivery docks and service entrances found around back. The foreground and background inherent in all bird's-eye views provide a powerful way to establish an information hierarchy. Try to choose a view that places important features in the foreground (the visitor center and historic buildings) and less important features (the picnic area and restrooms) in the background.

Viewing angle

The viewing angle, sometimes called camera pitch or inclination angle, determines how oblique a scene appears when viewed from above. Shallow viewing angles create highly oblique scenes complete with a horizon and sky that can appear strikingly realistic. Higher viewing angles create map-like scenes that better portray spatial relationships and are better for site navigation. As a general rule the viewing angle should be somewhere between these two extremes, perhaps slightly favoring the higher angles (figure 8). If the angle is too high, however, it places undue emphasis on the roofs of buildings at the expense of their distinctive facades. Go higher still and eventually the bird's-eye view for all intents and purposes becomes a plan map, which defeats the reason for using an oblique view in the first place.

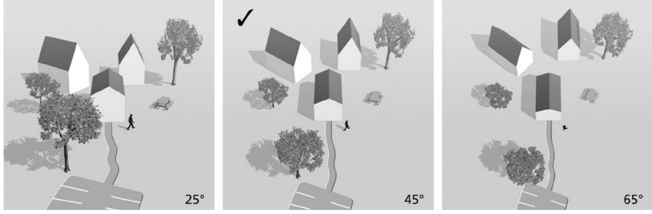

Figure 8. Viewing angle. (left) When the viewing angle is too low, tall objects in the foreground obscure lower objects in the background and spatial relationships are difficult to judge. (middle) An angle between 40 and 60 degrees generally works well. (right) Higher angles of view place too much emphasis on the tops of buildings and trees. (see page 98 for full color version)

In perspective scenes the apparent viewing angle varies according to where you are in the scene, becoming steeper from background to foreground. Three-dimensional objects in the background appear more in profile than similar objects in the foreground, where their tops become more evident. What this means, as counterintuitive as this may sound, is that buildings in the foreground of a scene may not be as recognizable as those farther back because their sides are not as visible.

The viewing angle also influences visual foreshortening, the front-to-back (top-to-bottom) compression that you see on obliquely viewed scenes (figure 9). There are both advantages and disadvantages to this. Foreshortened bird's-eye views occupy much less space than plan maps, allowing their placement into cramped layouts. On sites with widely scattered features, the effect is to pull the foreground and background closer together, making them appear more compact. The opposite holds true on scenes with dense information, which become even more congested and less legible because of foreshortening.

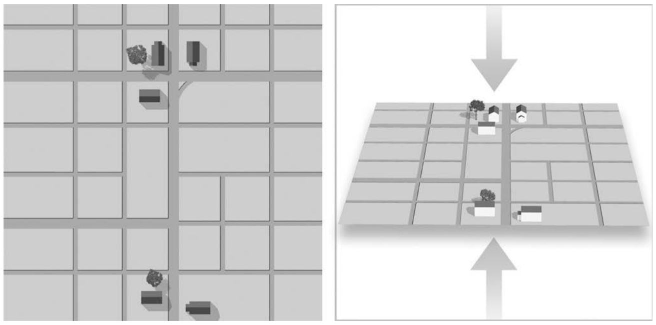

Figure 9. (left) A plan map. (right) Because of foreshortening a bird's-eye view needs less space to show the same area. (see page 98 for full color version)

Finally, the slope of the terrain is a factor when choosing an viewing angle (and also the view direction). In a bird's-eye view, terrain that slopes uphill towards the back of the scene is preferable to terrain that slopes downhill. On downhill views, as the terrain falls away from the reader the exaggerated foreshortening reduces the visible terrain surface appreciably and makes relative elevation differences difficult to judge. For the many cultural sites that occupy nearly level ground, however, slope is a moot consideration.

Field of View

This seemingly esoteric camera setting greatly influences the appearance of bird's-eye views. Most 3D applications use central perspective (sometimes called central projection) because of how it mimics what the human eye sees (Jenny, 2004). The average human with binocular vision who gazes toward the horizon takes in a view shaped as a flattened cone and spanning 140 degrees from side to side. In 3D applications this area of visibility, called the Field of View (FOV), assumes the shape of a symmetrical four-sided pyramid with the camera at the apex. The FOV in 3D applications ranges anywhere from 1 to 180 degrees and even wider if you count 360-degree QTVR scenes.

FOV relates directly to the focal length in cameras. As the name suggests, wide-angle lenses have a wide FOV and telephoto lenses have a narrow FOV. Moderately telephoto FOV angles (10°–50°) produce more useful results than those that are wide-angle (figure 10). Displaying too broad of an area within the confined rectangular space that bounds a bird's-eye view leads to undesirable distortions. If the FOV angle is too wide the perspective convergence becomes extreme—background areas pinch toward the vanishing point, and foreground areas become too enlarged. On the sides of the scene away from the central axis of view, tall 3D objects splay outward at unnatural angles. In the opposite situation, as the FOV angle becomes lower a scene loses its perspective qualities and becomes

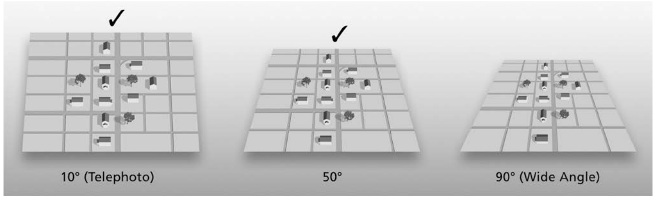

Figure 10. Adjusting the Field of View (FOV), which is a camera setting in 3D applications, controls the amount of perspective in a scene. From right to left the examples become increasingly orthogonal. (see page 99 for full color version)

more orthogonal, albeit in an oblique view. The advantage of oblique orthogonal views is that similarly sized objects in foreground and background are comparable. The disadvantage of having less perspective is the lack of visual depth in such a scene. However, as we shall see in the upcoming discussion of environmental effects, adding background haze can effectively remedy this deficiency.

DEMs—Beneath it All

Digital Elevation Models (DEMs), which show topographic surfaces when rendered in a 3D application, serve as a foundation for building even the largest-scale bird's-eye views. In addition to the usual mountains and valleys, large-scale DEMs contain micro topography, much of which is the result of human activity, such as graded roadbeds and leveled land around buildings. Without these subtle but important details cultural features on the surface would appear divorced from the terrain below.

Finding DEMs at a fine enough resolution for making large-scale bird's-eye views is a problem. The finest resolution DEMs commonly available from the USGS have elevation samples every 10 meters on the ground, much too coarse to serve as a base for a cultural site where many buildings would be less than 10 meters in length. In recent years LIDAR (Light Detection and Ranging) DEMs at one-meter resolution have offered promise, but they are all but impossible to find for NPS sites and are prohibitively expensive to have produced. LIDAR x, y, z point data at 2 to 3 meter height postings costs US $1,000 – $2,000 per square mile (2.6 square kilometers), a price that does not include final DEM processing (NOAA, see references for URL). This leaves the user little choice: either modify existing 10-meter DEMs to show more detail, or make a new higher-resolution DEM from scratch using specialized software. Both options are difficult and involved, and I will discuss them only briefly here.

Modifying an existing DEM is the faster of the two options and, not surprisingly, it yields less accurate results. At the NPS we modify existing DEMs in Adobe Photoshop after importing them as 16-bit grayscale images. DEMs in this format appear with dark pixels representing lower areas and light pixels higher areas. Raising and lowering the pixels for selected parts of the DEM with the image editing tools in Photoshop transforms the DEM and produces an altered landscape surface when rendered in a 3D application (figure 11). For example, applying a large amount of Gaussian blur to the area on a DEM that falls directly under the draped image of a road creates a graded surface with cuts and fills similar to the real thing (Patterson, 2003).

Making custom DEMs from scratch requires that you have a dense network of contour lines or spot elevations from which to start. These can take the form of digital data or paper map sources. If neither is available the only recourse is to survey the site yourself or have someone do it for you, adding significantly to the cost of a project. Fortunately, at most park sites large-scale contour maps are available for the built-up areas—finding them often involves rummaging through drawers.

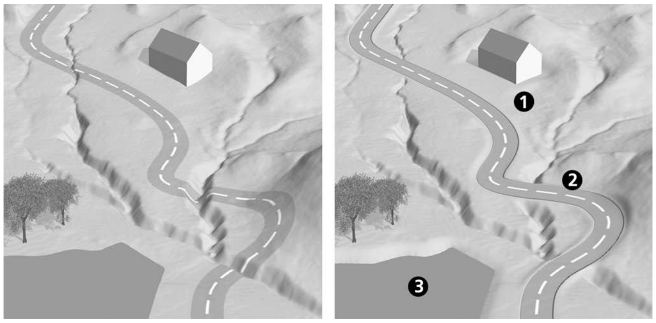

Figure 11. (left) A scene created from a DEM without supplemental modification. (right) The same scene with modifications, which include (1) building site leveling; (2) road cuts and fills; and, (3) pond lowering. (see page 99 for full color version)

From digitized contours you create a DEM by either of two methods. The proper method is to use an application like ArcGIS or Surfer to assign elevation attributes to each of the contours, interpolate a Triangulated Irregular Network (TIN) from the contours, and, lastly, output a DEM. With technical help from GIS staff, the NPS created a custom 3-meter resolution DEM from contours in ArcGIS for the bird's-eye view of Huffman Prairie Flying Field (figure 12).

The second method—the "DEMs for dummies" method, as I sometimes call it—is easier to accomplish and more logical for those who work primarily with graphical software. It also yields far less accurate results. This is how it works. First, you trace contour lines from a map in a drawing software application like Adobe Illustrator. Next, you fill the zones between the contours with gray tones progressing in consistent increments from dark to light as you go higher. The result is a gray Illustrator file with terraced elevation zones. Then, the Illustrator file is rasterized in Photoshop and blurred liberally to create a smooth image with no evidence of the terraces. Finally, you import the blurred grayscale image into a 3D application and extrude it to represent the terrain surface (Foley, 1997). The amount of blurring applied is key to success. With too much blurring, the terrain looks overly smooth and generalized, and with too little blurring, more details become visible, including the unwanted terraced edges. Complicating matters is the fact that widely spaced elevation zones require more blurring to appear smooth than do tightly spaced zones. Producing optimal landscape surfaces depends on trial and error.

Figure 12. This scene shows the counter-clockwise flight of the Wright Flyer in 1908 over the Huffman Prairie Flying Field, Dayton, Ohio. The foundation of the scene is a custom DEM at 3-meter resolution derived from contour lines processed in ArcGIS software. A second hand-made DEM with a bumpy dark-green texture extrudes upwards through the surface of the first DEM to depict background trees. Art by Chris Casady. (see page 100 for full color version)

The view of Marsh-Billings-Rockefeller National Historical Park, Vermont, uses a primitive DEM created with this method (figure 5, middle).

I will finish this section by stating the need for an inexpensive and easy-to-use application for making DEMs from contour lines saved in Adobe Illustrator format, which would produce DEMs of higher quality than the technique discussed above.

Landscape textures

DEMs look better when they are not bare. At large scales even the most detailed DEM rendered in a 3D application without any textural covering looks artificial, like molten plastic. An aerial photograph precisely registered to the DEM and draped onto its surface goes a long way toward making the final rendered terrain look more presentable. At other times, such as when aerial photographs are too noisy or have dark and conflicting shadows, custom-made textures comprised of colors and embossed textures, known as bump maps, are the better solution. Custom-made textures can derive from multiple sources, often used in combination with one another, including rasterized vector art, fractal textures generated in Photoshop and other graphical applications, hand painting in Photoshop with a Wacom stylus and tablet, and photographs of all kinds. To produce a grassland texture for the bird's-eye view of Fort Larned, Kansas, NPS contractor Don Foley shot a digital photograph of his front lawn from an upstairs window. He then tiled this small photograph as a larger seamless texture and draped it on the DEM.

The following will help you make effective landscape textures:

- Avoid flat unvarying textures at all costs even if the landscape you are portraying is that way. Subtle modulations in light and shadow bring a level of realism and visual interest to even the most boring features. For example, the bird's-eye view of Appomattox Court House, Virginia, is comprised largely of empty fields. Instead of representing these areas with flat green Chris Casady created an image texture that emphasized subtle natural variations in tone (figure 13).

- Do not over apply landscape textures so that they become noisy and distract from more important information in the bird's-eye view. Be especially careful when applying bump mapping, which can easily become too dark and contrasting.

- Readers can't help but take notice of overly symmetrical, geometric, and repetitive textures, especially in natural areas. Use them sparingly.

- Clean bright colors may look fine on a traditional map but they are less applicable to realistic bird's-eye views. Instead select a color palette comprised of the slightly impure colors typically found in nature and, if possible, refer to photographs of the site for greater accuracy. And if most park visitation occurs at a certain time of the year, say, late summer, the selected colors should reflect that season.

Buildings—assembly required

Like their brick and mortar counterparts, buildings in a bird's-eye view take a long time to construct. The meticulous modeling of small but important architectural details—eaves, gables, porticos, and the like—accounts for the slow pace. Given the unavoidable detail,

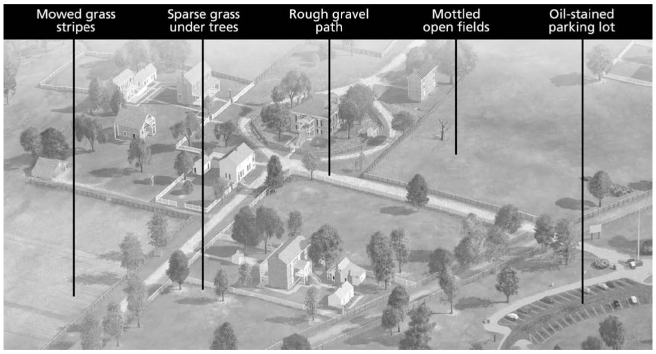

Figure 13. Custom landscape textures bring subtle realism to the bird's-eye view of Appomattox Court House, Virginia. Art by Chris Casady. (see page 100 for full color version)

this section looks at how to create building models as efficiently as possible.

Generalization is a logical place to start. Depending on the scale of the scene and its purpose, not every architectural detail deserves portrayal, thereby saving valuable production time. One must evaluate all components of a building for what it is they contribute to our visual understanding of the building in a bird's-eye view. For example, does including the rain gutters and downspouts better allow readers to identify a building? Image resolution is also a factor when generalizing buildings. On buildings that will appear at thumbnail size, why go to the trouble of modeling the dozens of sub-pixel-sized porch railings that are below the threshold of visibility? Because only two sides of buildings (plus the roof) are visible in any given view, a simple way to decrease modeling time is to keep the obscured backsides of buildings blank, much like a movie set. To do this you must be completely decided about the viewing direction and have no plans to use the buildings for a virtual reality scene that will be viewable from every which way. The NPS used this method to decrease costs on the bird's-eye view of Eisenhower National Historic Site (figure 24).

The options for generalizing buildings range from simple 2D footprints all the way to complex 3D models with realistic textures (figure 14). Like the stylized recreational symbols (camping, hiking etc.) used on NPS visitor-use maps, a building can be distilled to a much simpler 3D form and still be recognizable to readers. The problem is that, being the primary information on a bird's-eye view, buildings demand detailed depiction. The detail attracts a reader's eye and subconsciously informs them that these are indeed places worthy of attention, more so than, say, the parking lot. Sometimes it makes design sense to show both detailed and generalized buildings in the same scene. For example, for a park site within an urban setting, depicting the park buildings with more detail than non-park buildings focuses the reader's attention on the park. This also spares you hours of unnecessary labor.

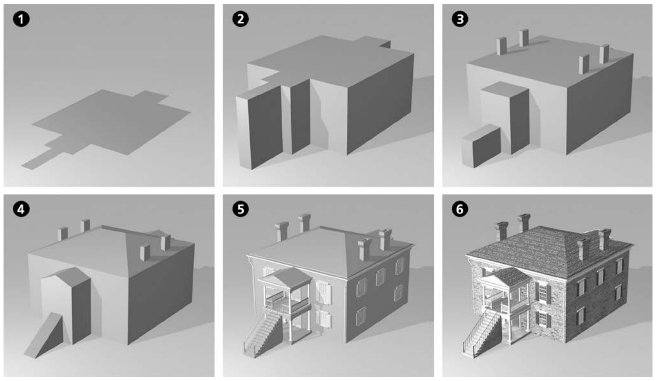

Figure 14. Starting with a simple footprint (1), building depiction becomes more realistic with each successive image. The most critical steps are going from a blocky "prismatic" model (3) to a model with angled roofs and flat-shaded detail (5). Building model by Chris Casady. (see page 101 for full color version)

The NPS is continually on the lookout for new software to more easily produce models. Photogrammetric modeling software is one of the intriguing methods that we have tried (we have tested Canoma 1.0, now discontinued, and ImageModeler 4.0). With this software, which uses oblique aerial or terrestrial photographs of buildings as a guide, the user carefully constructs 3D wireframe models over the building shapes seen in the photographs below. Identifying common points on a building on multiple photographs increases the accuracy of the resulting 3D model. When the model is complete the software then "maps" the photographic textures to the surfaces of the building providing realistic detail (figure 15).

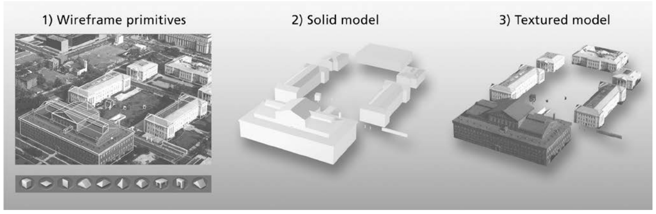

Figure 15. Canoma 1.0 software uses photogrammetric methods to create 3D models from oblique aerial and terrestrial photographs. (see page 101 for full color version)

Photogrammetric modeling software is widely used in the related field of urban simulation to model entire cities. When used in conjunction with LIDAR DEMs (to determine heights), rectified aerial photographs (to determine locations), terrestrial video (to obtain facade detail), and semi-automated procedures (to reduce production time), this software can model thousands of buildings. These are big-budget productions for big-time cities—London, New York, and Tokyo are among the notable projects (Shiode, 2001). The best-known urban simulation is perhaps *Virtual Los Angeles*, created by the Urban Simulation Team, University of California at Los Angeles. They have modeled large swaths of Los Angeles in sections (see references for URL).

At the NPS, photogrammetric modeling applications have not proven to be the panacea that we had hoped for. Considering the small size of park sites, which provide little economy of scale, creating building models with these applications has offered no time savings. The dense tree growth often found next to buildings in parks also presents problems. Without unobstructed photographs of buildings from the proper angles, photogrammetric modeling is next to impossible to use. Finally, there is the highly subjective matter of aesthetics. Buildings created with photogrammetric modeling software tend to look like computer simulations rather than the artistic renderings desired by the NPS

The most detailed and artistic building models produced by the NPS so far have come from the least sophisticated and most time-consuming techniques. Analogous to the "stick built" techniques used in real-world construction, this method of modeling involves assembling sometimes hundreds of 3D objects of various sizes and shapes piece by piece (figure 16). Building footprints draped on a DEM serve as a guide for positioning and sizing the assembled buildings in the 3D scene. Borrowing a technique from the 19th-century city panoramists, we use digital photographs taken of the buildings from the ground as an indispensable reference for filling in details on the facades. When imported into 3D software, the photographs also serve as templates for gauging the relative sizes of buildings. Strict accuracy, however, is not the intent; our aim is to create buildings that look realistic and recognizable to readers. In fact, the NPS occasionally exaggerates the size of the buildings in scenes to improve legibility. For example, at park sites where the buildings are scattered across expansive tracts of land, at true scale they are barely noticeable. Exaggerating the size of the buildings—the smaller the scale, the more exaggeration needed—helps to focus the readers' attention on them.

