

Beyond Stories

Geospatial Influences on the Practice of Environmental History

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Donald Worster's *Dust Bowl* exemplifies the work of the first generation of self-consciously environmental historians in its quest to fundamentally reinterpret familiar events by asking new questions about historical causality. Since the 1970s US historians have increasingly narrated environmental change by interrogating ideas about nature, examining the operations of agricultural and industrial ecosystems, and by seeking to understand the patterns in nature itself.¹ Environmental history has forced the consideration of ecological factors within the discipline, challenging the once-dominant assumption that environmental conditions exercised only a marginal influence on political, social, and economic events. The effort to add a new category of analysis to the interpretation of historical events initially left little room for quantification, and narrative innovations drove the first forty years of scholarship. Recently, however, technological advances in geospatial analysis and big data capabilities have introduced new opportunities for studying environmental change at a range of temporal and geographical scales, promising to expand the interpretative potential of the field even further.

This essay traces the evolution of the spatial humanities and distills its methods, signaling the paths that beckon as scholars build upon these foundations.² This spatial turn in environmental history promises to use geospatial analysis to quantify and visualize environmental change over time, complementing the natural and social science methods that have driven methodological innovations in environmental history since the 1970s and 1980s.³ A cohort of researchers investigating the spatial dimensions of historical change provides models for returning to the material origins of environmental history and demonstrates the potential to historicize ecological problems by mapping the temporal and spatial aspect of landscape change.⁴

Historical Geographical Information Systems (HGIS) expand both the scope and scale of historical research, even as the method's visibility within the field contrasts with its limited penetration in historical scholarship. Why is this the case? The start-up costs, technical literacy, and data management required for even a dissertation-sized HGIS project are daunting under the best of circumstances. With that in mind, it is worth investigating the primary benefits—and potential drawbacks—of developing this new research

“language,”⁵ and historians confront several obstacles as they consider integrating spatial analysis into their research. This method requires the acquisition of new research skills, cultivating new collaborations, securing funding, and developing a data management protocol to support the investment of time and resources needed to sustain spatial inquiries. However, HGIS has the capacity to synthesize “archival work, cultural analysis, and historical interpretation with ecological inventories and GIS-based analyses,” offering both explicative force and analytical innovations.⁶

“Indispensable Aids”: Integrating Methods from the Spatial Humanities

Environmental history emerged out of an interest in ecological change that by necessity was grounded in interdisciplinary methods,⁷ and many of the influential books in the field have borrowed theoretical frameworks from other disciplines.⁸ Much as the first environmental historians launched into a new area of inquiry with inspiration from elsewhere in the humanities and natural sciences, the new generation of spatial research represents the cutting edge of interdisciplinary thinking. Spatial methods are reshaping historical research, and environmental history will increasingly be influenced by a renewed attention to scale, interdisciplinary collaboration, and the use of digital techniques, including visualizations, that will complement narrative structure.⁹

First, while the choice of scale is an important framing device for all scholars, historians too rarely foreground it in their articulation of research problems. Geographical, temporal, and thematic framing often happens early in a project, prejudicing causal analysis even as scholars overlook the impact of these arbitrary boundaries. Scalar questions lay large in the framing of the early works of environmental history, as William Cronon’s *New England*, Alfred Crosby’s *Neo-Europes*, Carolyn Merchant’s *Scientific Revolution*, Richard White’s *Island County*, and Donald Worster’s *Southern Plains* each established a discrete landscape that privileged some categories of analysis while restricting others. “Each scale reveals some things while masking others,” White reminded readers of the *Journal of American History* as he reprised Henri Lefebvre in encouraging historians to think more critically about the production of space.¹⁰ The overt interrogation of the significance of scale will materially impact historical analysis, and contribute to an increasingly critical approach to both natural and political boundaries.

HGIS is inherently collaborative work. No individual scholar can manage the archival research, database management, and mapping of even a small project without technical input and support. Research teams consist of historians, geographers, ecologists, and, importantly, programmers and technicians who converge, each contributing questions and ideas derived from

diverse methodological frameworks. Much of the leading work in the spatial humanities has come out of research centers founded under the leadership of a researcher driven by a question that required investing in a new set of resources.¹¹ Research groups often span campuses, if not the globe, so spatial projects have also come to rely on methodological transparency paired with detailed accountability and management processes. Project contributors must ensure the integrity of their relational databases and metadata while simultaneously maintaining open access to the research. Disadvantages revolve around the expense of developing and running a research project with multiple contributors, complex project hardware and software, and the oversight of data collection and analysis.

A third key contribution of the spatial humanities lies in its focus on new forms of visualization to represent the movement of goods, ideas, and living things across space and time. Visualization offers not simply to map the patterns of historical change but also to illustrate movements of people and materials that are not easily narrated. The resulting product is often a means to a larger end, as Lynne Heasley explained, a method for detecting and making visible patterns across space and time, as well as a “rigorous mapping tool for visualizing alternative historical narratives” using a new a mode of analysis.¹² Visualizations enable the researcher to conceptualize historical change and often illustrate patterns not otherwise visible using other methods. These visualizations are based upon the collection and analysis of historical data equivalent to a journal article or monograph, yet rarely fit into disciplinary expectations for research products.¹³ As a result, graduate students and untenured scholars—those most likely to experiment with new research methods—are often dissuaded from spatial analysis because of the challenges of developing the skills, the illegibility of the research process, and the difficulty of disseminating work products.¹⁴ Ultimately, however, significant interpretative advantages are gained through data visualization and mapping historical information. Early adopters of these methods within environmental history have illustrated the benefits of mapping historical information, and the following sections trace the burst of scholarship employing HGIS.

