Emerging Trends in Historical GIS

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This issue of *Historical Geography* presents scholarship in the emerging field of historical GIS, the term increasingly used for the application of geographic information systems (GIS) and other geospatial technologies to the study of history.[1] Most of the articles in this volume are the authors' first publications in this vein. Several of the contributors are young scholars whose dissertation research was grounded in the use of GIS as a core method of analysis. They represent the leading edge of what seems certain to become a new generation of historical-geographical scholarship built with GIS. Other articles are the fruit of one or two decades of research that began with conventional archival and statistical methods but evolved to embrace GIS as a means of managing and analyzing large, complex historical datasets, or long-term GIS-based projects that were started when the application of GIS to history was in its infancy.

These articles consider a much wider range of subjects than have previous thematic issues of *Historical Geography*. While it may soon be possible to produce a collection of GIS-based scholarship that addresses a single historical theme, at this point in its development historical GIS is too diverse for that. Scholars from many branches of historical study are turning to geospatial techniques to explore spatial relationships, to reconstruct past places and natural environments, and to probe the qualities and explanatory value of historical sources. The genre of historical GIS is not defined by topical or regional focus, a particular geographical scale or degree of complexity, style of writing, theoretical framework, or preference for qualitative or quantitative data. Nor is it necessarily a genre defined by methodology,[2] for the GIS-based methods being employed by historical scholars range from basic cartography to sophisticated forms of spatial analysis and spatial statistics. (This range may seem all of a piece to historians using GIS as a new tool, but many geographers consider cartography and spatial analysis to be methods as different as literary analysis

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and econometrics are to historians.) What unites the authors in this volume is a new intensity of interest in geographical inquiry and the use of geographical evidence to understand the shaping influence of geography on history. The other common element in their work is their use of GIS to re-examine historical interpretations or to illuminate historical events or conditions that we could not otherwise grasp so well.

For all its eclecticism, historical GIS is developing certain signature themes, which these articles also represent. One broad theme has to do with administrative boundaries. A great deal of social science history has been based on statistical analysis of socio-economic data collected by governments for purposes of policy-making and social control. Productive as quantitative history has been over the past thirty years, it has not entirely fulfilled its early promise because of various obstacles to comparative and longitudinal analysis. Chief among those obstacles has been the lack of accurate historical boundaries for the administrative units for which demographic data were collected. As we enter the new millennium, research projects seeking to document administrative boundary changes and to make historical boundaries available for use in GIS are coming to fruition. In the section titled "Reports on National Historical GIS Projects," readers will find summaries of the current state of development and availability of nine national GIS infrastructure projects, all of which aim to facilitate historical-geographical research by enabling scholars and students to map and analyze longitudinal datasets within their correct historical boundaries.[3] The last two reports in the section cover projects of international scope that similarly aim to encourage studies of geographical change over time through the analytical interface of GIS.

Generally speaking, historians and historical geographers over the years have used administrative boundaries either unquestioningly or as necessary evils because they are the historical containers for all kinds of useful information, from national censuses to immigration records and electoral returns. Before the advent of historical GIS, scholars sometimes noted the artificiality of such boundaries—for example, that ward boundaries artificially divided a political stronghold or that urban populations actually spilled over the lines of city or county limits—but the boundaries remained as givens.

With the growing use of GIS, historians are becoming aware of what is called the modifiable areal unit problem (MAUP), a cluster of issues long familiar to GIS researchers. Of the several dimensions of MAUP, two are particularly relevant to the articles in this volume: (1) that administrative boundaries designed for gathering social statistics or exerting political control may have little or no relation to the continuous geographical phenomena they presumed to report; and (2) that changing the unit of analysis and display significantly affects the interpretation and the reliability of one's results.[4] Donald A. DeBats and Mark Lethbridge take on the first point in their analysis of residential and voting patterns in two mid-nine-

teenth-century American towns, Newport, Kentucky, and Alexandria, Virginia. They use geospatial analytical techniques to map ethnic and racial concentrations without resorting to the customary boundaries of urban wards. Their unusual approach reveals subtle but significant variations in the geography of political affiliation in the two towns. Paul S. Ell and Ian N. Gregory address the second issue in their study of the demography of the Irish Famine and its aftermath. They propose that analyzing demographic variables at scales finer than the county produces very different patterns that challenge long-standing interpretations based on county-level statistics. They also demonstrate one method for handling the problem of administrative boundary changes over time, which can seriously compromise longitudinal statistical analyses of population movement—an issue that too many scholars have ignored or swept under the interpretive carpet in the past.