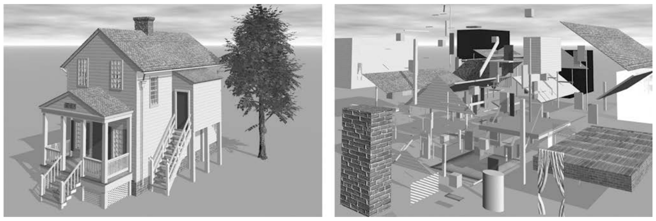

Figure 16. (left) Meeks Store is one of 55 buildings, scores of trees, and perhaps a mile of fence found in the bird's-eye view of Appomattox Court House National Historical Park, Virginia. (right) The exploded view of Meeks Store reveals that it is comprised of 308 separate objects. Building model by Chris Casady. (see page 102 for full color version)

The depiction of buildings involves more than modeling their forms. Exterior textures are essential for bringing believable realism to buildings, transforming even the most sterile 3D forms into an organic entity. With 3D software, applying exterior textures—shingles, bricks, stonework, reflective glass, etc.—is often as easy as clicking a mouse in the libraries of preset textures that come with most 3D applications. If the right texture is not available in a library, you can create custom textures from photographs and by other means (figure 17). You many need to accentuate fine textures to make them noticeable depending on the size and resolution of the depicted building. Bump mapping, a type of 3D embossment, when used in moderation, is an essential technique for giving textures a more realistic look.

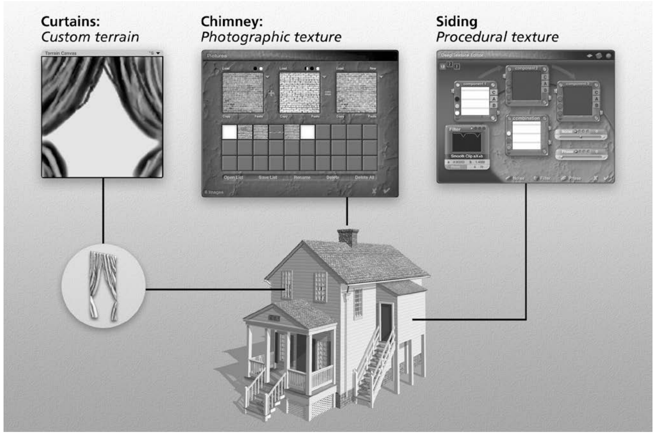

Figure 17. The custom textures applied to a model of Meeks Store. Building model by Chris Casady. (see page 102 for full color version)

Recently the NPS has found a simpler, cheaper, and faster way to model 3D buildings in Sketchup 5.0, an architectural application that offers user-friendly tools for rapidly creating 3D buildings. We learned more about the benefits of Sketchup from NPS contractor, Steven Patricia, an accomplished water colorist who is also a registered architect. Says Patricia of bird's-eye views "an artist has to make choices about what is to be truth and what is to be distortion." To depict buildings "truthfully" he uses wireframe models created in Sketchup as a visual reference for painting traditional art. Building models made in Sketchup are also applicable for an entirely digital workflow. The models are exportable in common 3D formats (3DS Studio, AutoCAD DXF, and VRML), complete with attached image textures. File sizes are small, which is an important consideration when working on projects with many buildings. In a 3D rendering application like Bryce, the textures on imported Sketchup models are editable, and realistic bump mapping is easily applied. The NPS has great hopes for Sketchup and intends to use it for the next appropriate project that comes along.

Trees

Like props on a stage, trees in bird's-eye views play a secondary role and should be treated accordingly. When designing a view you soon discover that trees are more abundant than you ever imagined and grow where you least want them, typically in front of the most important buildings, hiding their distinctive facades. There are several options for managing this arboreal profusion: delete, shrink, move, or prune the trees. Visitors to historical and cultural parks usually go there for reasons other than the trees and chances are good that they will never notice a few missing *Quercus alba* or *Acer rubrum* in your 3D scene. At many older sites the trees have now grown taller than the buildings, obscuring them from above. Shrinking the trees to the same height or slightly lower than the buildings improves visibility and still keeps the leafy ambience. Nudging a problematic tree to a new location a few millimeters to the side (in the 3D scene) can reveal just enough of an obscured building to permit readers to recognize it. The same applies to pruning unwanted branches. On the other hand, you should not be overzealous in removing trees or the scene will look too empty and manicured. The occasional tree that obscures non-essential parts of buildings imparts a sense of depth and natural randomness. Lastly, while it is permissible to delete the odd tree here and there to improve visibility, never plant trees where they do not exist.

Thanks to the capable software available today, dotting your scene with highly realistic trees is an accomplishable, if not easy task (figure 18). When designing trees you have the liberty to exercise some artistic license—for once. Viewed from an elevated and distant vantage point, trees all tend to look alike, particularly if they are entirely deciduous or coniferous. Getting the foliage color and tree shape approximately correct will do in most cases, unless, of course, you are depicting a site known for its famous trees. In the background and margins of a scene trees depicted as impressionistic green textures often will suffice. Trees that are too detailed may distract the readers' attention from more relevant information.

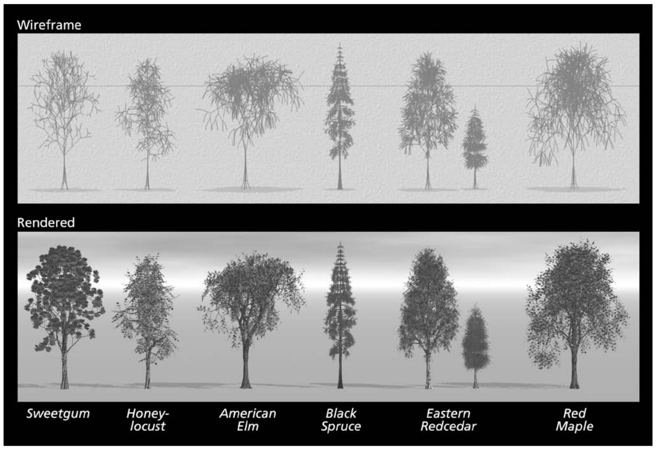

Figure 18. 3D tree models created in Bryce's Tree Lab. (see page 103 for full color version)

A problem with 3D trees is the computational overhead that they demand from even the most capable computer hardware. Because every leaf, twig, and branch adds to the size and complexity of a 3D scene, computer performance lags. For example, imported wirefame models of trees in DXF format are especially susceptible to "high polygon counts," which bloat file sizes and slow rendering times. Some applications, such as World Construction Set and Virtual Nature Studio, handle floristically rich scenes with comparative ease. With others, including Bryce, users must develop strategies to reduce file sizes. Eliminating complex bark textures, which are invisible to readers at small scales, is one way. Creating trees with fewer but larger leaves also reduces file sizes while keeping their crowns full. Going even further, Chris Casady breaks up his scenes into overlapping sections maintained as separate files. Once all of the sections are complete he renders them and stitches them together in Photoshop to create the final bird's-eye view. A technique to avoid is inserting 2D pictures of trees into 3D scenes. The 2D trees, which are planar, are all but impossible to see at steep viewing angles typically found on bird's-eye views. By comparison, 3D trees reveal their broad crowns as you would expect. (figure 19).

Environment

Warm light, soft shadows, background haze, and water reflections are some of the environmental effects that give an appealing ambience to bird's-eye views (figure 20). Although some environmental effects in 3D software are frivolous, others, such as lighting, are essential to the design of a successful scene.

Lighting behaves differently in bird's-eye views than it does on 2D shaded relief maps. On a north-oriented relief map the illumination invariably originates from the northwest or upper left, a direction that minimizes the occurrence of relief inversion. In a large-scale bird's-eye view relief inversion is not a concern, however. Here upper left lighting would throw shadows on the sides of buildings and terrain surfaces facing the viewer, darkening the scene and diminishing legibility. Placing the light source at the lower left or lower right side of a 3D scene is a better solution. Whether you choose a lower left or right placement depends on the orientation of the buildings. Ideally the light should illuminate as many important building faces as possible. Some 3D applications allow the light source (sun position) to be set according to the date and time of day, which rarely places the light where you want it to be. Selecting the light direction is ultimately a graphical decision.

In addition to the global lighting discussed above, 3D applications allow you to place other light sources in a scene. The effect is similar to a room illuminated by multiple lamps. But unlike the lamps, 3D lights

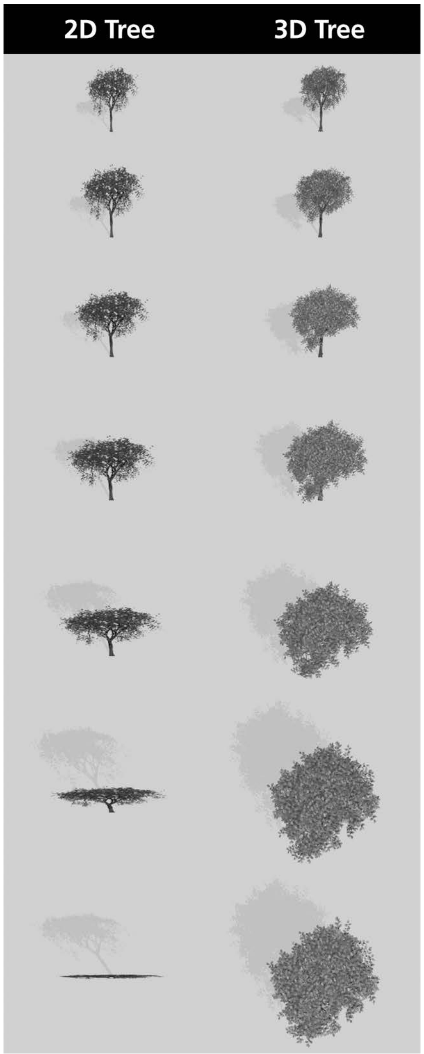

Figure 19. Slimming down. Clones of a 2D tree picture and 3D tree model arranged from background (top) to foreground (bottom) in a perspective scene. The 2D tree becomes less visible in the foreground because of the steeper viewing angle and its lack of volume. (see page 104 for full color version)

Figure 20. (left) A simple scene rendered without environmental special effects. (right) The same scene with exaggerated special effects, which include (1) background haze; (2) pale yellow illumination coming from the lower right; (3) soft cast shadows; (4) reflective water surface; and, (5) secondary blue light coming from the left. Environmental special effects come at a price; the scene on the left took 12 minutes to render compared to 2 hours and 18 minutes for the scene on the right. (see page 105 for full color version)

have options that allow them to behave in unusual ways. For example, a light source can be invisible while still emitting illumination, and the shadows that it casts are suppressible. Like virtual track lights, these 3D lights permit you subconsciously to direct the attention of readers to selected places within a scene, such as a building (Foley, 1995). In Figure 14, a secondary light source placed at the lower left emphasizes the front of the buildings. Secondary lights can also project colors into a scene. A favorite trick of Chris Casady's is using a supplemental blue light to tint shadowed surfaces blue-gray; this complements the warm illumination on opposing surfaces (figure 20). Bird's-eye views and shaded relief maps also depart from one another in the use of cast shadows. Cast shadows are highly inappropriate on shaded relief maps because they cause drainages to appear misregistered with the topographic shading. By comparison, on large-scale bird's-eye views cast shadows serve a useful purpose by anchoring buildings and trees to the ground below. Without cast shadows surface objects would appear to be floating in the air (figure 21).

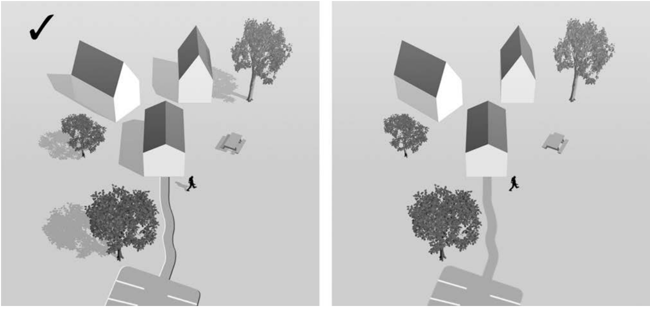

Figure 21. (left) A bird's-eye view with cast shadows. (right) The same view without cast shadows. (see page 105 for full color version)

What you do not see in a bird's-eye view is perhaps as important as what you do see. Adding haze to a scene diminishes unimportant information often occupying the background of a scene. Most 3D applications permit you to add haze of any color and density, also bringing a sense of depth to a final rendered image. Bird's-eye views generally need slightly more haze than occurs naturally (in reasonably non-polluted environments), although it is hard to over-apply background haze to a scene. Lastly, borrowing from the techniques of classical painters, foreground darkening can help guide the reader's eye deeper into the scene. For example, the bird's-eye view of Appomattox Court

House applies supplemental shadowing in the foreground to lessen the visual prominence of the parking area (figure 22).

Figure 22. Appomattox Court House, Virginia, without (left) and with (right) environmental effects. The effects include background haze (1) and foreground darkening (2). Art by Chris Casady. (see page 105 for full color version)

Finishing work

When making a bird's-eye view, the time eventually comes when one must exit the magical world of 3D and finish the job with ordinary graphical tools. Although you can make a complex bird's-eye view entirely within 3D software, this approach is not the most efficient way to work. For example, with 3D software, replacing a tree in the background of a scene that doesn't look right would involve replacing it with a new tree model and re-rendering the entire scene, which could take hours to accomplish (one NPS scene took 40 hours to render). Or you could simply use the Clone Tool in Photoshop to obliterate the offending tree in seconds on the rendered image. Knowing when and when not to use 3D software is key to keeping production costs down.

Adobe Photoshop is the final destination for all of the 3D scenes created by the NPS. In 3D software, we typically render a bird's-eye view multiple times, creating multiple images for final compositing in Photoshop. Because all of the images were rendered at the same size, when they are copied and pasted into a Photoshop document they register perfectly with one another. Some of the images are simple grayscale masks useful for making quick edits (figure 23). For example, inserting a grayscale distance mask into a layer mask in Photoshop permits easy changes to the background haze without having to re-render the entire 3D scene. Should an art director unexpectedly decide that beige haze is more desirable than blue haze, this change would take only moments to do in Photoshop. Full disclosure: I used Photoshop to add the background haze and foreground shadowing shown in Figure 22.

I will end with some advice about labeling bird's-eye views with Adobe Illustrator. Having spent a great amount of time creating beautiful art, labeling it in a less than effective manner would be a pity. Labels give bird's-eye views meaning and transform them from the realm of art to that of maps. In general the NPS prefers to label buildings directly rather than use numbers that readers must identify in a key. The noisy textures, dark shadows, and contrast often found in bird's-eye views interfere with the legibility of labels. In these situations, instead of traditional black labels, I have found that light-colored semi-bold fonts coupled with dark drop shadows are most legible (figure 24). Whether the drop shadows beneath text should fall to the lower right, as is the graphical standard, or coordinate with the shadows embedded in the art below, I leave for you to decide.

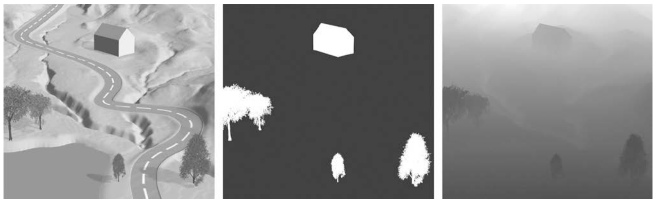

Figure 23. Multiple renders. (left) A simple scene rendered in 3D. (middle) A high-contrast object mask of the building and trees used for selective color edits. (right) A grayscale distance mask used for adding background haze. (see page 106 for full color version)

Figure 24. A portion of the bird's-eye view for Eisenhower National Historic Site, Pennsylvania. Note that the view contains a north arrow but not a scale, which would be inappropriate because of the perspective view. Art by Chris Casady. (see page 106 for full color version)

CONCLUSION

Bird's-eye views are far and away the most difficult "map-like" product that the NPS has attempted to make with digital tools. Although making beautiful artistic pieces is possible with 3D software, doing so requires considerable effort and outside assistance. You might say that it takes a village to make a village, of the 3D variety at least. Mapper, modeler, arborist, illustrator—few, if any, people possesses all the skills needed for making a complex bird's-eye view. On any given NPS project potential contributors might include

GIS staff for creating the DEM; Harpers Ferry staff for cartographic support and art direction; park staff for content review; and, most importantly, our contract illustrators for the 3D artistry that they bring to the final product.

So how do traditional and digital techniques for making bird's-eye views compare? Both require the assistance of a talented illustrator and considerable time and money. Deciding whether to use traditional or digital techniques may depend on the graphical look that you want. Another factor is the availability of data and map resources. If a site is unmapped at a large scale how then can you proceed with 3D software without a DEM, building footprints, and road alignments? Hiring a helicopter and taking oblique aerial photography would be the expedient alternative in this situation. An advantage of 3D production is the ease with which one can make edits. For example, if in a couple of years all of the elms at a site should die from Dutch elm disease, removing these trees takes only a click of the mouse in the 3D scene file. Scenes made from 3D software also lend themselves to repurposing as animations and QTVR scenes.

For the reasons given above, use of 3D software by most cartographers to create artistic bird's-eye views will not be a realistic option for some years to come, if ever. Few of us have worked as a Hollywood special effects artist. Looking a notch or two lower on the artistic scale, however, we find 3D solutions aimed at generalists. User-friendly Sketchup, which I discussed in a previous section, now lets users familiar with drawing software create competent 3D building models. Working from photographic references, in a reasonable amount of time one could make enough buildings to fill up a small park site. Importing these buildings into a consumer-level 3D application and placing them on an obliquely viewed street map would yield a basic scene suitable for static bird's-eye views and multimedia presentations. It won't be as eye-catching as L. Kenneth Townsend's view of the collapsing South Fork Dam, but it will be more refined than what a non-artist could accomplish without 3D software. And, over time and with practice, the results will only get better.

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Bollmann Photo Maps:
http://www.bollmann-bildkarten.de/

Casady, Chris (NPS contract illustrator):
http://www.tilenut.com/nps/

Foley, Don (NPS contract illustrator):
http://www.foleymedia.com/

Google Earth
http://earth.google.com/

Library of Congress Panoramic Maps 1847-1929:
http://memory.loc.gov/ammem/pmhtml/panhome.html

MSN Virtual Earth
http://virtualearth.msn.com/

NOAA - LIDAR DEMs:
http://www.csc.noaa.gov/crs/rs_apps/sensors/lidar.htm

NPS Harpers Ferry Center
http://www.nps.gov/hfc/

Virtual Los Angeles:
http://www.ust.ucla.edu/ustweb/projects.html

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http://magazine.audubon.org/birds/birds0011.html

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http://www.wrh-illustration.com/

Software

Adobe Illustrator and Photoshop:
http://www.adobe.com/

ArcGIS
http://www.esri.com/

Bryce
http://bryce.daz3d.com/

Canoma
http://www.canoma.com/

ImageModeler
http://www.realviz.com/

Maya
http://www.alias.com/

Sketchup
http://www.sketchup.com/

Surfer
http://www.goldensoftware.com/

World Construction Set and Virtual Nature Studio:
http://www.3dnature.com/

cartographic collections

From Drawer to Digital: A Statewide Collaboration for Building Digital Historic Map Collections

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ABSTRACT

Nowadays, when you tell someone you recently visited a map library, it's hard for them to discern whether you mean virtually or in person. The two comprehensive public universities in Nevada are building complementary digital collections of historic maps of interest to the region to enable virtual map library visits. This article briefly describes the two university library map collections, discusses the criteria that were used to select maps to be digitized, provides insight into some of the scanning issues and how they were resolved, discusses technical considerations in using CONTENTdm®, and talks about metadata issues in the collaborative effort. The conclusion provides insight into what has been learned and why the project is important as a foundation for the future.