*“The Time Has Come to Brush Away the Obscuring
Mythologies”: Mapping Environmental Change
through Geographic Information Systems*

The merger of visual and quantitative information emerged out of a fortuitous collaboration between innovators in the nascent computing industry and government officials seeking better mechanisms for cataloging natural resources during the early 1960s, when resource managers and software engineers came together to conceptualize the Canada Land Inventory (CLI).¹⁵

The CLI merged existing aerial and satellite photographs into a format suited to aggregation and analysis, which became the Canada Geographic Information System—the first spatially referenced database.¹⁶ This “digital sandwich,” containing multiple levels of data, had breathtaking potential applications, and governments, businesses, and scholars soon adapted this technology to locate, merge, and analyze vast quantities of spatial data for a variety of purposes.¹⁷

Over the past half century, GIS has evolved hand in hand with other technological improvements in computing. Today, it is possible to synthesize elevation data and features of interest in order to replicate a three-dimensional “viewshed”; to manipulate tens of thousands of shipping or flight records and visualize the movement of products and people across the globe; or to dissect historical maps and merge them with other types of landscape data in order to generate new insights into historical events.¹⁸ A GIS converts discrete landscape features into “vectors”: points, lines, or area polygons that delineate cities, roads, or population in a format that mimics traditional maps. These can be combined with “raster” data represented on a continuous pixelated surface in which each pixel has assigned values, including temperature, elevation, vegetation, or soil type.¹⁹

Various dimensions of data are then housed in a spatially referenced database, or geodatabase, which Stanford researcher Evgenia Shnayder described as serving “as a container that helps us organize, access, and analyze primary source data.” By creating a consistent system of categories, the geodatabase “bridges spatial and nonspatial temporal data to allow for analyses of discrete and seemingly unrelated primary sources,” and maintains control over project metadata, thus regulating “how researchers and the general public access our data and to maintain quality control in the project’s core.”²⁰ The database provides a management system that not only converts polygons to data points, and links them to other polygons, but offers combinations of information “contain[ing] infinite dimensions of information.”²¹ One GIS practitioner explained that “[b]eyond the academy, GIS opened questions of vertigo-inspiring scale,” but this vertigo is magnified in historical analysis in accounting for the static temporal nature of maps, because “[a]s a visual representation, a GIS is like a palimpsest, which, instead of erasing the past to transcribe a new one merely absorbs all moments of the past into an image of the present.” When representing the transformation of place over time, historians struggle to situate temporal change alongside the other geographical information, seeking to capitalize on the opportunity to account for the fact that “in a map, the primary narrative device becomes not time, but space,” which explains the importance of visualizations for building a temporal dimension to geographical information.²² Historical maps can be

georeferenced to align with the coordinates of an accurate modern map layer, with relevant features converted to vector or raster form, and then combined with data from other sources to interrogate features in spatial layers covering vast territories and time scales.²³

Historians have been some of the academy's late adopters of GIS, which is explained in part by the challenge of employing GIS to examine temporal change. Integrating the passage of time into the analysis of already complex geographies adds an additional complication, especially when boundaries or landscape features have been modified. A small cohort of historians joined historical geographers in adapting historical GIS in the late twentieth century. In 1995, the Inter-University Consortium for Political and Social Research at the University of Michigan initiated the Great Plains Population and Environment Project, exploring the relationship between demography and environment during the period from 1870 to 2000. This project brought together an interdisciplinary team to assess the transformations of land and communities at the regional level of the expansive Great Plains.²⁴ Shortly thereafter, the Social Science History Association featured sessions on GIS at its 1998 and 1999 annual meetings, and *Social Science History* published a special issue, "Historical GIS: The Spatial Turn in Social Science History," in autumn 2000. Articles from historical demography, migration studies, urban history, economics, and print culture studies demonstrated the many ways in which historical GIS was influencing scholarship in history and related disciplines.²⁵

Other research projects and publications soon followed. The first, and to date, only, article featuring historical GIS published in the *American Historical Review* appeared only a few years later. William Thomas III and Edward Ayers's "An Overview: The Differences Slavery Made: A Close Analysis of Two American Communities," suggests how the comparative use of GIS offered new opportunities for resolving historical questions.²⁶ The authors explained how researchers at the Virginia Center for Digital History's *Valley of the Shadow Project* revisited the long-standing debate over the role of slavery in precipitating the Civil War. The team merged economic, demographic, and community data from the Shenandoah Valley, using Franklin County, Pennsylvania, and Augusta County, Virginia, to investigate trade relations and political decision-making. HGIS facilitated the systematic analysis of economic patterns, transportation networks, and the exchange of information, and demonstrated that the question of slavery proved more significant than any other in the years leading up to the war.²⁷

Ayers and Thomas had founded the Virginia Center for Digital History (VCDH) in 1998 with the goal of using mapping and data visualization as a means of revisiting long-standing historical questions and engaging the public.²⁸ One of the VCDH's teaching tools, the Salem Witch Trial Archive,