In this volume's simplest yet most challenging essay, Merrick Lex Berman argues that the convention of representing administrative areas as polygons is inadequate for understanding the conceptions of space reflected in Chinese administrative history for most of the past 2,000 years. The polygons to which we are so accustomed (in the West and in Asian countries) poorly represent the overlapping domains and complex hierarchies of Chinese administration. Berman also contends that bounded areas inhibit one's ability to visualize and understand the shifting, multiple-scale geographies of administrative control. He finds network models more appropriate because they more accurately depict historical-spatial relationships.[5] His argument offers a compelling alternative to historical researchers working in any period and place where government was not organized according to the kinds of strict hierarchies of nested administrative units that developed with the rise of the nation-state in Europe and the township and range system in the post-colonial United States—in other words, most of history in most of the world. Berman's critique also challenges our unthinking acceptance of what are called the cartographic primitives of point, line, and polygon. These shapes are the building blocks of vector GIS. Identifying their limitations for historical analysis is the first step toward envisioning new models for GIS that meet historians' needs. As Tim Cresswell noted in a very different context, "Humanists . . . would be the last to claim that place was clearly and unambiguously bounded."[6] We need to develop new graphic models to represent the complexity of social space.

Another theme running through historical GIS is how scholars should acknowledge and deal with the uncertainty of historical locations and the imprecision of historical data. Historical scholars are often troubled by the implied certainty of GIS, as software packages by default assign geographical location at a level of precision that may far exceed the precision of the source. Marking the location of a historic site with a pencil on paper often represents one's knowledge better than would entering the

same location in degrees of latitude and longitude in a GIS program. It can be even more problematic to determine the temporal duration of a geographical feature or phenomenon. Few changes in shoreline, for example, are as well documented as the landfills that expanded the land area of Boston during the nineteenth and twentieth centuries.[7] The problems of assessing the quality of locational information and its implications for analysis concern both historical researchers and GIS scholars. In GIScience, the study of uncertainty, error propagation, and related issues has become a recognized branch of study.[8] Some GIScience approaches to uncertainty can be directly adopted into historical studies, such as the use of cartographic symbols on maps to indicate researchers' relative certainty about the location of settlements, roads, and other geographic features.[9] But the ways the two disciplines customarily assess and discuss uncertainty and data quality stand at the opposite poles of positivist science and the humanities. GIScientists use the quantitative measures of statistical models, while most historians gauge the quality of a given source and the limits of its interpretive power qualitatively, in light of their experience with similar sources and their understanding of the historical context within which the source was created. Finding common ground on this issue in historical GIS is complicated by the clumsy, wooden structure of pre-packaged metadata files in GIS software. We need more flexible modes for capturing the nuance and web of qualifications that convey historians' sense of their sources.

Historical GIS work tackling these issues takes advantage of the technology's ability to integrate various kinds of data, as exemplified by the two articles here that explicitly address locational accuracy and data quality. A central element of Philip C. Brown's study of corporate land tenure in nineteenth-century Japan is to document the location of villages that have partially or wholly disappeared from the landscape. In the absence of comprehensive, reliable information in print sources, Brown developed a method of triangulating between historical maps, local textual and oral histories, interviews, and field investigation using GPS (global positioning systems) technology. In his study of changing forest cover in the Shenandoah Valley, James W. Wilson offers a systematic approach for bridging the evidentiary divide between paper and digital documentation of land use and land cover, an issue of growing importance for environmental historians. He suggests that by comparing land-use data from textual sources, such as the agricultural census, against evidence from printed and digital maps, one can gain a better sense of the quality of information in each source and better gauge the reliability of one's analysis.