INTRODUCTION

The history of mapping the New World and the North American continent goes back to the 16th century; until the mid-nineteenth century, Nevada, along with much of the Southwest, was identified, if at all, as terra incognita – unknown land. Historic maps of Nevada and the Southwest are relatively scarce and, within Nevada, are scattered across a large territory among a small number of historical institutions, libraries, and repositories. These maps have not been readily accessible to researchers nor to the general public except through on-site visitation. Compounding the issue of physical access, cataloging of these historic Nevada maps has been limited and incomplete; therefore, these maps were largely unknown.

The two comprehensive universities in Nevada – the University of Nevada, Reno (UNR) and the University of Nevada, Las Vegas (UNLV) – are changing this reality. The in-state rivalry between the two universities not withstanding, their many shared concerns include a deep interest in making resources available to university clientele and citizens of the state and world. Both institutions have developed digital historic map collections which make these maps available to anyone with Internet connectivity. The goal is to make these historic maps available and easily accessible to the public and to researchers in our respective university communities.

Nevada is a sizable state with only two universities. With limited staff and limited digital capabilities, UNR and UNLV have worked together to develop digital historic map collections for the state available to scholars worldwide as well as students in the state's remote one-room schoolhouses. UNR and UNLV have collaborated extensively and continuously, sharing digital expertise while respecting the local focus of each institution in presenting digital historic map collections that replicate original printed copies housed in hundreds of map drawers spread throughout the state.

NEVADA'S UNIVERSITIES' HISTORIC MAP COLLECTIONS

Significant historic map collections documenting the exploration and settlement of western North America are located in the Special Collections Departments in the libraries of UNLV and UNR, the Mary B. Ansari Map Library at UNR, the Nevada Historical Society (located on the UNR campus), and the Nevada State Library and Archives (located in Carson City). Due to the proximity of the Nevada Historical Society and the Nevada State Library and Archives to UNR, these maps are readily available, via special arrangement, to staff at UNR. Each university's collection focuses on the area of the Great Basin that became the state of Nevada; the local history of its respective half of the state is emphasized.

The universities also serve as repositories for the oldest government publications and maps including the 19th century government surveys and explorations by Fremont, Wheeler, King, Hayden, and Powell. Other 19th century maps in the collections came from travel accounts, diaries and commercial maps and atlases. Most of the maps were published on printing presses but some are handwritten manuscripts. Most are in English but a few are in other European languages.

SCOPE OF THE DIGITAL MAP COLLECTIONS

The digital map collections offered by UNR and UNLV currently include rare historic maps of great interest to virtual users. In the future, they will include historic maps in high demand. The maps in each digital map collection provide not only a history of each region through its changing political boundaries, but also a history of map-making and the development of the cartographic knowledge of this area. These collections are being developed as clearinghouses for those who might not otherwise have the opportunity to view and use them; we have in mind not only the most sophisticated researchers in our respective university communities but also the public for personal and professional use. When considering user interface design concerns, we often cite as a target audience the students in the one-room schoolhouses in the remotest corners of Nevada. They are also considered in the collection-building process when deciding whether a map fits the scope of the digital map collections. Preservation concerns, in addition to providing remote access, also affect the decisions made regarding what materials get added to the digital map collections. Rather than physical, now there will be "virtual" wear and tear on these rare and fragile artifacts.

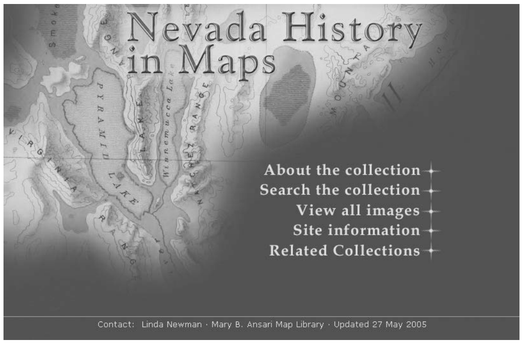
COLLABORATIVE DIGITAL COLLECTION BUILDING

A variety of factors went into deciding which maps would be scanned for inclusion in the initial digital map collections. Some factors were philosophical – the importance of the map and the likelihood of use (remember the student in the one-room schoolhouse). Many factors were more practical in nature – physical condition, ease of scanning, preservation concerns, etc. Where possible, there will not be duplication of scanning efforts, but there may be duplication of digital versions of the maps between the two collections. Future additions to the sites will broaden the spectrum of maps represented in the digital collections.

Selection – UNR

The maps chosen in the initial phase of building the digital collection in 2002 by UNR were selected, by the map librarian, from indexes of historic U.S. Geological Survey topographic maps[1]. This first group included maps bordering Nevada with a variety of scales: 1:250,000, 1:125,000, and 1:62,500. The digital collection was later extended to include most 'historic' topographic maps no longer in print, including the 15-minute topographic series. As federal publications, the maps are not subject to copyright restrictions. When this series was discontinued, it was quite incomplete for Nevada.

Along with the topographic maps, scanning was commenced on significant Nevada geologic and mining district maps because they are fragile, rare, relatively uncataloged and not to be found in any one map collection in Nevada.



Contact: Linda Newman · Mary B. Ansari Map Library · Updated 27 May 2005

Figure 1. Opening page for UNR's digital historic map collection (http://www.delamare.unr.edu/maps/digitalcollections/nvhistory/). (see page 107 for color version)

The maps chosen for the collection's second phase, begun in November of 2003, were selected from the substantial map collections of the Nevada State Historical Society, the UNR Special Collections Department, and the Nevada State Library. This Nevada History in Maps portion of the digital collection covers a span of history and events of importance to Nevada's political and physical development. Maps published by the U.S. government, Nevada and other state or territorial governments, local and national publishers of commercial maps and atlases, and associations such as the Lincoln Highway Association have been included. The intent is to depict the region's European development of one of the last of the American frontiers. Native American subjects are included, albeit as presented by European settlers.

Selection – UNLV

UNLV's digital map collection, Southern Nevada and Las Vegas: History in Maps, was unveiled in late October of 2004. It documents the cartographic history and context of the region, telescoping in scale from the western hemisphere to the streets of Las Vegas. Maps were selected to highlight individually important maps as well as to illustrate the breadth and variety of the collection. These maps show the history of the exploration of the West and the Southwest, the drawing and re-drawing of political boundaries, the creation of the state of Nevada from the territories of Utah and New Mexico, the geology and water resources of the region and the dynamic growth of the city of Las Vegas.

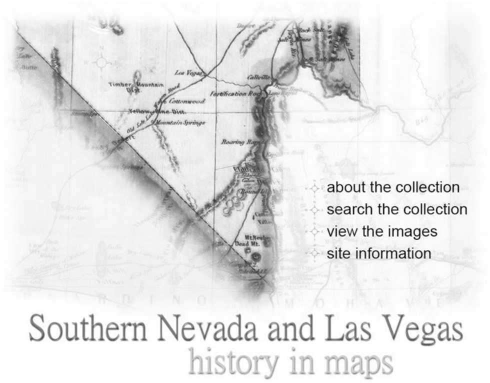
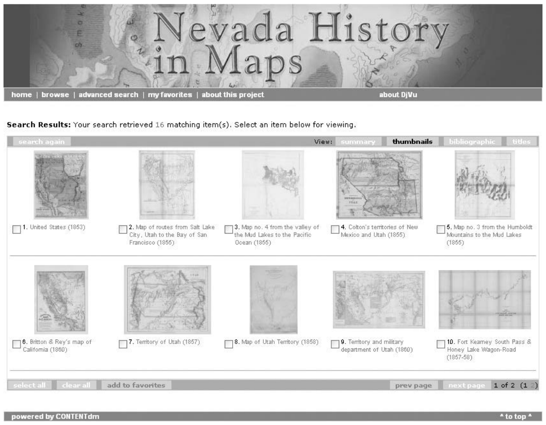


Figure 2. Opening page for UNLV's digital historic map collection (http://www.library.unlv.edu/maps). (see page 107 for color version)

The maps for this digital collection were selected by age, condition, and how well they would be presented on a web site, in addition to their general representation of the development and settlement of the area which became the state of Nevada.



Search Results: Your search retrieved 16 matching item(s). Select an item below for viewing.

☐ 1. United States (1853)
☐ 2. Map of routes from Salt Lake City, Utah to the Bay of San Francisco (1855)
☐ 3. Map no. 4 from the valley of the Mud Lakes to the Pacific Ocean (1855)
☐ 4. Colton's territories of New Mexico and Utah (1855)
☐ 5. Map no. 3 from the Humboldt Mountains to the Mud Lakes (1855)
☐ 6. Britton & Rey's map of California (1860)
☐ 7. Territory of Utah (1857)
☐ 8. Map of Utah Territory (1858)
☐ 9. Territory and military department of Utah (1860)
☐ 10. Fort Kearney South Pass & Honey Lake Wagon-Road (1857-58)

Figure 3. Thumbnails display for a CONTENTdm digital collection. (see page 107 for color version)

SCANNING – FROM OUTSOURCING TO IN-HOUSE PRODUCTION

The initial scanning efforts at UNR came about with the convergence of the elements of need, favor and convenience: In 2001, AngloGold, a major gold producing company in Nevada (indeed, the world), approached the UNR map librarian to express its interest in creating digital reproductions of non-copyrighted geologic maps in her collection for its own use, and an agreement was struck soon thereafter. AngloGold was granted special permission to borrow, for scanning purposes, a large set of USGS publications relevant to their exploration. In exchange, a few maps selected by the UNR map librarian were scanned for UNR. These complimentary map scans, at 200 dpi, represented the modest beginning of a digital collection. At the time, UNR had no convenient means by which to scan large format items. When Anglo’s project ended in 2002, UNR next outsourced its large format map scanning to the Nevada State Library and Archives’ Micrographics and Imaging Program in Carson City, 30 miles south of Reno. All of the maps scanned in Carson City were scanned at 300 dpi.

During this period it was learned that maps could be scanned while encapsulated provided the scanner’s settings were carefully maintained to avoid glare. Indeed, it was required for the protection of fragile pieces—they were inserted into a 3-mil Mylar envelope for the process.

In 2003, the outsourcing venue changed yet again when the Nevada Bureau of Mines and Geology, conveniently located in the building next door to the UNR map library, purchased a large format scanner, and was willing to accept scanning commissions. During this time, the maps were still being scanned at 300 dpi. All outsourcing of large format map scanning ceased early in 2004 when, with financial assistance from the Mary B. Ansari Endowment for the Map Library at UNR, the library acquired its own IDEAL/Contex Magnum XL 54” Plus Color Scanner. We continue to use the commonly accepted scanning rate of 300dpi although some other projects use a higher resolution.

Owning the hardware and directly supervising the scanning staff is preferable to outsourcing, but in this case, the latter initiated this effort and provided a demonstration of the possibilities, the methods, and the value to the end users. In the long run, it resulted in administrative and funding support to expand UNR’s efforts.

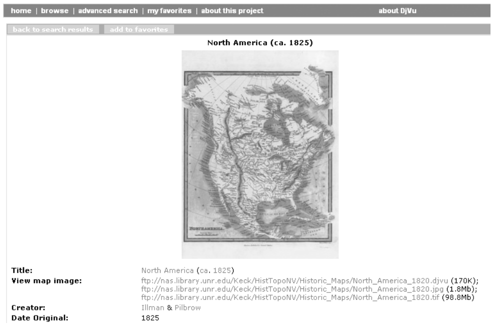
Maps in the UNLV libraries were all scanned at 300 dpi by the staff in its Web & Digitization Services Department using a 24-bit color Vidar TruScan Titan Atlas 40”’ scanner set to the default color configurations.

TECHNICAL CONSIDERATIONS IN CONTENTdm PROJECT PLANNING

In 2003, UNR created the first phase of its CONTENTdm-based digital historic maps collection, Nevada History in Maps, loosely modeled after Washington State University’s (WSU) Early Washington Maps collection (http://www.wsulibs.wsu.edu/holland/masc/xmaps.html). Since maps interest an audience that covers a range of computer users, we needed to provide access to our scanned maps in several choices of file formats, including one that is highly compressed since, for some of our users, the sizes of the files they are viewing are of greatest importance. As was noted previously, students dialing up from the one-room schoolhouses in extremely remote locations in Nevada such as Jiggs and Duckwater are an audience of equal importance to scholars on campuses with ultra-high speed Internet connections.

The most important idea gleaned from the WSU collection was the use of a hyperlink included in the metadata in its CONTENTdm records as a pointer to a location on a file server. We logically inferred from this that the scanned files could reside on a server other than the one being used for CONTENTdm. UNR already had a fileserver that was devoted to storage of a collection of GIS files and data, as well as scanned map images.

A group of 63 historic non-topographic maps held by UNR were selected to be the first to have CONTENTdm records created for them as a test of how suited WSU’s model would be for use by Nevada’s university libraries. The ability to hyperlink from within a metadata record in CONTENTdm allows access to as many different file formats as is deemed appropriate. Three different file formats are provided for each scanned map: TIFF (uncompressed), JPEG (medium compression), and DjVu (wavelet-based high compression). Hence, each metadata record includes three hyperlinks per map for each file format in the “View map image” field of the metadata (see figure 4).



North America (ca. 1825)

Title: North America (ca. 1825)
View map image: ftp://nas.library.unr.edu/Keck/HistTopoNV/Historic_Maps/North_America_1820.djvu (170K); ftp://nas.library.unr.edu/Keck/HistTopoNV/Historic_Maps/North_America_1820.jpg (1.8Mb); ftp://nas.library.unr.edu/Keck/HistTopoNV/Historic_Maps/North_America_1820.tif (98.8Mb)
Creator: Illman & Pilbrow
Date Original: 1825

Figure 4. Example of the “View map image” field including multiple URLs for various formats for scanned historic map files in a CONTENTdm record. (see page 107 for color version)

The file sizes for the TIFF and JPEG formats for scans of large maps can be huge -- often up to 450 Mb for a TIFF for a map scanned at 300 dpi. Of the many paths that could have been taken to offer highly compressed files to our end users, the one we felt would work best was also the one that required the least expense, both for us and for them. Since we had not, at the time, planned to georeference any of the historic maps, we opted for the much higher file compression we would gain by using the DjVu® Solo 3.1 encoder from LizardTech™ rather than its MrSID® encoder. For wavelet compression on georeferenced maps, the MrSID encoder must be used. We opted not to use the

MrSID product, thus there was no need to purchase the MrSID server, nor to use the MrSID encoder, nor to require the end user to download the MrSID web browser plug-in. Instead, we downloaded LizardTech's free standalone DjVu encoder which converts files in TIFF format into files in DjVu format. Although not the ideal solution, we decided to require end users wishing to view the maps at their smallest file sizes to download and install the DjVu browser plug-in. Both institutions provide links to the DjVu plug-in download.

By December of 2004, UNR had added almost 400 historic topographic maps to its digital collection. Earlier in 2004, the UNR libraries' GIS unit volunteered to georeference them, which has allowed digital access to georeferenced versions of the historic topographic maps as a fourth hyperlink in the "View map image" field of its metadata.

In response to DiMeMa's July 2004 release, with version 3.8, of its JPEG2000 extension to the CONTENTdm software, both institutions will migrate their DjVu files into JPEG2000 files in the future because they will provide fast viewing and the ability to zoom and pan without requiring the users to download any web browser plug-ins. Neither institution has yet decided whether we will rescind/discontinue access to the DjVu formatted versions of the files. Regardless, access to both the TIFF and the JPEG formats will continue to be provided.

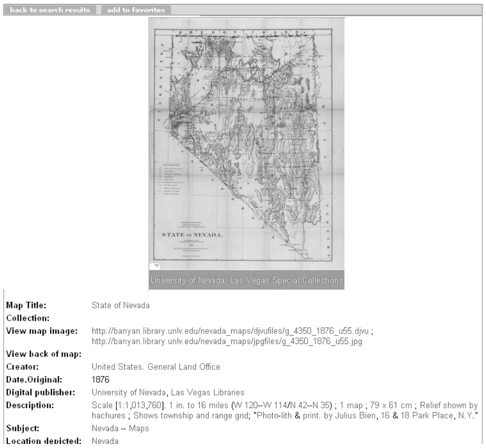
CREATING METADATA FOR THE DIGITAL COLLECTIONS

At the northern end of the state, UNR's historic maps have not been cataloged, so its special formats cataloger created the metadata for them directly in CONTENTdm, working from the scanned images rather than having the map in hand. When the standard sources of cataloging records held multiple records for the same map, it was often time-consuming to determine which one best fit the map that had been scanned. At the southern end of the state, UNLV's special formats cataloger worked from the actual map, cataloging them all first in MARC for entry into the online catalog. Out of the 88 maps that UNLV scanned for its first digital map collection, only 20 required cataloging for the project.

UNLV and UNR are members of the Utah Academic Library Consortium (UALC), and are participants in its collaborative digital initiative, the Mountain West Digital Library (MWDL) -- a multi-site harvester of the consortium's CONTENTdm metadata records. In order for our CONTENTdm metadata records to be properly harvested into the MWDL, they must comply with its Dublin Core metadata standards. In turn, the MWDL's metadata standards conform to those formulated by the Dublin Core Metadata Working Group of the Western States Digital Standards Group.

CONTENTdm uses Dublin Core as its default metadata schema and allows for customization of the labels for each field in the metadata viewed by the end user. CONTENTdm also allows for the use of additional non-Dublin Core fields, as appropriate. Both institutions use similar custom field labels for their historic maps digital collections. Each field is configured to be either hidden or visible to the public, as well as either searchable or not; each field has a configurable data type such as text, date, or full text; and each field can be configured to hold a large number of characters (as in a transcription).

Both collections use the following fields: title, identifier, creator, date original, date digital, original publisher, electronic publisher, description, LC subject, type, coverage, rights, contributing institution, format, digitization specifications, contributors, language, relation, and audience.



Map Title:	State of Nevada
Collection:	
View map image:	http://banyan.library.unlv.edu/nevada_maps/djvufiles/g_4350_1876_u55.djvu ; http://banyan.library.unlv.edu/nevada_maps/jpgfiles/g_4350_1876_u55.jpg
View back of map:	
Creator:	United States. General Land Office
Date.Original:	1876
Digital publisher:	University of Nevada, Las Vegas Libraries
Description:	Scale [1:1,013,760]. 1 in. to 16 miles (W 120--W 114/N 42--N 35) ; 1 map ; 79 x 61 cm ; Relief shown by hachures ; Shows township and range grid; "Photo-lith & print. by Julius Bien, 16 & 18 Park Place, N.Y."
Subject:	Nevada -- Maps
Location depicted:	Nevada

Figure 5. Sample record display from UNLV's digital collection. (see page 108 for color version)

To minimize keying of metadata that is duplicated throughout the collection, CONTENTdm provides a metadata entry template into which constant data can be entered for the appropriate fields. Any field can be configured to use a controlled vocabulary for authority control such as the Thesaurus for Graphic Materials or a local subject heading file.

