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IN THIS ISSUE

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IN THIS ISSUE (CONTINUED)

REVIEWS

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ABOUT THE COVER: Detail from *Surfing Saco Bay*, by Margot Dale Carpenter, which appears in the 5th volume of the *Atlas of Design*. You can see more of Margot's work at hartdalemaps.com.

All material published in the journal is independently reviewed and/or edited. Submissions are accepted from members of the journal staff and editorial board, but the authors play no role in the assessment or editing of their contribution.

LETTER FROM THE PAST PRESIDENT

I want to start by saying thank you to each and every NACIS member, conference attendee, and volunteer—past and present—for being part of the NACIS community and fostering its growth. In our organization's 41 years, we've experienced *a lot* of changes, both in the field and in the world around us. What has always been constant is the NACIS community, and our ability to keep evolving our Society to remain relevant as the field of cartography changes. The caliber of our conferences, our organizational initiatives, and our passionate volunteers make us one of the most unique societies out there, and one that we should all feel proud to be a part of.

The past two conference years, Virtual NACIS 2020 and Hybrid NACIS 2021, are testament to our Society's ability to forge new ground even in the toughest of times. As program planner for our first fully virtual conference in 2020, I feel so proud of what we were able to accomplish together, and of the bright spot the conference was able to offer to many of us during a difficult and unprecedented time. Virtual NACIS 2020 required a completely new conference model, one that we adapted to quickly and which gave our Society the amazing opportunity to bring people in our industry together from around the world.

Kicking off NACIS 2020 was our keynote speaker, the passionate and insightful **Marusia Musacchio**, who set the stage for what we all hoped our virtual conference would be: engaging, fun, and memorable. Our session moderators brought Virtual NACIS to life with live speaker engagement, made possible by the incredible team at **e3 Webcasting** and our Slack channels. We got to virtually meet our Corlis Benifideo Awardees, **Tonika Lewis Johnson and Paola Aguirre Serrano** and learn more about their imaginative cartography. The sessions on **Mapping for Change** and **Mapping for Society** were inspirational and show the power of stronger collaboration between program planners and our Diversity, Equity, and Inclusion Committee, which took the lead in recruiting a diverse set of speakers. NACIS 2020 also brought a lot of new ways for our content and organization to be made more accessible. We had our first ever virtual Map Gallery which opened up cartographers' entries to a much wider audience, and we also introduced a revamped version of our Student Dynamic Mapping Competition, with attendees now voting to select the winning entries. On the social side, Slack took on a life of its own and continues to be a way for our members to engage with each other between conferences. The virtual social events in Remo were so memorable, and took the conference experience to the next level. And within days, all talks were posted to our **YouTube Channel**.

In short, all of the positivity that was familiar to those of us who had attended in-person NACIS was radiating around the world through our computer screens. I can't say thank you enough to **the Board and volunteers** that I had the fortune of working with during my program planning year. We will forever be bonded by the experience of pulling off the NACIS 40th Annual Meeting in the middle of a global pandemic.

2021 has been another, totally different version of a pandemic year. This year, some people could travel, while others could not. As an organization we had to figure out yet another conference model that built off of the success of the 2020 virtual experience and the previous 39 years of in-person experiences, while keeping our organization financially healthy and responsible. Huge congratulations are due to Pat Kennelly and Travis White for a successful Hybrid NACIS 2021. Planning a conference that had the energy it did both in Oklahoma City and online was no small effort.

Even while the Hybrid conference was in the works, this all-volunteer organization tirelessly pushed forward on other NACIS initiatives. Our Diversity, Equity, and Inclusion Committee worked closely with Pat and Travis on speaker recruitment for the 2021 program. The committee also gathered feedback from the NACIS community via surveys, and is actively working on ways to bring more awareness about DE&I to our organization across different initiatives. Our Communications and Outreach committee continues to increase our presence on social media, maintain **nacis.org**, and send out the wonderful NACIS Newsletter. In addition, the committee worked with several volunteers to expand our outreach mailing list, adding nearly 200 new contacts at Historically Black Colleges and Universities, and other Minority-Serving Institutions. The Awards Committee continues to manage everything from conference swag to map galleries to travel grants, while also working on ways to fund more people from underrepresented groups to attend our conference. The NACIS Store has been a big hit and is becoming *the place* to find the latest mappy gear. All proceeds from the store go to student and member travel grants and conference accessibility. Finally, the Membership and Analytics Committee worked to analyze conference survey results from the past few years. As a result, the committee redesigned this year's conference survey, focusing on the right kind of feedback so we can continue to make improvements and measure their impact over time.

This coming year, under Pat's leadership, all of these efforts (and more!) will continue to grow. In addition, our Finance Committee will evaluate the 2021 hybrid model to determine what version is most sustainable for Minneapolis 2022 and beyond, giving special attention to the impacts on long-term financial viability if in-person conference attendance declines.

My first NACIS was St. Louis, in 2007. Over the years, as an attendee and a volunteer, I have made best friends, found mentors, and maintained meaningful relationships. The NACIS community has been instrumental in making me feel more confident in myself as a professional in our industry. The fact that I, like many, reference life events on a NACIS conference timeline is a testament to how meaningful this organization is and the sense of community it has brought.

As Past President, I feel a tremendous amount of gratitude and appreciation for the work NACIS does as an all-volunteer organization. I've had the opportunity to work alongside the most passionate group of volunteers, who care so deeply about this Society and the people who are a part of it. To all the Board members I've had the honor of working with, thank you for lifting me with courage and joining me in making a true impact on this Society. An extra special thanks to our Director of Continuity, Ginny Mason, our Director of Operations, Nick Martinelli, and our Super Woman Business Manager, Susan Peschel. Thank you for your constant mentorship and friendship and keeping this all going from the background. I've grown so much because of you and can't thank you enough for everything you do for NACIS.

In closing, NACIS is a community first and a Society second. Let's continue to ask tough questions and be the change that we want to see. Let's continue to cultivate a safe space where all feel welcome and that is more representative of our industry. Let's continue to keep the field of cartography relevant. Most importantly, let's all do it together and through community, continue building the Society that we feel proud being a part of.

Mamata Akella
NACIS Past President

LETTER FROM THE ASSISTANT EDITOR

Hello there! I'm Daniel Huffman, the Assistant Editor of *Cartographic Perspectives*. While these introductory letters normally come from the journal's Editor, Amy Griffin, she's been kind enough to turn this space over to me this time around.

For the last nine years, I've handled the copyediting of each article, as well as the layout work and some final publication details. My side of things comes in after Amy and our Section Editors have put in the work to solicit and review content, and get it into publication shape. One great advantage of my position is that it ensures that I carefully read through the entire contents of each issue, and this often causes me to pick up valuable information that I didn't even know I was looking for (as an example, I now use QuickOSM all the time thanks to **J. C. Ehrig-Page's piece in CP95**). Most of us tend to read journals in a targeted fashion, seeking out specific articles for research purposes. But my position has shown me how much real value there is in just sitting down and browsing through everything, even if you aren't sure where it will take you. I know that's the sort of thing that many of us find challenging to fit into our busy lives, but if you're the sort of person who's already taking the time to read this letter from me, you're probably on the right track.

This issue of CP opens with a piece by Andrew Rhodes on James Monteith, "Master of the Margins." I was unfamiliar with Monteith (whom Rhodes describes as "largely forgotten"), and I appreciated not only the insight into the world of nineteenth-century geography education, but also the many lovely examples of Monteith's cartographic style and unique approach to marginalia.

Our second PEER-REVIEWED ARTICLE is by Michael Peterson, who meticulously reviews the density of features on large-scale maps from Bing, Google, and Mapbox. Many of us make use of slippy maps as part of our cartographic products, and this research gives a better sense of which services offer the best information for which parts of the world.

Michael Peterson also joins us, along with Paul Hunt, in the PRACTICAL CARTOGRAPHER'S CORNER. Together, they walk through how to set up a public display of a frequently-updated map—think of something like a large monitor in a lobby, automated to show the latest weather radar.

Afterwards, you can journey through a variety of experiential landscapes thanks to Darren Sears's *Worldviews* series in VISUAL FIELDS. Read through how Darren's background and thought processes led him to craft multi-perspective views of individual places that capture "the full experience of a place." It's inspiring stuff for anyone who thinks about maps.

Finally, we have our book REVIEWS. I always appreciate this section because, even if I don't purchase the book in question, I usually end up learning a little something just from the general description of its subject matter. So, even if you're not in the market for new cartography texts, these are worth a look. This time around we have nine reviews, covering everything from textbooks (*Cartography: Visualization of Geospatial Data, 4th Edition*) to critical cartography (*When Maps Become the World*) to histories of often-overlooked mappers (*Mapping Indigenous Land: Native Land Grants in Colonial New Spain* and *Women in American Cartography: An Invisible Social History*), plus plenty more.

Before you go, make sure to check out this issue's cover, a detail from Margot Dale Carpenter's *Surfing Saco Bay*. Part of my role as Assistant Editor is to secure the cover art for each issue, and it's always a joy to be able to showcase excellent cartographic work. Check out Margot's website at **hartdalemaps.com**.

I hope you enjoy, and find something that you didn't expect to learn. Thanks for spending part of your day with us!

Daniel P. Huffman (they/them)
Assistant Editor

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James Monteith: Cartographer, Educator, and Master of the Margins

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James Monteith (1831–1890) was a leading figure in American geography education in the late nineteenth century, but his career has been largely forgotten and his contribution to cartography has been underappreciated. Monteith's maps and geography textbooks were targeted at the general reader, but included innovative ways to highlight comparative spatial relationships. Much of the text in Monteith's books is typical of that found in other works of the period, but his geography volumes included unique illustrations to help the reader visualize terrain on a continental scale and place individual maps in a global context. Monteith produced fairly pedestrian maps in his books but surrounded them with remarkable symbology and amplifying data that ought perhaps to earn him the title "master of the margins."

KEYWORDS: James Monteith (1831–1890); geography textbooks; cartography; map symbols; map margins; nineteenth century education; comparative geography

James Monteith (1831–1890) has been largely forgotten as an American cartographer, but his four-decade career demonstrated a surprisingly innovative and sophisticated approach to educating map users about comparative spatial relationships. Monteith's geography textbooks were published widely in the United States from the late 1850s until well after his death, and they offered some of the most readily available reference maps in the country in the late nineteenth century. However, Monteith's work has gone underappreciated, possibly because his books targeted school-aged audiences and his maps did not attempt to provide comprehensive detail. He was fundamentally an educator and publisher of teaching materials: he was not trying to create the latest sophisticated reference atlas. Indeed, it is not the maps themselves that make Monteith's work so interesting, but rather the way he used comparative data, especially in the margins of those maps to amplify the map reader's understanding of the cartographic story on the page. Monteith's work evolved steadily over his career, and his later maps are complex works that invite continued study and generate new insights for the map reader.

WHO WAS JAMES MONTEITH?

Monteith's life has not been well documented, despite his commercial success. He received a brief passing reference in *Tooley's Dictionary of Mapmakers*, which calls his maps "crude" and states the years of his life incorrectly (Scott 2003, 273), and he is not mentioned in Ristow's *American Maps and Mapmakers* (1986). Yet the *New York Times* noted in their September 12, 1890 obituary for Monteith that his name was one "nearly every school boy and girl in the country is familiar with because of its being on the covers of the geographies."

James Monteith's story resembles the idealized nineteenth-century tale of the successful immigrant. He was a self-made man who started from modest means and grew wealthy and successful on the strength of his own curiosity and creativity. Monteith was born on April 3rd 1831 in Strabane, along the banks of the Foyle River that now marks the border between the Republic of Ireland and Northern Ireland. He immigrated to the United States at four years old and attended New York public schools. He started teaching in the same school system not long after graduation: it does not appear that he received any post-secondary education, and he was listed as a teacher employed by New York Board of Education as early as 1849 (New York Board of Education 1849). In 1854 he was teaching in a school on 47th Street for an annual salary of $800 (New York Board of Education 1855). Monteith was reportedly a "splendid draughtsman" and taught art—among other subjects—to his students, but sometime in the 1850s he started to combine his artistic talents with his teaching and began to create textbooks (Delaware Gazette and State Journal 1890).

Monteith's first published books were small, trim volumes, such as *Youth's Manual of Geography* and *First Lessons in Geography,* first published in 1853 and remaining in print through the 1850s. By 1856–1857, his textbooks were starting to receive favorable reviews in New York and New England (The R. I. Schoolmaster 1858). Monteith was prolific in his twenties, and had published at least four textbooks by 1858, the year he turned 27. All of this he apparently did in addition to his usual work as an educator—he kept teaching as the Civil War broke out, and by 1863 was the headmaster of the school on 47th Street (New York Board of Education 1863).

Monteith's most direct influence appears to have been Francis McNally, another New York public school teacher who published geography textbooks until his death in 1854 (there is no apparent relation to the printer Andrew McNally of Chicago who started, with William Rand, the great mapmaking firm of Rand McNally). It is not clear how long the two men collaborated—it is possible that McNally identified Monteith's talents while the younger man was still a student, or perhaps they met when Monteith began his teaching career. Nevertheless, the two men launched a successful collaboration in the final years of McNally's life, and the McNally brand would remain a part of Monteith's work for several years after the older man's death. Although Monteith developed his own techniques and style, he clearly learned a great deal from McNally, and the fact that A. S. Barnes published both men together as a series likely allowed Monteith to make use of McNally's maps, as the company already owned the copyrights. One of Monteith's obituaries suggested that it was the death of McNally that prompted Monteith to stop teaching and dedicate himself full time to the publishing work that he and McNally had shared, but this may be incorrect or only partially true, as he remained employed by the New York Board of Education until at least 1863.

Monteith married Emma Palmer in the 1860s and they had three children before Emma's death in 1870. He later married Ella Florence Brown in 1888, who gave birth to a daughter not long before Monteith died suddenly in his New York home, of an apparent heart attack, on September 11th, 1890. He was 59 years old. He was buried together with Emma, who was from Philadelphia, in that city's Laurel Hill Cemetery in a plot with a commanding view of the Schuylkill River. Ella was buried in the same plot upon her death in 1916. At the time of his death, Monteith had become wealthy not only due to the great commercial success of his books and maps, but also his purchase in the 1860s of land in the Washington Heights neighborhood of New York, which grew immensely in value in the following decades. Despite his dedication to the study and comparison of distant and exotic locations, Monteith spent his whole adult life in New York City.

MONTEITH AND NINETEENTH-CENTURY GEOGRAPHY TEXTBOOKS

Monteith was far from alone in creating geography textbooks for the students of a rapidly expanding United States. The mid-nineteenth century was a golden age for innovative mapmaking, and the market was fiercely competitive for atlases and textbooks (Patton 1999). As Jeffrey Patton notes, these textbooks had a major influence on how Americans came to understand the world around them, even if the books themselves "were in no way reflective of the highest form of the atlas makers [*sic*] craft" (1999, 4). Monteith's books are excellent examples of geographies that could not only "show the location of places, but also what those places were like" (11). Monteith's textbooks were well illustrated, some of them lavishly so, and much of the art was probably done by Monteith himself, particularly in the earlier phase of his career.

Many common elements appear in geography textbooks of the 1870–1890s, and both Monteith and his competitors were drawing on many of the same reference sources to compile their books. Monteith indicated in an 1866 textbook that the references he had consulted included those of Charles Lyell, Edward Hitchcock, James

Figure 1. "Transcontinental View of High Europe," circa 1890. Monteith's later books include several of these illustrations that create an oblique compilation of exaggerated terrain across a full continent—from the Atlantic Ocean to the Black Sea in this example. This is a composite scan of the original, which is more than 43 centimeters wide, spanning both pages.

Dwight Dana, Hugh Miller, Alexander K. Johnston, Thomas Milner, Carl Ritter, Arnold Guyot, and Matthew Fontaine Maury (Monteith 1866). A. K. Johnston is well known for his nineteenth-century atlases, which helped introduce Americans to the great European geologists, geographers, and cartographers of the period, such as Alexander Humboldt and Humboldt's favorite cartographer, Heinrich Berghaus. Through Johnston's work, Monteith further illustrated, visualized, and popularized the scientific work of these geographers for the general American reader.

The influence of Johnston's 1848 atlas is suggested in Monteith's drawing of, from the 1860s, his own versions of diagrams that appeared in atlases like Johnston's, such as a composite view of the world's mountains to show their relative height. Wolter notes that these composite mountain height diagrams derive principally from the work of Humboldt in the early nineteenth century, as popularized in the atlases by Johnston and Berghaus (Wolter 1972). American cartographers began to adapt these comparative diagrams in the 1820s and 1830s, but Monteith was not the first American to do so: Emma Willard (1831, 97) had done so decades earlier. Monteith does not mention Willard, nor her close collaborator William C. Woodbridge, as sources, but the organization of the text and the use of some similar visual elements suggest they did influence Monteith, and A. S. Barnes was publishing books by both Willard and Monteith in the 1850s (Woodbridge 1844).

Guyot and Maury both published geography textbooks later in life—though they were probably not greatly involved in the actual writing of these books—and the Guyot-branded series from 1861–1875 may have been a particular influence on Monteith. Monteith's organization of textbook sections and topics, the inclusion of map-drawing supplements, and the repeated use of small terrain cross-sections, bear key similarities, for example, to the 1867 edition of Guyot's *Intermediate Geography*. From the late 1860s Monteith's textbooks showed the influence of Maury's published work, including maps of climate zones and ocean currents. Maury's grand *Washington Map of the United States* first published in 1860, does not exhibit the specific devices that Monteith later employed, but it may have encouraged Monteith to use the margins more creatively, for, as Susan Schulten points out "the real innovations on the 'Washington Map' are actually at its edges" (2012, 109).

While Monteith's textbooks are full of illustrations unrelated to the maps, such as views of foreign cities or depictions of foreign cultures and customs, many of Monteith's diagrams are geographic, and help amplify the maps. The "balloon views" of large regions or composite "transcontinental views" resemble the late nineteenth-century "bird's eye" city views, only at a vastly different scale (see Figure 1). The introduction to the 1885 edition of Monteith's *New Physical Geography* takes particular pride in noting that this textbook is the "only Physical Geography to contain ***Bird's-eye Relief Maps***" (emphasis in original). In some ways they also preview the oblique orthographic views of the globe popularized in the twentieth century by cartographers like Richard Edes Harrison.

Monteith's books frequently employ a catechistic style typical of mid-nineteenth century textbooks (especially those targeted at the youngest students), asking students to answer a series of questions by reference to the book. The books also contain practical exercises in map drawing and knowledge tests. Monteith regularly took his students (and their teacher) on a guided tour, imagining a region and its geographic features, then depicting it with fictional vistas, detailed engravings, and a notional map. Sometimes he would ask the reader to follow a shipping route in the real world and name some of the geographic features passed along the way.

EVOLUTION OF MONTEITH'S STYLE

Although Monteith benefitted greatly from, and was influenced by, other cartographers like McNally, Johnston, and Guyot, he was making his own original maps from the beginning and remained committed to using maps as an instructional device throughout his career. A complete listing and description of every variety of Monteith map or textbook would require a very lengthy study, as he authored several related and complementary textbook series, and updated many of them regularly. There are probably more than one hundred different Monteith geography textbooks, some with only subtle variation between editions and minor changes to individual maps between editions. As was typical of geography texts from the period, the publisher also created specialized editions for different regions by adding an appendix with more maps and details on the home region where that edition would be sold. The Library of Congress (LOC) has 44 entries for Monteith in its catalog, mostly geography textbooks but also three atlases—a very incomplete sample, because the LOC generally does not catalog school textbooks (Castner 1997). The LOC and the New York Public Library also have a small number of individual sheet maps created by Monteith.

The maps Monteith created near the end of his career have a unique style, incorporating multiple amplifying elements of comparative geography (see Figure 2). These maps—which represent Monteith's late style and will be referred to later as "fourth generation"—pack information into all four margins of each map, most notably showing:

- **Comparative extent and latitude** in the left and right margins.
- **Comparative area symbols**, particularly the outline of an American state at the same scale (after the 1870s, always Kansas).
- **Multiple scale bars**, showing travel time by land and sea, in addition to distance.
- **Terrain cross sections** along the bottom margin of the map, often combined with a bar showing the east-west extent of regions.

Figure 2. An 1885 full-page Monteith map, showing the use of all four margins and innovative symbology to provide contextual and comparative information.

In addition to this unique combination of marginal information, Monteith also included a variety of conventional data typical of other atlases, such as longitude east of both Greenwich and Washington, temperature isolines, distance of key shipping routes, and clocks to indicate time differences from London.

By contrast, the maps in his earliest books are, as noted in *Tooley's* (Scott 2003), somewhat crude; but from these humble beginnings to his late style, there is a clear evolution in the quality of his maps. Monteith included more and more contextual information over time, such that the last maps he produced were rich infographics with amplifying details crowded into the margins. The key trends in the evolution of Monteith's textbooks may be seen by generalizing his work into four main "generations":

- **First Generation (beginning in the 1850s):** elementary textbooks with simple reference maps, such as *First Lessons in Geography*.
- **Second Generation (from the late 1860s):** increasingly sophisticated maps with early signs of Monteith's innovations with comparative data, as demonstrated by *Physical and Intermediate Geography*.
- **Third Generation (throughout the 1870s):** a wide variety of detailed maps and diagrams, best represented by his 1876 *Comprehensive Geography*.
- **Fourth Generation (from the mid-1880s):** perfected around 1885 and bringing all elements together, and with richly detailed margins. This generation is typified by *Barnes's Complete Geography*, which stayed in print for three decades.