Brown's and Wilson's articles also raise the third theme prevalent in much of today's work in historical GIS, namely historical researchers' use of physical environmental data and analytical techniques developed in the natural sciences. In another overview of historical GIS, I argued that geospatial methods are bound to become increasingly important for envi-

ronmental history.[10] As Deryck Holdsworth recently observed, however, environmental studies in historical GIS differ from the well-established field of environmental history in some important ways. Where environmental historians have largely focused on the meanings of nature and humanity's physical alteration of the environment in pursuit of economic interest, scholars using GIS tend to focus on the physical environment as the geographic context of site-specific studies. They also tend to ask how the characteristics of the physical environment influenced historical outcomes.[11] Two very recent book-length examples of this approach are Brian Donahue's *The Great Meadow*, a study of farming and inheritance in colonial Concord, Massachusetts, and Geoff Cunfer's *On the Great Plains*, which includes a reassessment of the causes of the Dust Bowl.[12]

This approach also applies to the environmental articles in this volume. For Philip Brown, determining the location of Japanese villages is a vital first step toward his broader aim of analyzing the extent to which topography may have been associated with particular kinds of land tenure. James Wilson constructed cross-sectional comparisons of land use and land cover at a series of dates to lay the groundwork for his broader investigation of forest clearance. He hopes to explain whether, and how, our understanding of environmental change differs according to the scale of analysis. In her essay on Akimel O'odham (Pima) agriculture, Wendy Bigler demonstrates the value of historical evidence embedded in an unparalleled cartographic source, evidence that can be analyzed far more thoroughly and revealingly with GIS than with analog cartographic methods. But she also argues that changing physical conditions fundamentally affected Pima settlements and may even have altered the structure of local Pima society. From a strictly methodological point of view, perhaps the most innovative use of GIS in this volume is Don DeBats and Mark Lethbridge's application of kernel-density analysis, a method commonly used in wildlife ecology, which they use to analyze human population density.

The fourth and final theme common to much historical GIS, and to four of the six articles in this collection, is the application of geostatistical methods to historical questions. Much of what is called spatial analysis in GIS applies mathematical operations to layers of geographical information—literally adding, subtracting, multiplying, or dividing numerical values, for example (as in raster overlay) or running equations to calculate the probability of a particular attribute or numerical value occurring in a given location. Although the spatial statistical capabilities of most GIS software remains rudimentary in mathematical terms in comparison to aspatial statistical programs, we can only expect that the growing interest in spatially referenced statistical analysis will improve what GIS can do. In this collection, Ell and Gregory give an example of geographically weighted regression, which differs from standard regression analysis by factoring in the observed tendency of proximate instances to be more

similar than those at a distance from one another. Kernel-density analysis (DeBats and Lethbridge), determining the statistical significance of field size (Bigler), and image processing to derive land-use and land-cover categories from remotely sensed data (Wilson) are common kinds of spatial analysis that bring new insights to historical scholarship.

Wilson helpfully distinguishes between "geohistorical" approaches, based on archival research and close reading of the secondary literature (one could add pre-digital methods of field work as well), and "geocomputational" approaches, which use computers to analyze spatial data and model geographical processes. The differences between these approaches are conspicuous now, when GIS is still unfamiliar to most historical scholars and history seems remote from the interests of most GIS scholars. Yet the distance between geohistorical and geocomputational research is rapidly shrinking. Some of the most striking evidence of the closing gap comes from the scientific community. In 1992, concern about global warming inspired scientists to organize the International Satellite Land Surface Climatology Project (ISLSCP) Initiative, which has produced a series of projects modeling global land cover as far back as 1700. The U.S. Geological Survey has mounted an ambitious historical project on the web relating changes in land cover to various social phenomena, including population change and urbanization.[13] These projects necessarily required researchers to apply both of the approaches Wilson identifies. Growing numbers of National Park Service historical sites and historical museums are contemplating or actively using GIS as a tool for historical interpretation. The trend of applying GIS to history is clearly accelerating. As more historians become conversant with geospatial technologies, and more GIS scholars take an interest in history, the better historical GIS will become. The field offers tremendous possibilities for creative, stimulating scholarship.