PRESENTATION

UNR has developed several types of searchable indexes to its historic digital maps collection. For the historic topographic maps, it has built alphabetical, chronological, county, and geospatial indexes. For the historic non-topographic maps, it has formulated numerous pre-defined search queries for its visitors to execute as "explorations" of the collection -- these include time

CONTENTdm Field Properties

Click on a field name to edit the properties for that field:

Field Name	Dublin Core Mapping	Data Type	Large field	Searchable	Hidden	Controlled Vocabulary
Title	Title	Text	Yes	Yes	No	No
View map image	Identifier	Text	Yes	No	No	No
Creator	Creator	Text	Yes	Yes	No	No
Date Original	Date	Date	No	Yes	No	No
Electronic Publication Date	Date	Date	No	Yes	No	No
Original Publisher	Source	Text	No	No	No	No
Electronic Publisher	Publisher	Text	No	No	No	No
Description	Description	Text	Yes	Yes	No	No
Map Type	None	Text	No	Yes	Yes	Yes
Geographic code	None	Text	No	Yes	Yes	No
Subject	Subject	Text	Yes	Yes	No	No
ResourceType	Type	Text	No	No	No	No
Location Depicted	Coverage-Spatial	Text	Yes	Yes	No	No
Rights Management	Rights	Text	Yes	No	No	No
Contributing Institution	None	Text	Yes	Yes	No	No
Format	Format	Text	No	Yes	No	No
Digitization Specifications	None	Text	No	No	No	No
Contributors	Contributors	Text	No	Yes	Yes	No
Language	Language	Text	No	Yes	No	No
Relation	Relation	Text	Yes	Yes	No	No
Audience	None	Text	No	Yes	No	No

Figure 6. Field properties definition screen in CONTENTdm®. (see page 108 for color version)

Historic Period: Prior to 1850

Topics: Cities and towns

Geographic Area: North America

Related Collections:
- Historic Topographic Maps
- Historic geologic and mining district maps and atlases
- Sanborn Town Maps (UNR users only)

You may also:
- Go to Advanced Search
- View all images

Figure 7. UNR's search page for its digital historic maps collection. (see page 108 for color version)

period queries, topical queries, and broad geographic area queries, the latter reflecting the evolution of the state from terra incognita into a territory and finally into a state. UNLV has assigned local subject headings that will be the basis of similar predefined queries to be constructed in the near future.

Both institutions have constructed web "front ends" for their historic digital maps collections. These front ends include explanatory information about the scope of the collection, site and contact information, and links to browse and search pages. UNR has customized the look that visitors see when they are viewing the CONTENTdm display pages.

STAFFING

At UNLV, the participants in building its digital historic map collection were the director of the Special Collections Division, the special formats cataloger, the server administrator, and staff from the Web & Digitization Services Department including the head of the department, the scanning technician, and the graphics/multimedia designer. At UNR, the participants in building its digital historic map collection were the map librarian, the special formats cataloger, the graduate student who scanned the maps, the digital projects librarian, the web development librarian, and the server administrator.

MORE ON COLLABORATION

Because UNR was already working on its digital maps project and had more experience with digital projects in general than UNLV, the UNR digital projects librarian provided substantial assistance to UNLV with technical problems. In October 2004, the UNR digital projects librarian, the map librarian, and the special formats cataloger traveled to meet for the day with staff involved in UNLV's digital map project. They discussed technical problems, decided which Nevada maps each institution would scan, and agreed to share, upon request, reprinted paper and/or digital copies of maps owned by the sister institution.

FUTURE OF THE DIGITAL HISTORIC MAP COLLECTIONS

Expansion of these digital historic map collections in Nevada is ongoing. UNR's Nevada History in Maps site is being enlarged with a significant contribution of maps from its special collections department. Likewise, UNLV's Southern Nevada and Las Vegas: History in Maps site is being expanded with the maps of Mexico and the American Southwest that were scanned for an online exhibit (http://www.library.unlv.edu/millionth) about UNLV Libraries' millionth volume, Historia General de los Hechos en las Islas I Tierra Firme del Mar Oceano, by Antonio de Herrera, published in Madrid in 1601-1615. Maps scanned for other research or digital projects may also be added to the site.

At UNLV, pre-defined queries will be added to guide users through suggested explorations of the digital collection. At UNR, alphabetical, chronological, county, and geospatial indexes for the historic topographic maps will all be migrated onto the search page in the Nevada History in Maps collection. The geospatial index is being expanded to indicate not just topographic maps, but any map in the digital collection from the area selected from the geospatial index.

CONCLUSION

The collaboration between UNLV and UNR in developing and creating parallel digital map collections is instructive of how institutions geographically distant can support each other. While the UNR and UNLV map projects were, for the most part, conceived independently, they were collaboratively developed based on similar interests, collections, institutional agendas and awareness of earlier model projects for providing access to historic digital map collections within CONTENTdm. It was a convergence of ideas shared by a number of people in Nevada, an interest in the history of Nevada, in historic maps, the need to preserve them and, most importantly, to make them accessible and usable with the most sophisticated technology at hand. The benefits of these two projects go beyond the presentation of this still relatively small collection of maps. Both institutions have benefited from the sharing of ideas, problems and solutions. As we have learned to resolve technical issues in our own institutions and to help each other solve problems, we have developed a desire to work with each other on future projects.

Both institutions will add to our digital map collections using new enhancements as they become available and as we master them. We now have a deeper knowledge of each other's collections, the potential and limitations of hardware and software, and a better idea of how we can build a truly statewide digital collection that presents the rich history of the entire state of Nevada while highlighting the unique aspects of our own regions. It is the best of both worlds -- local detail in a state and regional setting, in a format and with information that can be shared anywhere in the world. We have helped each other develop and create new digital collections that benefit all the people of Nevada. The digital world is about sharing; this sometimes presents a challenge when we are customarily so focused on our own collections and institutional structures and agendas. Collections and technology to access, link and use collections should also link the people who manage these collections. In Nevada, the success of this first digital collections collaboration has laid the foundation for real and effective future collaboration.

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reviews

World Atlas of Epidemic Diseases
By Andrew Cliff, Peter Haggett, and Matthew Smallman-Raynor
New York: Arnold, London, and distributed by Oxford University Press, Inc. 2004. ISBN 0-34076-171-7

Reviewed by Tom Koch, Department of Geography, University of British Columbia

First and foremost, *The World Atlas of Epidemic Diseases* stands as a beautiful and rich statement of contemporary knowledge about, and mapping of, epidemic disease as it exists and has existed over time. It is also, less evidently, a status report on the relation between human populations and the viral or bacterial colonies embedded in various communities and geographic regions. Its chapters on the mechanics of disease transmission, the methods of study (and mapping), and "Changing patterns of disease" suggest the means by which we understand epidemic and pandemic disease, and the degree to which socioeconomic changes and population patterns contribute to the evolution of disease and its introduction to various populations.

The *Atlas* also serves as a departure point in the history of atlases in general, and especially medical atlases as they are currently developing in an era of inexpensive, four color printing capable of incorporating a voluminous, shared library of digitally stored and easily reproducible maps, pictures, and medical images. While printed and published as a library resource—at a cost of $225 U.S. it is beyond the reach of most casual readers—its layout, use of color, and clearly written text has the feel of an Internet Atlas with its links to medical databases, microbiological image libraries, and social histories of disease. What distinguishes it from that genre is the clarity and depth of its writing and thinking about the subject it attempts to present.

The oversize (10 ¾ x 14.5"), 212-page *Atlas* surveys 50 epidemic diseases in chapters distinguishing classic plagues (plague, cholera, smallpox, etc.), persistent scourges (tuberculosis, syphilis, typhus), children's diseases (Rubella, chickenpox, diphtheria), seasonal ailments (influenza), tropical diseases, vaccine-preventable diseases, and newly emergent diseases (Legionnaires' Disease, HIV, Lime, etc.). Its introductory chapter is a short course in the history and practice of disease studies, the problem of data collection and the techniques of epidemic disease analysis, including mapping. It's final chapter, certainly its most riveting, considers a broad conceptual frame within which one can begin to understand the emerging epidemics that currently confront humankind.

To understand the *Atlas* and its place in the genre, and the genre's place in the greater body of medical mapping and writing, it is useful to compare it with Cliff and Haggett's classic 1988 A*tlas of Disease Distributions: Analytic Approaches to Epidemiological Data* (Blackwell). That *Atlas* was unabashedly methodological, including detailed descriptions of the techniques used to analyze outbreaks and the history of specific, largely classical outbreaks as subjects of scientific, and specifically cartographic discourse. In it the diseases addressed were largely incidental, the methodological issues were the focus. The diseases used as teaching examples were those the authors had themselves studied in pioneering work on disease diffusion: measles, influenza, and in its early chapters, cholera.

That Atlas, now out of print, remains perhaps the single best book on approaches to a rigorous and broadly constructed mapped analysis of epidemic disease. It was, for its day, lavishly illustrated with black and white images, including maps. The result was a brilliant primer of the methodologies of medical mapping. The section on cholera, for example, included images from newspaper archive, maps, statistics and in technical sections, equations that laid bare the state of the medical-statistical art of disease mapping up to that time.

The Atlas of Disease Distribution was based in part on its authors' work in Iceland and elsewhere, and their focus on the incidence and diffusion of classic epidemic diseases like measles and influenza. It premiered at the same time that Peter J. Gould's now iconic series of color maps of the progression of AIDS in the USA was garnering great attention, a series whose sophisticated algorithms projecting the progress of that pandemic were less discussed than the visually stunning result. Cliff and Haggetts' work laid bare the practical mechanics of work whose endpoint became the color maps by Gould; theirs was the foundation for the next step in sophisticated, predictive spatial mapping his work represented.

In 1988 the popular belief, one encouraged by many officials, was that uncontrolled epidemic disease, with the notable exception of AIDS, was a largely historical phenomenon. Modern medicine and modern science could and would control the traditional scourges. Drug resistant tuberculosis, Legion-naire's Disease and the Human Immunodeficiency Virus were anomalies that would be quickly brought under control. One might therefore study the mechanics of disease mapping without urgency and without attention to urgent contemporary epidemiology.

By 1992, in part thanks to Gould's pioneering work, AIDS was being acknowledged as a pandemic with widespread international ramifications. With Cliff and Haggett, Smallman-Raynor authored the *London International Atlas of AIDS* (London: Blackwell), a volume that attempted to both summarize the state of knowledge to that time and through its maps to present an understanding of AIDS's pandemic spread.

The World Atlas of Epidemic Disease follows both the 1988 and 1992 atlases. Most importantly, perhaps, it takes epidemic disease as a contemporary reality rooted in social and socioeconomic patterns of land use and behavior. In each of its cases attention is paid to the environmental and ecological determinants of the disease. Its theoretical stance is understated, except in the first and especially its last chapter, but the message is clear. Epidemic disease is no longer something others must worry about. If it ever left epidemic and pandemic disease are back in a variety of bacterial and viral forms we encourage in a variety of ways. AIDS is not an anomaly. It is simply an example, one of several, of an historical pattern brought into the present by processes more or less well understood.

Unlike the two earlier volumes, both conceived by the authors and then submitted to a publisher, "the new atlas came from an initiative by the publishers," Peter Haggett informs me. "They already publish a series of atlases (the first was 'Desertification') and so this atlas was simply another in the series." The size, format, and design were set and the authors then invited to create their atlas of epidemic diseases within the series format.

The publisher's general series signaled the growing public interest in the Atlas as a form, one that permitted the broad survey of a subject through maps and other images. As a form this incarnation of the atlas is based on electronic maps and images that can be easily reproduced on the page and stored electronically. The publisher's invitation to create a volume on epidemic disease for their series argued as well a growing popular interest in and awareness of epidemic and pandemic disease as real, urgent, and exigent. The result is designed to sell, the traditionally marketable if expensive atlas revitalized by a four-color printing technology facilitating complex layouts of photos, maps, portraits, and scanned pictures.

The resulting mix is too often a recipe for vacuity, a wealth of maps and pictures that hang without a coherent theme, skin without a skeleton to give it form. Fortunately, however, this volume is different. What distinguishes this atlas is the ease with which the authors write authoritatively but in plain, straightforward language about a range of complex diseases. The images serve the text in a fashion that is encyclopedic rather than atlas-based. Indeed, the ratio of text to images, and non-map images to maps, makes this more an encyclopedia than an atlas that assumes the maps are the thing that will tell the story.

Most infectious disease specialists in North America will have at best only a passing acquaintance with, say, *Leishmaniasis*, a disease caused by single-celled parasites and transmitted by sandflies either directly to humans or through an intervening animal vector. Once common to parts of Africa, the Middle East, and India it has spread through much of the world, including Central and South America and much of western Europe. The description of the disease includes nine maps of the global distribution of the disease, photographs of both the agent and its vector, of patients with characteristic, cutaneous lesions, and finally, charts describing the agent's passage from animal reservoir (the picture of a gerbil is included) to sandfly vector to other animals and to humans.

Together, the images and the text present the portrait of a local or regional disease that has spread, as the last map shows, to well behind its historical boundaries. It exemplifies a formerly regional disease whose diffusion has been assured not through animal migration but the intense globalization of international trade and migration. It thus stands as an example of the relation between economic development and a pattern of disease diffusion discussed, albeit briefly, in the final chapter.

The result would equally serve the medical resident in an Illinois hospital examining room faced with a condition he or she has never seen but suspects is imported, the epidemiologist seeking to understand the diffusion of a formerly limited parasite with a severely local vector, and the medical geographer interested in the general diffusion pattern of parasitic diseases. For those who work in this field the consistency of the text, disease by disease, and the wealth of its presentation (images of bacteria or virus, maps of diffusion and disease intensity, photographs of patient lesions and animal vectors abound for each), the result is not simply praiseworthy but wholly admirable.

In this encyclopedia cum atlas, maps are a tool that with a range of others—physical (microscope, camera, etc.) and conceptual (statistical analytics) promotes an understanding of both the nature of an epidemic disease and of such diseases as a class. It thus is distinguished from the majority of mapped atlases that are map rich but short in thinking or authoritative text. Implicit in this *Atlas* is the message that mapping is not the answer but a part of its grammar, a tool of understanding not the endpoint of our knowledge.

I would have preferred the book be organized chronologically with older epidemics (plague, cholera, smallpox, yellow fever) antecedent to more modern diseases. That would have permitted more thinking about the methodologies of mapping and medical statistics, a la the 1988 *Atlas*, and perhaps, more on the relation between epidemic disease patterns, their socioeconomic contributors, and the effect of anthropogenic land change on some of the more recent diseases included here. It would have been a meatier piece of work.

And I find it curious the Atlas contains a number of maps lifted from the authors' previous works, maps done first in black and white, but here colored without any authorial comment on the changes made to those earlier maps. Comparing a map from the *AIDS Atlas*, 1992, to its colorized version in this *Atlas*—the first black and white and the second color—says much about coloration that is important. At the least, it would have been honest to note when changes were made. To read about why the authors decided to colorize their older maps, about the benefits and drawbacks, would have been useful.

These concerns are not, however, fatally limiting flaws. They may be missed opportunities but even so, the result is greater than its individual chapters. The 2004 *Atlas* shows what can be done within a publisher's commercial template when intelligent, informed authors seek to develop a text with maps that serve public understanding of a subject that is complex and whose science is clearly incomplete. As a general resource for those who are not specialists in infectious disease the resulting volume is without peer. As a first reference—for a library or a medical geographer/cartographer's home library, it is that rare *Atlas* that is worth its price, and perhaps a little more. For the young epidemiologist or public health expert, it is a resource he or she will turn to again and again over the next few years.

Tom Koch (http://kochworks.com) is a professor of geography (medical) at the Univesity of British Columbia and of gerontology at Simon Fraser University. He is the author of 14 books, including *Cartographies of Disease: Maps, Mapping, and Medicine* (ESRI Press, CA) to be published this spring.

Mapping the News: Case Studies in GIS and Journalism

By David Herzog
Redlands: ESRI Press 2003
148 pages, with full-color illustrations throughout
$19.95 softcover
ISBN 1-58948-072-4

Reviewed by Mary L. Johnson,
Technical Writer, Remington & Vernick Engineers, Haddonfield, New Jersey

The Case Studies Series from ESRI Press provides actual accounts of Geographic Information System (GIS) use by and for many professions, including transportation, law enforcement, education, and government. GIS is helping these individuals to plan transportation corridors, analyze crime patterns, inform the public, and provide emergency response scenarios worldwide. In my own province of civil engineering, GIS technology monitors utility infrastructure systems, manages tax assessment data, directs emergency personnel, aids in the development and planning of neighborhoods, and provides a variety of municipal mapping services.

Mapping the News describes the impact of GIS technology on the field of journalism, and focuses on its use in newspaper reporting. Whether using GIS maps to illustrate an article or performing a complex GIS analysis for an investigative report, journalists across the country are taking advantage of this technology to enhance the storytelling process.

The author of this book is a former investigative reporter who currently teaches journalism, so he is able to tackle this subject as both participant and instructor. He begins with an overview of GIS mapping technology and describes some of its general uses in the public and private sector. Maps have been used in journalism for many years to show us where the headline stories occur, or to provide color-coded comparison studies of different areas. Maps have also been used to help readers better understand the concept of place. Even a simple relativity query, such as establishing the distance between two locations, becomes an abstract proposition without a map to guide us. A good map provides a source of visual reference that is virtually unsurpassed by any other means.

But GIS takes mapping one step further by linking digital maps to tables of related data that pertain to the geographic features appearing on the computer screen. Each line of information stored in these tables is referred to as an attribute. Attributes regarding a geographic location can include demographics, topography, or in-depth government information, such as tax assessment or housing data. Because GIS maps are created in a layered format, the user is able to look at a single geographic element in an area, such as flood locations, or combine this element with others, such as roadways, housing, and business locations, to see how they relate. The same layers can be interchanged, added, or subtracted from the whole as needed to provide the customized information needed for a variety of stories, rather like shuffling a stack of transparencies behind the computer screen.

A GIS also allows the user to query the database to locate or highlight specific map features by attribute. In one example, GIS highlights the locations of public schools in and around Newport, Rhode Island, that are within five hundred feet of a leaking underground storage tank. In essence, GIS allows a journalist to perform a variety of analytical and investigative functions with one software program that might otherwise take hours of cross-referencing to accomplish.

GIS is widely utilized by government agencies with access to vast quantities of demographic, economic, social, and political data they often share with the public for little or no cost. Related geographic data can be accessed directly over the Internet through a variety of local, regional, and national organizations. Combine this plethora of resource material with the emergence of GIS software as a simplified desktop computer program, and its appeal to journalists becomes apparent.

The author explains the basic terminology and principles involved, demystifying concepts like geocoding, which is the process used to link street addresses and related attribute data to their geographic locations on the map, or extolling the importance of color and symbology in the creation of thematic maps. The explanations are brief and understandable without being overly simplistic. Ample color illustrations, mostly in screenshot format, are provided as reference throughout the volume. The screenshots offer a unique opportunity to view each GIS project in much the same perspective as the journalist creating it would have on a simulated computer screen.

The main portion of the book is comprised of actual case studies demonstrating how journalists are using GIS to analyze trends, perform research studies, and ultimately map the headlines. Many of the stories presented are truly monumental in proportion, such as the *Miami Herald's* Pulitzer Prize-winning coverage of how poor construction practices contributed to the devastation wreaked by Hurricane Andrew in 1992, or the *Dallas Morning News* story noting the proximity of many public housing projects to air pollution and toxic waste sources, or the *Washington Post* story tracing disqualified ballots by race during the 2000 presidential election. Other stories reflect more general interests, such as the *San Diego Union-Tribune* analysis of local demographic changes based on Census 2000 data.