FIRST GENERATION

Few examples remain of the textbooks that Monteith published in the 1850s in modest print runs. *Youth's Manual of Geography* was first copyrighted in 1853 and circulated within the New York Public School system, but by 1860 was sold more broadly and carried the endorsement of a list of New York teachers, including Francis McNally. By the late 1850s, A. S. Barnes and Co. had published four works by Monteith: *Youth's History of the United States*, which was "copiously illustrated with Maps and

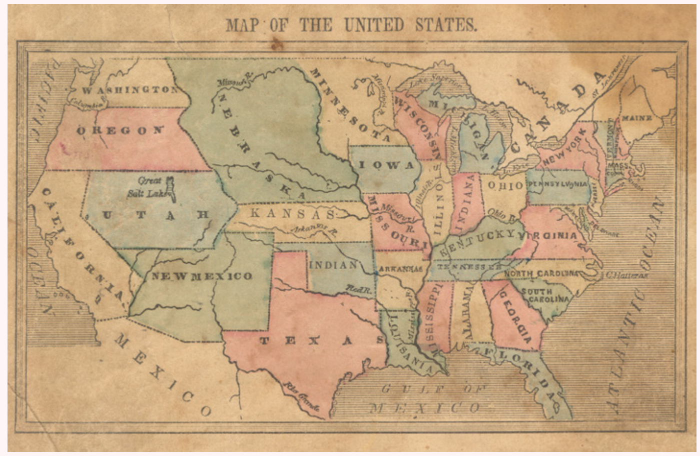

Figure 3. This simple, hand-colored reference map from a first-generation Monteith textbook of the mid-1850s has none of the contextual symbology of later Monteith maps.

Engravings" and three geography textbooks for different levels (Monteith 1858). The geography books were advertised as part of the "National Series of Geographies" by James Monteith and Francis McNally. Initially three books in 1856 (priced from 25 cents to one dollar), the series soon grew to four: *Monteith's First Lessons in Geography*, *Monteith's Introduction to Manual of Geography*, *Monteith's New Manual of Geography*, and *McNally's Complete School Geography*.

First Lessons in Geography is around 13 by 18 centimeters in size, running 63 pages with twelve color maps and a small illustration on most pages. These 1850s books were relatively inexpensive to produce, printed by wood engraving and hand-colored with watercolor stencils.[1] The catechistic style of the text and Monteith's illustrations are consistent with his later work, but the maps in this first generation include none of the amplifying symbols and devices Monteith later employed. In this period Monteith had not yet found his own approach to explanatory cartography.

SECOND GENERATION

By 1866 the Barnes geography series had grown to five books, adding *Monteith's Physical and Intermediate Geography* as a more detailed accompaniment to his three introductory texts, though *McNally's Geography* remained the "advanced" option. The 1866 edition was larger, measuring 24 by 30 centimeters, with many more maps and illustrations in its 90 wood-engraved pages.

1. I am grateful to Ms. Karen Cook, Special Collections Librarian at the University of Kansas, for examining a number of Monteith textbooks and sharing her expertise on the printing and coloring techniques.

These second-generation Monteith textbooks, mostly from the late 1860s, begin to introduce limited examples of his innovative comparative techniques and marginal symbols. Monteith was clearly experimenting in this period with new ways of making the reader draw connections between an individual map and distant areas beyond the map's extent. These include bands of comparative extent and two different methods of showing foreign areas compared to more familiar geography in the United States. However, these elements are isolated, used inconsistently, and are not as refined as seen in Monteith's later work. World maps added in this generation chart data on climate trends and ocean currents, the best example of the influence of Matthew Fontaine Maury on Monteith.

One characteristic of this generation of textbooks is the inclusion of a variety of sophisticated cross-sections. Some of these are derivative of other cartographers, including the terrain diagrams used by McNally, Willard, and Woodbridge. However, many of Monteith's cross-section diagrams bring much finer detail and compelling context, such as his depiction of the Great Lakes, which shows their configuration, elevation, depth, and the location of key cities and landmarks (see Figure 4).

THIRD GENERATION

Various editions of *Physical and Political Geography* and *Comprehensive Geography* produced in the 1870s are some of Monteith's finest work. Commercially successful and published in many regional editions, copies of *Comprehensive Geography* are still available to collectors today.[2] This is a confusing generation of textbooks to sort out: not only are there many different names and versions of each title, but this was also a period in which Monteith was making great strides with his own style, and the subtle differences between editions from the early 1870s and the late 1870s reveal important refinements. Although they do not exhibit the full maturity of his style, these editions again grew larger (25 cm by 32 cm) and are packed with maps and inventive diagrams. The larger format is consistent with a trend Patton (1999, 11) identifies in geography textbooks of the period, which grew from an average size of around 258 square centimeters in the 1840s, to 451 square centimeters in the 1860s, and 645 square centimeters in the 1880s. The quality of the printing and color alignment are notably improved in this generation, which made a shift from wood engraving to cerography (wax engraving). These editions were around 100 pages, plus any

2. It is not clear when the transition from *Physical and Political Geography* to *Comprehensive Geography* took place, but the two titles are very similar in scope and content. More copies of *Comprehensive Geography* are available from book dealers; *Physical and Political Geography* was produced first, with a stated copyright of 1866, although the edition studied for this article was revised sometime after 1875. This dating is based on a printed notation pertaining to Stanley's 1875 claims about the source of the Nile. Monteith may have plotted the source—which is off by hundreds of miles—from a preliminary newspaper account, as Stanley published his detailed maps in 1878.

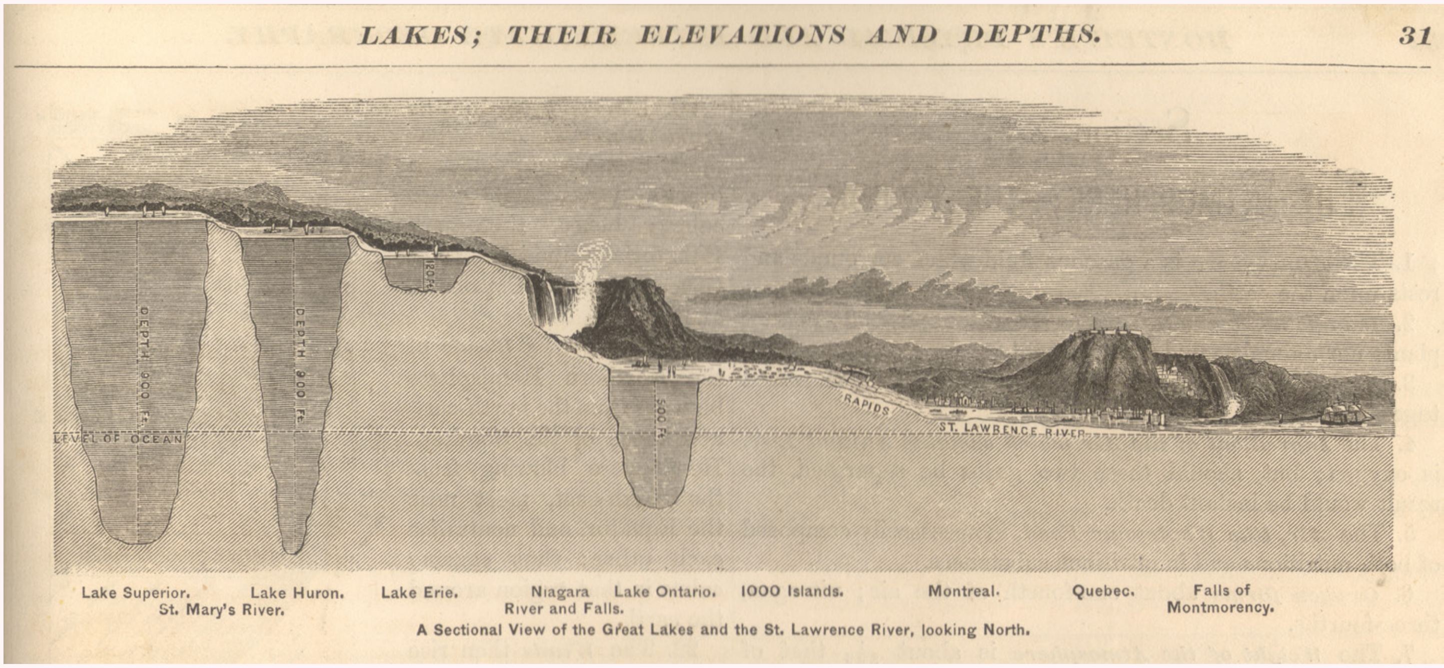

Figure 4. Diagram showing the configuration, depth, and context of the Great Lakes and the St. Lawrence River watershed, circa 1866.

regional edition supplement, and printed on a thicker and rougher, probably rag, paper.

These editions also include a commitment to making the geography student into an amateur cartographer by offering detailed exercises on map drawing. These exercises in the third-generation Monteith texts resemble those published by Guyot in the 1860s: they assign letters to key vertices and direct students to connect these points with lines of defined length to create a framework within which the amateur cartographer can fill in natural contours. Some editions of the 1876 *Comprehensive Geography* in this generation included a globe-making exercise in an appendix, with colored gores to be cut out and pasted together by the student (Monteith 1876). The gores themselves were drawn by the German-American cartographer Joseph Schedler who began his career in New York around the same time as Monteith. This edition also included an advertisement for "Monteith's globes," although these appear to have been rebranded Schedler globes for what was probably a brief collaboration in the 1870s, based on a review of advertisements and Schedler's *Illustrated Manual for the Use of the Terrestrial and Celestial Globes* (1878).[3]

FOURTH GENERATION

Editions of *Barnes's Complete Geography,* the primary Monteith textbook published after 1885, show the full evolution of Monteith's late style, which will be discussed further below. Versions of this book stayed in print for more than three decades. These editions kept the large (25 by 32 centimeter) size of the third generation, and ran to 140 pages before any special regional supplements. They also feature a thinner paper with a slight gloss, reflecting a possible shift to wood pulp paper, a major change in American publishing technology that began to take hold in the 1870s (Valente 2010).

During this period, A. S. Barnes continued to publish a range of different textbooks for different classrooms. Even though Monteith's advanced books had grown more and more sophisticated, he also continued to author introductory texts during this period, such as *Barnes's Elementary Geography*. These are smaller (20 by 25 centimeters, 96 pages), with only 15 color maps, and less amplifying detail on the maps, but there are some clear efforts to employ Monteith's comparative techniques, even in the simpler editions.

Most of the large maps from these editions indicate a copyright of 1885, with some noting revisions in 1890, the year of Monteith's death. In 1890, A. S. Barnes and many other textbook producers were acquired by the American Book Company, which led to the blending and adaptation of work by many cartographers, illustrators, and educators in this period.[4] The American Book Company gained the copyrights to and continued to publish Monteith's maps, with minimal revisions (changes to titles and attribution) well into the twentieth century. Mutual imitation and influence were rampant in American textbooks throughout the nineteenth century, and many books bearing Monteith's name after his death were corporate products with illustrations and some reference maps sourced from other artists and cartographers. For example, the geography texts authored by Jacques Redway and published by E. H. Butler and Company and the American Book Company overlap closely with the Monteith/Barnes series and include some identical illustrations, as well as some—but not all—of Monteith's comparative elements (Redway 1887). The latest Monteith edition that I have identified is a 1916 revision of *Barnes's Complete Geography*, which still lists Monteith's 1885 copyright, along with additional copyrights to the American Book Company in 1896 and 1914. Despite the corporate rebranding and the mingling with others' work, there is a recognizable style that Monteith perfected around 1885, and which endured after his death.

BRINGING ELEMENTS TOGETHER AND PACKING THE MARGINS

As stated above, the devices that Monteith used had emerged slowly and separately but were all in use in some form in the 1870s and, by 1885, Monteith had integrated all the pieces into the unique late style of his

3. Only some editions of *Comprehensive Geography* included the globe-making appendix, but this 1876 printing has other characteristics of a deluxe edition, such as color versions of maps that appear only in black and white in similar editions.

4. The Special Collections Research Center at Syracuse University holds the archives and business records of the American Book Company, a valuable source on textbooks and textbook publishers from the late nineteenth century. See **library.syr.edu/digital/guides/a/amer_book_co.htm**.

fourth-generation books (as listed earlier in the section "Evolution of Monteith's Style"). This style is best represented by the widely produced *Barnes's Complete Geography*. Some early editions in this generation were titled *Monteith's Complete Geography*, but the Barnes-branded editions were produced in large numbers and are still widely available to collectors. The Barnes-branded editions still bore James Monteith's name on the title page and included his copyright.

Monteith steadily added more and more details and comparative data to his maps over the course of his career, mostly through creative use of the margins. But he did so without clutter—indeed there is a modernist aspect to his later work, in that it is highly functional, with no wasted ink on the page. The margins are packed with fine lines, but only with information and not decorative adornments.

COMPARATIVE EXTENT AND LATITUDE

Comparisons of latitude appear in the margins of some of Monteith's earliest maps, and he continued to include this element throughout his career. The 1866 *Physical and Intermediate Geography* includes colored marginal bands to depict the relative extent of other regions at comparable latitude, as in the case of the vertical margins of the Europe map, or regions of comparable east-west extent, as in the Africa map. Occasionally maps in the late 1860s editions use both (see Figure 5), which is confusing to the map reader since the symbology is actually different, showing two pieces of data (latitude and extent) on the vertical but only one (extent) on the horizontal. Perhaps due to this contradiction, Monteith's later maps employ the horizontal margins only for the longitudinal span of the adjacent map.

Editions of Monteith's *Comprehensive Geography* from the 1870s make heavy use of comparative latitude and extent in the vertical margins, but also, in a foldout map of the United States, include a detailed column aligning nearly forty world cities with their comparative latitudes. These editions also include several examples of a graphic symbol within the marginal band. These rare symbols, scattered around individual maps in different editions, go beyond a simple geometric point symbol for a city and show the stylized shapes of distant mountains, lakes, capes, and straits (see Figure 6).

The 1870s textbooks also introduce other marginal devices on a "Physical and Commercial Chart of the World," which charts "Number of Miles in a Degree of Longitude" in the left margin and "Longest Day and Night at Different Latitudes" in the right margin (Monteith 1872). Abstract and not as intuitive as other techniques, Monteith seemed to move away from these experiments: later editions of a similar chart include more inventive symbology and only the number of miles in a degree of longitude remained, as tiny numbers in the right-hand margin. The technique of

Figure 5. Detail of a second-generation Monteith map using both the horizontal and vertical margins to show comparative extent, but in different ways, circa 1866.

Figure 6. Detail of left and right margins of a map of Maine at the 46th parallel, which, beyond the borders of Maine, also passes near Mont Blanc and Trieste far to the east and the Strait of Mackinaw (sic) and the mouth of the Columbia River far to the west. From the 1872 New England edition of *Comprehensive Geography.*

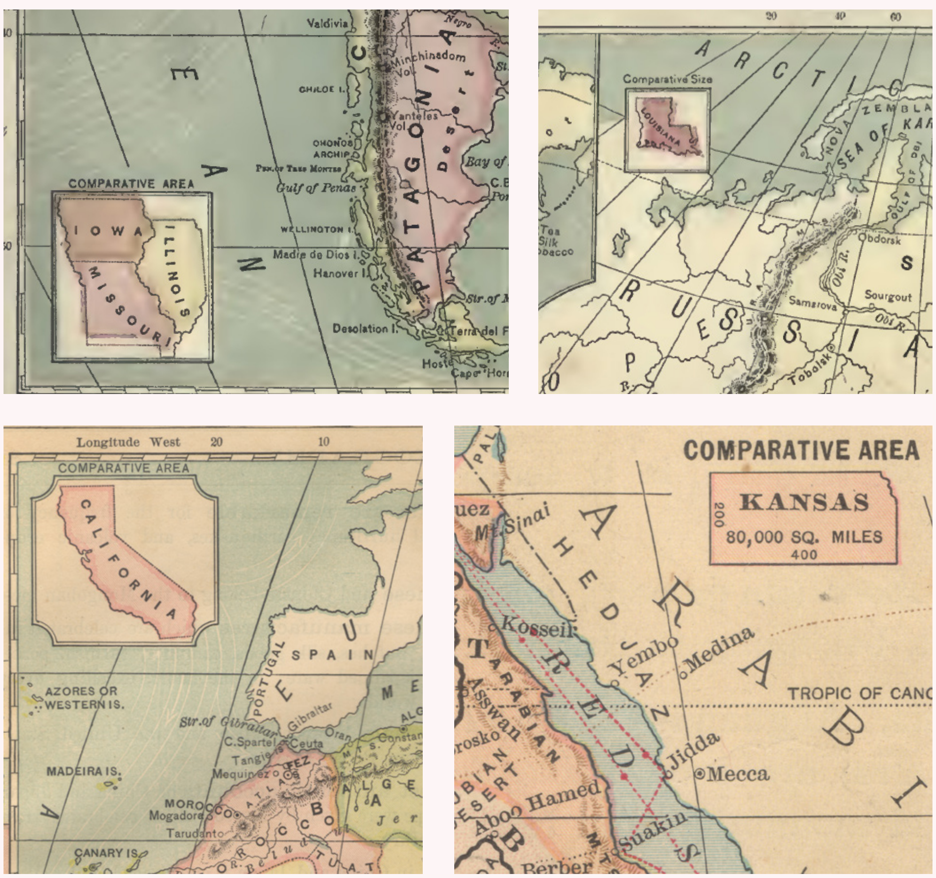

Figure 7. Outlines of US states used as comparative area symbols. Monteith started making area comparisons to states in the mid-1860s, but did not begin using these symbols until the late 1870s, experimenting with different states, and groups of states, before finally settling on Kansas as the standard comparative area symbol.

locating cities at comparable latitude appears in some other textbooks of the period, but all of them later than Monteith and on a more limited scale (Redway 1887; Frye 1906).

After experimenting with a variety of different techniques, Monteith's fourth-generation style settled into using the horizontal margin for the adjacent map and using the vertical margins for comparative latitude and extent, as well as comparative temperature (which connected to temperature isolines crossing through the map; see Figure 2).

COMPARATIVE AREA SYMBOLS

Several of Monteith's marginal devices were in use before he began making maps, but the one that is most characteristic of his work may also be the most original: the comparative area symbol. Monteith had a clear interest in helping map readers understand the comparative area of different regions of the world early in his career. As noted above, Monteith first published a map explicitly comparing US states to foreign countries and regions in the second-generation textbooks in the late 1860s. This practice became commonplace in geography textbooks in the late nineteenth century but it is not clear that anyone did it before Monteith. Patton (1999) notes the trend in his review of nineteenth-century geography textbooks but does not identify when the technique started or who originated it. Monteith experimented in the 1870s with using many different states—occasionally the entire United States—as comparative outline symbols (see Figure 7). These comparative symbols generally appear on regional or continental maps using conic or polyconic

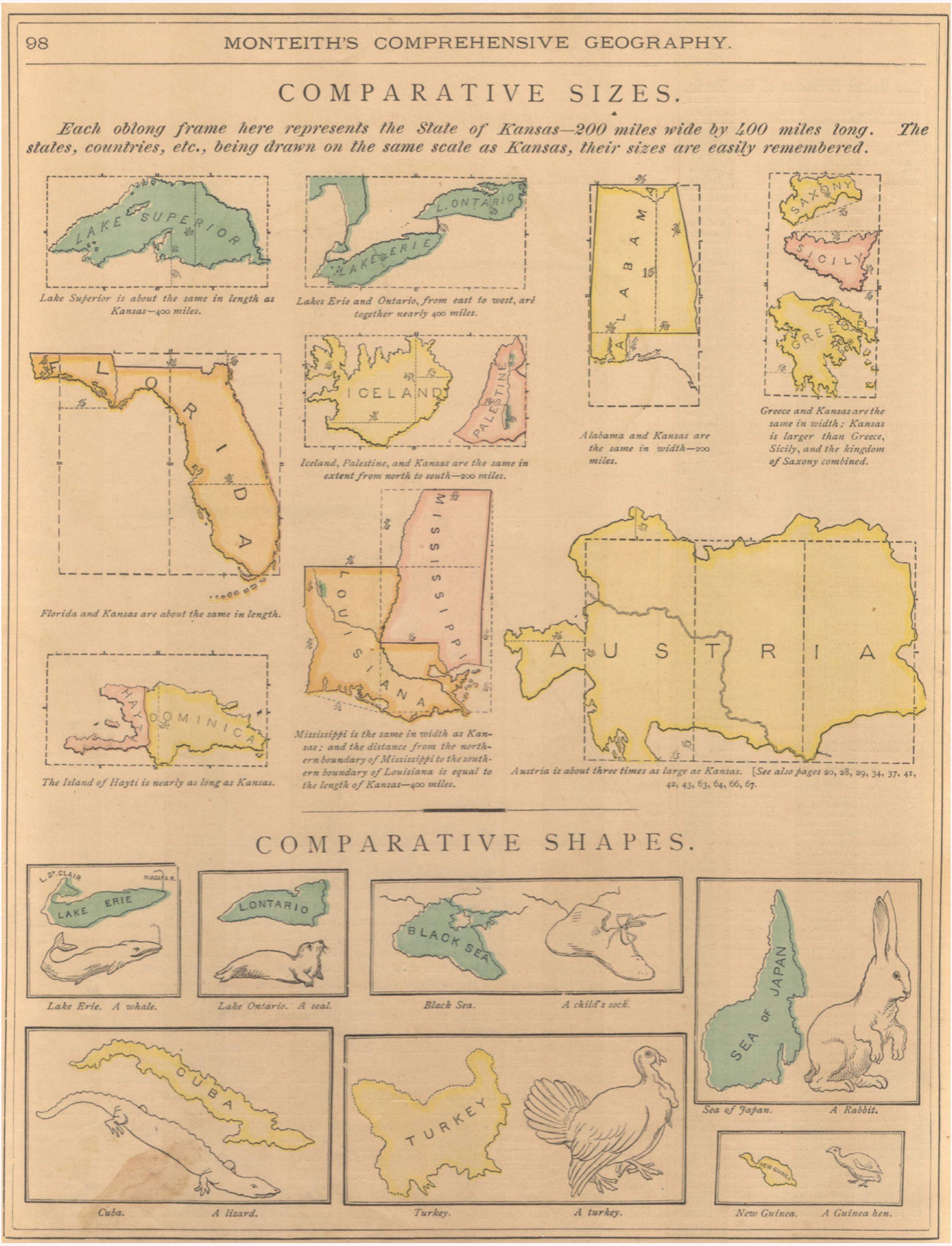

Figure 8. This remarkable page of comparative shapes and sizes appeared in several editions of *Comprehensive Geography* in the 1870s, although only some were printed in color. The comparisons range from technical to playful in helping the reader to study, memorize, and reproduce map shapes.

projections that do not preserve area. Since Monteith provided no details about the projections for the map or symbols, the accuracy of the comparisons is uncertain and serves only as a general heuristic.