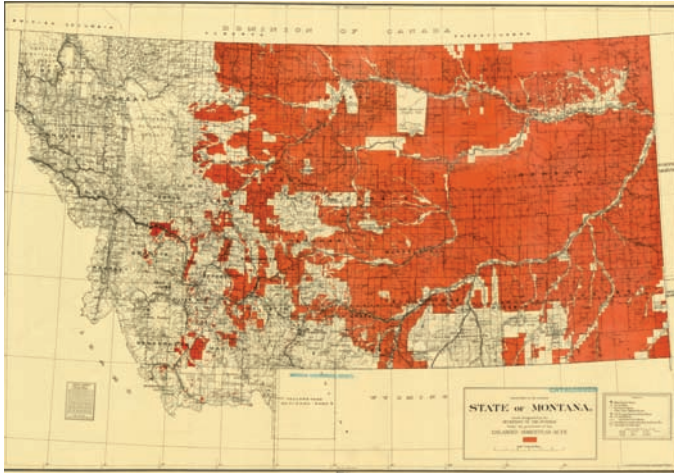


Figure 14.1. Department of the Interior, *State of Montana: Lands Designated by the Secretary of the Interior under the Provisions of the Enlarged Homestead Acts*, compiled and drawn by Daniel O'Hare, edition of July 1, 1916, engraved and printed by the US Geological Survey. From the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries. Figures 14.1 and 14.2 come from my own work on the Enlarged Homestead Act, and demonstrate the visual force of geographic information within the early twentieth-century land agencies as well as the potential value of adapting historical maps to Historical Geographic Information Systems. Converting paper maps to a digital format and rectifying for use in spatial analysis illustrates the stages of converting historical materials to spatial representation. See also figure 14.3.

hosts an open-access teaching database including court documents from the 1692 trials alongside maps placing the residences of important figures in the affected towns. This project combined the efforts of archivists, database designers, GIS technicians, and graphic designers, who concluded that witchcraft accusations in Salem spread along “disease-like vectors,” reinforcing the argument that interpersonal relationships and property, rather than class or religion, precipitated this crisis. The spatial component of the archive reshaped the historical understanding of the causal forces at play in Salem and the surrounding towns.²⁹

In most cases the scale of research began at a local level, and urban historians were among the first to employ HGIS, taking advantage of the early digitization of census tract data. During the late 1990s urban studies researcher Amy Hillier revisited historian Kenneth Jackson's assertion in *Crabgrass Frontier* (1985) that the Home Owners Loan Corporation (HOLC) had classified mortgage security according to perceived risk. Jackson had concluded that HOLC's residential maps, with their green, blue, yellow, and red zones, exercised a significant influence on federal and private mortgage lending patterns, thus dooming certain mixed-race areas to decline. Hillier narrowed

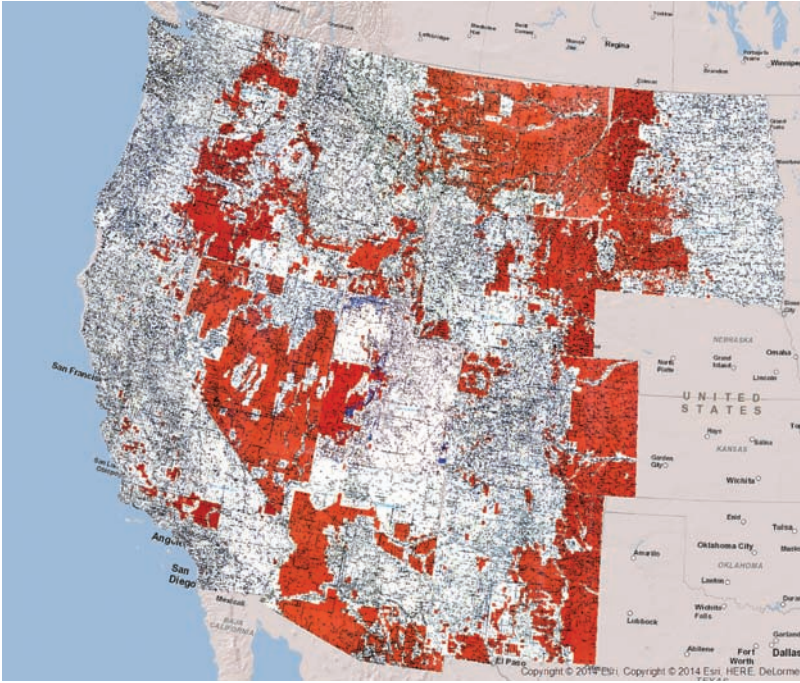


Figure 14.2. US Geological Survey map series, georeferenced and clipped using ArcGIS 10.2. Map created by Sara Gregg using 1916 state-level maps and overlaid on a topographic map of the United States. Maps used with permission of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries; and Esri. See figure 14.1 caption for additional commentary. See also figure 14.3.

her focus to racial distribution in Philadelphia, combining census tract and lending data in a GIS and discovering that while “redlining” did alter the ways in which lenders approached urban real estate, other forms of disinvestment were occurring simultaneously and independently, demonstrating that federal valuations represented only one part of a complex lending landscape.³⁰ By taking a township-, county-, or census-tract-scale approach to sweeping historical questions, most of these first-generation GIS studies offered finely tuned quantitative evidence that engaged with dominant historical interpretations. Local and temporally discrete studies provided a model for the more expansive projects that came later.