The Hurricane Andrew story is presented as the first major use of GIS in investigative reporting, and the author leads us through the process beginning at the aftermath of the storm in August 1992. Because construction practices in southern Florida were believed to be among the most stringent in the nation, a group of reporters wondered how the storm damage could have been so devastating. Area contractors claimed that nothing could have been done to lessen the damage inflicted by such a powerful storm, but many homeowners remained unconvinced. The reporters set out to prove either that the impact of Hurricane Andrew was truly unpreventable or that human factors contributed to the massive devastation.

GIS links tabular data to geographic locations by means of unique identification numbers, such as property addresses or tax assessment parcel numbers. The *Miami Herald* reporters were able to obtain a Dade County database that contained surveys of storm damage in tabular format, documenting the level of damage to each residence and whether or not it was still habitable. Because this database included the tax assessment identification number for each storm damaged property, reporters were able to merge the storm damage data with local property assessment data, such as the construction date, value, and location of each of the properties involved. A local hurricane researcher provided a hardcopy map of wind contour, which displayed the hurricane wind speeds experienced in each geographic area. The reporters digitized this information and incorporated it into their GIS database for further analysis.

After seeing no clear pattern to the storm damage based strictly on wind velocity and location, the reporters mapped the damage again by date of construction for each of the homes involved. In doing so, they discovered that the newest homes had suffered the most damage. Further investigation uncovered major design and construction flaws in the damaged homes, as well as serious inadequacies in the building inspection process. This combination of factors had largely contributed to the devastation caused by Hurricane Andrew.

As a result of this investigative reporting, new and tougher building codes were adopted in the hardest hit areas of Florida. The *Miami Herald* won the Pulitzer Prize for public service in 1993 and successfully launched GIS as a major reporting tool in newspaper journalism.

A recurring theme throughout many of the case studies presented was the difficulty journalists often had when trying to reconcile the public's need to know with its contradictory desire for privacy. Compromises are usually necessary, as when the *Charlotte Observer* attempted to measure the impact of busing on area children and had to settle for data that does not include the names or even the exact home addresses of the students in question.

Even when data is freely and wholly available, the

GIS process is not always straightforward. Although today's GIS software programs are presented as comparatively easy to navigate in relation to earlier versions, diverse data formats must still be reconciled before maps can be created and the results analyzed. This is not an instantaneous process.

Various ESRI software extensions, such as StreetMap USA and Spatial Analyst, are also employed in some of the case studies, and their unique capabilities are briefly but satisfactorily touched on. The author clearly presents the challenges involved in bringing the journalistic idea to fruition, whether through issues of software and data incompatibility or simply gaining access to the necessary resources.

Each case study is presented in stand-alone format, making the book equally suitable for casual browsing or in-depth reference purposes. The reader is taken through the journalistic process in a concise, authoritative manner, providing an inside look at how each story was conceived, researched, documented, and illustrated through GIS technology.

The book also examines the use of MapShop, an Internet mapping service that allows users without traditional GIS programs to create the locator graphics that often accompany news stories. MapShop was developed by ESRI and the Associated Press. The service is available by subscription to news organizations or for more limited use by the general public. The maps can be created on the Internet inside a browser, then downloaded for use and editing in various graphics programs.

The *Chicago Tribune* used MapShop in its coverage of the November 2001 plane crash in Queens, New York. A color-coded map of the crash site was created to show where the scattered wreckage was found and how much greater the death toll would have been had the plane crashed into one of the more densely populated neighborhoods only a few blocks away.

Two valuable appendices complete the book. The first offers tips for new GIS users who are looking for everything from general information to creative inspiration. The second offers available GIS data sources suitable for new or experienced users. A variety of useful websites are presented. Some, such as the National Institute for Computer-Assisted Reporting (www.nicar.org) and Environmental Systems Research Institute (www.esri.com), offer GIS training and resource material suitable for journalistic applications. Others, such as the U.S. Census Bureau (www.census.gov) and U.S Geological Survey (www.usgs.gov), offer geographic and related data products for public use. I explored many of the websites provided and found the information there to be timely and helpful.

I have only two negative comments about the book, and both are relatively minor. I found some of the illustrations to be rather small, perhaps to accommodate the book's 7.5"x 9" paperback format. This factor made it difficult to truly appreciate many of the mapping examples presented, particularly where a large geographic location or a high concentration of reference points was displayed. The descriptions accompanying the maps tended to compensate somewhat, but the full-page illustrations scattered thinly throughout the volume left me wanting more.

I was also disappointed that only case studies involving ESRI software products and related services were discussed, perhaps because the book was published by ESRI Press. Although ESRI is quite deservedly one of the most well-known and hallowed names in GIS technology, I would like to have learned if reporters are using other GIS alternatives for journalistic expression, and how these products might or might not compare.

The previous paragraph aside, I would definitely recommend this book to anyone with an interest in journalism or GIS, whether that individual is on the newsroom floor, involved in the classroom, creating maps for the public, or ensconced in an armchair as amateur sleuth or observer. I found the book to be very informative, and I came away charged with many new ideas for interweaving the writing and mapping processes I enjoy so much. I also look forward to discovering other books in *The Case Studies Series.* I have experienced firsthand what GIS can do in the municipal mapping and civil engineering realm, and I am eager to follow its continuing evolution as a research and analytical tool with seemingly endless applications for the masses.

visual fields

Heber Valley Camp, 1:9,000

Designed by Brandon Plewe
Produced by Brandon Plewe, Whitney Taylor, and Sterling Quinn
Brigham Young University Mapping Services Center
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In 2004 we were hired by The Church of Jesus Christ of Latter-day Saints to produce a recreation map of the Heber Valley Camp, an 8,000-acre campground the Church owns above Heber City, Utah. The Camp is designed primarily for church youth groups, so they wanted a map that was easy to use, accurate, and aesthetically pleasing; they were especially enamored with the recent national park maps, although they wanted their own look.

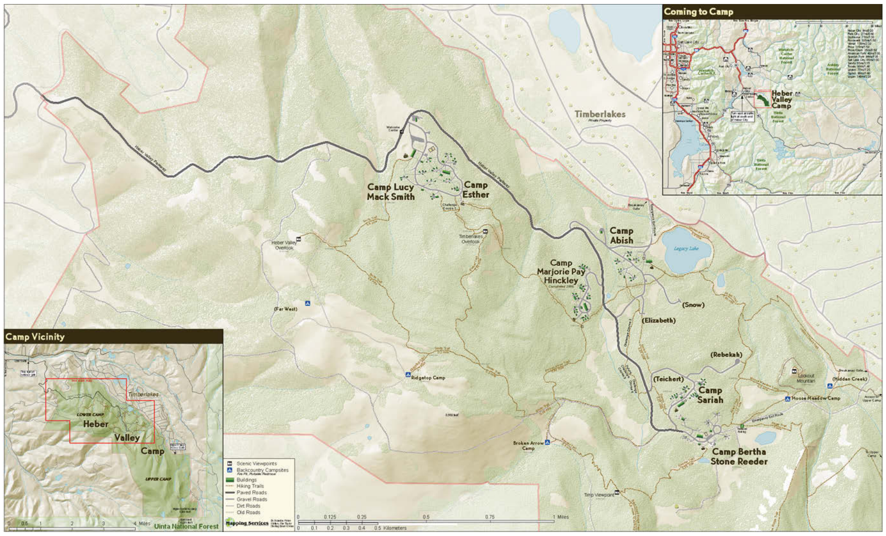
The concentrated development of the camp (which includes 5 camps in addition to the two shown) required a large scale (1:9,000) for the main map, which provided several challenges, but also some opportunities. Specifically, I saw it as a chance to implement several of the techniques I had learned from the NACIS community over the past several years. For example, this seemed to be the perfect scale to use vegetation textures.

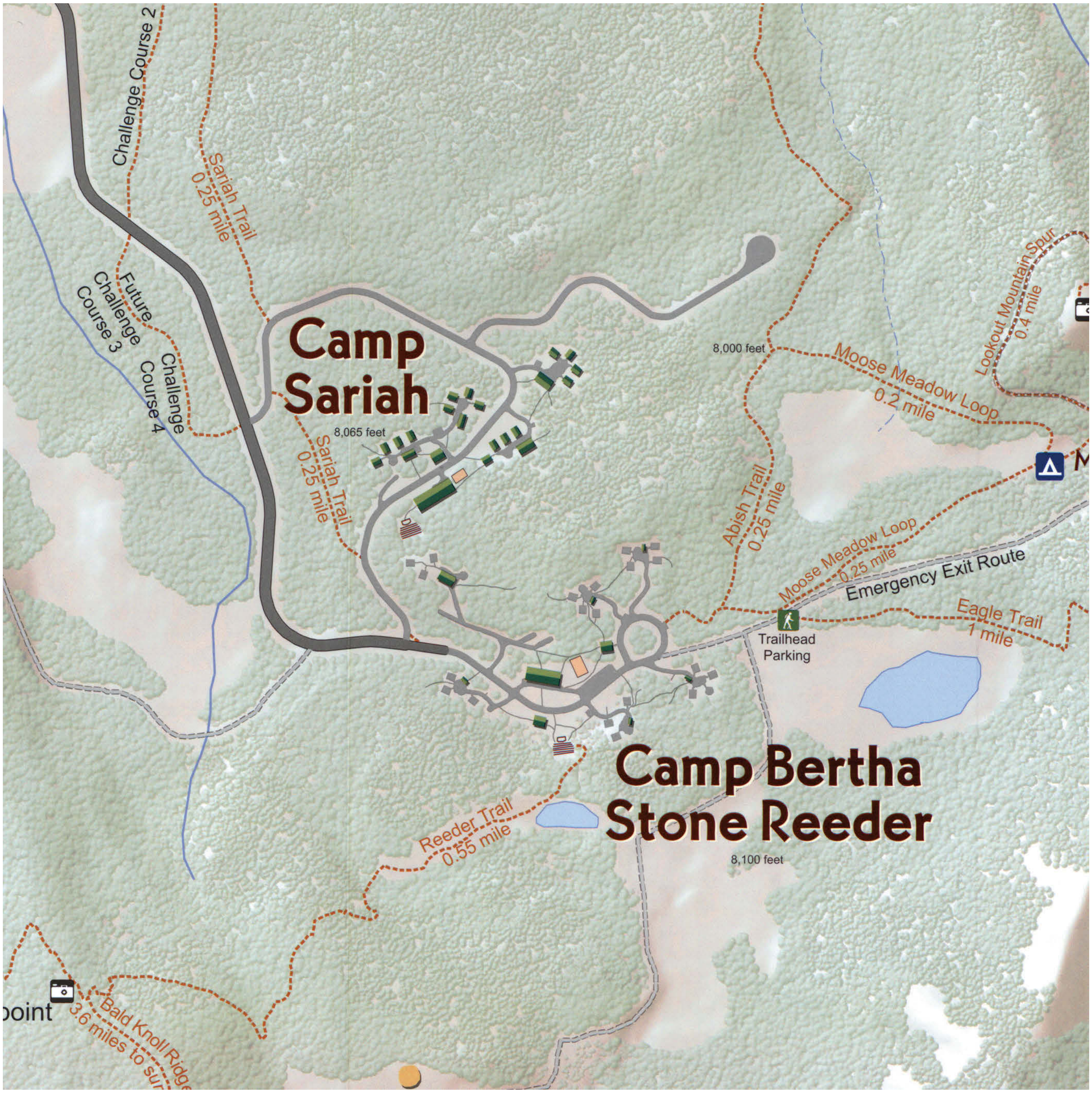
The primary challenge was collecting large-scale data. The terrain is a blending of USGS 10 meter DEM's with a raster interpolated from 2-foot contours created by the engineers that designed the camp. Camp features (roads, trails, buildings) were obtained from the engineers' CAD files, then updated and corrected in the field, primarily by students in our GPS course.

To create the vegetation texture, we classified a recent Landsat image into four vegetation types (Aspen, Conifer, Shrub, Grass). We then refined the result using recent 1 meter orthophotos (2004 USDA NAIP) and the feature vector data. We then used ModelBuilder in ArcGIS 9 to create a raster algorithm to generate tree/shrub patterns (including two sizes of trees for added texture), based loosely on Jeff Nighbert's random-dot-growing method. The resultant 1-meter texture was combined with the DEM for shading, and also used as a color mask. In general, we were very pleased with the result, although we found it difficult to create realistic conifers, and the landforms may be too large at this scale to be easily recognizable from shaded relief.

The final design was performed in ArcGIS (a first for us). It was then exported to Adobe Illustrator for composition with text and photographs. The map was published in January 2005, and is now distributed to all leaders of camping groups, and is available for purchase in Church bookstores.

For more information, contact Brandon Plewe, BYU Geography, plewe@byu.edu.

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color figures

Mapping the Miasma

Tom Koch

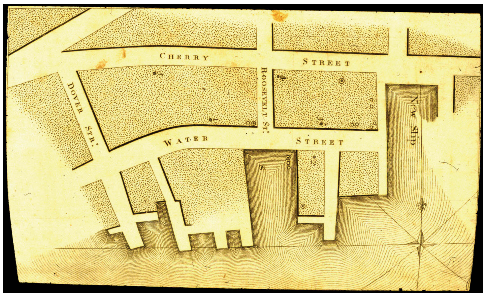


Figure 4. Seaman's 1798 map of yellow fever deaths in the Roosevelt Street basin area, New York. Fatalities are number sequentially. Near-fatal deaths are symbolized by an E, cases whose diagnosis was uncertain were symbolized by an "o". Source: the National Library of Medicine.

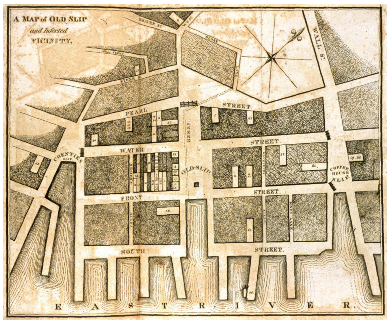


Figure 6. Pascalis's map of yellow fever cases near Old Slip, New York, 1819. Fatal cases are numbered sequentially by time of death. Source: the New York Academy of Medicine.

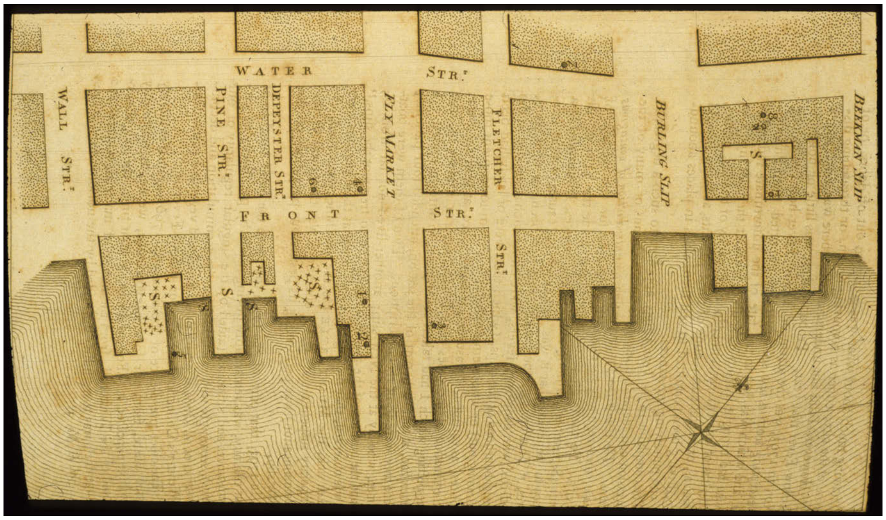


Figure 5. Seaman's map of the sources of the 1795 yellow fever outbreak in New York City. Fatal cases are numbered sequentially. An "S" symbolized "slips, puddles, filth, and garbage". An "x" was used to indicate "common convenience." Source, the National Library of Medicine.

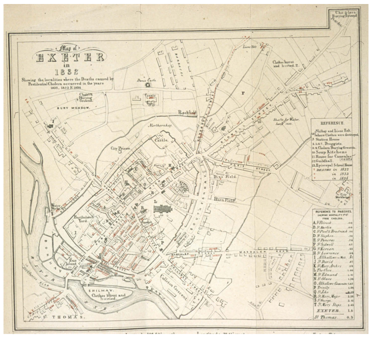


Figure 7. Map of cholera in Exeter, 1832, published by Shapter in 1849. The map includes a statistical table of deaths by parish population and incidence of disease by parish in the years 1832-4. Source: the New York Academy of Medicine.

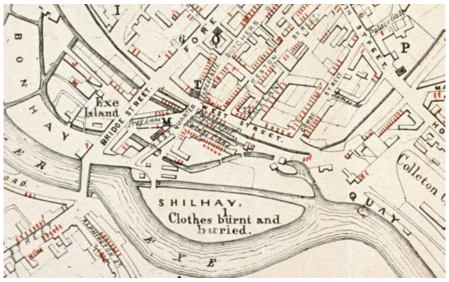


Figure 8.

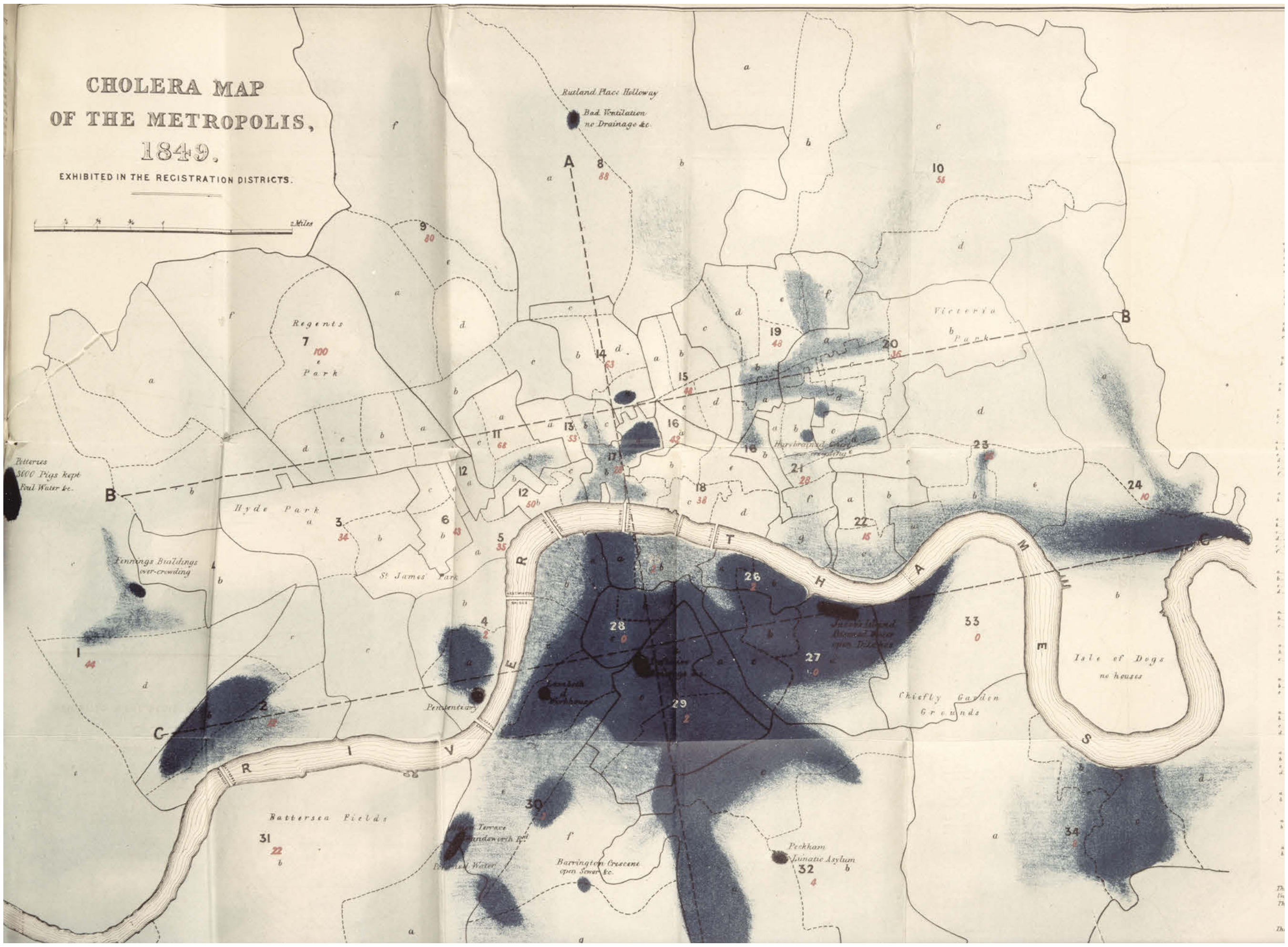


Figure 9. Grainger's density map of the 1849 cholera epidemic in London showing intensity by political district and sub-district. Source: the College of Physicians of Philadelphia Library, Philadelphia, PA.