Starting in the 1870s, Monteith developed a particular fixation on the state of Kansas as a standard comparative metric. In his 1870s *Comprehensive Geography* he reveals his thinking in detail, using the outline of Kansas as an "oblong frame" to remember the sizes of geographic features and even a means to master these shapes by drawing them (Monteith 1872). He uses the easily remembered 200 × 400 mile outline of Kansas no fewer than 26 times in this edition, sometimes rotated or sometimes multiplied: drawing Lake Superior inside one Kansas or Austria around the outlines of three upright Kansases (see Figure 8). The fixation on Kansas is interesting because few of Monteith's students, and few Americans in general in the nineteenth century, would have visited Kansas or have a personal sense of its size. The direct comparative symbol is nonetheless effective in showing how vast Africa, or a part of the Pacific Ocean, is next to Kansas. Monteith wished to have a uniform symbol for use across the entire book, instead of a different state-symbol on each map, and Kansas proved useful as a standard of measure.

By contrast, Monteith did not commit to his experiment in his third-generation textbooks of comparative shapes. In contrast to the plain rectangle of Kansas, and perhaps to compensate for his fixation on a single geometric shape, Monteith suggested comparing the shape of geographic features to familiar objects. An amusing effort, but less compelling than his other comparisons, these editions suggested remembering that the shape of Cuba resembles a lizard and the Sea of Japan looks like a rabbit (see Figure 8).

MULTIPLE SCALE BARS SHOWING TIME AND DISTANCE

Time scale bars are a useful and inventive element that appear in later Monteith maps and were ideally suited to the rapid growth of rail and steamship travel in the late nineteenth century. As the editors of the recent book *Time in Maps* point out, static maps do not often intentionally depict time, but when they do, the results are often surprising and versatile (Wigen and Winterer 2020, 6–7). Communicating practical knowledge through common

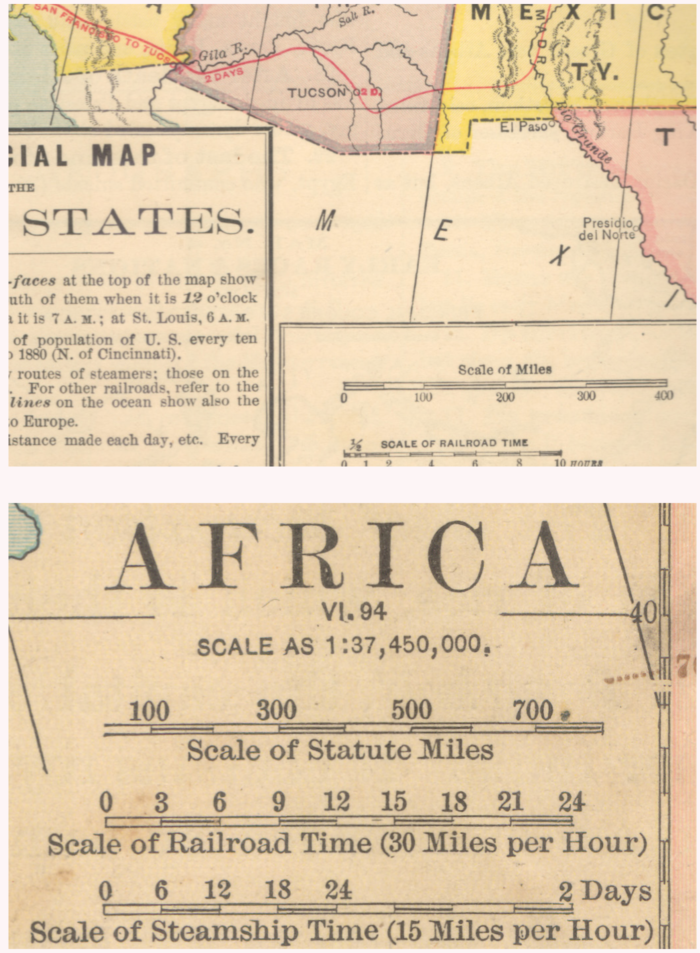

Figure 9. Time scale bars. *Top*: Railroad time on an 1870s map of the United States, *Bottom*: Triple scale bar typical of Monteith's late maps, which remained in use for many years after his death.

analogy, alongside the abstract map, is consistent with Monteith's educational approach. Adjacent to a scale bar of abstract units, Monteith placed a scale of railroad time (in hours) and steamship time (in days). Thus, the map reader could more easily grasp how long it would take to travel across the area in Monteith's map without having to make their own calculations and assumptions. Although a simple addition to the legend, these time scale bars explicitly highlight the linkage between space and time that is left unstated by most maps, past and present.

The bars first appear in some of Monteith's maps in the late 1870s, where a scale of "railroad time" appears together with, and in the same style as, the traditional scale bar of statute miles.[5] In many of the fourth-generation maps, Monteith uses three scale bars together: statute miles, railroad time, and steamship time (see Figure 9). As noted above, Monteith did not indicate the details of

5. The earliest example that I have been able to identify to date is in the regional US maps from an edition of *Comprehensive Geography* with a stated copyright of 1872. However, there is considerable variation among editions of *Comprehensive Geography*, and the railroad time scale bars do not appear in all of them.

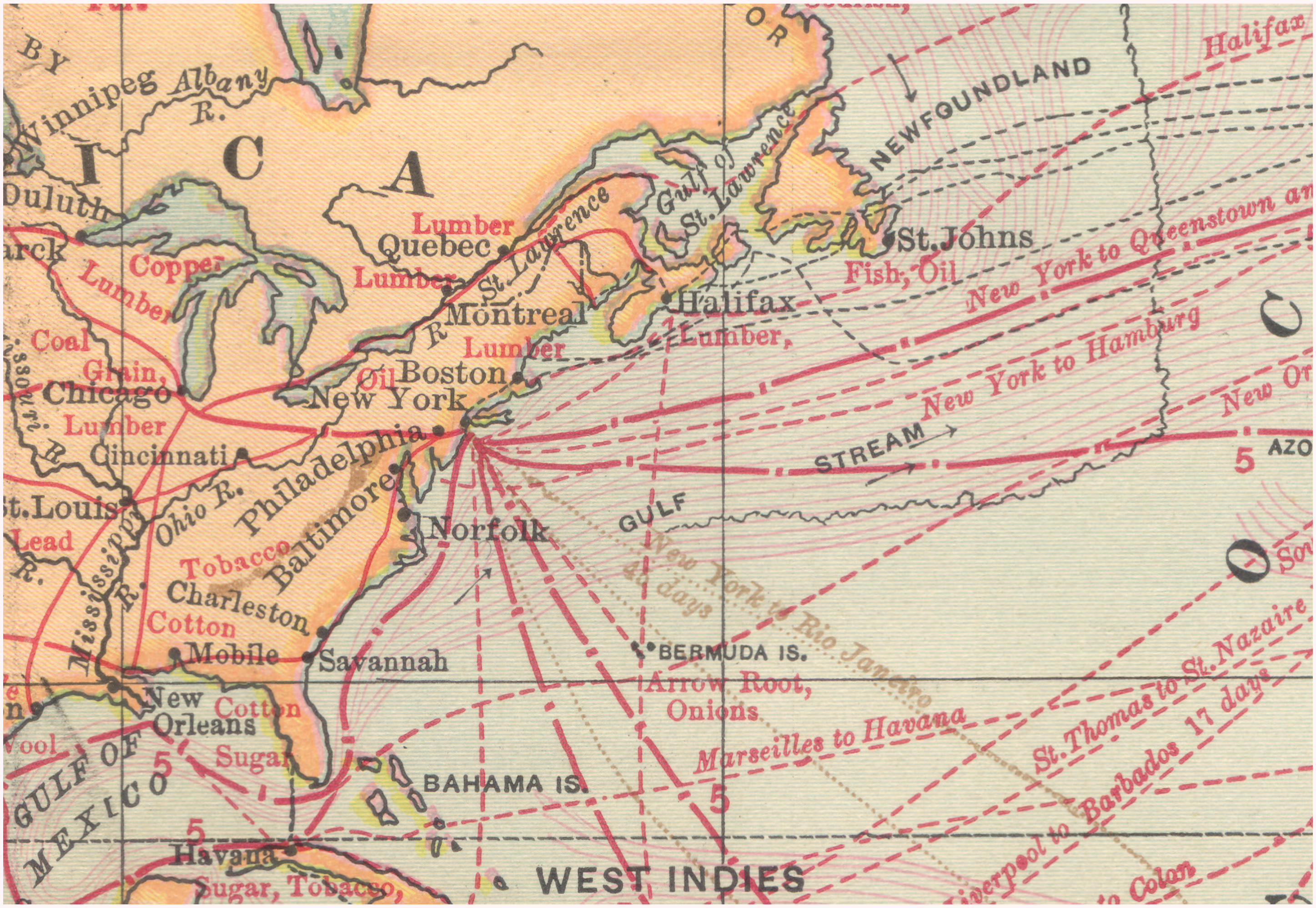

Figure 10. Detail of a "Physical and Commercial" world map from an 1885 Monteith textbook showing steamship and railroad routes in red, with tick marks denoting the distance traveled in one day and numerals for every fifth day. Finer black lines in the background show sailing ship routes and submarine cables. Later revisions of this map, appearing in *Barnes's Complete Geography* after Monteith's death, eliminate the sailing routes and the numerals for elapsed travel time.

the projections that he used, nor the standard lines along which these scales would be accurate.

In addition to the scale bars, Monteith's "commercial" maps of both the world and the United States bring time scales onto the main body of the map, showing rail and steamship travel routes either with marked divisions in the lines for elapsed time in days or hours, or using a dashed line in which every segment represents one day or hour of travel. The "Physical and Commercial Chart of the World" from the post-1885 editions also captures an interesting moment in the evolution of global shipping; it displays, with different symbology, the routes taken by commercial sailing ships in contrast to the more direct routes taken by steamships (see Figure 10).

TERRAIN CROSS SECTIONS

Nineteenth-century cartographers had many different techniques for depicting topography, but Monteith used no tints or contours to show elevation in his maps, and used hachures very sparingly to show mountain ranges. Nevertheless, he encouraged careful consideration of terrain and separately included a number of unlabeled shaded relief maps and the aforementioned oblique views with exaggerated terrain (Figure 1). Monteith's clear preference for emphasizing the terrain of his color reference maps was the terrain cross section. Wolter (1972) states that the profile technique may have been used as early as dynastic Egypt, but entered widespread use in the eighteenth century with French sea-level diagrams of islands, and English canal plans. The influence of Humboldt was key to popularizing this technique: multiple terrain cross sections were featured in German atlases of the early nineteenth century, and they appeared in American geography textbooks by the 1840s, such as Woodbridge (1844). The way McNally used cross sections in the 1850s suggests it was his influence that started Monteith onto the path of including so many of them (see Figure 11). Monteith's interest in capturing the terrain variation across a large east-west extent is also in evidence with his wide-angle oblique illustrations. These views are impossible and deliberately distorted, but nonetheless compelling for showing how all of the mountain ranges, rivers, and cities of an entire continent relate.

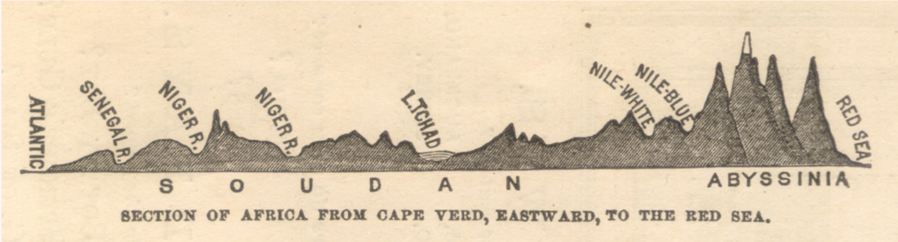

Figure 11. A monochrome terrain cross-section of Africa, typical of Monteith texts from the 1860s. These diagrams, which were not always attached to a map or inside the neatline, appeared in many atlases and geography textbooks in the mid-nineteenth century.

Monteith had two particular emphases with the terrain cross-sections: he placed them in the bottom margin to align with the main body of the map, and he wanted students to draw them. While in the 1870s editions of *Comprehensive Geography* he overlays the cross-sections (or multiple sections) directly atop a continent in the map drawing exercises (see Figure 12), Monteith in the post-1885 books like *Barnes's Complete Geography* regularly includes the regional or continental cross section, along with a minuscule scale of the exaggerated elevation, in the bottom margin. Placing the cross section in the margin and aligning it with the main body adopts the same technique he used for comparative latitude in the vertical margins. Indeed, the later Monteith maps include both a terrain cross section and multicolor bar showing east-west extent of the areas in the main map (see Figures 2, 13, and 14).

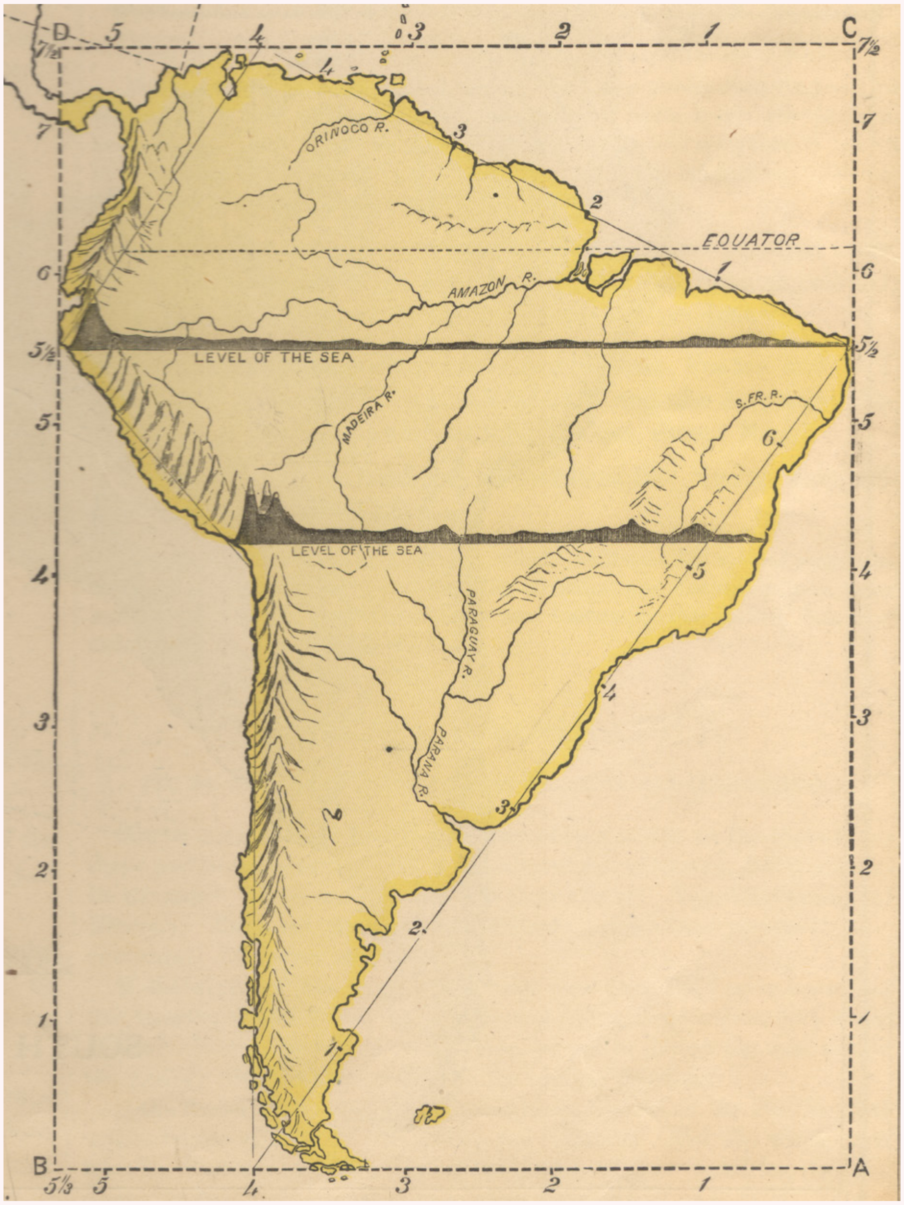

Figure 12. These map drawing exercises appeared in Monteith textbooks in the 1870s. Such cross-sections, often at multiple latitudes, had been in use for decades, but Monteith placed greater emphasis on aligning them with the map.

CONCLUSION

It is not clear that Monteith had any training in technical cartography: his fourth-generation textbooks

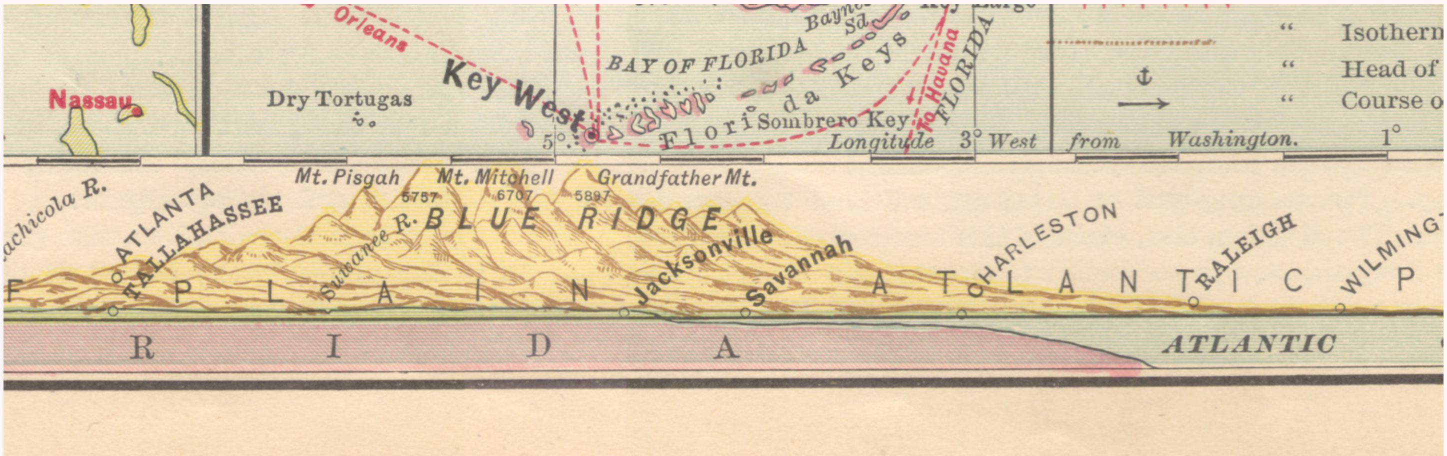

Figure 13. A detailed terrain cross-section in the bottom margin, aligned in longitude with the base map, typical of fourth-generation Monteith maps. Monteith's cross-sections grew more refined over time, and versions after 1885 were rendered with shading, depth, rivers, and cities.