Notes

1. Other terms are visual history, spatial history, and temporal GIS. "Visual history" is a term used to distinguish image-rich, often Internet-mounted presentations of historical materials and arguments from traditional print narratives. "Spatial history" dates back to Paul Carter's use of the term in *The Road to Botany Bay* (London: Faber and Faber, 1987), if not earlier. It generally refers to scholarship based on critical social theory that focuses on the exercise of control over social relations through the control of space. "Temporal GIS" differs from the other terms in privileging geographical over historical inquiry and in its focus on theoretical concerns about how to represent and model time in GIS database structures. See also Deryck Holdsworth's review of historical GIS in "Historical Geography: The Ancients and the Moderns—Generational Vitality," *Progress in Human Geography* 26:5 (2002): 671-78.
2. I previously defined historical GIS as essentially a methodology, in "Introduction," in Anne Kelly Knowles, ed., *Historical GIS: The Spatial Turn in Social Science History*, *Social Science History* 24:3 (Fall 2000): 452-53 and in the "Is GIS Changing the Practice of History?" paper delivered at the conference "History and Geography: Assessing the Role of Geographic Information in Historical Scholarship," Newberry Library, Chicago, March 26, 2004.
3. Two important projects that are not represented in this volume are the "Atlas of Historical County Boundaries" at the Newberry Library in Chicago and the "IPUMS Project (Integrated

Public Use Microdata Series)" at the Minnesota Population Center, University of Minnesota. After producing print atlases of boundary changes for twenty-four states and the District of Columbia, the Newberry turned to producing digital atlases. Four are complete and available online as this volume goes to press (California, Virginia, West Virginia, Wyoming) at www.newberry.org/ahcbp.

4. Stan Openshaw, *The Modifiable Areal Unit Problem*, CATMOG (Concepts and Techniques in Modern Geography) 38 (London: Study Group in Quantitative Methods, Institute of British Geographers, 1983). See also Stan Openshaw and Seraphim Alvanides, "Applying Geocomputation to the Analysis of Spatial Distributions," in *Geographic Information Systems: Principles and Technical Issues* 1, 2nd ed., Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind, eds. (New York: John Wiley and Sons, 1999): 267-82.
5. Doreen Massey makes a similar point without cartographic reference in "A Global Sense of Place," in *Reading Human Geography*, Trevor Barnes and Derek Gregory, eds. (London: Arnold, 1997): 315-23.
6. Tim Cresswell, *Place: An Introduction* (Malden, Mass.: Blackwell, 2004): 74.
7. Alex Krieger and David Cobb, with Amy Turner, eds., *Mapping Boston* (Cambridge, Mass.: MIT Press, 1999); Nancy S. Seasholes, *Gaining Ground: A History of Landmaking in Boston* (Cambridge, Mass.: MIT Press, 2000).
8. See, for example, Jingxiong Zhang and Michael F. Goodchild, *Uncertainty in Geographical Information* (London: Taylor & Francis, 2002).
9. Michael F. Goodchild, "Acknowledging and Representing Uncertainty," paper delivered at "History and Geography," March 27, 2004; Tom Elliott and Richard Talbert, "Mapping the Ancient World," in Anne Kelly Knowles, ed., *Past Time, Past Place: GIS for History* (Redlands, Calif.: ESRI Press, 2002): 149-59.
10. Knowles, "Is GIS Changing the Practice of History?"
11. Deryck Holdsworth in conversation at the Social Science History Association meeting in Chicago, November 20, 2004.
12. Brian Donahue, *The Great Meadow: Farmers and the Land in Colonial Concord* (New Haven: Yale University Press, 2004); Geoff Cunfer, *On the Great Plains: Agriculture and Environment* (College Station: Texas A&M University Press, 2005).
13. National Aeronautic and Space Administration, Goddard Space Flight Center Distribution Active Archive Center, ISLSCP Initiative I and Initiative II Site, http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/ ISLSCP/ISLSCP_i1.html; and U.S. Geological Survey, Land Cover Characterization Program, http://landcover.usgs.gov/index.asp, both accessed on December 11, 2004. Thanks to Lee Perlow for introducing me to the ISLSCP site and Jim McManus at the Goddard Space Flight Center for directing me to background information on ISLSCP data creation, and to James Wilson for telling me about the USGS program.