WARDS.	Population.	Population on each Acre.	No. of Streets.		Births to Population.	Deaths to Population.
			Good Streets	Bad Streets.		
Nos. I & II.	28,775	207	64	109	1 in 22	1 in 23
III, IV & V.	23,039	118	60	100	1 in 28	1 in 30
VI, VII & VIII.	30,306	84	120	130	1 in 28	1 in 36

Figure 11. Chadwick's map of Leeds in which increasing incidence of contagious disease is correlated graphically with declining income. Map courtesy of Wellcome Trust.

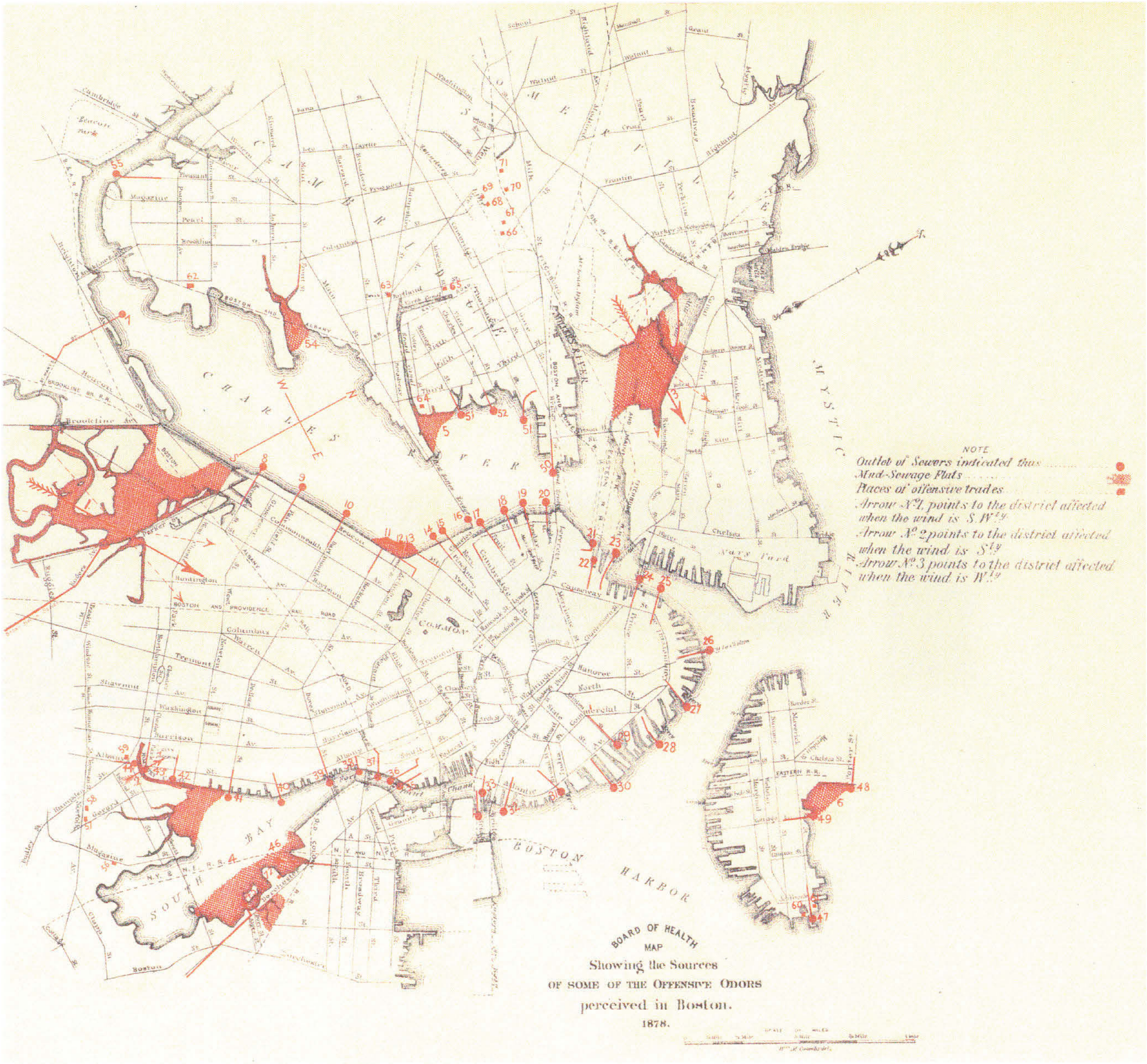


Figure 16. Board of Health Map of offensive odors in Boston, Massachusetts, 1878. Red hatching shows the location of mud flats and marshes, large dots of sewer gratings, from which foul odors were carried across the city by prevailing winds marked with separate arrows. Boston Board of Health, 1878. Source: City of Boston Archives. Source: City of Boston archives.

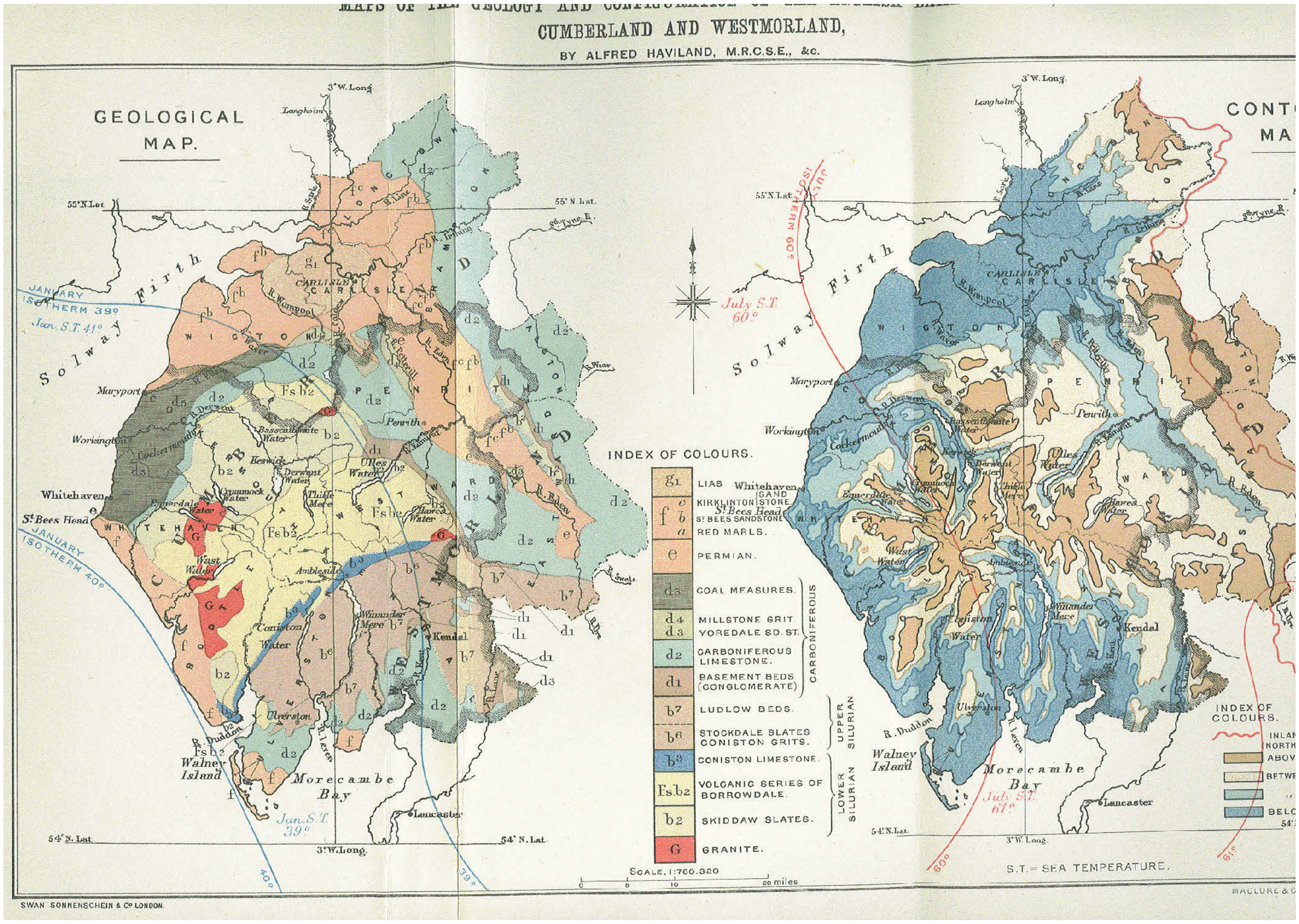


Figure 17. A. Haviland's map of geology of select British districts as part of an explanatory thesis in medical geography. Local soils and airs were used to explain patterns of greater and lesser disease incidence. Source: Rare Books and Special Collections: University of British Columbia.

Attention on Maps

Robert Lloyd

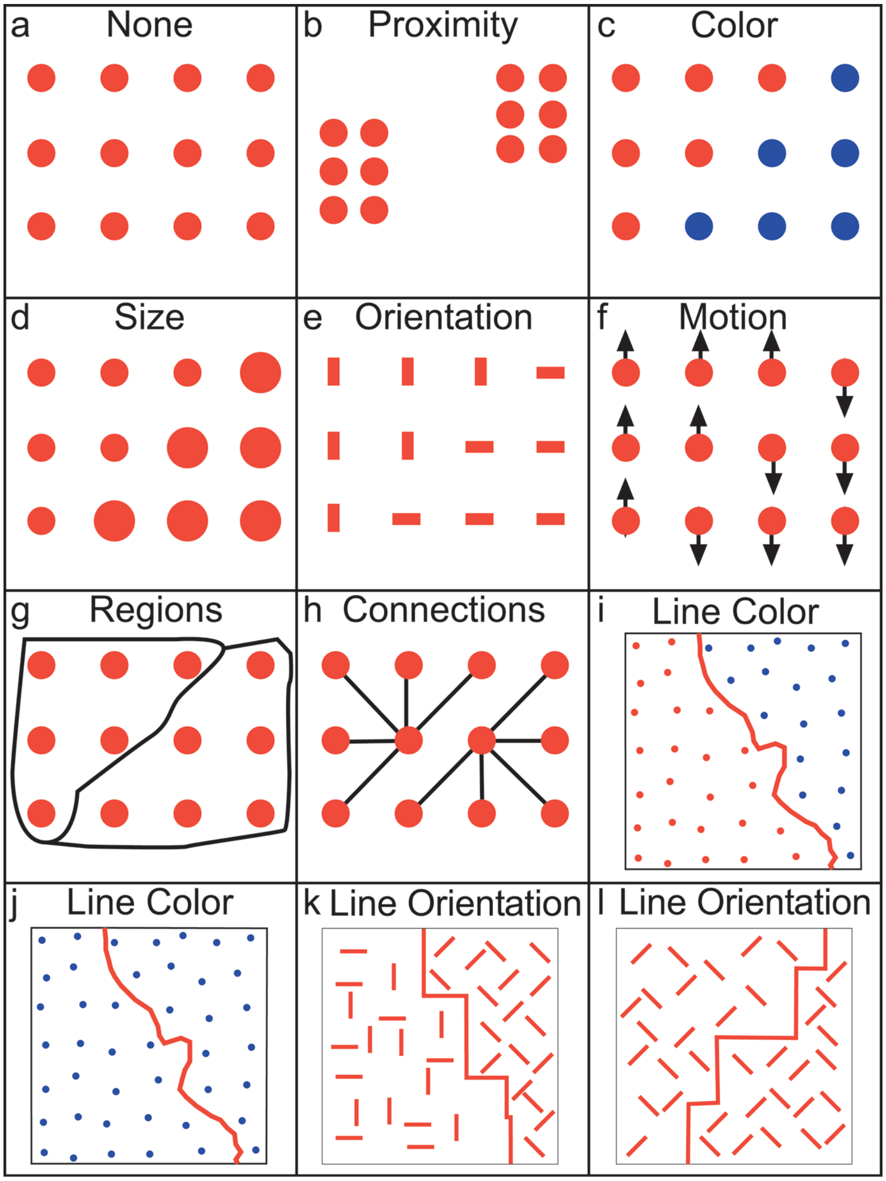


Figure 6. Visual grouping with map symbols. Simple examples show no differentiation (a), and two groups based on proximity (b), color (c), size (d), orientation (e), and motion (f). More complex examples show two groups based on common regions (g) and connections (h). Figure selection (i) and no figure selection (j) based on common line and texture color and figure selection (k) and no figure selection (l) based on common line and texture orientation.

Looking Closer : A Guide to Making Bird's-eye Views of National Park Service Cultural and Historical Sites

Tom Patterson

Figure 1. Johnstown Flood National Memorial, Pennsylvania. The South Fork Dam as it appeared when newly constructed (left), in a state of disrepair (middle), and breaching (right). Art by L. Kenneth Townsend.

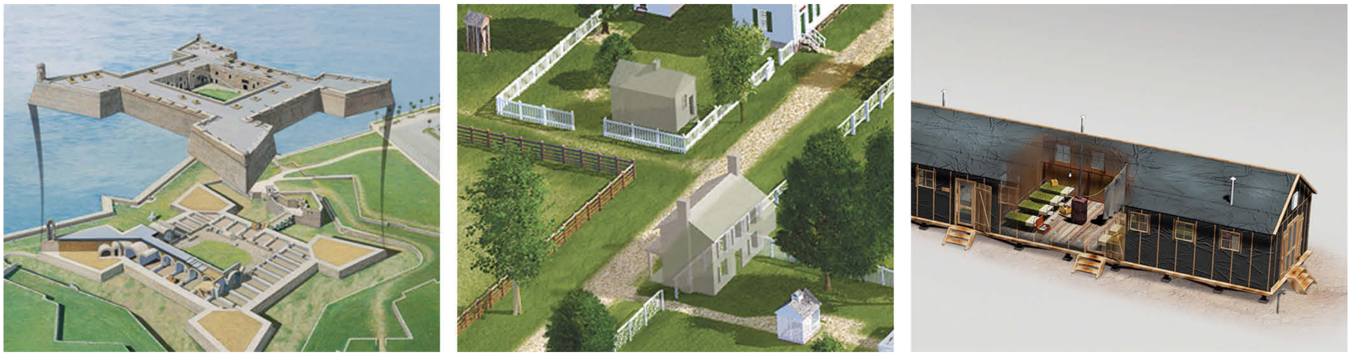


Figure 2. Building visualization. (left) The Castillo de San Marcos, St. Augustine, Florida, lifted off its foundation. (middle) Buildings at Appomattox Court House, Virginia, that no longer exist, shown in ghosted form. (right) The interior of a barracks at Manzanar, California, revealed in an "X-ray" or cutaway view. From left to right, art by L. Kenneth Townsend, Chris Casady, and Don Foley, respectively.

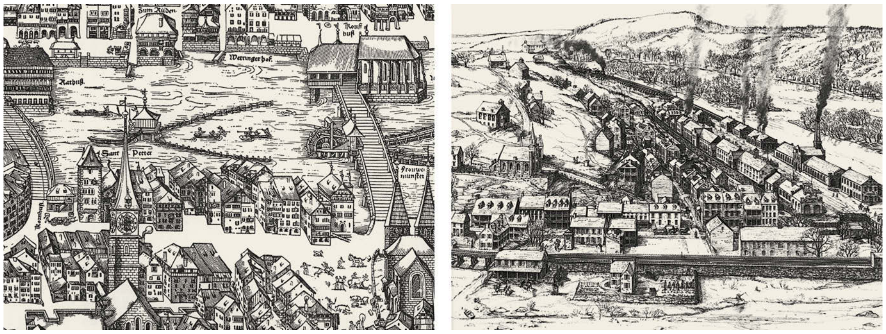


Figure 3. (left) A 1576 map of Zurich, Switzerland, by Jos Murer. (right) A map showing Harpers Ferry, West Virginia in 1860, drawn by Richard Schlect circa 1980. Zurich map source: Imhof, 1963.

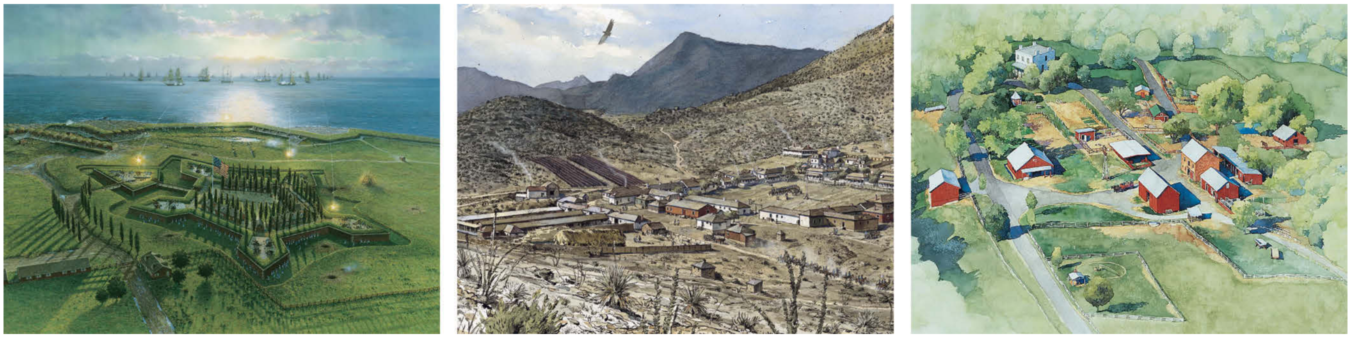


Figure 4. Some of the varying artistic styles found in illustrative NPS bird's-eye views. (left) Fort McHenry, Maryland, by L. Kenneth Townsend. (middle) Fort Bowie, Arizona, by Richard Schlect. (right) Oxon Hill Farm, Maryland, by Greg Harlin.

Figure 5. A portion of Eisenhower National Historic Site, Pennsylvania. (left) A plan map draped on a DEM and viewed obliquely in Bryce. The park approved this view as the basis for final production. (right) The final bird's-eye view. Art at right by Chris Casady.