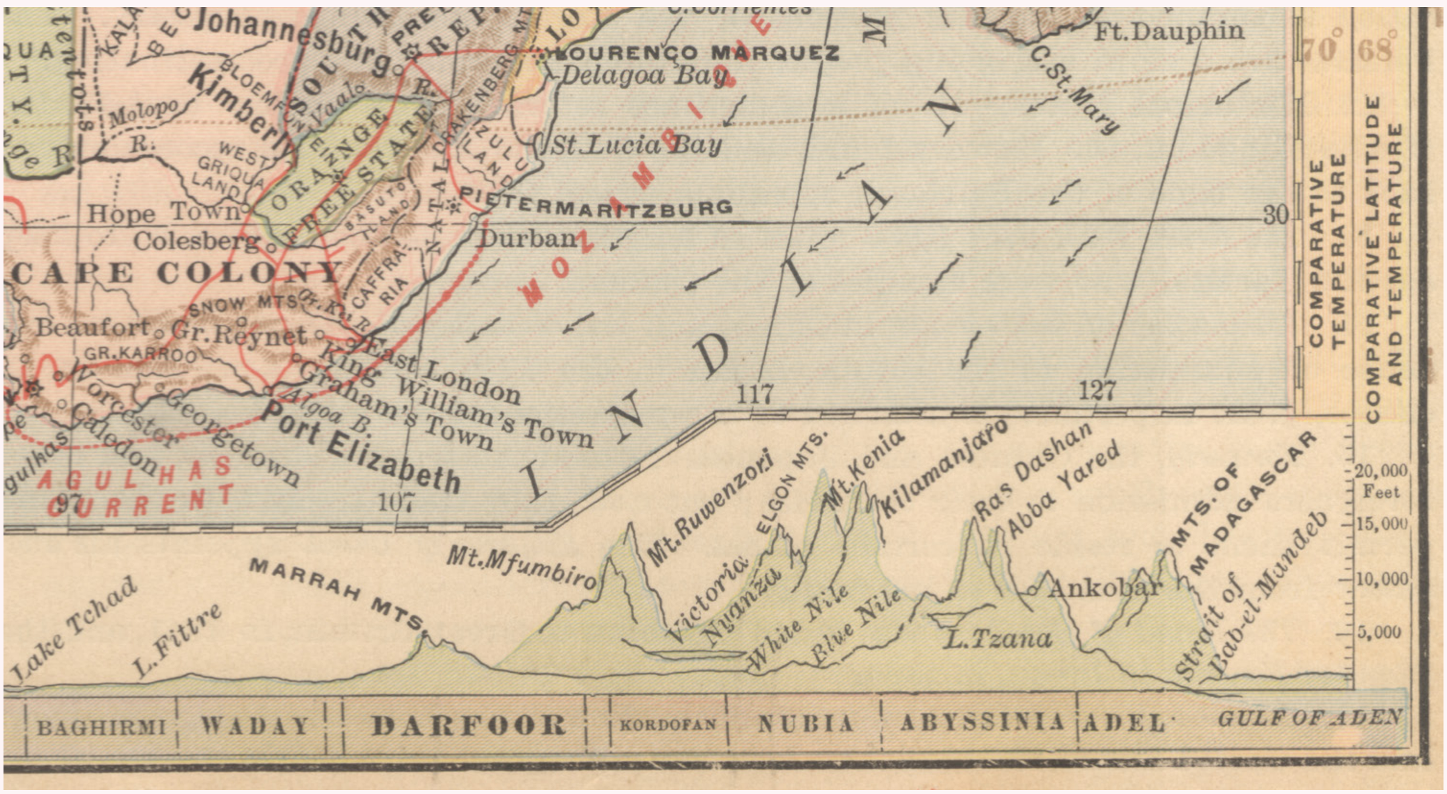

Figure 14. Detail from a full-page Africa map, circa 1890, with the densely-packed margins typical of late Monteith maps. Note the terrain cross-section aligned to the horizontal extent for the map, with twin bars for comparative latitude and temperature in the right margin.

briefly discuss the differences between conic, polyconic, and Mercator projections, but many of his comparative techniques fail to account for how those projections distort area or distance. Monteith never employed equal area or equidistant projections, nor does he indicate that his comparative area symbols or time scale bars would be accurate only for portions of the map. Despite any technical shortcomings, the way Monteith framed and contextualized maps added greatly to their value as teaching tools, and he surrounded them with more and more beautiful detail as his style developed. His evolution towards packing the margins also helped Monteith avoid one common pitfall of nineteenth century mapmaking: cluttering the main map with a plethora of small, hard-to-distinguish symbols (Robinson 1982, 17).

Monteith's style clearly represents his focus on educating the general reader through maps. He experimented with simple, practical techniques to help his reader think about geography, and refined his methods to create visually compelling texts that remain engaging today. Monteith's work invites us to explore many comparisons within and across the maps in each book. Such study is more engaging than that encouraged by school atlases produced a century later. As Castner wrote in 1997, "[t]here is little evidence that our twentieth-century atlases actually encourage, in their design, any user goals, other than the rather simplistic activities of 'looking up' various place-names or other geographic facts" (410).

Many aspects of Monteith's maps were basic and unoriginal, and there was nothing obviously revolutionary about his geography books. Yet, his cartographic style was more than the sum of its parts. His margins offered more than mere exuberance or ornamentation, relying on inventive symbology and comparative techniques to help the reader better understand the world. Unfortunately, none of what Monteith included in his margins remains in common use today. John Wolter laments, after tracing the evolution of some nineteenth-century diagrams similar to those in Monteith's geographies, that "we will, however, probably never again see the elaborate, exuberant, and colorful illustrative plates that were so popular a hundred or more years ago" (1972, 200).

Mapmakers now have access to data and visualization tools that Monteith couldn't have imagined, but today's challenges of mapmaking have less to do with assembling details and ensuring the accuracy of the maps, and more to do with what they can tell us about our world. Monteith's tools may have been imperfect, but these are challenges that he understood well: challenges that he met with inventive cartography. Modern software's ability to manage projections and layer data make trivial the handling of technical inaccuracies in Monteith's comparative symbology. But the way that Monteith's maps draw the eye to those comparative symbols and contextual margins makes today's typically unadorned maps seem bleak. Not only has James Monteith largely been forgotten, but his maps brought together an array of largely forgotten techniques. These techniques of Monteith and his contemporaries merit further study: modern cartographers could learn from this master of the margins and use their powerful cartographic tools and rich data sets to adapt his style to the twenty-first century.

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A Comparison of Feature Density for Large Scale Online Maps

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Large-scale maps, such as those provided by Google, Bing, and Mapbox, among others, provide users an important source of information about local environments. Comparing maps from these services helps to evaluate both the quality of the underlying spatial data and the process of rendering the data into a map. The feature and label density of three different mapping services was evaluated by making pairwise comparisons of large-scale maps for a series of randomly selected areas across three continents. For North America, it was found that maps from Google had consistently higher feature and label density than those from Bing and Mapbox. Google Maps also held an advantage in Europe, while maps from Bing were the most detailed in sub-Saharan Africa. Maps from Mapbox, which relies exclusively on data from OpenStreetMap, had the lowest feature and label density for all three areas.

KEYWORDS: Web Mapping Services; Multi-Scale Pannable (MSP) maps; OpenStreetMap; Application Programming Interface (API)

INTRODUCTION

One of the primary benefits of using online map services like those available from Google, Bing, and OpenStreetMap, is that zooming-in allows access to large-scale maps. Maps at these large scales are not available to most (if any) individuals from any other source. The features and labels that are included on these large-scale maps are an important indicator of both the completeness of the underlying database and the conversion process from data to map.

Online mapping services all rely on vector databases composed of point, line, and area features, along with feature attributes. When using these services, we view a version of the vector data, rendered appropriately for the scale. The rendering process involves the scale-dependent generalization and symbolization of the spatial data, and subsequent tiling (Clouston and Peterson 2014). Rendered map tiles can then be zoomed and panned from side-to-side, producing what we refer to as multi-scale pannable (MSP) maps (Peterson 2015; 2019).

Since the introduction of the technique in 2005 by Google, all major online map providers have adopted the same underlying technology. Vector data is projected and divided into vector tiles at multiple scales. The tile boundaries are identical between all mapping services. The maps vary only as a result of differences in the underlying vector database, and the generalization / symbolization used in their rendering.

MSP maps from the major online providers receive considerable use, and it is therefore important to evaluate the quality of the maps provided by these services. In this paper, my evaluation method centers on examining the density of both features and labels at the 19th zoom level for three online map providers: Google, Microsoft, and Mapbox. This zoom level was chosen because, when examining large-scale maps from these services, it can be observed that no new features are added above the 19th zoom level. While features are made larger at larger scales, additional features are not being added to the display. This seems to be true even in more densely populated urban areas where competition for map space would normally result in a selection of displayable features.

By assessing the density of features and labels for a set of randomly chosen locations, the findings reveal which of these online map providers has made the greatest effort to offer detailed large-scale maps.

ORIGINS OF THE MAP DATA

As we are evaluating differences in the underlying vector databases between these online mapping services, it is important to understand their origins. There are essentially three different types of sources that MSP map providers can draw upon: (1) a governmental agency, such as a city, state, or federal entity; (2) a proprietary database, as created by Google, TomTom, HERE, and others; or (3) a public-domain database based on crowdsourcing, as created by OpenStreetMap (OSM) and Wikimapia. The distinctions between these are becoming increasingly fuzzy as local governmental agencies provide data at no cost to commercial entities such as Google. The same agencies may also contribute to OSM, a service that itself relied initially on data made freely available by some governments, notably the United States. Some commercial mapping entities, like Mapbox, rely solely on data from OSM.

There are only a few sources of global geospatial data. While governments generally restrict mapmaking to the area within their borders, some governments map foreign lands for military purposes. Not only are military maps kept secret but many governments also keep secret, or charge fees for, maps of their own territories, even in the more developed parts of the world. On the opposite end are crowdsourcing platforms like OSM and Wikimapia that make their data available to anyone (Hall et al. 2010). Both platforms produce a large proportion of their data using satellite imagery, often from Google Earth—a proprietary source. GPS devices are also used to trace roads and pathways. Of the two, OSM maintains a much larger crowdsourced database. This volunteered geographic information (VGI) is made available under the Open Database License (Feick and Roche 2013).

Only a handful of companies collect proprietary global geospatial data, including Google, HERE, and TomTom. Google is fairly new to the world of mapping, introducing Google Maps in 2005 with acquired technology. Initially, Google had spatial data only for the United States and the United Kingdom. It was 2009 before their maps included features for every country (Garfield 2012). Its spatial-data-capturing Street View vehicles have driven more than 10 million miles since 2007 (Mogg 2019), in countries where they have been allowed to drive. Maps from Google are now the most used maps in the world.

In contrast to Google, HERE had its origins in the mid-1980s as NavTeq, a pre-GPS car navigation company. It was subsequently acquired by the Finnish company Nokia in 2007 to provide navigation for its phones, and then by a consortium of German automobile companies, Audi, BMW and Daimler, in 2016 for autonomous car navigation. TomTom has been building a proprietary map database for navigation since 2001. Its Automotive and Licensing division, providing GPS-based navigation for car manufacturers, represents a major part of its business. Like HERE, the company is also based in the Netherlands.

After selling its mapmaking technology to Uber in 2015, Microsoft no longer collects geospatial data. It has instead built business relationships with both HERE and TomTom (Stevenson 2016), even contracting with HERE for map rendering services. Microsoft has been using the Bing moniker for many of its services, including maps, since 2009.

Mapbox has become a major player in online mapping. It classifies itself as a developer platform only and does not provide a publicly available MSP map. The only way to view Mapbox-rendered tiles is to use the Mapbox Application Programming Interface (API). It is completely reliant on OSM for its map data (Bliss 2015). Figure 1 shows two pairwise comparisons between OSM and Mapbox-generated maps. While the symbolization varies, the comparisons clearly demonstrate that they have identical features and labels and are based on the same vectors.

Figure 1. Two comparisons between OpenStreetMap (left) and Mapbox (right) demonstrating that Mapbox relies exclusively on data from OpenStreetMap. The maps are based on identical vector points. The symbolization and labeling vary only slightly.

COMPARING VECTOR DATABASES

While evaluations of the accuracy and completeness of vector databases are a major area of research, they have unfortunately been limited to assessments of VGI. Since it is not possible for researchers to obtain proprietary vector data, they have focused on comparing crowdsourced data with government sources, or have assessed the completeness and accuracy of OSM data using a variety of other indicators such as a ranking of its contributors. The main purpose of this research has been to demonstrate the basic utility of crowdsourced spatial data (Flanagin and Metzger 2008). This is analogous to previous research that examined the validity of Wikipedia pages as compared to published encyclopedias (Okoli et al. 2012). The primary comparisons that have been made are between OSM and so-called "authoritative" spatial data, usually government databases like Britain's Ordinance Survey and Germany's ATKIS (Haklay 2010; Fan et al. 2014; Zielstra and Zipf 2010; Wang et al. 2013). Jackson et al. (2013) propose a method for quantifying the completeness and accuracy of volunteered geographic point datasets using a national geospatial dataset as the reference.

A number of studies have examined OSM data quality for a particular country or region. Arsanjani and Vaz (2015) assess the accuracy of its land use classifications in seven large European metropolitan regions. Siebritz and Sithole (2014) assess the quality of OSM data in South Africa with reference to national mapping standards. Zhao et al. (2015) implement a statistical analysis of OSM data for Beijing, China. Corcoran, Mooney, and Bertolotto (2013) examine the growth of OSM street networks in Ireland and demonstrate that two elementary spatial processes of *densification* and *exploration* are responsible for increasing the density of information and expanding the network into new areas. Girres and Touya (2010) assess data for France based on geometric, attribute, semantic, and temporal accuracy; logical consistency, completeness, lineage, and usage; and different methods of quality control. Their study raises questions about heterogeneity of processes, scales of production, and contributors' compliance to standardized and accepted specifications. They suggest that in order to improve data quality, there needs to be a balance between the contributors' freedom and their respect of specifications.

Another area of research has examined approaches to defining and measuring spatial data quality. Ciepłuch, Mooney, and Winstanley (2011) suggest generic quality indicators for OSM. Barron, Neis, and Zipf (2014) present a framework containing more than 25 methods and indicators for OSM quality assessments based solely on the data's history. Antoniou and Skopeliti (2015) contribute to the ongoing effort to create a practical method for evaluating data quality. Senaratne et al. (2017) review VGI quality assessment methods. Sehra, Singh, and Rai (2017) present an extension of the QGIS Processing toolbox to assess the completeness of spatial data using intrinsic indicators.

Muttaqien, Ostermann, and Lemmens (2018) propose an intrinsic measure of OSM data quality not based on the data itself but by a measure of aggregated expertise of the contributors. Similarly, Nasiri et al. (2018) suggest an improvement in the quality of contributed data by examining historical contributions of data providers.

Other researchers have compared building footprints, a common feature in large-scale maps. Hecht, Kunze, and Hahmann (2013) examine the spatial accuracy and completeness of OSM footprints using official data from national mapping and cadastral agencies for comparison. They found a completeness rate of about 25% in different German states by 2012. Brovelli and Zamboni (2018) also examine completeness, and Brovelli et al. (2016) implement a process of automatic homologous pairs detection for the same purpose. Törnros et al. (2015) apply two commonly used, unit-based methods to evaluate building completeness in OSM data and find strongly different results depending on the method used. They propose a simple pre-processing of the building footprint polygons that leads to a more accurate completeness estimation for one of the methods.

All of this research has essentially demonstrated the basic validity of OSM data, at least as compared to data gathered by some government entities. Heterogeneity of data collection is a recognized problem, as crowdsourcing favors the more densely-populated area and affluent countries (Bittner and Glasze 2018). As with anything crowdsourced, the quantity and quality of data is a function of the crowd. Where there are few people, there is less data—and fewer to check its quality. Put simply, crowdsourced data compares favorably to government data in spatial accuracy, but it is uneven in coverage.

COMPARING RENDERED MAPS

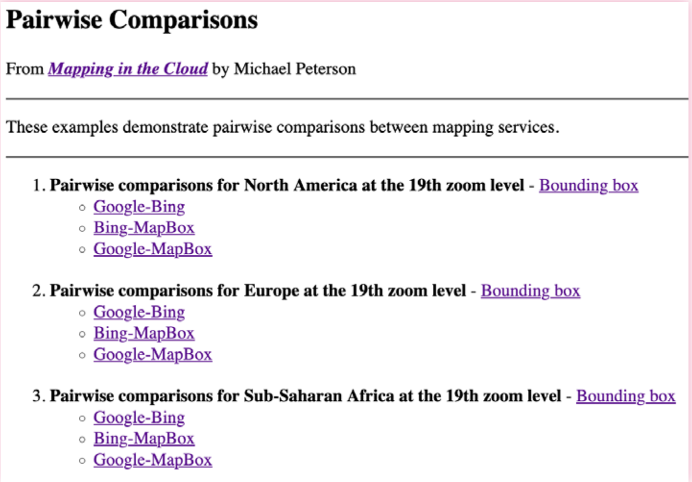
While a number of studies have examined the spatial accuracy and feature density of OSM vector data, rendered maps from online map providers have received little attention. One exception is Boottho and Goldin (2017), who implement an automated approach to assess the quality of rendered maps from different web mapping services. They use the APIs from Google, HERE, MapQuest, and Bing to perform repeatable queries and compare the results to reference data gathered by ground survey and external sources. In a study on a small area in Thailand, they found that HERE had a higher completeness score, MapQuest had the least discrepancy score, and Bing and Google tied for the highest richness score, a measure of feature density. The automated method used for analysis did not examine labeling.

It is important to examine the rendered maps that map users actually see. In order to compare feature and label density, I implement a pairwise comparison of large-scale maps of randomly selected locations in North America, Europe, and sub-Saharan Africa. The advantage of this approach, compared to more automated approaches, is that both feature and label density can be assessed. The pairwise comparisons are implemented through the use of the APIs for Google Maps, Bing Maps, and Mapbox. These three services represent a cross-section of online mapping technology. Google Maps, the most-commonly used online mapping service (Panko 2018), relies heavily on its Street View vehicles for collection of spatial data. Bing Maps is based on business agreements with both HERE and TomTom, two major global spatial data providers. Mapbox was chosen for its exclusive reliance on OSM data.

I have made the tools for pairwise comparison openly available on the web page for my *Mapping in the Cloud* (Peterson 2014) book at **maps.unomaha.community/cloud/code/code10/Pairwise** (see Figure 2). The pairwise comparison approach represents an easy-to-replicate method for comparing mapping services. Comparisons between other mapping services could be easily implemented by integrating their API code. Examining other areas of the world would only require a modification to the bounding box used for randomly selecting points.

My initial attempt at comparing large-scale maps involved the counting of features and labels. For example, Figure 3 shows a comparison between Google Maps and Mapbox for a randomly selected point in North America. Here, the number of labeled features (the road) would be identical, while the map from Google on the left depicts one more feature in total, as it shows a waterway paralleling the road.

However, a particular map service may present a whole layer of information that is not present on another, such as land ownership boundaries (cadastre), building footprints, business establishments, traffic directions, or alternative road names (see Figure 4). When this is the case, the counting of features and labels becomes problematic. For example, each land ownership boundary line segment could be counted as a separate feature.



Pairwise Comparisons

From ***Mapping in the Cloud*** by Michael Peterson

These examples demonstrate pairwise comparisons between mapping services.

1. **Pairwise comparisons for North America at the 19th zoom level** - Bounding box
   - Google-Bing
   - Bing-MapBox
   - Google-MapBox
2. **Pairwise comparisons for Europe at the 19th zoom level** - Bounding box
   - Google-Bing
   - Bing-MapBox
   - Google-MapBox
3. **Pairwise comparisons for Sub-Saharan Africa at the 19th zoom level** - Bounding box
   - Google-Bing
   - Bing-MapBox
   - Google-MapBox

Figure 2. Website for pairwise comparisons at maps.unomaha.community/cloud/code/code10/Pairwise.

While a count of features or labels between the two maps cannot be easily done and may unfairly advantage one map service over another, it is a simple matter to judge that the Google map on the left of Figure 4 has a greater feature and label density. A similar assessment can be made for the two maps in Figure 3. This type of evaluation can be represented by a binary classification: the denser map is assigned a “1” and the other a “0.” Such a binary classification, based on a visual inspection, is the basis of the experiment. I use this method to answer the research questions of how the map services compare in judged feature and label density at the 19th zoom level, and whether this varies by continent.

Figure 3. A pairwise comparison between Google Maps (left) and Mapbox (right) for a randomly chosen location in North America. Google Maps displays a water feature that is missing in the OSM-based Mapbox map. Both services label the road.

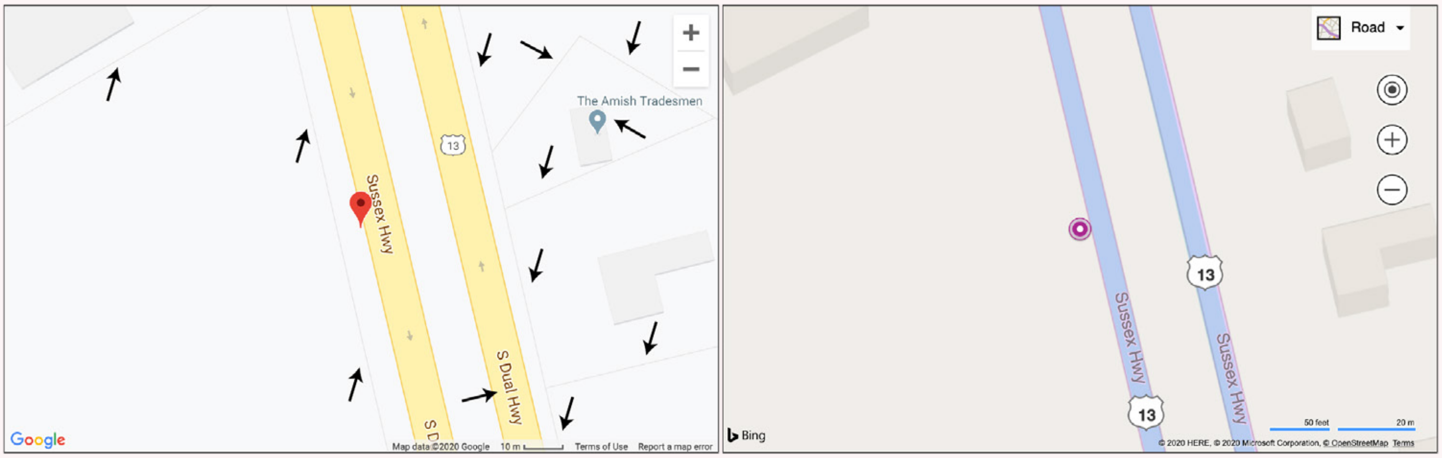


Figure 4. A pairwise comparison between Google Maps (left) and Bing Maps (right) for a randomly chosen location in North America. While both maps include building footprints (extruded with Bing), the map from Google also depicts property boundaries (cadastre), the name of a business establishment, and an alternative name for the highway. None of these features and labels are visible on the map from Bing.