*“A Reason, and an Opportunity, for Substantial Reform”:
HGIS and Revising Environmental History*

Among the earliest adopters of GIS among environmental historians were those seeking to quantify the sweeping interpretations offered by the first generation of canonical books.³¹ Donald Worster had asserted in *Dust Bowl*:

The Southern Plains in the 1930s (1979), “Out on the high table land of the plains occurred one of the most tragic, revealing, and paradigmatic chapters in our environmental history.” Worster based this argument on evidence of ecological disruption: The deep roots of prairie plants supported a rich ecosystem that endured for millennia, but during the 1910s the replacement of shortgrass prairie with wheat contributed to the unraveling of this system, exacerbating the effects of cyclical drought. Worster blamed the “ecological values taught by the capitalist ethos” for the Great Plains Plow-Up and the Dust Bowl that ensued, but historian Geoff Cunfer contested this argument in *On the Great Plains: Environment and History* (2005).³² Cunfer examined data from all 450 counties of the Great Plains, using HGIS to survey more than a century of land-cover and land-use data that had been gathered within the Inter-university Consortium for Political and Social Research (ICPSR) Great Plains Population and Environment Data Series, integrating roughly 150 years of agricultural records alongside wind erosion, weather, and land-cover data.³³

Cunfer sought to moderate the narrative emphasizing decline on the Great Plains, instead stressing continuity and adaptation. Arguing that rainfall and high temperatures, rather than land-use practices, were the primary contributors to these famous dust storms, Cunfer sought patterns not evident in Worster’s local and temporally specific approach. Cunfer classified seventy percent of the Great Plains as remaining in grazing land, and argued that this acreage included the land most severely affected by the piercing drought and dust storms of the 1930s.³⁴ By analyzing the data on land-cover change Cunfer concluded that Worster’s study lacked both the temporal and geographical scale necessary to contextualize the Dust Bowl within the larger history of the Great Plains.³⁵ This research evokes the promise of large data sets to re-envision patterns of historical change, and it raises questions about how quantitative data are interpreted.³⁶

On the Great Plains stresses adaptation, and several methodological questions emerge as a result: How might we classify stability or sustainability accurately and consistently across land-use regimes? What is the best method for differentiating among types of land use? Cunfer classified counties by land-cover type and grouped all unplowed land, even that which was heavily grazed, alongside areas remaining in native grasses. Analyzing grasslands separately from cropland permitted Cunfer to critique Worster’s assertion that plowed land was the primary culprit in the dust storms of the 1930s. Unplowed land is also subject to disturbance, and the loamy and friable soils of large parts of the Great Plains are eroded by grazing almost as readily as by the plow. Cunfer’s conclusions demonstrate how distinctions within the classification of data, no less than the choice of scale, demand attention from

scholars who embrace empirical methods of analysis.³⁷ Spatial historians open up new avenues of interpretation, but they too run up against the limits of evidence and analysis.

The transformation of the Great Plains through agriculture has received sustained scholarly attention, yet it pales in comparison with the literature on colonial New England. Another foundational book in US environmental history to have been revisited using HGIS is William Cronon's *Changes in the Land: Indians, Colonists, and the Ecology of New England* (1983), which influenced generations of scholarship on land use in colonial New England. Cronon emphasized that the arrival of the first Europeans in North America reshaped the New England landscape, spurring a transition away from indigenous patterns of adaptive land use. Cronon's book revolutionized scholars' thinking about the ecological impacts of European colonization and inspired an effort to map and assess land-use practices in New England, Brian Donahue's *The Great Meadow: Farmers and the Land in Colonial Concord* (2004). Donahue examined land records for the township of Concord, Massachusetts, from the first plats of the 1650s through the early nineteenth century, interrogating the assumption that radical changes accompanied the first Europeans in colonial New England. Donahue digitized land records and located a diverse assortment of land holdings within each family. This research revealed that traditional practices of shifting resource gathering and land uses endured in Concord until the early nineteenth century. Township-level analysis elucidated a key finding: Concord families adapted to the varied landscapes of their new home, mimicking Native American uses alongside European mixed husbandry. Town proprietors recognized the diversity of resource needs among the first freeholders, granting tiny plots of cedar forest alongside alluvial meadowland, pasture, arable land, and house lots, which families managed as a diverse patchwork.³⁸ The farm-level evidence—scaled temporally over centuries—led Donahue to conclude that Cronon's "world of field and fences," however transformative, did not fully explain the remarkable continuity in land practices during the colonial period and the Early Republic, and especially the early settlers' continued reliance on ecologically varied land holdings through the nineteenth century.³⁹ These results demand further examination of the patterns that emerged elsewhere in the American colonies.