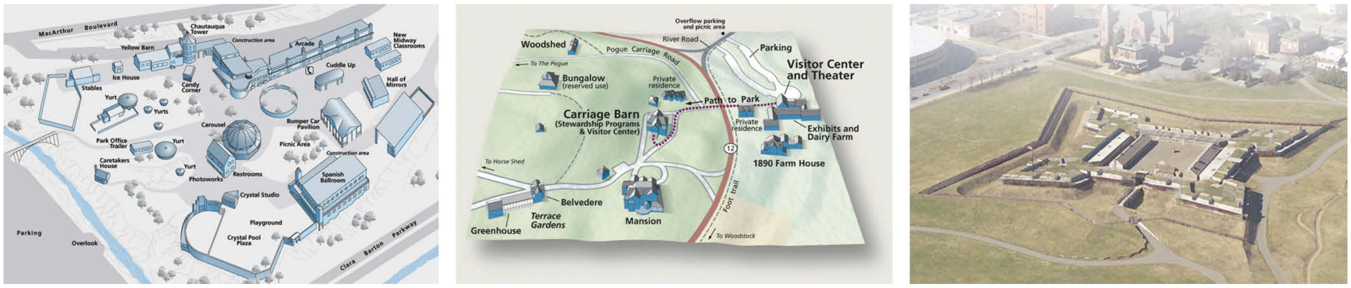


Figure 6. (left) Glen Echo, Maryland, was sketched in Adobe Illustrator using an older inked map as a guide. (middle) Marsh-Billings-Rockefeller National Historical Park, Vermont, was made from a 3D terrain base upon which buildings were drawn in 2D in Adobe Illustrator to appear three-dimensional. (right) Fort Stanwix National Monument, New York, derives from an oblique aerial photograph artistically filtered in Adobe Photoshop.

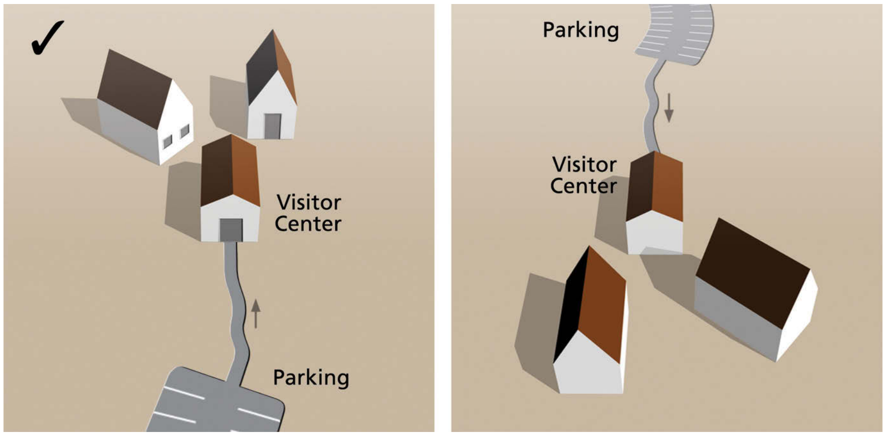


Figure 7. Direction of view. (left) A bird's-eye view should approximate, from a raised vantage point, what a visitor sees when entering a site. (right) A view from the opposing direction makes it harder for visitors to orient themselves because left and right, and, front and back, no longer corresponds to what they see on the ground.

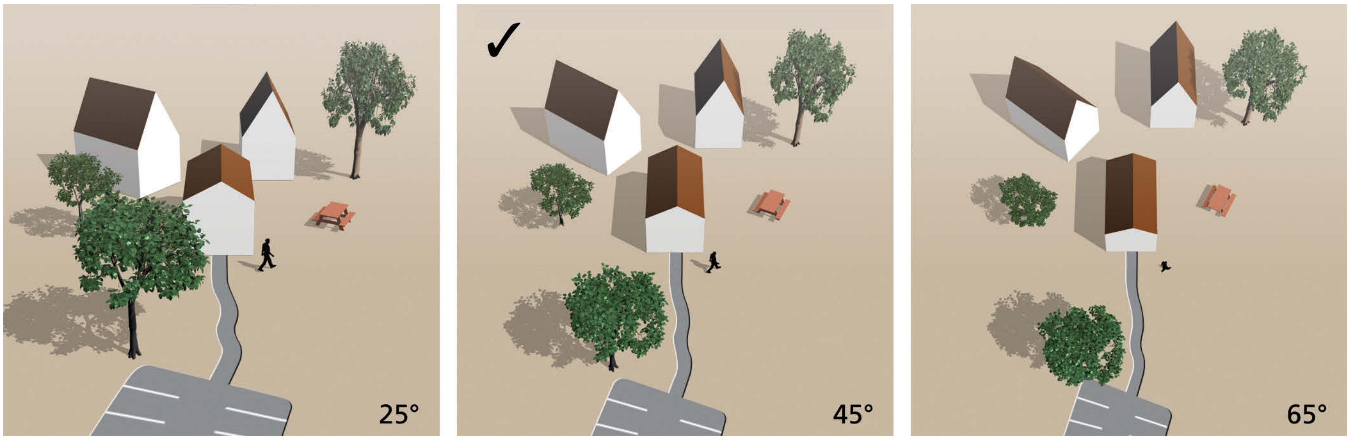


Figure 8. Viewing angle. (left) When the viewing angle is too low, tall objects in the foreground obscure lower objects in the background and spatial relationships are difficult to judge. (middle) An angle between 40 and 60 degrees generally works well. (right) Higher angles of view place too much emphasis on the tops of buildings and trees.

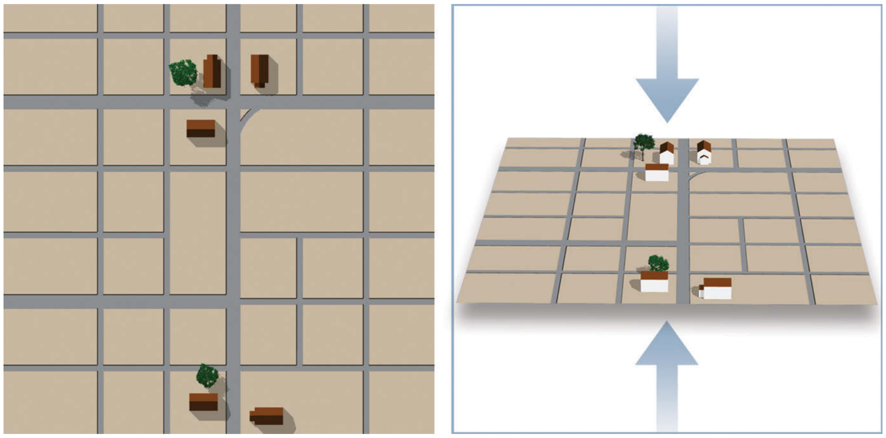


Figure 9. (left) A plan map. (right) Because of foreshortening a bird's-eye view needs less space to show the same area.

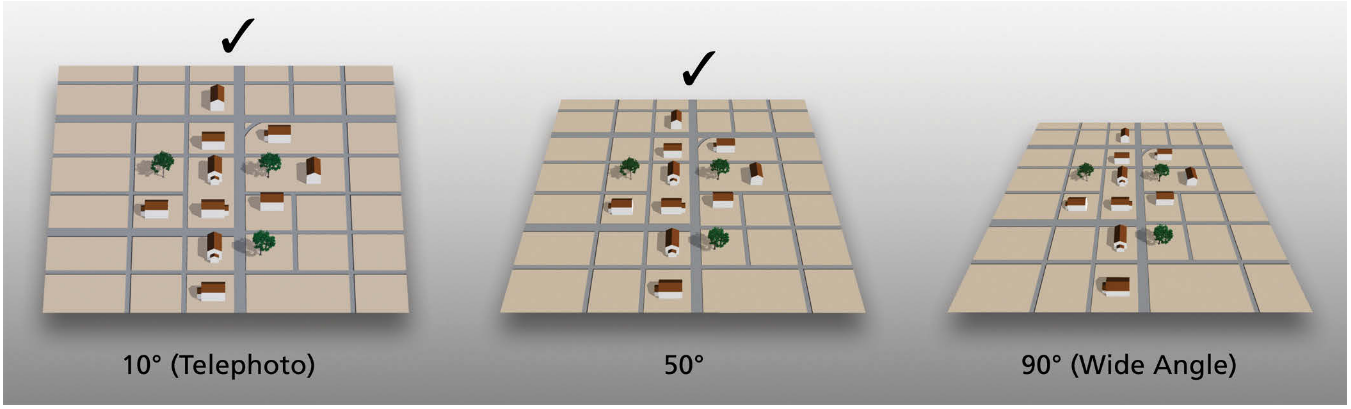


Figure 10. Adjusting the Field of View (FOV), which is a camera setting in 3D applications, controls the amount of perspective in a scene. From right to left the examples become increasingly orthogonal.

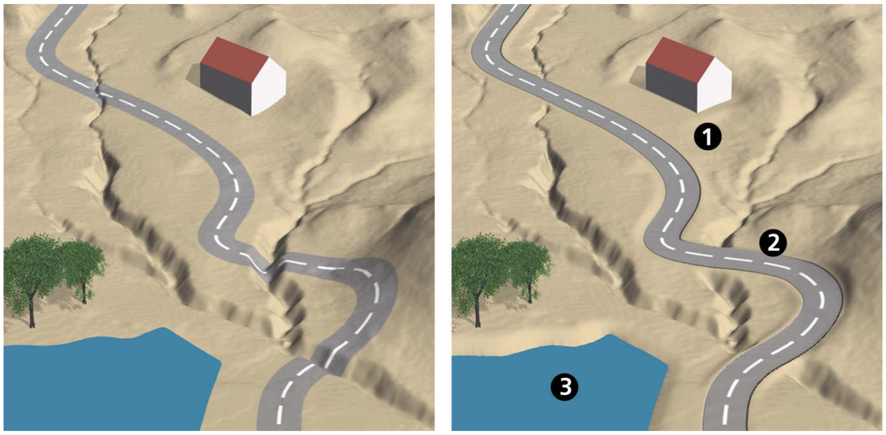


Figure 11. (left) A scene created from a DEM without supplemental modification. (right) The same scene with modifications, which include (1) building site leveling; (2) road cuts and fills; and, (3) pond lowering.

Figure 12. This scene shows the counter-clockwise flight of the Wright Flyer in 1908 over the Huffman Prairie Flying Field, Dayton, Ohio. The foundation of the scene is a custom DEM at 3-meter resolution derived from contour lines processed in ArcGIS software. A second hand-made DEM with a bumpy dark-green texture extrudes upwards through the surface of the first DEM to depict background trees. Art by Chris Casady.

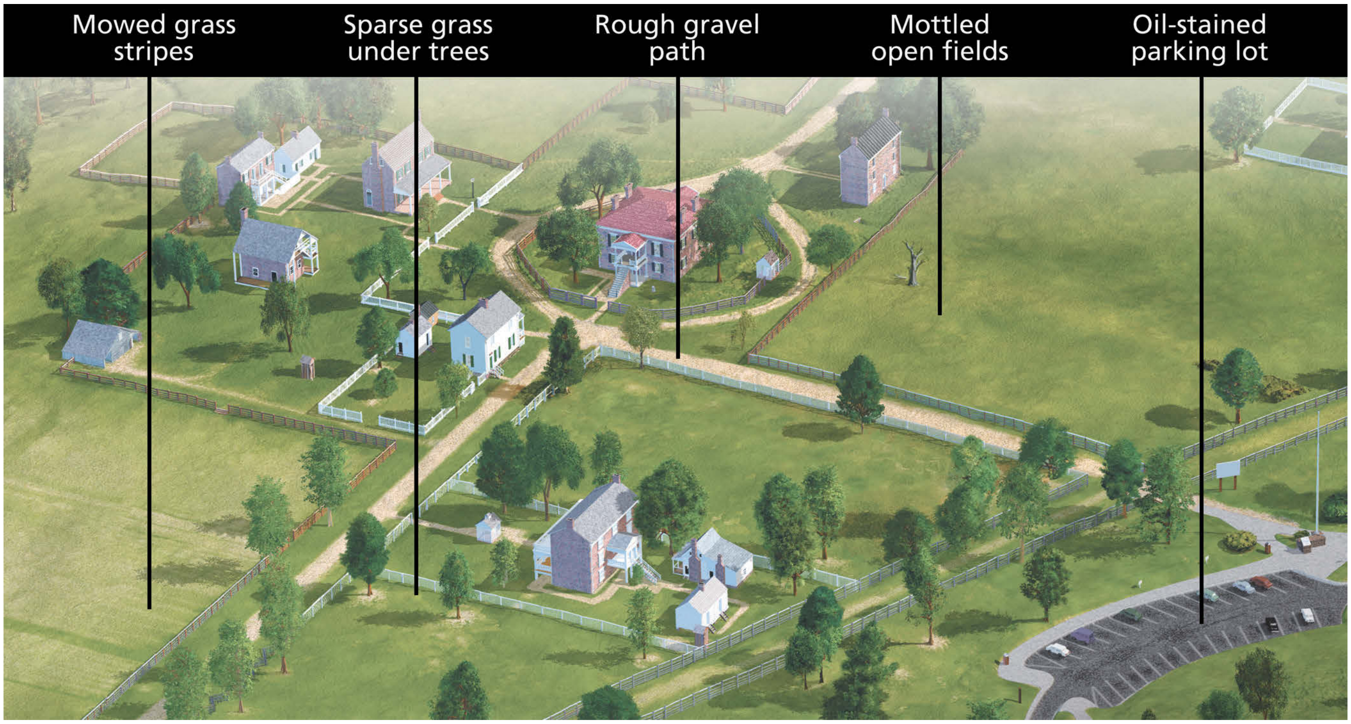


Figure 13. Custom landscape textures bring subtle realism to the bird's-eye view of Appomattox Court House, Virginia. Art by Chris Casady.

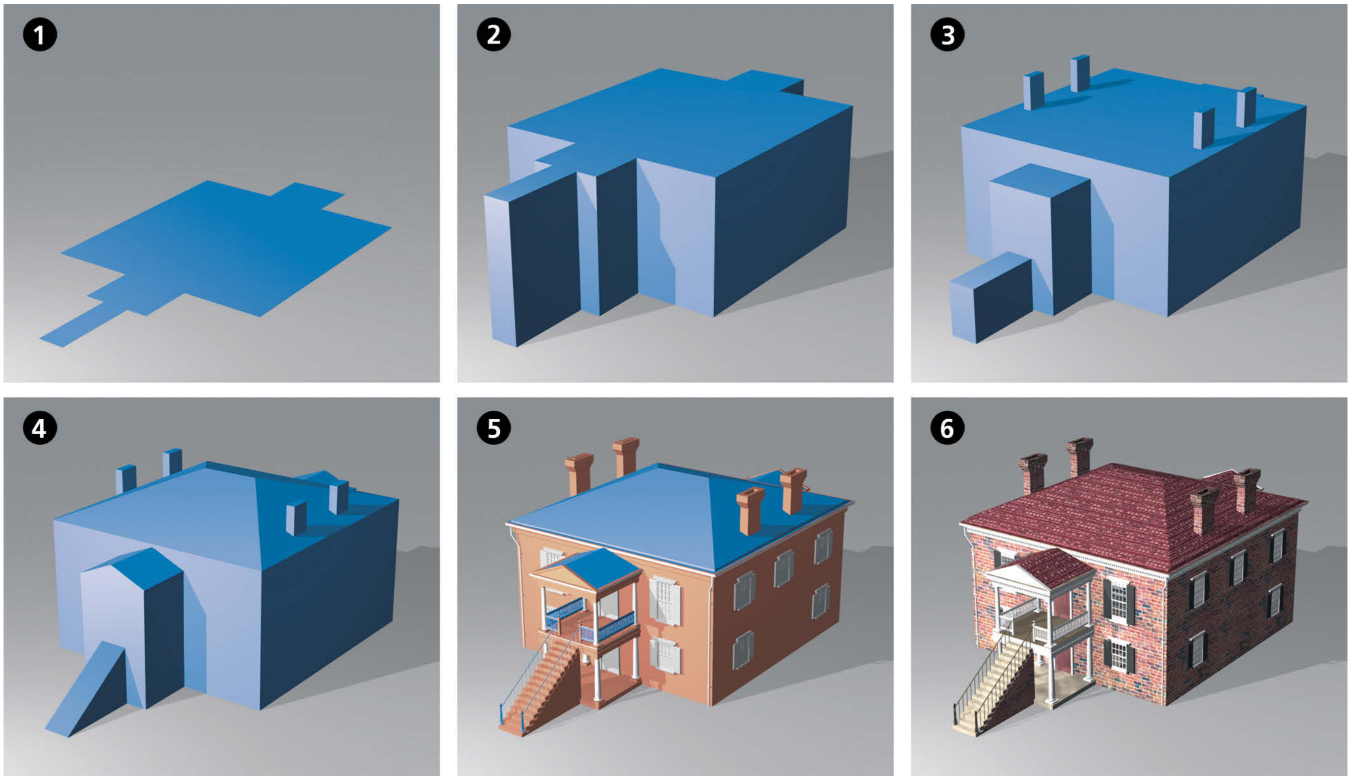


Figure 14. Starting with a simple footprint (1), building depiction becomes more realistic with each successive image. The most critical steps are going from a blocky "prismatic" model (3) to a model with angled roofs and flat-shaded detail (5). Building model by Chris Casady.

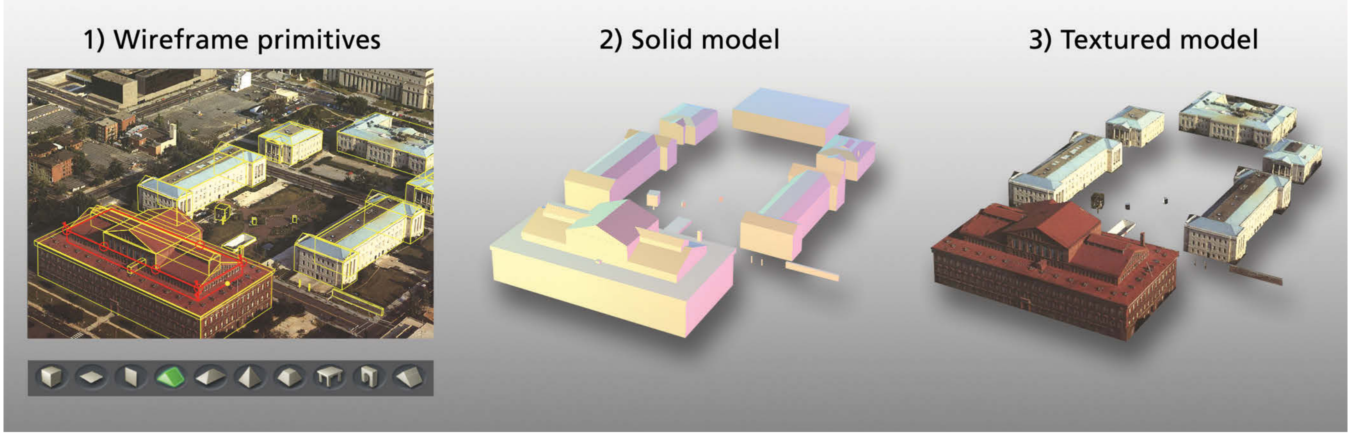


Figure 15. Canoma 1.0 software uses photogrammetric methods to create 3D models from oblique aerial and terrestrial photographs.

Figure 16. (left) Meeks Store is one of 55 buildings, scores of trees, and perhaps a mile of fence found in the bird's-eye view of Appomattox Court House National Historical Park, Virginia. (right) The exploded view of Meeks Store reveals that it is comprised of 308 separate objects. Building model by Chris Casady.