THE 19TH ZOOM LEVEL

The 19th zoom level (also referred to as the 19th Level of Detail) is a very large-scale representation. With a screen resolution of 96 dots per inch, it corresponds to a scale of 1:1128.50 (1 cm: 11.29 m) at the Equator (Microsoft 2018). As a result of the Web Mercator projection used in most MSP maps, the scales become even larger as one moves north and south of the Equator (Lapon, Ooms, and De Maeyer 2020). At 60°N (Shetland Islands in Scotland), the scale is exactly twice that at the Equator, 1:564.25. For a far northern part of mainland Norway, about 71°N, the scale is approximately 1:367.4. Variations in scale will affect the density of represented features, with the smaller scales showing more area and therefore having a greater possibility of features being present. It should be emphasized that these scales given above are only for purposes of comparison. The exact scale of any map presented through the internet varies based on monitor resolution, browser zoom settings, and other factors influencing the display size. Maps presented by MSP map services include only a bar scale, because representative fraction and verbal scales cannot be provided without knowing the final display size of the map on the monitor.

I am evaluating maps at the 19th zoom level since it seems to represent the scale at which all features in the underlying vector database are displayed. It is a zoom level that is not normally accessible to most users of Google Maps, Bing Maps, or OpenStreetMap; the largest scale that is presented on their respective websites is the 18th zoom level. But, when presenting maps through their API, zoom levels are extended up to at least 22, though the maximum zoom level that is available may vary for different parts of the world, and different map types. Because these services charge a cost to use their respective APIs (above a certain number of monthly map downloads), one could say that the value of the API is being evaluated as well as the density of features and labels.

Since the 19th zoom level is so large-scale, a small map of a randomly selected location will most often include no features beyond land or water. Of a random selection of 100 North American locations on Google Maps, only 16 depicted any other features. For Europe, the number was 32. While Europe is more densely settled, it lies further north and therefore the maps would typically be at a larger scale, thus covering less area and correspondingly less possibility of features being present.

The possible features that can appear at the 19th zoom level include roads, paths, railroads, forested areas, rivers, water bodies, political boundaries, building footprints, churches, commercial establishments such as stores or post offices, and land-ownership boundaries. Of these, roads, rivers, and building footprints are the most commonly found. Maps from Google often also include business locations and corresponding names.

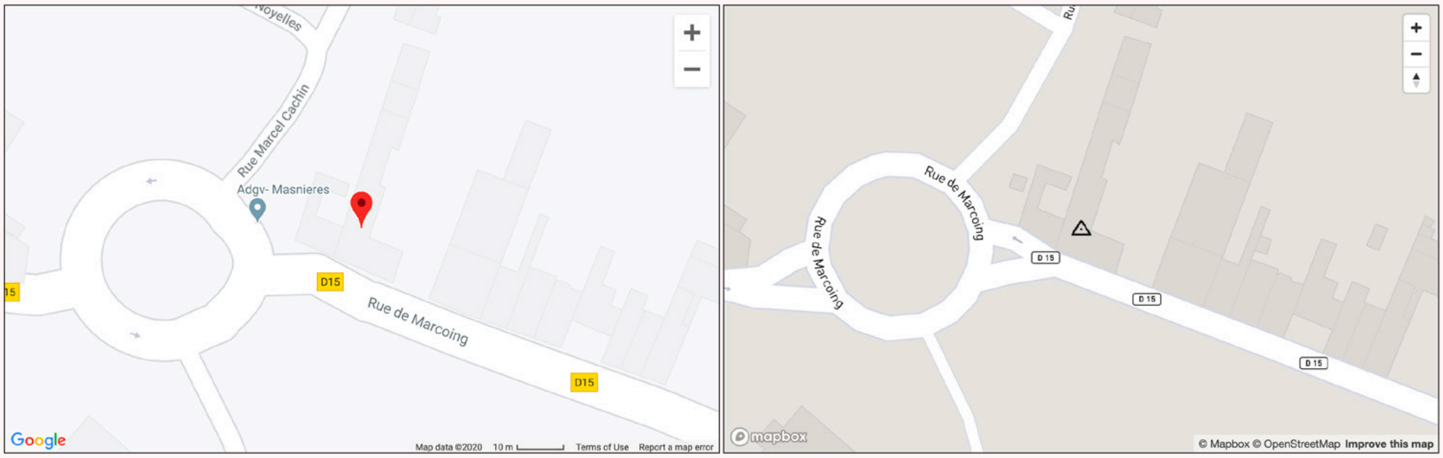


Figure 5. A map from Google at the 19th zoom level (left) compared to one from Mapbox at the 18th (right). The maps are at the same scale. Mapbox uses a different numbering scheme for its zoom levels compared to other online map providers.

The pairwise comparison is implemented by simultaneously displaying maps from two services in a single web page, utilizing each service's API. The two maps show the same exact (randomly chosen) point on the Earth's surface at the same scale. Each map is 800 × 500 pixels, corresponding to what would be easily visible on most mobile phone displays. The different map services that are being compared each offer a variety of named map styles (emphasizing terrain, imagery, roads, etc.). The specific styles being compared are Roadmap from Google Maps, Road from Microsoft Bing, and Streets-v9 from Mapbox. Note that Mapbox labels its zoom levels in a non-standard way. While Google's 19th zoom level matches Bing's 19th zoom level, Mapbox's corresponding zoom level is 18 (Figure 5).

Figure 6. Bounding boxes used for the random selection of locations within North America, Europe, and sub-Saharan Africa.

For each of the three regions chosen for the study (Europe, sub-Saharan Africa, and North America), a bounding box is first defined, covering the central regions while avoiding large bodies of water (Figure 6). To randomly choose a location for comparison within a region, a random point is determined using JavaScript's random number generator, which returns a number between 0 and 1. This value is multiplied by the range of latitude or longitude covered by the bounding box, and then added to the minimum value. For example, the bounding box used for North America has a minimum latitude of 30° N and a maximum of 50° N, for a difference of 20°. If the random number function returns a value of exactly 0.5, the randomly determined latitude is 40° N (0.5 × 20 + 30) — half-way between the latitudes that define the bounding box. Part of the JavaScript code for the random definition of points is shown in Figure 7.

```
var lngSpan = northEast.lng() - southWest.lng();
var latSpan = northEast.lat() - southWest.lat();

    var lat= southWest.lat() + latSpan * Math.random();
    var lon= southWest.lng() + lngSpan * Math.random();
    var location = new google.maps.LatLng(lat, lon);
    var myOptions = {
        zoom: 18,
        center: location,
        mapTypeId: google.maps.MapTypeId.ROADMAP
```

Figure 7. JavaScript code for randomly determining a latitude and longitude within a bounding box. The first two lines determine the `lngspan`/`latspan`, or difference, between the bounding box's latitude and longitude. The `lat` and `lon` values are then calculated by multiplying the `latSpan` and `lngSpan` by a random number (always a value between 0 and 1), and then adding this to the minimum latitude and longitude values. The last four lines interface with the Google Maps API, centering the map on the randomly chosen location.

When comparing maps, differences in symbolization were ignored. For example, a small road may be indicated by a dashed line on one map and a solid line on the other. While these differences were not assessed here, they could be an area for further research. Differences in generalization, however, were considered. For example, the two maps in Figure 8 feature different levels of detail in the coastline. This may be a result of either a less detailed database, or a line generalization process taking place during rendering. The coastline is clearly more detailed on the Bing map (on the right), and therefore it is chosen as the map with greater feature density. Feature density is interpreted as both the number of the features and the amount of detail within the features themselves.

During the experiment, a web page creates two maps from two different map services. A comparison can be made only if at least one of the two maps includes any features other than land or water, and the web page is refreshed (randomly choosing a new location) as many times as is needed to meet this condition. When features are found, an assessment is made about which of the two maps depicts more features and labels, and that map is given a value of 1. A tie is declared when features and labels are identical between the two maps. The process continues until 100 comparisons have been made, after which the results are compared by map provider and continent. At the end, conclusions are drawn about which of the three map services offers greater feature/label density at the 19th zoom level, and how this varies by continent.

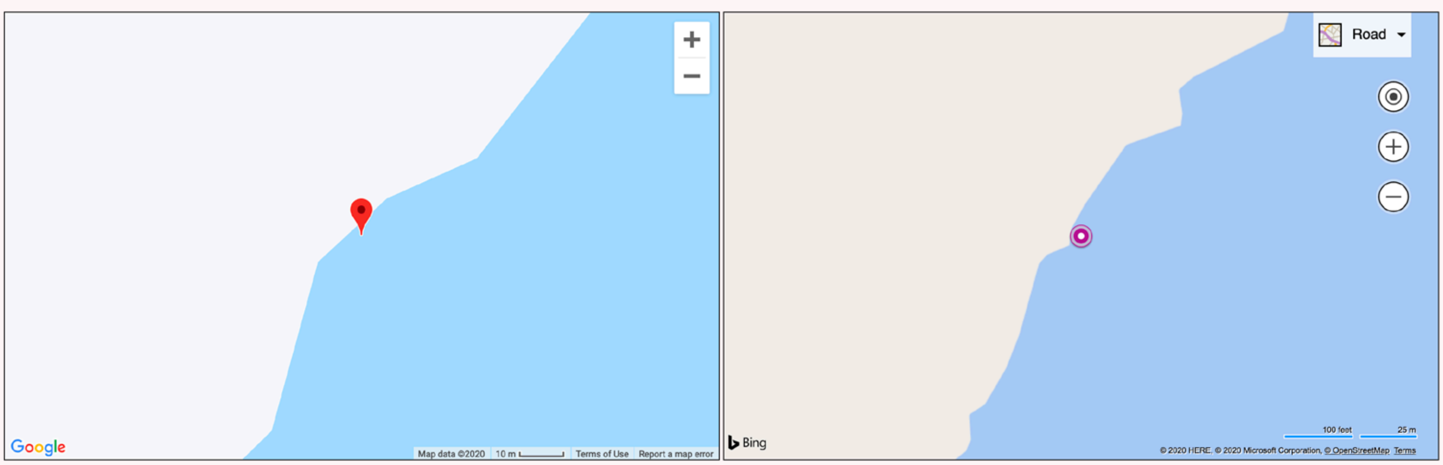


Figure 8. Comparison of a coastline between Google Maps (left) and Bing Maps (right) at the 19th zoom level. The two are either using a different underlying vector databases or different line generalization settings. Whatever the case, the Bing representation includes more detail.

RESULTS OF PAIRWISE COMPARISONS

Figure 9 presents some of the pairwise comparisons between Google and Mapbox for the three continents. The relative ease of making a judgment on feature density between the two maps should be apparent in all of these illustrations.

RESULTS: NUMBER OF TRIES

The number of page refreshes needed to find maps with features varied by both continent and map provider. Figure 10 shows the combined number of tries needed for each continent. Similar numbers of tries were required for North America (1163) and Europe (1179) to reach the necessary 300 comparison pairs (100 comparisons each of Google/Bing, Bing/Mapbox, and Google/Mapbox). However, the maps for sub-Saharan Africa had far fewer features, and more than three times as many total attempts were needed, 3648, to find the required number of maps with features.

Figure 11 shows the number of tries needed by map service across all comparisons. Here, a lower number reflects better on the mapping service. Bing Maps fared the best, while comparisons involving Mapbox required the most tries to find a map with features.

RESULTS: NUMBER OF TIES

The number of ties in pairwise comparisons also varied by continent and map service. A tie was declared if no difference in feature/label density could be determined between two maps. Figure 12 shows the ties by continent. In this comparison, North America and Europe were again almost identical. The number of ties for Africa was far lower, indicating less congruity in features and labels

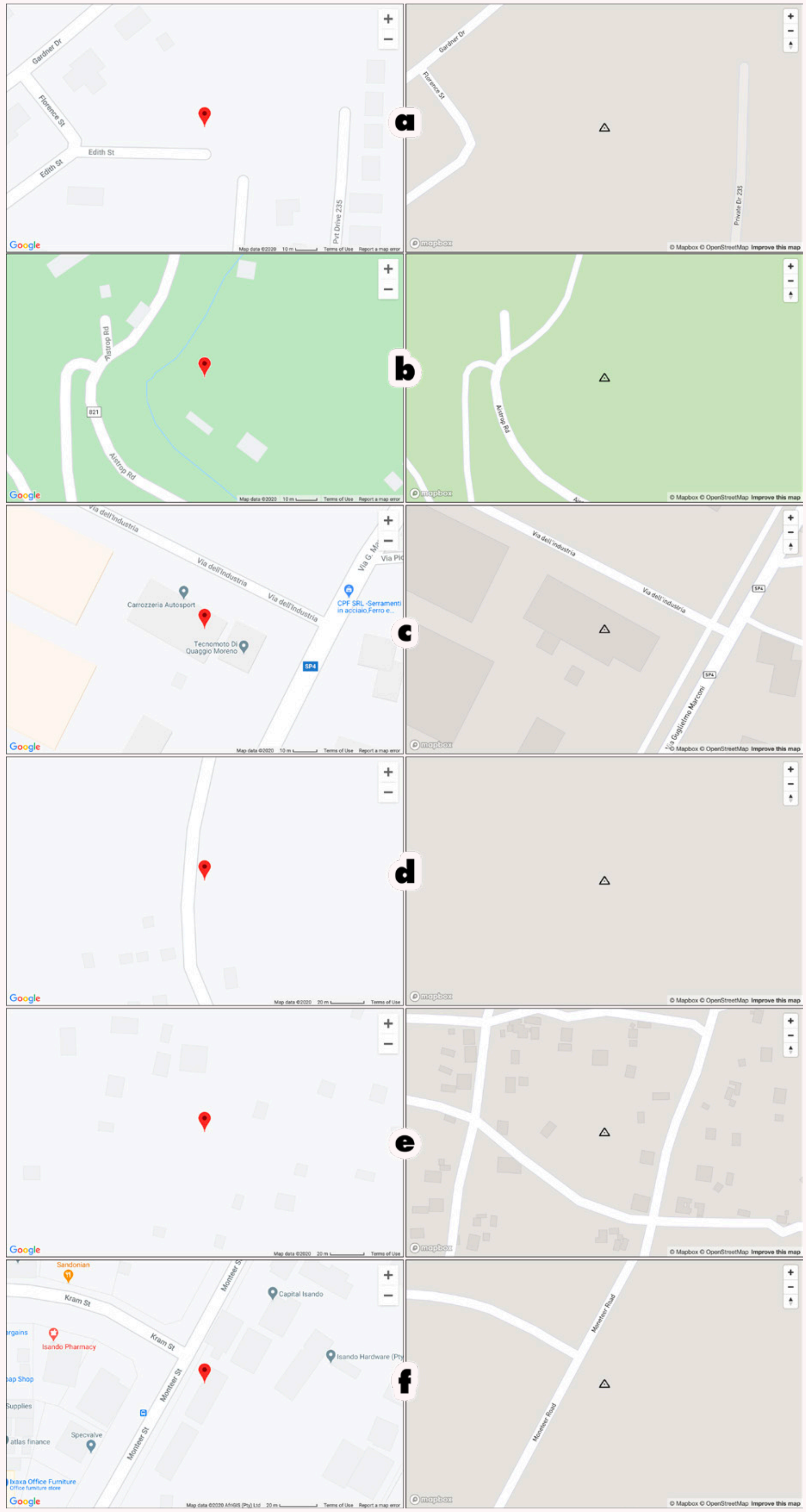


Figure 9. Comparisons between two randomly-chosen locations in North America (**a–b**), Europe (**c–d**), and sub-Saharan Africa (**e–f**). With the exception of pair **e**, the Google Map on the left has more features and labels than the Mapbox map on the right.

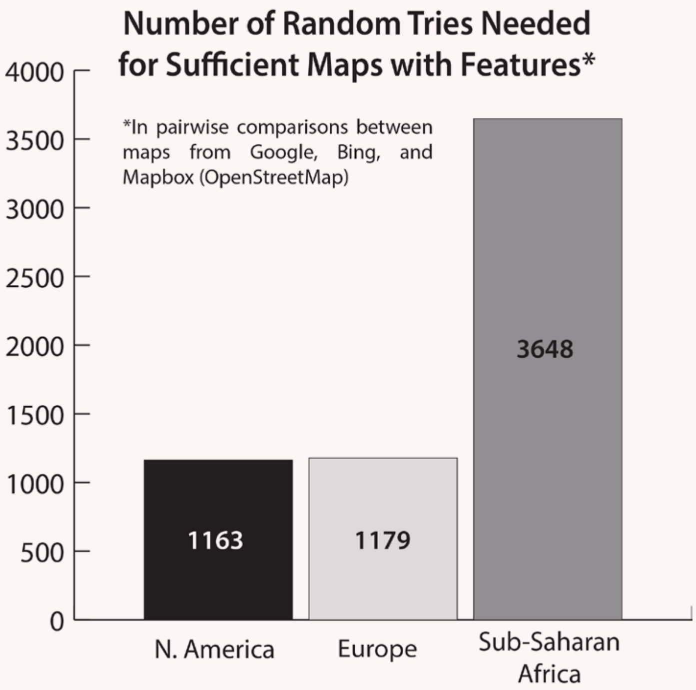


Figure 10. Number of tries needed by continent to find 100 comparison pairs in each of the three pairwise comparisons. The values for North America and Europe are remarkably similar, while more than three times more pairwise comparisons were needed to find the required number for Africa.

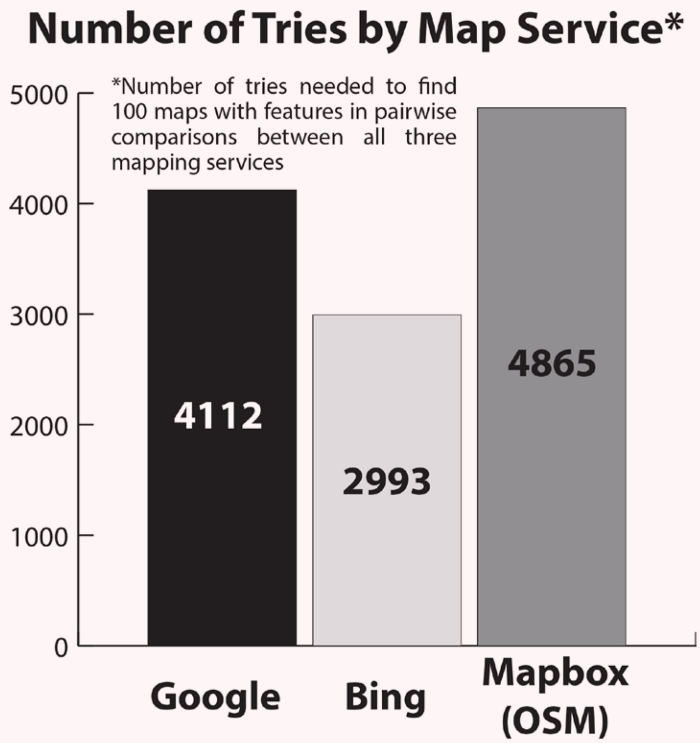


Figure 11. Number of tries needed by map service over all comparisons.

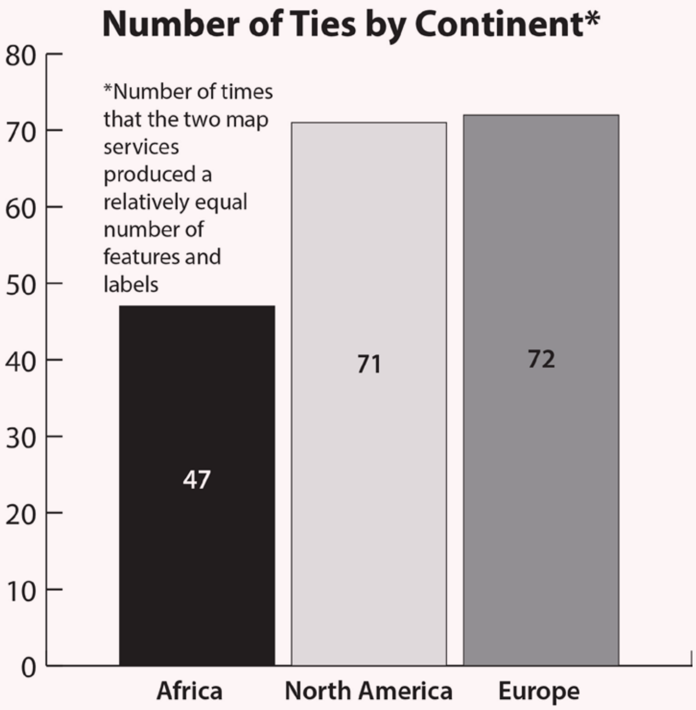


Figure 12. The number of ties for all pairwise comparisons by continent. The maps in the pairwise comparison were rarely identical but merely had a relatively equal number of features/ labels.