Donahue's township-level survey suggests the challenge of scalability of this sort of tract-level analysis. This project was the product of over two decades of work with students, archivists, and National Park Service staffers to map the Concord plats, and while other research teams could replicate Donahue's work in different areas, we are left with questions about what this study can tell us about the larger region.⁴⁰ Might we identify patterns

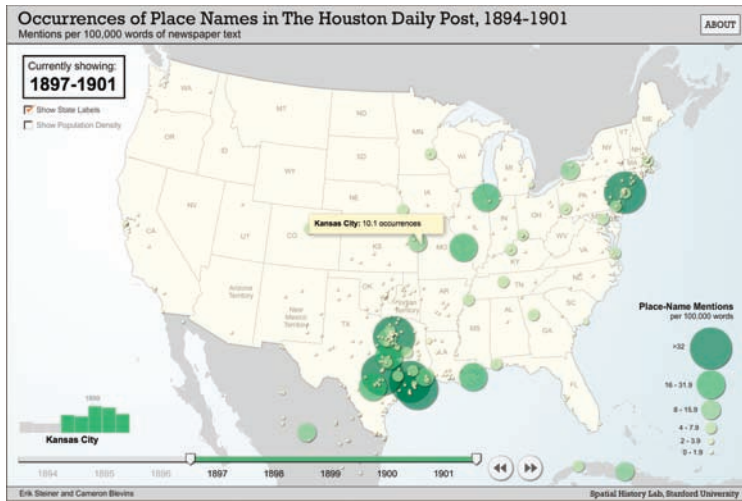


Figure 14.3. Snapshot of a visualization of “A View of the World from Houston,” by Cameron Blevins. Using copy of the *Houston Daily Post* made available using OCR (optical character recognition) courtesy of the University of North Texas Libraries, Blevins compiled a database, which he analyzed to assess the relative importance of rail networks and other urban centers in Houston’s imagined geography. Image from Cameron Blevins, “Mining and Mapping the Production of Space,” Spatial History Project, <http://web.stanford.edu/group/spatialhistory/cgi-bin/site/pub.php?id=93#swf11>. Used with permission of Cameron Blevins. This figure provides another example of HGIS in historical research illustrating the opportunities spatial analysis offers to environmental historians. This particular case demonstrates how database-derived maps and visualizations enable the quantitative analysis of otherwise overlooked historical information. See also figures 14.1 and 14.2.

that extend to the rest of New England? If so, what does that tell us about Euro-American understandings of resource ecology? What can it teach about the importance of adaptation to local landscapes during the early decades of settlement? If not, how might we analyze land use patterns for larger areas using seventeenth- and eighteenth-century sources? Is there a way to adjust this township-level research to a broader region without losing the nuance and specificity of *The Great Meadow*? These questions have led to energetic discussions among historians eager to apply new spatial technologies to environmental change, and clarify how the choice of scale impacts on the findings of historical research. Local and regional studies have driven much of the richness of environmental history. HGIS has the potential to scale it up to the regional, national, or global level.⁴¹

*“Discover Some Fresh Truths”: Recent
Developments in the Spatial Humanities*

Over the past several years the spatial humanities have gained wide

public appreciation.⁴² For example, Donahue's work on Concord informed the National Park Service's efforts to interpret the Concord battlefield and manage the Minute Man National Historical Park.⁴³ The *New York Times* featured spatial humanities projects in a 2011 article entitled "Digital Maps Are Giving Scholars the Historical Lay of the Land" integrating the work of several influential scholars.⁴⁴ In 2014 *Smithsonian Magazine* published "The Unlikely History of the Origins of Modern Maps," both synthesizing for a broad public audience the technological and interpretative innovations that launched the first geographic information systems and highlighting the types of work being done using these systems and other articles in a variety of national newspapers and magazines have similarly celebrated the cross-pollination of historical research and GIS methods.⁴⁵

Academic publishers have devoted less attention to research employing HGIS than the popular press. In 2006 *Environmental History* published a four-page reflection, "Positioning the Past With the Present: The Use of Fire Insurance Plans and GIS for Urban Environmental History," by Jason A. Gilliland and Mathew Novak on studying urban development using GIS methods. The journal published its first full-length article in 2012, Kenneth Sylvester and Eric Rupley's, "Revising the Dust Bowl: High Above the Kansas Grasslands," which surveyed agricultural development using the Great Plains Population and Environment Data Series. By honing back in on local cases within this regional project these researchers sampled representative townships in order to explore patterns in agricultural practice and land-use change over the past century.⁴⁶

Other US history journals are working to adapt to the challenge of publishing HGIS research and its visualizations by integrating digital supplements to supplement traditional articles.⁴⁷ *Agricultural History* hosted an expansive digital portfolio to accompany Geoff Cunfer's article "The Southern Great Plains Wind Erosion Maps of 1936–1937" in its fall 2011 issue.⁴⁸ The *Journal of American History (JAH)* published Cameron Blevins's "Space, Nation, and the Triumph of Region: A View of the World from Houston," in the June 2014 number; the first article published in the journal of record in US history to have been based upon a digital history method.⁴⁹

In March 2017, the journal published a second article, "Accounting for Conquest: The Price of the Louisiana Purchase of Indian Country" by Robert Lee, analyzing the cost of land transfers in the trans-Mississippi West by merging digital maps of land cessions with a forensic accounting of federal payments to tribes.⁵⁰ These publications, in addition to the 2003 *American Historical Review* piece featuring the *Valley of the Shadows* project, represent only a half dozen articles among the dozens published each year in major US history journals—overall a rather small contribution given the amount of funding

and general interest devoted to historical GIS. This figure is also striking given the range of scholarship in the field, and it hints at the difficulty of translating data visualization into print format—the two *JAH* authors have arranged for their own online visualizations to supplement the print journal. As methodologies continue to evolve and as models for alternative forms of research dissemination gain a wider audience, the publishing landscape will need to integrate more scholarship employing spatial methods.