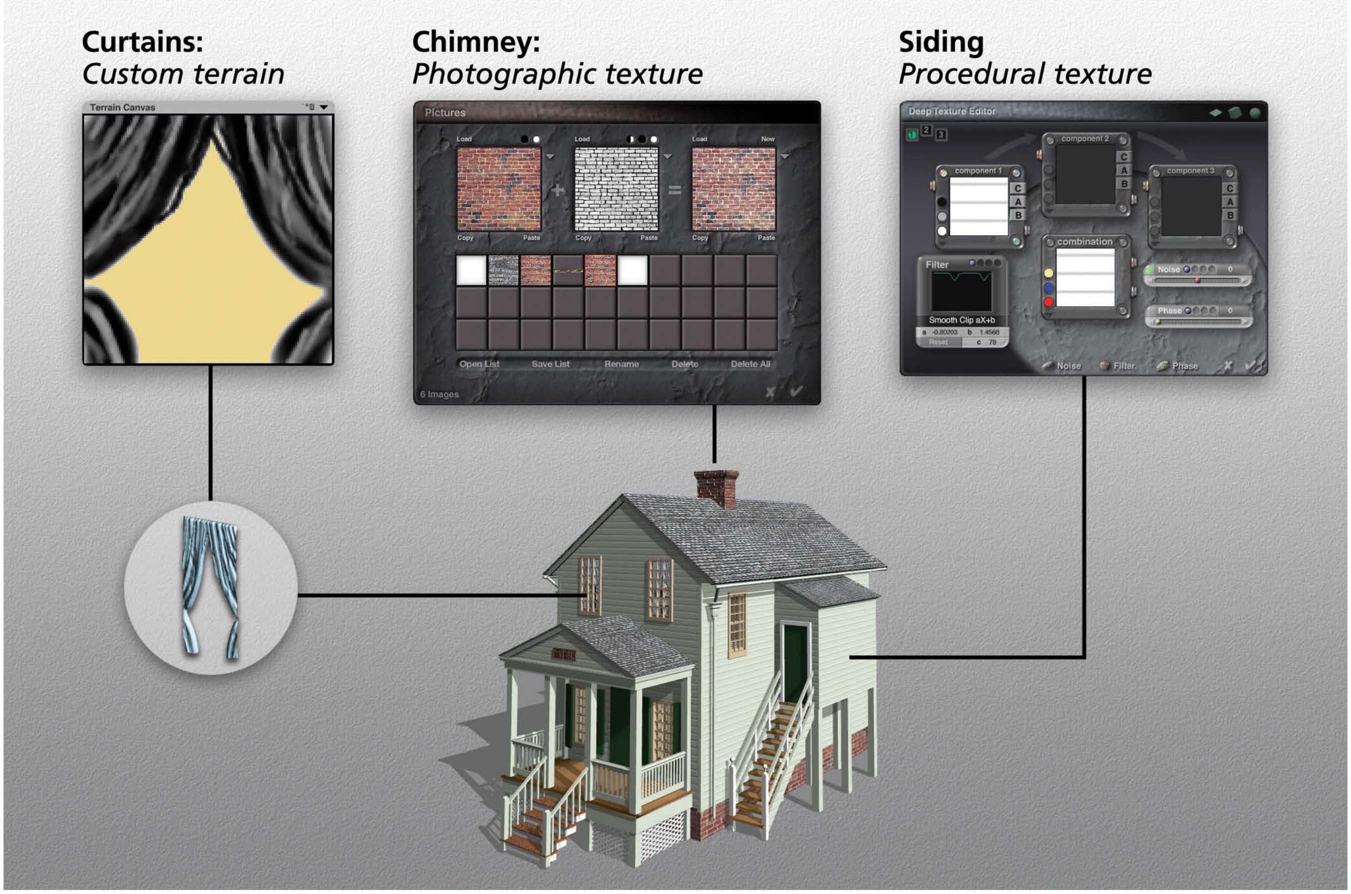


Figure 17. The custom textures applied to a model of Meeks Store. Building model by Chris Casady.

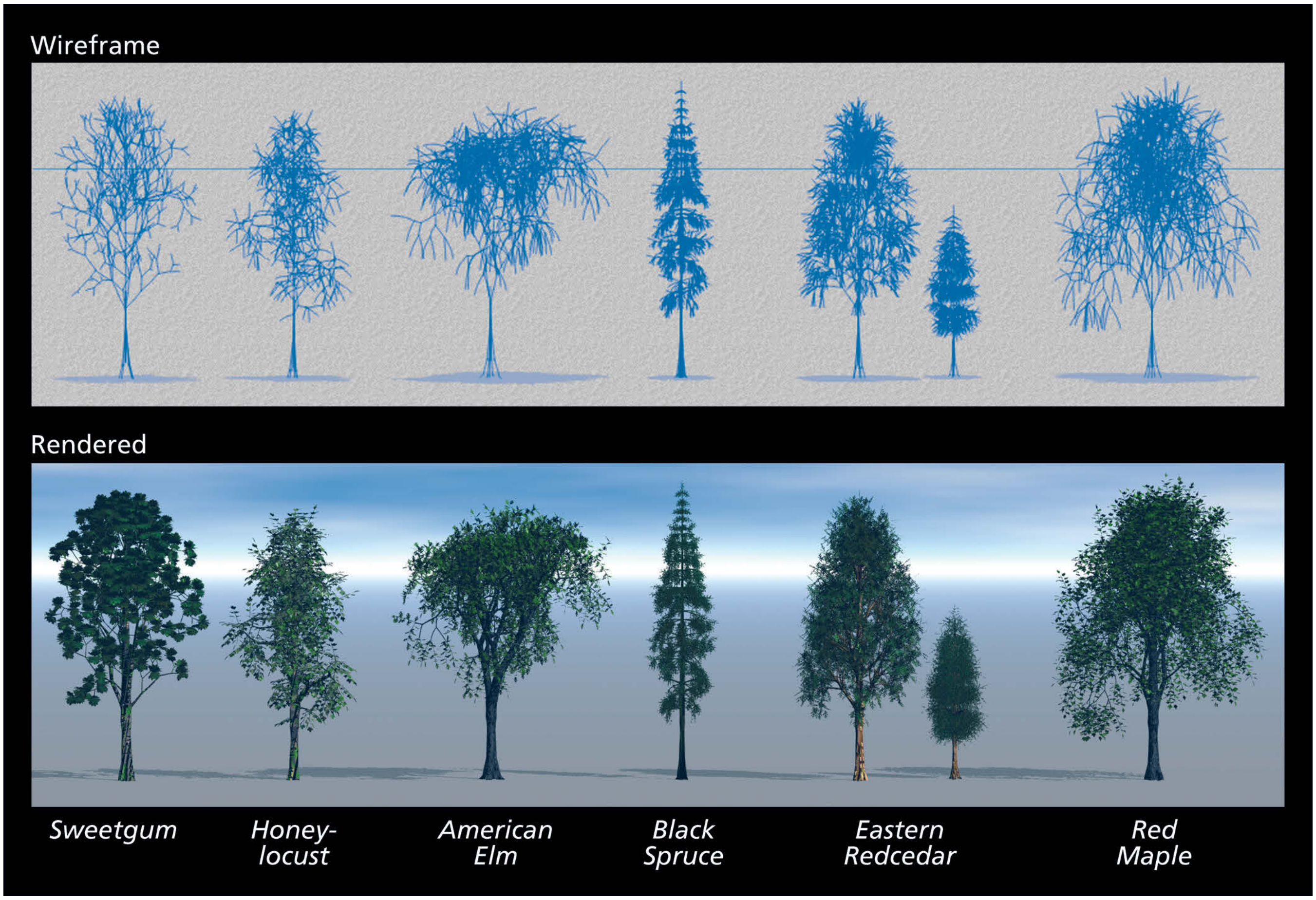


Figure 18. 3D tree models created in Bryce's Tree Lab.

Figure 19. Slimming down. Clones of a 2D tree picture and 3D tree model arranged from background (top) to foreground (bottom) in a perspective scene. The 2D tree becomes less visible in the foreground because of the steeper viewing angle and its lack of volume.

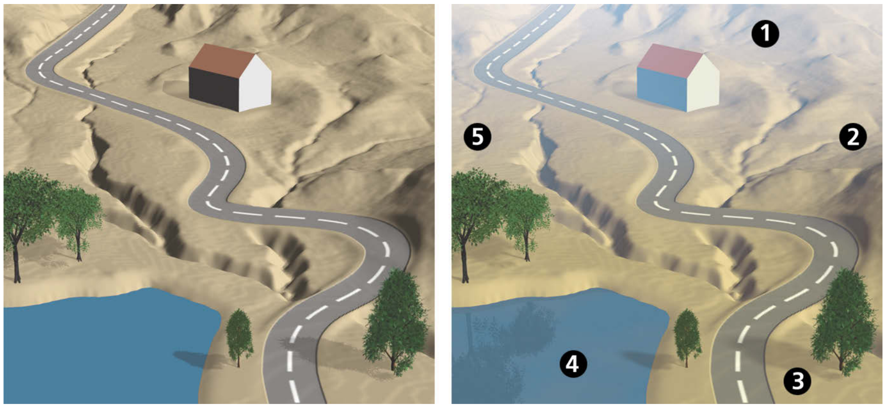


Figure 20. (left) A simple scene rendered without environmental special effects. (right) The same scene with exaggerated special effects, which include (1) background haze; (2) pale yellow illumination coming from the lower right; (3) soft cast shadows; (4) reflective water surface; and, (5) secondary blue light coming from the left. Environmental special effects come at a price; the scene on the left took 12 minutes to render compared to 2 hours and 18 minutes for the scene on the right.

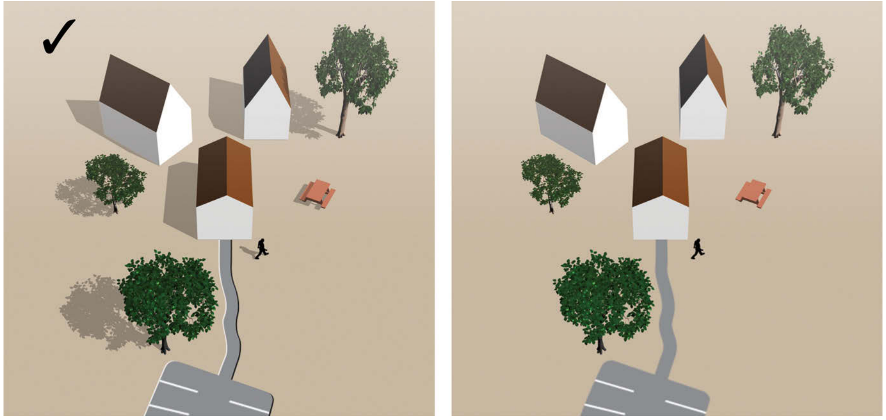


Figure 21. (left) A bird's-eye view with cast shadows. (right) The same view without cast shadows.

Figure 22. Appomattox Court House, Virginia, without (left) and with (right) environmental effects. The effects include background haze (1) and foreground darkening (2). Art by Chris Casady.

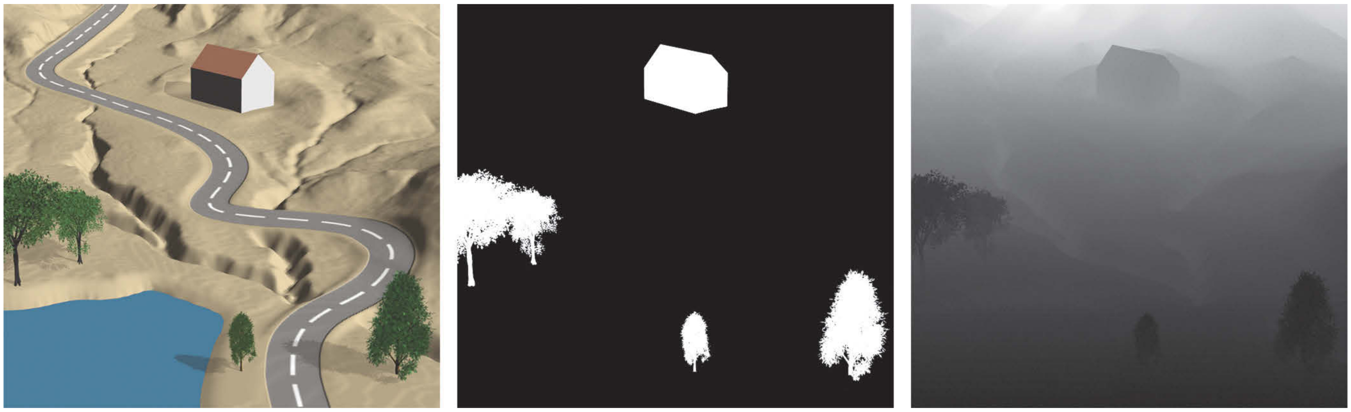
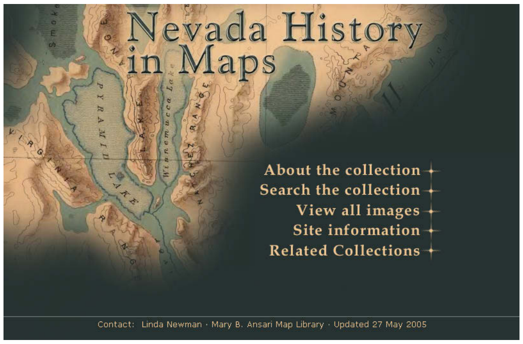


Figure 23. Multiple renders. (left) A simple scene rendered in 3D. (middle) A high-contrast object mask of the building and trees used for selective color edits. (right) A grayscale distance mask used for adding background haze.

Figure 24. A portion of the bird's-eye view for Eisenhower National Historic Site, Pennsylvania. Note that the view contains a north arrow but not a scale, which would be inappropriate because of the perspective view. Art by Chris Casady.

From Drawer to Digital: A Statewide Collaboration for Building Digital Historic Map Collections

Peter Michel, Linda Newman, Katherine Rankin, Vicki Toy-Smith and Glee Willis



Contact: Linda Newman · Mary B. Ansari Map Library · Updated 27 May 2005

Figure 1. Opening page for UNR's digital historic map collection (http://www.delamare.unr.edu/maps/digitalcollections/nvhistory/).

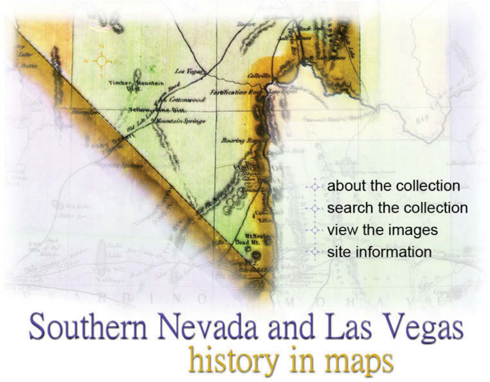


Figure 2. Opening page for UNLV's digital historic map collection (http://www.library.unlv.edu/maps).

Search Results: Your search retrieved 16 matching item(s). Select an item below for viewing.

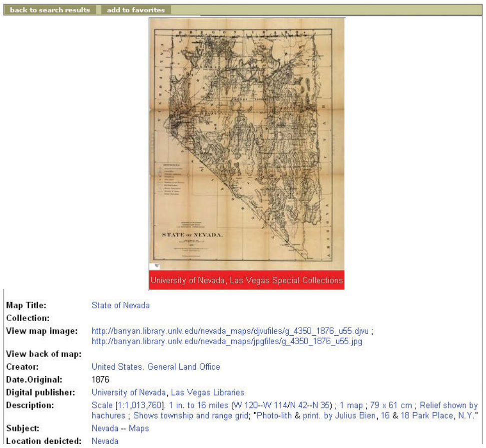
☐ 1. United States (1853)
☐ 2. Map of routes from Salt Lake City, Utah to the Bay of San Francisco (1855)
☐ 3. Map no. 4 from the valley of the Mud Lakes to the Pacific Ocean (1855)
☐ 4. Colton's territories of New Mexico and Utah (1855)
☐ 5. Map no. 3 from the Humboldt Mountains to the Mud Lakes (1855)
☐ 6. Britton & Rey's map of California (1860)
☐ 7. Territory of Utah (1857)
☐ 8. Map of Utah Territory (1858)
☐ 9. Territory and military department of Utah (1860)
☐ 10. Fort Kearney South Pass & Honey Lake Wagon-Road (1857-58)

Figure 3. Thumbnails display for a CONTENTdm digital collection.

North America (ca. 1825)

Title:	North America (ca. 1825)
View map image:	ftp://nas.library.unr.edu/Keck/HistTopoNV/Historic_Maps/North_America_1820.djvu (170K); ftp://nas.library.unr.edu/Keck/HistTopoNV/Historic_Maps/North_America_1820.jpg (1.8Mb); ftp://nas.library.unr.edu/Keck/HistTopoNV/Historic_Maps/North_America_1820.tif (98.8Mb)
Creator:	Illman & Pilbrow
Date Original:	1825

Figure 4. Example of the "View map image" field including multiple URLs for various formats for scanned historic map files in a CONTENTdm record.



Map Title:	State of Nevada
Collection:	
View map image:	http://banyan.library.unlv.edu/nevada_maps/djvufiles/g_4350_1876_u55.djvu ; http://banyan.library.unlv.edu/nevada_maps/jpgfiles/g_4350_1876_u55.jpg
View back of map:	
Creator:	United States. General Land Office
Date.Original:	1876
Digital publisher:	University of Nevada, Las Vegas Libraries
Description:	Scale [1:1,013,760]. 1 in. to 16 miles (W 120--W 114/N 42--N 35) ; 1 map ; 79 x 61 cm ; Relief shown by hachures ; Shows township and range grid; "Photo-lith & print. by Julius Bien, 16 & 18 Park Place, N.Y."
Subject:	Nevada -- Maps
Location depicted:	Nevada

Figure 5. Sample record display from UNLV's digital collection.

Click on a field name to edit the properties for that field:

Field Name	Dublin Core Mapping	Data Type	Large field	Searchable	Hidden	Controlled Vocabulary
Title	Title	Text	Yes	Yes	No	No
View map image	Identifier	Text	Yes	No	No	No
Creator	Creator	Text	Yes	Yes	No	No
Date Original	Date	Date	No	Yes	No	No
Electronic Publication Date	Date	Date	No	Yes	No	No
Original Publisher	Source	Text	No	No	No	No
Electronic Publisher	Publisher	Text	No	No	No	No
Description	Description	Text	Yes	Yes	No	No
Map Type	None	Text	No	Yes	Yes	Yes
Geographic code	None	Text	No	Yes	Yes	No
Subject	Subject	Text	Yes	Yes	No	No
ResourceType	Type	Text	No	No	No	No
Location Depicted	Coverage-Spatial	Text	Yes	Yes	No	No
Rights Management	Rights	Text	Yes	No	No	No
Contributing Institution	None	Text	Yes	Yes	No	No
Format	Format	Text	No	Yes	No	No
Digitization Specifications	None	Text	No	No	No	No
Contributors	Contributors	Text	No	Yes	Yes	No
Language	Language	Text	No	Yes	No	No
Relation	Relation	Text	Yes	Yes	No	No
Audience	None	Text	No	Yes	No	No

Figure 6. Field properties definition screen in CONTENTdm®.

Historic Period: Prior to 1850

Topics: Cities and towns

Geographic Area: North America

Related Collections:
- Historic Topographic Maps
- Historic geologic and mining district maps and atlases
- Sanborn Town Maps (UNR users only)

You may also:
- Go to Advanced Search
- View all images

Figure 7. UNR's search page for its digital historic maps collection.