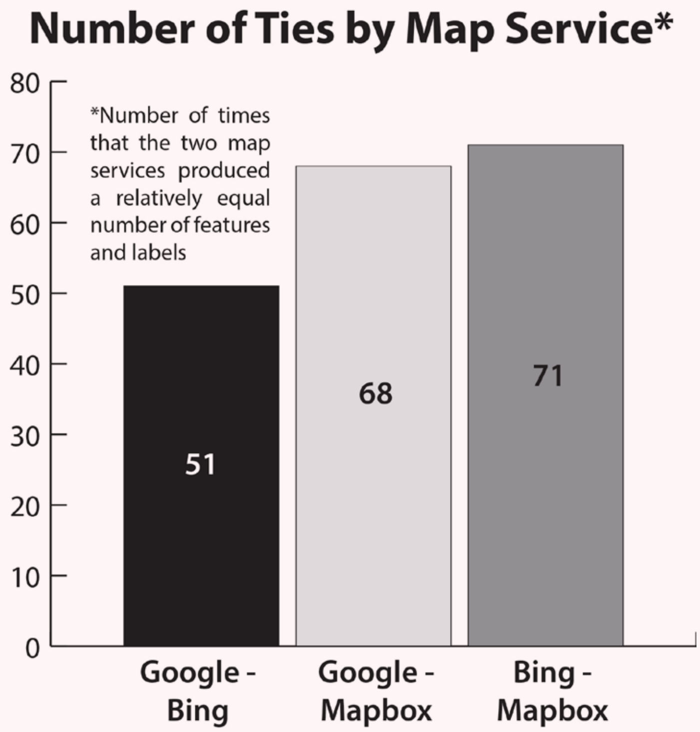


Figure 13. Total number of ties for each pairwise comparison of services.

between the three map services for this continent. When examining specific comparisons of services across all continents (Figure 13), the results show that the number of ties was lowest for the Google/Bing comparisons while almost identical for Google/Mapbox and Bing/Mapbox.

RESULTS BY CONTINENT

Figure 14 presents the results of the pairwise comparisons for North America: the number of times that one service had a greater feature density than the other. The results for each pair are remarkably similar, with Google having an advantage over both Bing and Mapbox, and Bing having an almost equal advantage over Mapbox.

A big advantage for Google Maps in North America is the inclusion of cadastral information in urban areas. Land ownership boundaries were not present on maps from Bing. Mapbox is missing not only cadastral information, but also many building footprints, as can be seen in Figure 15. Another factor in favor of Google, particularly in more rural areas, was the inclusion of labels for water features.

Figure 16 shows that the results for Europe are very similar to those for North America, with Google holding an edge over both Bing and Mapbox. The results for Bing and Mapbox are very similar. Bing's advantage here was in having more labeled features.

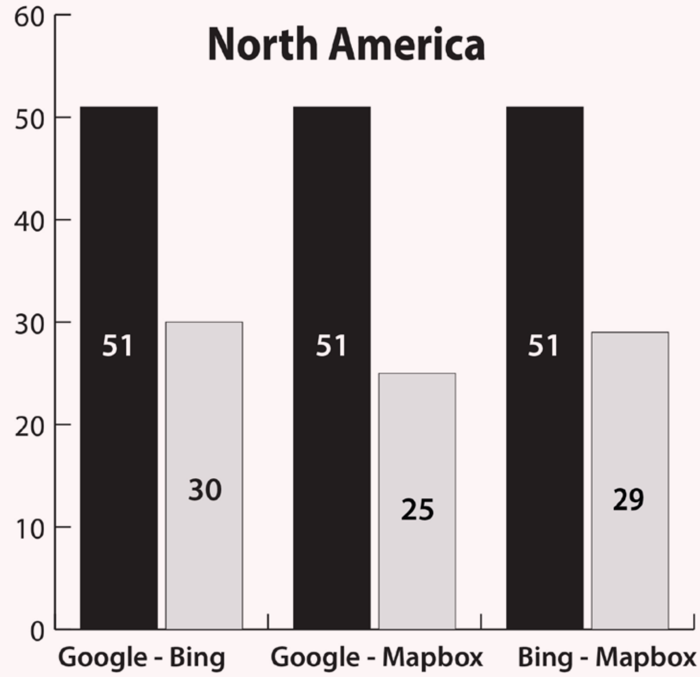


Figure 14. Comparison of densities of features and labels for North America. Ties are not included, so pairings will not add to 100 here or in subsequent figures. Google Maps benefitted from the inclusion of land ownership boundaries in the United States. Building footprints were often missing on maps from Mapbox.

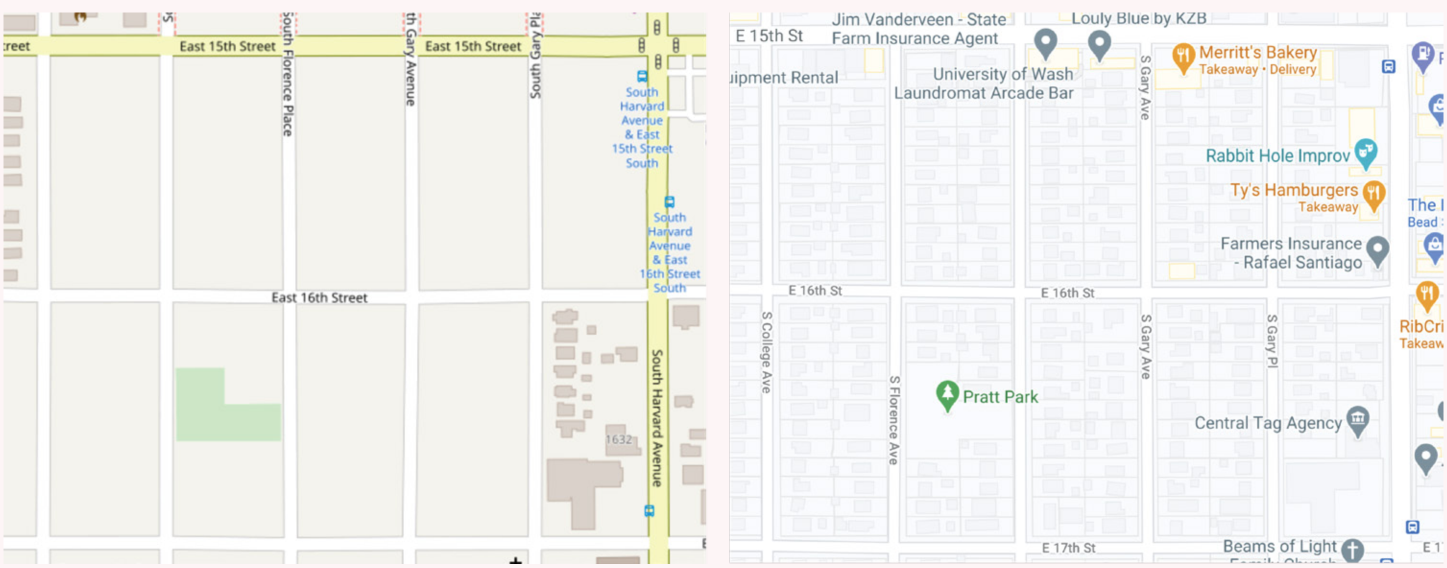


Figure 15. A comparison between maps from Mapbox (left) and Google (right) for a part of Tulsa, Oklahoma. The Mapbox map is missing most of the building footprints, as well as property boundaries.

The results for Africa diverge sharply from those for North America and Europe (Figure 17). Here we find that Bing Maps holds an advantage over both Google and Mapbox. Bing's main advantage was again in having more labels and building footprints. Google scored better than Mapbox.

Finally, Figure 18 shows a summary of the results by map service across all three continents. Google and Microsoft Bing have almost identical values. Maps from Mapbox, relying on data from OpenStreetMap, did not compare as favorably.

REPEATABILITY

The question with any experiment-based research approach is whether or not the results can be repeated reliably. The use of the random approach to select locations will result in some variability between trials. To check repeatability, a second, smaller experiment was done between Google and Mapbox in Europe to determine if the results are relatively consistent between trials (Figure 19).

In the second trial, 494 tries were needed to find 100 maps with features, compared to 430 in the initial trial. The number of times that each map provider was found to have greater feature density is similar between the two trials. While the exact numbers vary, the ratio between the two map services is approximately the same.

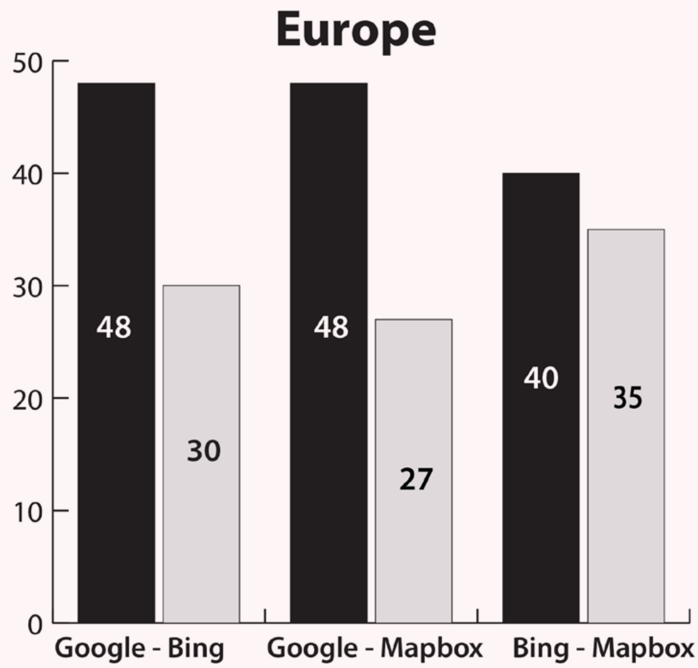


Figure 16. Comparison of features/labels for Europe. The results are almost identical to those for North America. Bing Maps had a smaller advantage over Mapbox than in North America.

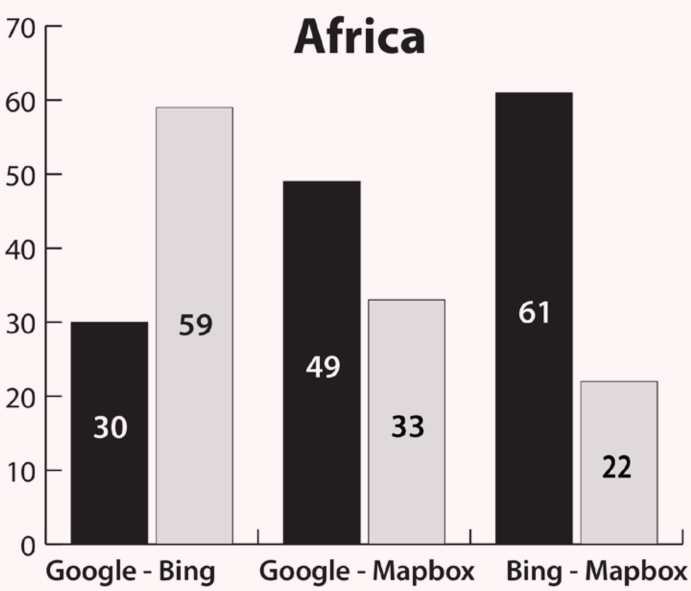


Figure 17. Comparison of features/labels for Africa. Bing Maps benefitted from the inclusion of more labels and building footprints. Google Maps had a smaller advantage over Mapbox than on other continents.

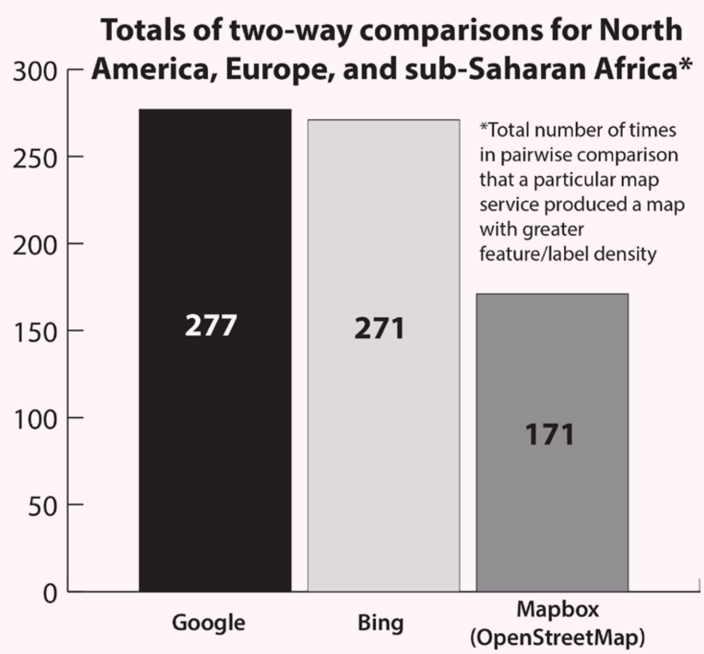


Figure 18. Overall results by map service for all three continents. The results for Google and Bing are almost identical. Mapbox, using data from OpenStreetMap, did not compare favorably in pairwise comparisons with Google and Bing at the 19th zoom level.

REGIONAL REPEATABILITY

Map providers will sometimes display slightly different maps to different regions of the world as a result of local interests and different interpretations of country borders. It has also been observed that map tiles within a map come from multiple servers in different locations. This may indicate a difference in feature/label density for maps accessed in one part of the world compared to another.

The results reported thus far compared maps generated from the United Kingdom. A VPN (Virtual Private Network) was used to instead make the map servers view my browser as being located in the United States. A trial was then done once again between Google and Mapbox for Europe. The results were 41 for Google, 32 for Mapbox, and 27 ties in 506 attempts. This compares to 48 for Google, 27 for Mapbox, and 25 ties in 430 attempts when done from the UK. The results are sufficiently similar to discount any major differences in maps served up between the UK and the US.

SCALE COMPARISON

The question arises as to what effect the choice of zoom level has on the results. To investigate this, a preliminary trial was done on the 22nd zoom level between Google and Mapbox for North America (Figure 20). With this much larger scale, many more attempts were needed to find maps with any features at all. The results showed that there were fewer ties and Google slightly expanded its advantage over Mapbox (its 51% to 21% lead became 61% to 23%) and the number of ties was markedly reduced. More research is needed to determine if whatever advantage one service has over the other at the 19th zoom level is accentuated at larger scales.

DISCUSSION

The pairwise comparison of online maps at the 19th zoom level showed some major differences in feature and label density. The differences occurred across map providers, and the area of the world that was being mapped.

Maps from Google had greater feature and label density for both North America and Europe, though their advantage was slightly less in Europe. A major factor in Google's favor in North America was the inclusion of land

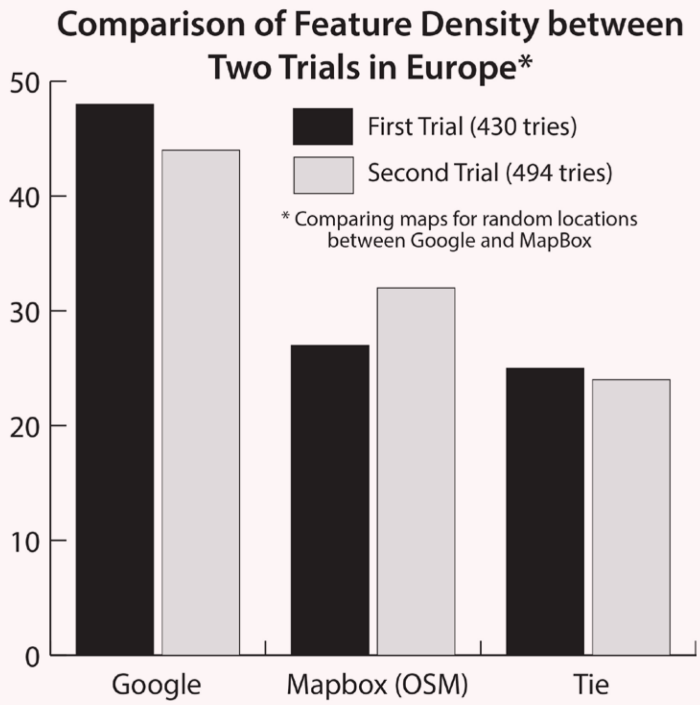


Figure 19. Results of two different trials between Google and Mapbox in Europe. The results are remarkably similar, considering the selection of random locations for map comparisons.

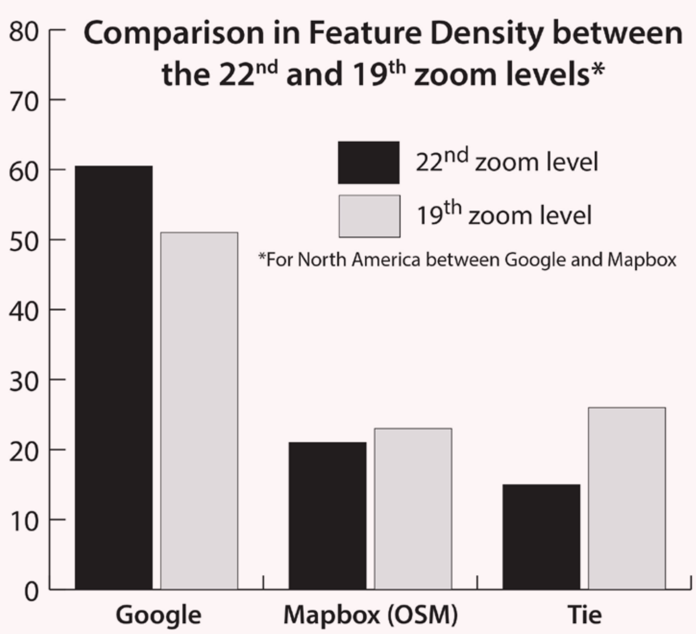


Figure 20. Comparison in perceived feature density between the 22nd and 19th zoom levels. Google Maps expanded its edge over Mapbox, and there were far fewer ties.

ownership boundaries in the United States (these were not found in the maps of Canada). Bing Maps and Mapbox (displaying spatial data from OpenStreetMap) had no such cadastral information. None of the services included land ownership boundaries in Europe. Interestingly, they were found within the country of South Africa, but not the remainder of the continent.

Mapbox also scored much lower in feature density because it was disadvantaged by a relative lack of building footprints. While all three services had relatively similar building footprints for Europe, there were considerable differences for North America and Africa. While building footprints for Mapbox and Bing were essentially identical, those used by Google seem to be derived from a different source. Building footprints are primarily acquired in an automated fashion from remote sensing imagery.

In more rural or undeveloped areas, the presence of roads, rivers, and lakes differentiated the three map providers. In general, Google represented more roads and water features, along with their labels, for the United States and Europe. In urban areas, maps from Google included more labels for businesses.

Perhaps the most troubling aspect of the study is the general scarcity of features in sub-Saharan Africa for all three services. More than three times more attempts were needed to find the necessary number of maps with features. The poor performance of Google Maps in Africa is particularly disturbing given the prevalence of mobile phones utilizing Google's Android operating system in Africa, where it has an 80% market share (vs. 69% in Europe and 44% in North America; StatCounter 2021). The Google Maps application that comes with Android would be a poor choice here for large-scale maps. Bing Maps performed much better. It appears that business alliances with HERE and TomTom have helped Microsoft provide more detailed maps compared to other services, at least for this part of the world.

Differences were also noted in spatial positioning, particularly between Google and the other two services. It was not the purpose of this study determine which representation is more spatially accurate—the best method for this would have been to conduct a GPS survey of the features in question. However, rectified remote sensing imagery could also be used in some cases where features are not obscured by vegetation or other features.

As most land area is more rural or undeveloped, the random point selection method employed here will favor the selection of maps in these less populated areas. These are precisely the areas where it is known that OSM has gaps in coverage, and this is likely why Mapbox performed so poorly. An alternative approach would be to randomly choose points only within more built-up areas. This may favor a crowdsourced spatial data source, but would reinforce the notion that OSM has uneven coverage.

The pairwise comparison method used here represents an alternative to prior research on OSM data that only examined the underlying vector data. As most vector data is located in more urbanized areas where features are located, prior research favored the comparison of spatial data in these areas. The advantage of the approach used here is that it appraises areas more evenly. In addition, both the underlying data and the rendering process are being evaluated. Most prior studies examined only the underlying vector data.

CONCLUSION

Making very large-scale maps of the world is not an easy task. Efforts have often focused on more developed parts of the world, where commercial interests lead to competition and some fairly detailed maps, including ground-level panoramic imagery as implemented by Google's Street View. This imagery, a major source of spatial data and updates for Google, is not acquired in most of Africa, nor in some countries where governments have forbidden it, like Belarus and Germany. Less developed parts of the world will continue to be dependent on crowdsourcing services like OSM for their maps—resulting in data that will subsequently be utilized by commercial interests without much scrutiny.

Comparing large-scale maps from online map providers is an important way of evaluating these services. Map providers need to be subjected to this constant scrutiny of their feature/label density and spatial accuracy. When a map provider is shown to have a product that compares unfavorably to their competitors, it should provide an impetus to improve their map databases and large-scale representations.

When making maps using these services, or when using them for navigation, we should be aware that there are some significant differences between them. Not only is finding a particular location only possible when it is included on the map, having more features and labels on a map increases our connection with the part of the world being depicted. This research showed that Google Maps would be a better choice when seeking large-scale maps of North America and Europe, but not Africa, where Bing Maps provides a better option. Mapbox, using data from OpenStreetMap, would not be a good choice for large-scale maps in any of the three continents.

The pairwise comparison procedure used here can be applied in numerous other ways. For example, an assessment could be made as to which map has more legible text, better design elements, more appropriate generalization for the particular scale, or is even drawn more quickly. Other map providers could also be evaluated such as MapQuest, Here.com, Apple, and Esri. The comparisons could also be done for different parts of the world such as Asia, Australia, or South America. A more automated approach could also be implemented, perhaps utilizing optical character recognition (OCR) for the recognition of text. The methodology presented here opens many avenues for future research to evaluate the quality of MSP maps presented by online services.