Early adopters of spatial methods in history continue to drive new uses of HGIS. Anne Kelly Knowles, an historical geographer who led the way in promoting historical GIS, spearheaded *What Could Lee See at Gettysburg?*, a mapping project that re-creates what was visible to General Robert E. Lee during the Battle of Gettysburg.⁵¹ Knowles's research team used orthophotos, surveyor's notes, and battlefield reports to generate raster and vector layers within a digital terrain model, which can be examined using viewshed and visibility analysis.⁵² The visualization explains the logic behind Lee's fatal miscalculations during the second day of battle, and highlights the limitations presented by topography and knowledge. Knowles has now turned her attention to mapping the geographies of the Holocaust.

In recent years spatial collaborations have broadened to include multinational teams of scholars using HGIS to analyze ecological systems as they function in a range of environments; perhaps most notable is *Sustainable Farm Systems: Long-Term Socio-Ecological Metabolism in Western Agriculture, 1700–2000*. This initiative merges the work of five research teams from six nations studying what they term socioecological metabolism, analyzing across time and space “how farmers managed soil nutrients, landscape processes, and energy flows to sustain communities and produce food for themselves and society.”⁵³ Cunfer, whose lab at the University of Saskatchewan now hosts the *Sustainable Farm Systems* project, also collaborates with the multi-institutional research surveys of agricultural change on the Great Plains of North America.⁵⁴ Similarly, White, after identifying the centrality of spatial questions to his research, designed *Shaping the West*, which provided a prototype for the Spatial History Project, now part of Stanford University's Center for Spatial and Textual Analysis (CESTA), which also fosters collaborations with scholars from around the world.⁵⁵ The institutions that facilitated the first efforts in historical GIS continue to drive projects that push the uses of spatial data into new geographical and thematic areas; and universities, government agencies, and Esri, the leader in GIS software design, all continue to add new resources to their online collections.⁵⁶

*“The Dream of a Land Unspoiled and Fertile with Possibilities”:
The Spatial Future of Environmental History*

Historians and other practitioners who employ HGIS are keenly aware of the potential of digital research to reshape the distribution of research findings to the widest scholarly and popular audience. Their work, and the methodological lessons that may be drawn from it, holds great promise for revitalizing enthusiasm for historical thinking both within the academy and beyond—as well as an opportunity to reach the broad audiences once attracted to books such as *Dust Bowl* and *Changes in the Land*.⁵⁷

With the proliferation of the digital humanities and the market demand for multiple skill sets, spatial methods offer scholars interrogating environmental change an opportunity to develop their facility with interdisciplinary inquiries and diversify their methodological practices. HGIS offers a mechanism for exploring the vast quantities of data related to environmental topics and enables the quantitative analysis of causality.

Environmental historians have an opportunity to adapt their analytical repertoire, integrating spatial questions, if not historical GIS itself, more consistently into their scholarship. Through a renewed attention to scale, an openness to collaboration across disciplinary and national boundaries, and a commitment to employing visual, as well as analytical methods, environmental history can broaden both its reach and its impact. A closer attention to the work being done elsewhere in the spatial humanities will help frame new research questions and situate historical conclusions with more nuance surrounding framing and scale. These new avenues will ensure that environmental history continues to engage at the forefront of interdisciplinary and socially useful research practices—something the founders of the field would embrace as consistent with its origins.

Notes

1. The author focuses almost exclusively on the North American context of HGIS research, as it is beyond the reach of this brief essay to capture the complex development of HGIS elsewhere in the world—a topic that merits its own work in each area of environmental research.

2. Brian Donahue, *The Great Meadow: Farmers and the Land in Colonial Concord* (New Haven, CT: Yale University Press, 2004); Geoff Cunfer, *On the Great Plains: Agriculture and Environment* (College Station: Texas A&M University Press, 2005); Lynne Heasley, *A Thousand Pieces of Paradise: Landscape and Property in the Kickapoo Valley* (Madison: University of Wisconsin Press, 2005); Anne Kelly Knowles, *Mastering Iron: The Struggle to Modernize an American Industry, 1800–1868* (Chicago: University of Chicago Press, 2013); Richard White, *Railroaded: The Transcontinentals and the Making of Modern America* (New York: Norton, 2012).

3. Jo Guldi, “What Is the Spatial Turn?,” Spatial Humanities, Scholars’ Lab,

accessed August 13, 2015, <http://spatial.scholarslab.org/spatial-turn/what-is-the-spatial-turn/>.

4. Esri, the manufacturer of the dominant GIS software platform, ArcGIS, defines “spatial analysis”: “The process of examining the locations, attributes, and relationships of features in spatial data through overlay and other analytical techniques in order to address a question or gain useful knowledge. Spatial analysis extracts or creates new information from spatial data.” “Spatial Analysis,” GIS Dictionary, Esri, accessed March 3, 2016, <http://support.esri.com/en/knowledgebase/GISDictionary/term/spatial%20analysis>.