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Frequently Updated Maps and their Public Display

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The display of maps on computer monitors in a public setting can be used to emphasize their value in conveying spatial patterns. For thematic maps, by removing the possibility for interaction, more attention can be focused on the mapped distributions. Maps that lend themselves best for public display are those that are frequently updated, such as weather maps. Other types of frequently updated maps (FUMs) include those of earthquakes, air pollution, and health conditions, such as the spread of a virus. These types of maps are increasingly provided through the internet in an interactive format, making the resultant maps less suited for public display. Described here are available maps that could be displayed in a public setting, and a method to make maps for quick display based on available data. A series of these maps can then be assembled and shown in a continuous loop. The display of maps for the public can be implemented using the low-cost, Raspberry Pi computer. Maps that are suitable for public display, instructions for implementation, and the required code are available at: ***maps.unomaha.community/FUMPD/About.html****.*

INTRODUCTION

A fundamental change in cartography since the beginning of the 1990s has been the incorporation of interaction (Peterson 1995) into many maps. However, this trend has not always been for the best. For example, the most common type of interaction that is implemented for thematic maps is the ability for users to view individual data values. As a result, the map is reduced to little more than a spatial table, often to the detriment of its main purpose of communicating spatial patterns.

One way around this problem is to offer non-interactive maps more often, to promote better pattern recognition. These may be shown as part of automated map displays in public settings, such as on monitors in lobbies, airports, offices, etc. Frequently updated maps (FUMs; Peterson and Wendel 2003) work well here, as they generate the most interest in a public setting. However, the trend toward interactive map design means that there are few ready-made examples to display in such settings. In this article, we introduce (1) an inventory of FUMs that could be part of such an automated display; (2) methods for converting existing interactive maps to non-interactive, but frequently updated maps; (3) how to make maps directly from the underlying data; and (4) a low-cost solution for setting up a public display.

The FUMforPD website (**maps.unomaha.community/FUMPD/About.html**) accompanies this article. It assembles many of the currently available FUMs and shows how maps for public display can be made from the underlying data. It also includes code for the display of a series of maps in a continuous loop and shows how a low-cost computer can be used for such displays.

EXAMPLES OF FREQUENTLY UPDATED MAPS

Weather maps are a prime example of FUMs, with some being refreshed every 30 minutes. Initially, these maps were once only available through the internet as static images. Today, most weather websites have incorporated interaction into their display. **Weather.com**, for example, offers multi-scale pannable maps (MSP), implemented through Mapbox, to display radar imagery and storm paths. A limited number of static maps, more suitable for a public display, are also available under a "Classic Weather Maps" link (Figure 1). Likewise, the Sat24.com website offers similar products for Europe (Figure 2).

While weather maps have been available through the internet for many years, a new kind of FUM became necessary in early 2020: maps that depicted the spread of COVID-19. Figure 3 shows two maps from ourworldindata.org/coronavirus that depict cases and deaths over a two-week period. These maps are updated daily and made available in SVG, a vector format suitable for display through a web browser.

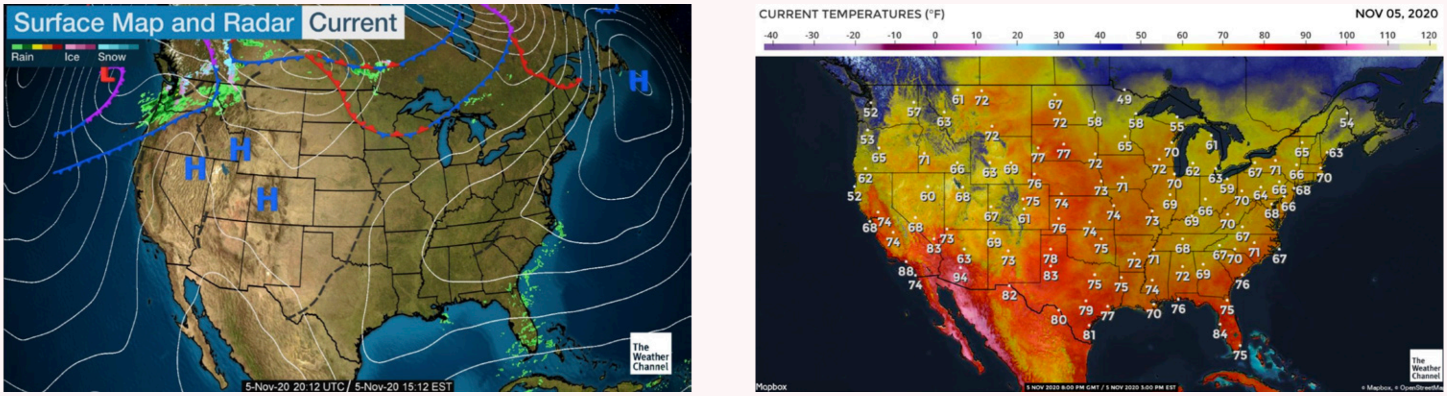

Figure 1. Two examples of "classic" maps from Weather.com.

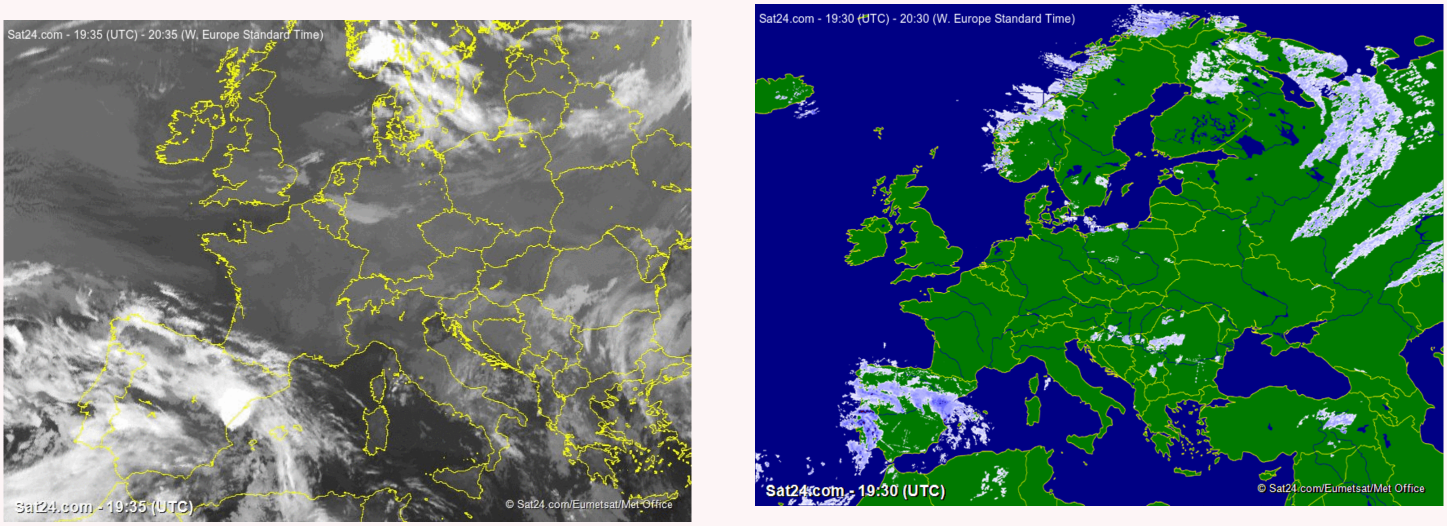

Figure 2. Single frames from two animated GIFs from Sat24.com, showing cloud cover (left) and rainfall (right).

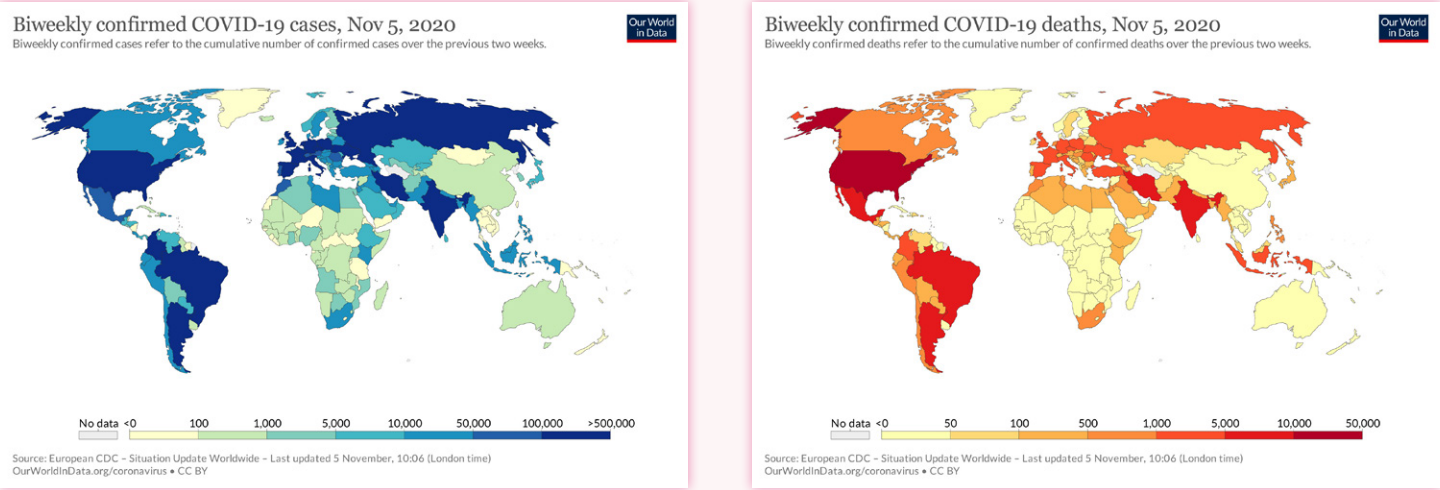

Figure 3. Two maps of COVID-19 from ourworldindata.org/coronavirus, showing biweekly cases and deaths.

Current maps of earthquakes are provided by the United States Geological Survey (USGS) as MSP maps, made with the Leaflet API, atop a basemap from OpenStreetMap (**earthquake.usgs.gov**). The underlying data is also available, provided in a JSON format. Maps specifically designed for non-interactive display can be created from this data using a variety of online tools. Figure 4 shows both the map provided by USGS and a map made from USGS-supplied, real-time data using the Google Maps API. The latter was saved in the PNG format for display.

Frequently updated maps of air pollution are also available. PurpleAir operates a citizen network of over 16,000 sensors that measure particulate pollution, both PM2.5 and PM10 (**purpleair.com**). They offer a web map that uses the Mapbox API to display data from these sensors (**purpleair.com/map**), as well as the underlying data (**purpleair.com/data.json**). Both the PurpleAir map, and a map that we prepared based upon their data, can be seen in Figure 5. Our map was built using the Google Maps

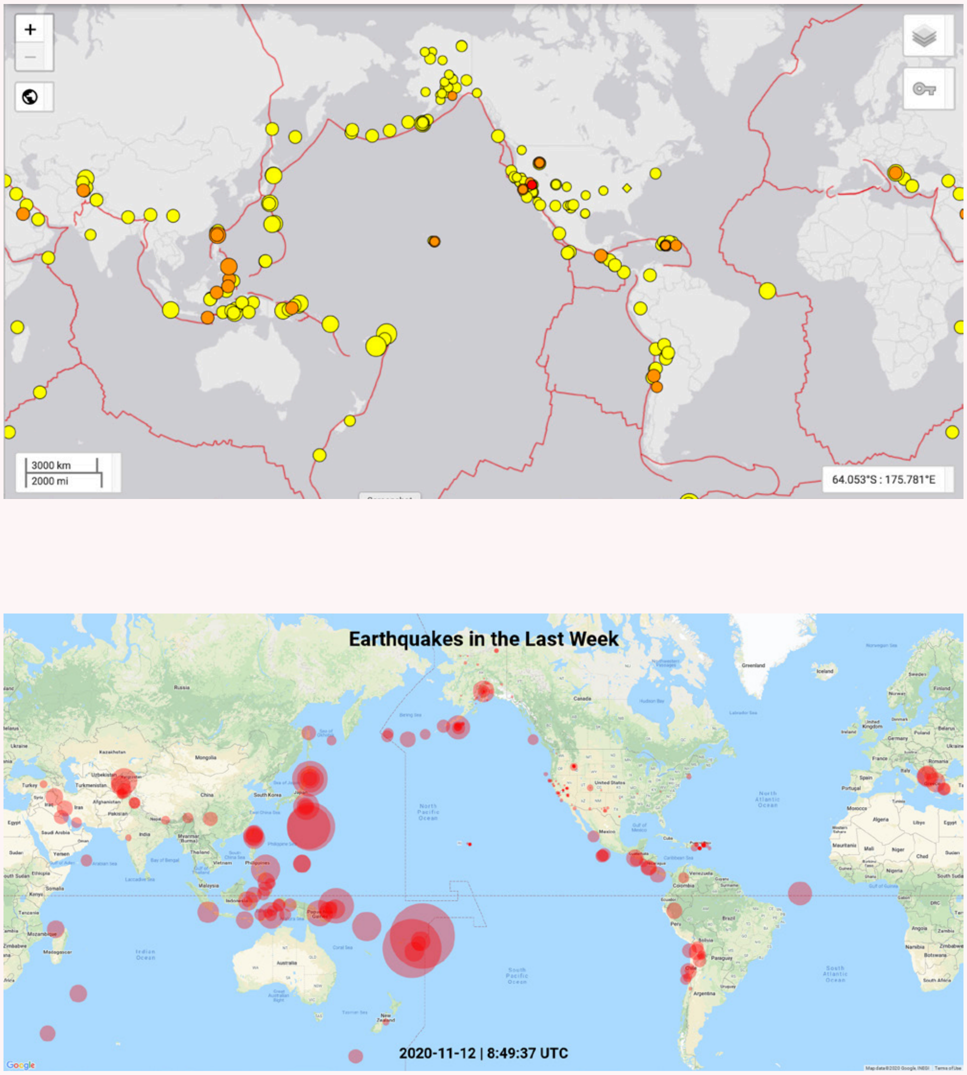

Figure 4. Two maps of earthquakes for a 7-day period. The top, interactive, map, including plate boundaries, is from the USGS (orange and red circles indicate more recent earthquakes). The bottom map is based on the same USGS data feed. It was made with the Google Maps API and saved in the PNG format.

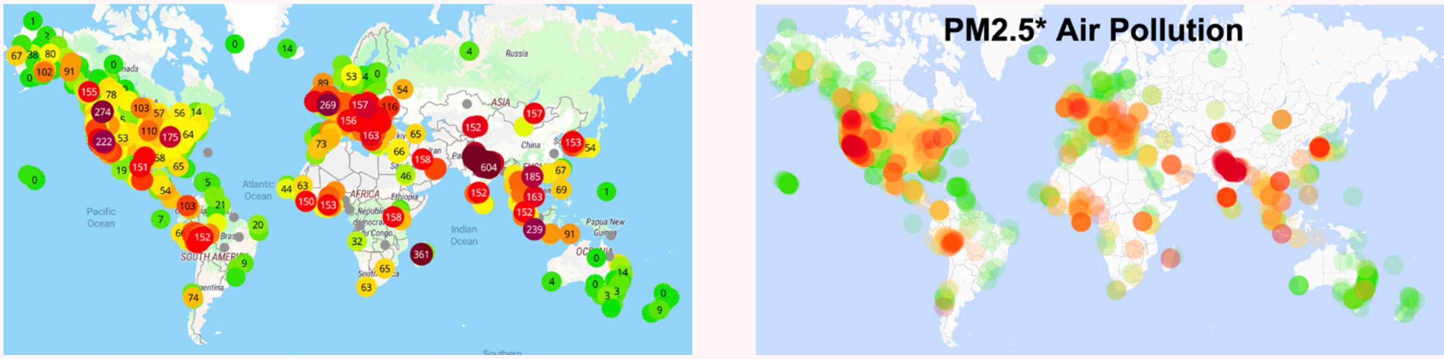

Figure 5. Two maps of PM2.5 particulate air pollution. The map on the left is from PurpleAir, while the map on the right was produced by us based on PurpleAir data. The map on the right is not interactive and does not include numbers within each circle. The green forest cover shading has also been removed from the basemap. While the green/yellow/red color scheme may create an accessibility issue for those with atypical color vision, the scheme was used to mimic the original PurpleAir map.

API, and has been simplified, as compared to PurpleAir's, by removing the green shading for forest cover to improve the visibility of the green symbols. The symbols have also been made partly transparent.

CONVERSION OF MAPS TO IMAGES

Now that we have some idea of the available maps and datasets, we'll walk through how we showed them on a public display. One option would have been to simply point a web browser at one of the interactive maps described above and let it refresh at regular intervals. However, many interactive maps (such as those for earthquakes and air pollution) require considerable time to display, due to the quantity of data being loaded. Even with a fast internet connection, the loading time can sometimes exceed 30 seconds. The recognition of spatial patterns on maps is generally thought to occur more quickly. As a result, the slow display interferes with spatial pattern recognition, particularly in a public setting where people may have limited time to examine the map. The fastest image display times are achieved with pre-made, suitably-sized maps in either the PNG, JPG, or GIF formats. Vector SVG files can also be displayed quickly depending on their complexity.

To make interactive maps more suitable for display, we made use of Puppeteer, a Node JavaScript API, that can take static screenshots of the interactive maps. The API can extract data from websites, a process called web scraping (Leitner 2019). Puppeteer installs the Chromium browser that works with the API. Example 1 shows a segment of Puppeteer code that will capture a screenshot. All of our code is available at the FUMforPD website (**maps.unomaha.community/FUMPD/About.html**). Puppeteer sets an initial page size to 800×600px, and the size of the image can be customized with `Page.setViewport()`. The size of both the earthquake and air pollution maps seen in this article was 2100×1000 pixels.

To simplify the maintenance and infrastructure needs of Puppeteer, an Amazon Web Services (AWS) serverless architecture was implemented. AWS Lambda (**aws.amazon.com/lambda**) is a serverless compute service that runs code in response to events and manages the underlying compute resources. AWS Lambda extends other AWS services by, for example, creating back-end services such as an HTTP request. The server-side JavaScript screenshot code is executed here with AWS Lambda.

```
const puppeteer = require('puppeteer');

(async () => {
  const browser = await puppeteer.launch();
  const page = await browser.newPage();
  await page.goto('https://example.com');
  await page.screenshot({path: 'example.png'});

  await browser.close();
})();
```

Example 1. Puppeteer code that works with the Chromium browser to capture a screenshot of a web page.

We used AWS Simple Storage Solutions (S3), an object storage service, to store the static screenshot images generated by Puppeteer. AWS S3 is essentially storage for the internet. It can be used to store and retrieve differing amounts of data from anywhere on the web. Within the S3 service, users create "Buckets," which can be thought of as folders that are used to store the object-based files. In our case, the PNG screenshots were stored in a bucket called "peterson-screenshots," producing the following URL for one of the png files: **peterson-screenshots.s3.amazonaws.com/2_Day.png**. This particular PNG file depicts earthquakes for the past day using the Google Maps API, and is updated every hour. The USGS supplies JSON files for earthquakes in four time intervals: past hour, past 24 hours, past week, and past month. We added some code that incorporates a time-stamp into the bottom of each map (see Example 2).

For showing air pollution, we downloaded data from PurpleAir and produced multiple maps at different scales for multiple regions of the world. To limit server load, PurpleAir allows their data to be accessed once every 30 seconds. Because multiple maps are being made, the full dataset is temporarily downloaded to an S3 bucket, and our code makes maps based on this local file. The data is then overwritten an hour later when the next series of maps are made.

```
// Put timestamp on the map
        var myTitle = document.createElement('h1');
        myTitle.style.font = 'bold 28px arial';
        myTitle.style.color = 'Black';

        var today = new Date();
        var date = today.getFullYear()+'-'+(today.getMonth()+1)+'-'+today.getDate();
        var time = today.getHours() + ":" + AddZero(today.getMinutes()) +
                ":" + AddZero(today.getSeconds());
        dateTime=date+' | '+time+' UTC';

        myTitle.innerHTML = dateTime;
        var myTextDiv = document.createElement('div');
        myTextDiv.appendChild(myTitle);
        map.controls[google.maps.ControlPosition.BOTTOM_CENTER].push(myTextDiv);
```

Example 2. JavaScript code that adds the time stamp to each map. The time for AWS Lambda servers corresponds to UTC.

The PNG maps of earthquakes and air pollution are updated hourly. This is achieved by establishing an AWS CloudWatch EventBridge (**docs.aws.amazon.com/eventbridge**). The EventBridge framework allows for scheduling the execution of the cloud-based screenshot function in AWS Lambda.

AUTOMATED DISPLAY OF IMAGES

After generating images, the next step is to automatically display them. Again, all the code is available through the **FUMforPD website**. There, you can find HTML/JavaScript that can be run on Google Chrome on Windows or Mac OS. Example 3 presents a part of both the HTML and JavaScript code where the images are referenced. In our example, the size of the images has been adjusted for a 1920×1200 pixel monitor, with some made larger to zoom-in on an area of interest.