5. Donald Worster, “Appendix: Doing Environmental History,” in *The Ends of the Earth: Perspectives on Modern Environmental History*, ed. Worster (New York: Cambridge University Press, 1988), 294.

6. Lynne Heasley, “Shifting Boundaries on a Wisconsin Landscape: Can GIS Help Historians Tell a Complicated Story?” *Human Ecology* 31 (June 2013): 210.

7. The subhead for this section draws its title from Donald Worster’s call for environmental historians to employ models from the natural sciences as “indispensable aids” to the practice of history. Worster, “Appendix,” 294, 306.”

8. These include Immanuel Wallerstein’s conceptualization of the binary of core and periphery, Lucien Febvre and other Annalistes’ theorization of space and total history, and the importance of bioregion rather than nation as the defining boundary for historical study.

9. Richard White described the importance of spatial analysis for historical research by explaining that HGIS “allows us to merge things created at dramatically different times to create what are in effect new modern images which potentially reveal things about the past that the original artifacts did not. It also allows us to visualize space in ways that go far beyond mapping.” Richard White, “What Is Spatial History,” newsletter of the Spatial History Lab, February 1, 2010, 4.

10. Richard White, “The Nationalization of Nature,” *Journal of American History* 86 (December 1999): 976, 978.

11. At the vanguard of historical GIS initiatives in North America are the Center for Digital Humanities at the University of Nebraska, NULab for Texts, Maps, and Networks at Northeastern University, the Spatial History Project at Stanford University, the Digital Scholarship Lab at the University of Richmond, the HGIS Lab at the University of Saskatchewan, the Scholars’ Lab at the University of Virginia, and the GIS Lab at the University of Western Ontario.

12. “Shaping the West,” Spatial History Project, Stanford University, accessed August 17, 2015, <http://web.stanford.edu/group/spatialhistory/cgi-bin/site/project.php?id=997>; White, “What Is Spatial History?,” 6; Heasley, “Shifting Boundaries,” 187, 192.

13. Even the major GIS labs have not disseminated a clear set of standards for analyzing research based upon spatial analysis. In part, this reflects the relative novelty of the practice and the pace of work in these labs, which have developed their own protocols but rarely codified expectations. Cameron Blevins, “The Perpetual Sunrise of Methodology,” *Cameron Blevins* (blog), January 5, 2015, <http://www.cameronblevins.org/posts/perpetual-sunrise-methodology/>; “Committee on Professional Evaluation of Digital Scholarship by Historians,” *AHA Today* (blog), January 27, 2014, <http://blog.historians.org/2014/01/committee-professional-evaluation-digital-scholarship-historians/>.

14. Even when other scholars examine historical visualizations, they too often get distracted by the novelty of the technology, “infatuated with the power of digital tools and techniques to do things that humans cannot,” or, alternately, get bogged down in questioning the details of the study while interrogating only superficially the researcher’s choice of scale, categorizations, and interpretative conclusions. Blevins, “Perpetual Sunrise of Methodology.”

15. “The time has come to brush away the obscuring mythologies” is from Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), 4.

16. Jessica Camille Aguirre, “The Unlikely History of the Origins of Modern Maps,” *Smithsonian*, June 2, 2014, <http://www.smithsonianmag.com/history/unlikely-history-origins-modern-maps-180951617/?no-ist>; Guldi, “What Is the Spatial Turn?”

17. Aguirre, “Unlikely History.”

18. Ben Schmidt, “Data Narratives and Structural Histories: Melville, Maury, and American Whaling,” *Sapping Attention* (blog), October 30, 2012, <http://sappingattention.blogspot.com/2012/10/data-narratives-and-structural.html>.

19. Anne Kelly Knowles, “Introducing Historical GIS,” in *Past Time, Past Place: GIS for History*, ed. Knowles (Redlands, CA: Esri Press, 2002), xiv–xv.

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28. “About the Virginia Center for Digital History,” VCDH, accessed May 28, 2017, <http://www.vcdh.virginia.edu/index.php?page=About>.

29. Benjamin Ray, “Teaching the Salem Witch Trials,” in Knowles, *Past Time, Past Place*, 30–32.

30. Amy Hillier, “Redlining in Philadelphia,” in Knowles, *Past Time, Past Place*, 88.

31. “A reason, and an opportunity, for substantial reform” is from Donald Worster, *Dust Bowl: The Southern Plains in the 1930s* (New York: Oxford University Press, 1979), 5.

32. Worster, *Dust Bowl*, 4.

33. “Great Plains Population and Environment Data Series.”

34. Cunfer, *On the Great Plains*, 37, 152–68.

35. Geoff Cunfer, “Scaling the Dust Bowl,” in Knowles, *Placing History*, 101–2.

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37. Cunfer, “Scaling the Dust Bowl,” 105–6; Cunfer, *On the Great Plains*; Karen Merrill, “Whose Home on the Range?” *Western Historical Quarterly* 27 (Winter 1996): 433–51; Karen Merrill, “In Search of the ‘Federal Presence’ in the West,” *Western Historical Quarterly* 30 (Winter 1999): 449–73; Matthew Pearce, “Bringing History into Range Management,” *Rangeland Ecology and Management* 66 (July 2013): 387–400.

38. Donahue, *Great Meadow*, 78–86.

39. “In the long run it was this latter conception of land—as private commodity rather than public commons—that came to typify New England towns. Initial divisions of town lands, with their functional classifications of woodlot and meadow and cornfield, bore a superficial resemblance to Indian usufruct rights, since they seemed to define land in terms of how it was to be used. Once transferred into private hands, however, most such lands became abstract parcels whose legal definition bore no inherent relation to their use: a

person owned everything on them, not just specific activities which could be conducted within their boundaries. . . . The uses to which land could be put vanished from such descriptions, and later land divisions increasingly ignored actual topography. What was on the land became largely irrelevant to its legal identity.” William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (New York: Hill and Wang, 1983), 74–75.

40. Donahue, *Great Meadow*, xx.

41. Richard White, foreword to Knowles, *Placing History*, x.

42. “Discover some fresh truths” is from Donald Worster, “Transformations of the Earth: Toward an Agroecological Perspective in History,” *Journal of American History* 76 (March 1990): 1106.

43. Brian Donahue, “Mapping Husbandry in Concord: GIS as a Tool for Environmental History,” in Knowles, *Placing History*, 174.

44. Patricia Cohen, “Digital Maps Are Giving Scholars the Historical Lay of the Land,” *New York Times*, July 26, 2011, <http://www.nytimes.com/2011/07/27/arts/geographic-information-systems-help-scholars-see-history.html>.

45. Aguirre, “Unlikely History.”

46. Jason Gilliland and Mathew Novak, “Positioning the Past with the Present: The Use of Fire Insurance Plans and GIS for Urban Environmental History,” *Environmental History* 11 (January 2006): 136–39; Kenneth Sylvester and Eric Rupley, “Revising the Dust Bowl: High above the Kansas Grasslands,” *Environmental History* 17 (July 2012): 603–33.

47. *Environment and History* has also published a few articles that employed GIS in order to interrogate historical maps and orthophotos (georeferenced aerial images). S. D. Smith, “Storm Hazard and Slavery: The Impact of the 1831 Great Caribbean Hurricane on St Vincent,” *Environment and History* 18 (February 2012): 97–123; Annika Dahlberg and Piers Blaikie, “Changes in Landscape or in Interpretation? Reflections Based on the Environmental and Socio-economic History of a Village in NE Botswana,” *Environment and History* 5 (June 1999): 127–74; and Anna Dahlström, Sara Cousins, and Ove Eriksson, “The History (1620–2003) of Land Use, People and Livestock, and the Relationship to Present Plant Species Diversity in a Rural Landscape in Sweden,” *Environment and History* 12 (May 2006): 191–212.

48. Geoff Cunfer, “The Southern Great Plains Wind Erosion Maps of 1936–1937,” *Agricultural History* 85 (Fall 2011): 540–59.

49. Cameron Blevins, “Space, Nation, and the Triumph of Region: A View of the World from Houston,” *Journal of American History* 101 (June 2014): 122–247, and accompanying digital supplement (hosted by the Stanford University Spatial History Lab), “Mining and Mapping the Production of Space,” <http://spatialhistory.stanford.edu/viewoftheworld>; Blevins, “Perpetual Sunrise of Methodology.”

50. This article won the 2016 Louis Pelzer Memorial Award from the Organization of American Historians. Robert Lee, "Accounting for Conquest: The Price of the Louisiana Purchase of Indian Country," *Journal of American History* 103 (March 2017): 921–42.

51. Anne Kelly Knowles, "A Cutting-Edge Second Look at the Battle of Gettysburg," *Smithsonian*, June 27, 2013, <http://www.smithsonianmag.com/history/A-Cutting-Edge-Second-Look-at-the-Battle-of-Gettysburg-1-180947921/>.

52. *Smithsonian Magazine* bestowed its American Ingenuity Award for Historical Scholarship upon geographer Knowles in 2012. Anne Kelly Knowles, "What Could Lee See at Gettysburg," in Knowles, *Placing History*, 239–58.

53. "Sustainable Farm Systems: Long-Term Socio-ecological Metabolism in Western Agriculture, 1700–2000," HGIS Lab, University of Saskatchewan, accessed July 24, 2015, <https://hgis.usask.ca/projects/sustainable-farm-systems.php>.

54. HGIS Lab, University of Saskatchewan, accessed August 1, 2015, <http://www.HGIS.usask.ca>.

55. "Shaping the West"; "The Broken Paths of Freedom," Spatial History Project, Stanford University, accessed August 5, 2015, <http://web.stanford.edu/group/spatialhistory/cgi-bin/site/project.php?id=1069>.

56. Spatial resources are proliferating everywhere, and a few places to start are as follows: The Library of Congress is building a digital collection of georeferenced Sanborn Maps, <https://www.loc.gov/collections/sanborn-maps/about-this-collection/>; Stanford University's collection of historical GIS links, <https://library.stanford.edu/rumsey/map-research/historical-gis-data>; the United States Geological Survey's Historical Topographical Map Explorer, <http://historicalmaps.arcgis.com/usgs/>; and the University of Richmond's georeferenced Historical Atlas of the United States, <http://dsl.richmond.edu/historicalatlas/1/a/>.

57. "The dream of a land unspoiled and fertile with possibilities" is from Donald Worster, *Shrinking the Earth: The Rise and Decline of American Abundance* (New York: Oxford University Press, 2016), 4.