To display other images, download the code from any of the examples on the FUMforPD website and change the addresses of the images shown in both the HTML and JavaScript parts of the code as shown in Example 3. The width of the images can be matched to the monitor using a value of 100% or zoomed to a particular area of interest by using a larger number for the width or height of the image.

```
<div class="fadein">
    <img src="https://s.w-
    x.co/staticmaps/uksat_1280x720.jpg"
    width=2200 id = "myImage1"/>
    <img
    src="https://api.sat24.com/animated/EU
    /infraPolair/3/" width=2200 id =
    "myImage2"/>
    <img
    src="https://api.sat24.com/animated/GB
    /rainTMC/3/" width=1920 id =
    "myImage3"/>
</div>
```

```
myImageElement1.src = 'https://s.w-
x.co/staticmaps/uksat_1280x720.jpg?
rand=' + Math.random()
myImageElement2.src =
'https://api.sat24.com/animated/EU/
infraPolair/3/?rand=' +
Math.random()
myImageElement3.src =
'https://api.sat24.com/animated/GB/
rainTMC/3/?rand=' + Math.random()
```

Example 3. Code segment for the automated display of images. The addresses of the images are entered in both the HTML (top) and JavaScript (bottom) parts of the code.

Once we have the code to show the maps, the next step is to display them seamlessly. We recommend the Google Chrome browser, which can be automatically started in full-screen mode. Full-screen mode is set in the view menu (Figure 6). In the browser's Preferences, you can also set it to "Continue where you left off," on starting the browser, meaning that Chrome will open in full-screen mode, displaying the last webpage viewed in the browser.

The last step to automating this process is to ensure that Chrome is launched on startup. In this way, if the computer is reset, Chrome will automatically begin again, go to full screen, and return to the map display. On a Mac, this is done using the **Login Items** tab under the **Users and Groups System Preference**. In Windows, in the **Start** button, select **Settings** > **Apps** > **Startup** and select Google Chrome to run at **startup.**

Depending on your settings, an electronic timer may be necessary to control when the display is active. While some computers can be set to turn on and off at specified times, this control may not extend to the monitor. Whether or not an electronic timer is used, the computer should be set to start automatically after a power outage.

Figure 7 shows a series of six automated weather and map displays at the University of Nebraska at Omaha. Initially based on older computers, primarily Macs, most displays have been converted to use a Raspberry Pi.

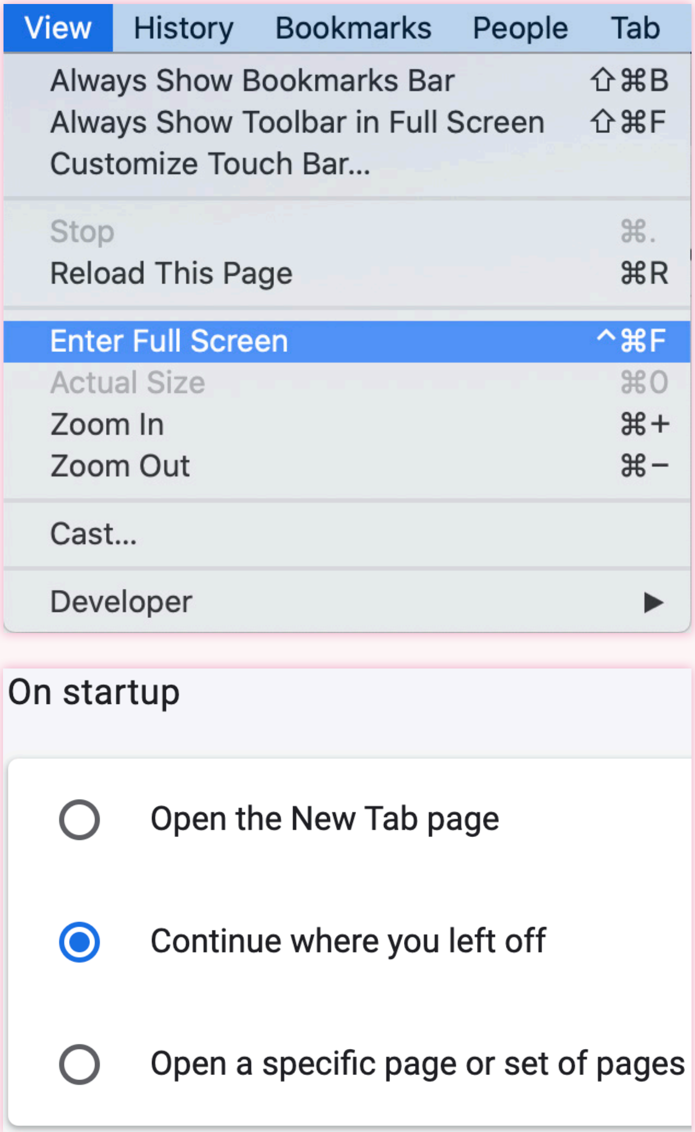

Figure 6. Google Chrome options for full-screen display and continuing with the current settings after re-start, including the full-screen display.

Figure 7. An automated map display consisting of six computers at the University of Nebraska at Omaha.

DISPLAY WITH A RASPBERRY PI

To reliably display maps in a public setting, we found the Raspberry Pi (RPi) computer to be a low-cost and low-power solution. An RPi consists of the computer (see Figure 8), a power supply, and an SD memory card. While these are all sold separately, they can be acquired as a kit for about US $65. A plastic case for the computer can also be purchased separately.

When purchased, the RPi does not include any software—even an operating system. All required software can be freely downloaded from raspberrypi.org. In a process called "flashing," the RPi OS is loaded onto the micro-SD card, which acts like a hard drive for the computer. The flashing process requires a Windows, Mac, or Ubuntu computer, running a flashing program such as Etcher (balena.io/etcher). Once the SD card has been flashed with the operating system, it can be physically installed

Figure 8. The $65 Raspberry Pi Model 4 computer. The device can be easily programmed to automatically display maps in a public setting.

in the RPi. The computer then boots to LXDE (Lightweight X11 Desktop Environment), a Windows-like desktop environment that includes standard menus and dialogs.

Some setup is necessary to configure the RPi to open a webpage at startup that displays the maps. This webpage should be configured to continuously cycle through a series of maps, and it's best if it webpage resides on a separate server so that it can be more easily modified.

The RPi uses the Chromium browser, and much like with the Chrome browser above, this needs to be set to enter full-screen mode on startup. Although the RPi can be set to start and shut down at specified times, it does not have this control over the monitor. A simple external timer must be used to remove power to both the computer and monitor during hours when it is not being viewed. The RPi and monitor will power up automatically when power is restored. The Chromium browser is set to start automatically, retrieving the webpage from a server that displays the maps.

Let's start setting things up by entering this command in LXTerminal:

```
raspi-config
```

and select "boot to desktop," as well as your local time zone. Next, to configure the RPi's wifi access, enter:

```
sudo nano /etc/wpa_supplicant/wpa_supplicant.
 conf

network={

ssid="YOUR_NETWORK_NAME"

psk="YOUR_WIFI_PASSWORD"

}
```

Save changes and quit (ctrl-o, ctrl-x). The Wifi address must be straightforward. For example, it is not a simple matter to enter the necessary parameters for an eduroam connection.

The unclutter app hides the mouse pointer, for a cleaner display. It is installed using this command:

```
sudo apt-get install unclutter
```

The screen is forced to stay on (not sleep) and the Chromium browser is automatically started by editing this file:

```
sudo nano /home/pi/.config/lxsession/LXDE-pi/
 autostart
```

If this file does not open, try the alternate location for the autostart file:

```
sudo nano /etc/xdg/lxsession/LXDE-pi/autostart
```

Then add these lines at the end of the file:

```
@xset s off

@xset -dpms

@xset s 0 0

@xset s noblank

@xset s noexpose

@xset dpms 0 0 0

@chromium-browser --noerrdialogs --incognito
 --autoplay-policy=no-user-gesture-required
 --check-for-update-interval=1 --simulate-
 critical-update --kiosk https://URL of the
```

```
web page that cycles through the maps
```

The computer can then be rebooted by entering:

```
sudo reboot
```

or by temporarily removing power.

When the RPi restarts, the images specified in the HTML link will be displayed in full-screen mode. They will automatically update and continue displaying until the computer is shut down or power is removed.

A good exercise in working with the RPi is to create a DAKboard (**dakboard.com**), a customizable web-based display. The instructions found at **blog.dakboard.com/diy-wall-display** explain the process of setting up a Raspberry Pi to create a personalized wall display via DAKboard.

CONCLUSION

The display of thematic maps in a public setting encourages spatial pattern recognition. However, many interactive maps available online load slowly enough that they can interfere with this pattern recognition. While watching a map being drawn on the screen might attract attention, interactive maps are rarely updated in a way that encourages the recognition of broad patterns. If pattern recognition occurs quickly—as is generally thought to be the case—any delay in creating the pattern can only be detrimental to pattern recognition. This would be especially be true in a public setting where the map viewer may not take the time to wait for the map to be completed.

Converting interactive maps to images for quick display may be the best solution to further spatial pattern recognition. The specific method we demonstrate here involves the hourly updating of earthquake and air pollution data, while incorporating design elements to promote pattern recognition. The maps available through the FUMforPD website will continue to be updated as long as the necessary infrastructure remains in place. We hope that others will create similar displays of frequently updated data, and expand on this method to show new datasets, and alternative visualizations of existing datasets. For example, PurpleAir data could be processed to display day-to-day *changes* in air pollution.

While we encourage the public display of maps and the use of the low-cost Raspberry Pi computer, we recognize that these displays will only be only viewed by a limited number of people. We believe, however, that displays of maps in a public setting will encourage better map design, towards more thoughtful visualizations that promote spatial pattern recognition. The public display of maps that we advocate should encourage better thematic map design for *all* applications.

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DOI: 10.14714/CP97.1685

Worldviews: Art, Cartography, and the Power of Places Beyond

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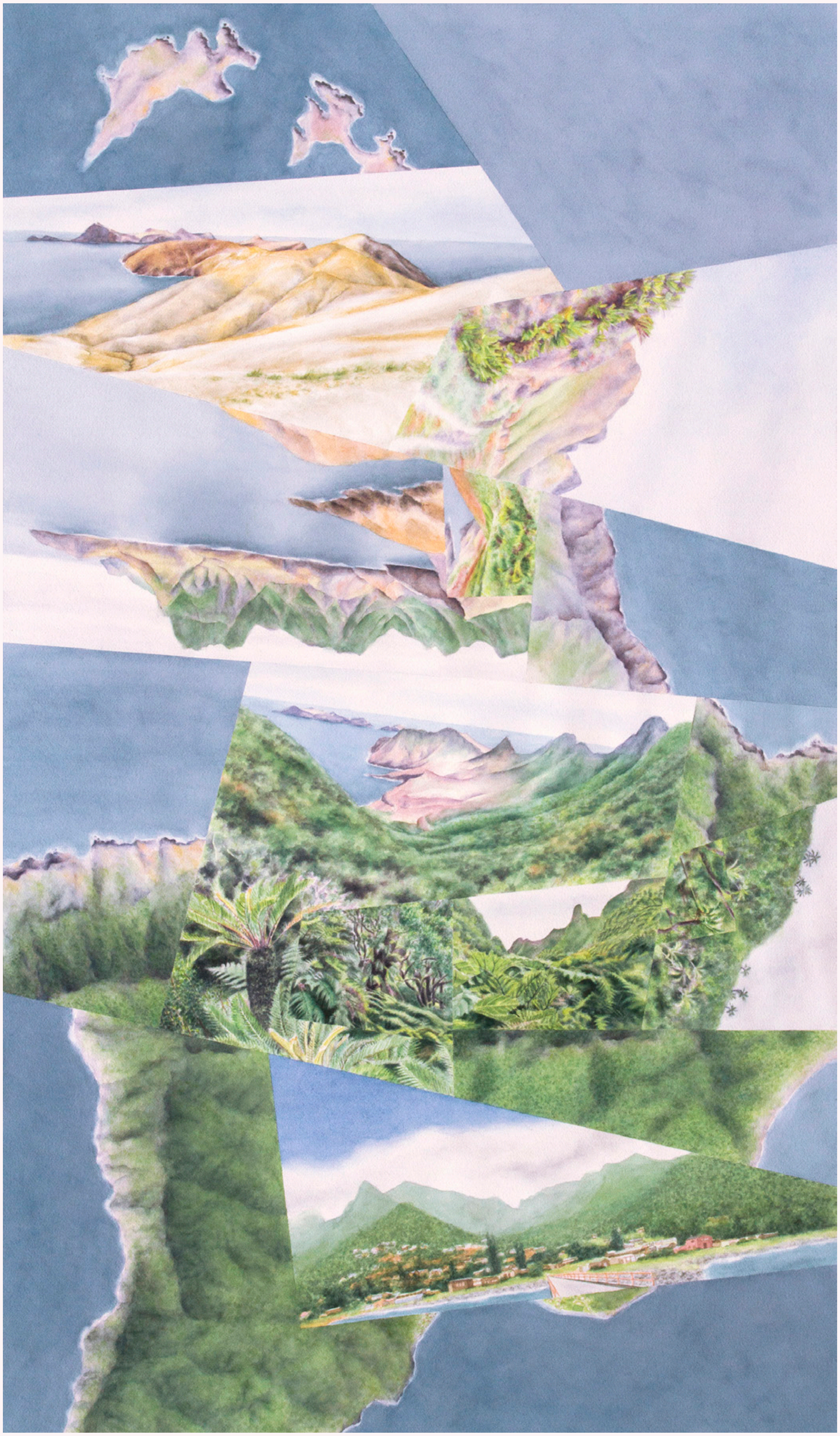
Represented by Hang Art Gallery

Cone (2020), inspired by Mt. Taranaki in New Zealand. Watercolor on paper, 36"×36".

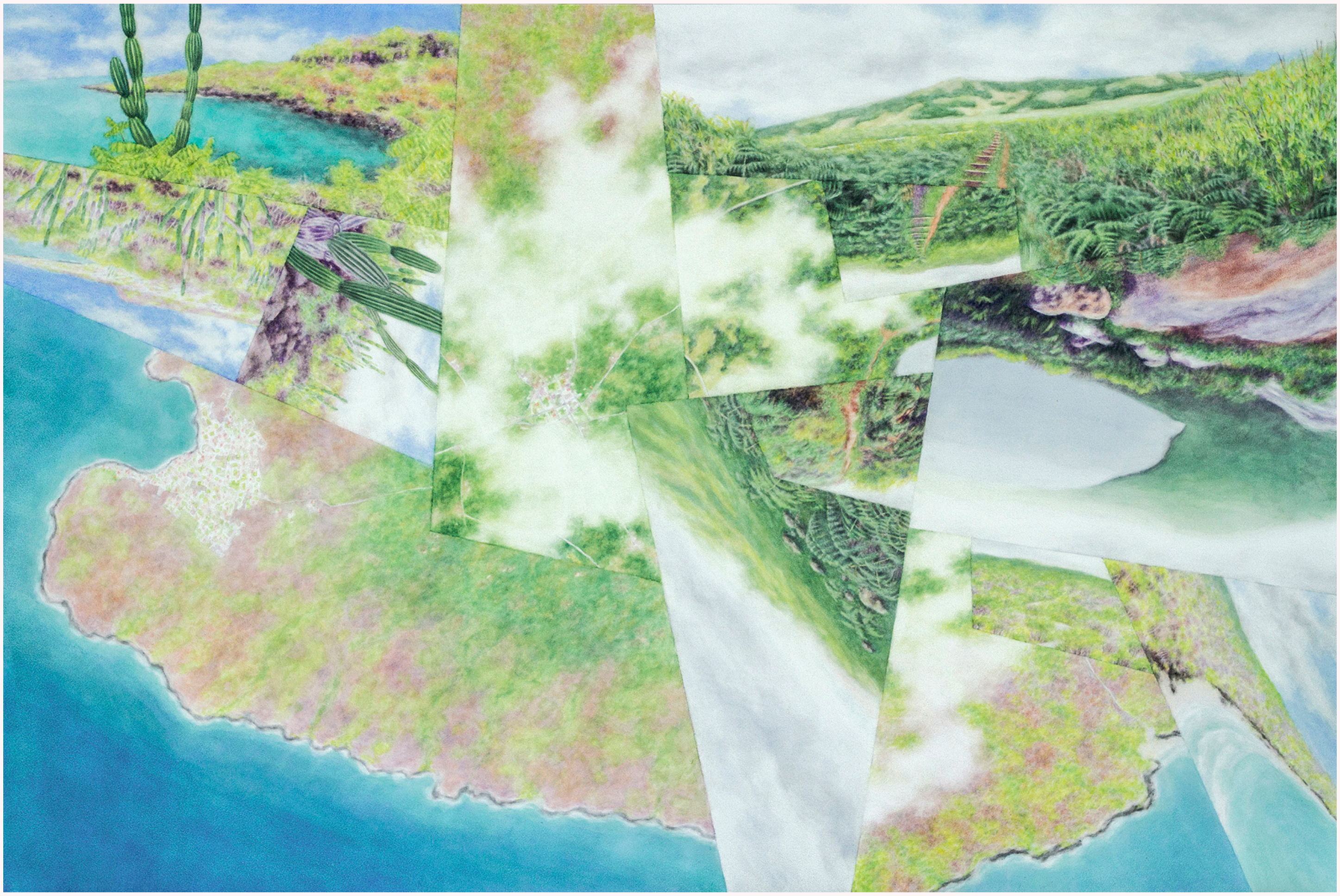
I AM ATTRACTED to maps for the same reason that I would guess many people are—they compress and organize large, complex pieces of the world onto tiny surfaces, giving me the empowering feeling of fully "knowing" those places. Some locations, though, feel compressed even before they are put on paper, making that sense of empowerment much stronger because I can explore them in the real world.

I remember my interest in these kinds of places beginning in childhood, and then strengthening when I started visiting them as a teenager. Most formative were the Hawaiian and Galápagos Islands, and Tanzania's Ngorongoro Crater, all with dramatic ecological gradients from wet to dry. Such contrasts are usually associated with entire continents, yet on these tropical islands and mountains it is possible to experience them within the span of only a few minutes. This idea of miniaturization also explains my long fascination with small volcanic cones and craters. I have a mental image of volcanoes as unapproachable and overpowering in scale and force, but when a volcano is "humanized"—accessible, easy to climb up and into, and isolated within some other contrasting landscape like a city—I experience a similar sense of empowerment.

This early obsession with environmental contrasts and microcosms probably developed



Mirador (2020), inspired by Robinson Crusoe Island in the Juan Fernández archipelago, Chile. Watercolor on paper, 48"×28".



Highlands (2020), inspired by San Cristóbal Island in the Galápagos. Watercolor on aquabord, 24"×36".

in part due to boredom with what I perceived to be the monotonous landscape of my native Ohio. It also conforms to an ongoing tendency toward ambivalence and the-grass-is-always-greener thinking in many areas of my life—I feel a lack of control when forced to satisfy myself with one thing at the expense of all the different possibilities I can imagine. That same feeling arises when I visit a landscape too big and undefined for me to fully comprehend and see beyond.

I think of these environmental microcosms as "lived maps." They include islands and landscape patchworks of many kinds, whether the edges separate desert and oasis, mountain and plain, land and water, or nature and city. Though they might not represent the downsizing of geological or climatic phenomena as radically as the volcano and rainfall gradient examples, I still experience them as normally massive and overwhelming entities made small, distinct, and comprehensible.

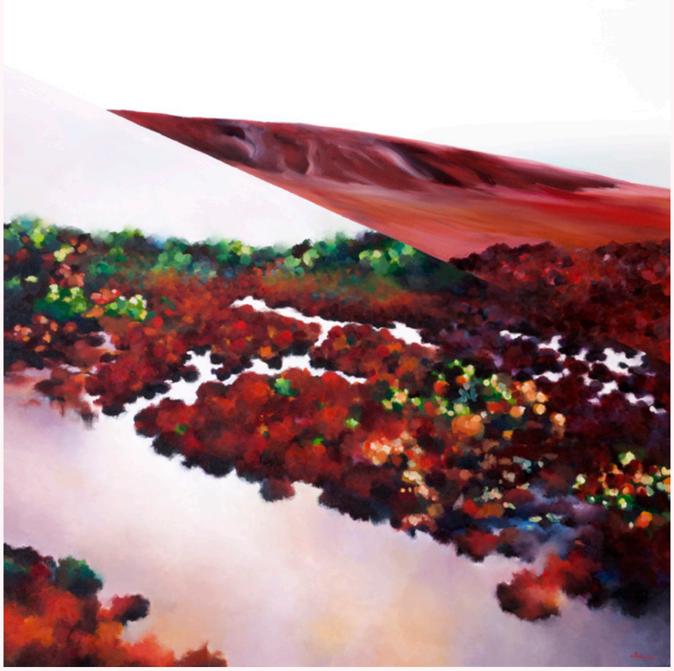
Harbour Island (2018), inspired by Rangitoto, a volcano just offshore from Auckland, New Zealand. Watercolor on paper, 18"×18".

Sacred Hill (2020), inspired by the volcanic cone Helgafell on the island of Heimaey, Iceland. Watercolor on aquabord, 30"×22".

Lagoon (2019), inspired by the ecological preserve and village of El Ángel, Ecuador. Watercolor on paper, 36"×36".

After exploring these lived maps I still have the urge to compress and structure them further. This led me to the field of landscape architecture and then, after realizing that the profession would give me only limited opportunities to follow this particular passion out in the real world, to instead re-imagine them in two dimensions. That was fifteen years ago, and those works have since evolved from photomontages to oils to watercolors, each composition now a mix of landscape and aerial perspectives based mostly on my own photography and on satellite imagery. I have recently begun to call them *worldviews*, alluding to the fact that each work depicts a complete, multi-dimensional

Two-sided Lake (2010), an imaginary juxtaposition of the highlands of Kauai with a crater lake on Isabela Island in the Galápagos. Photomontage, giclée print 36"×40".

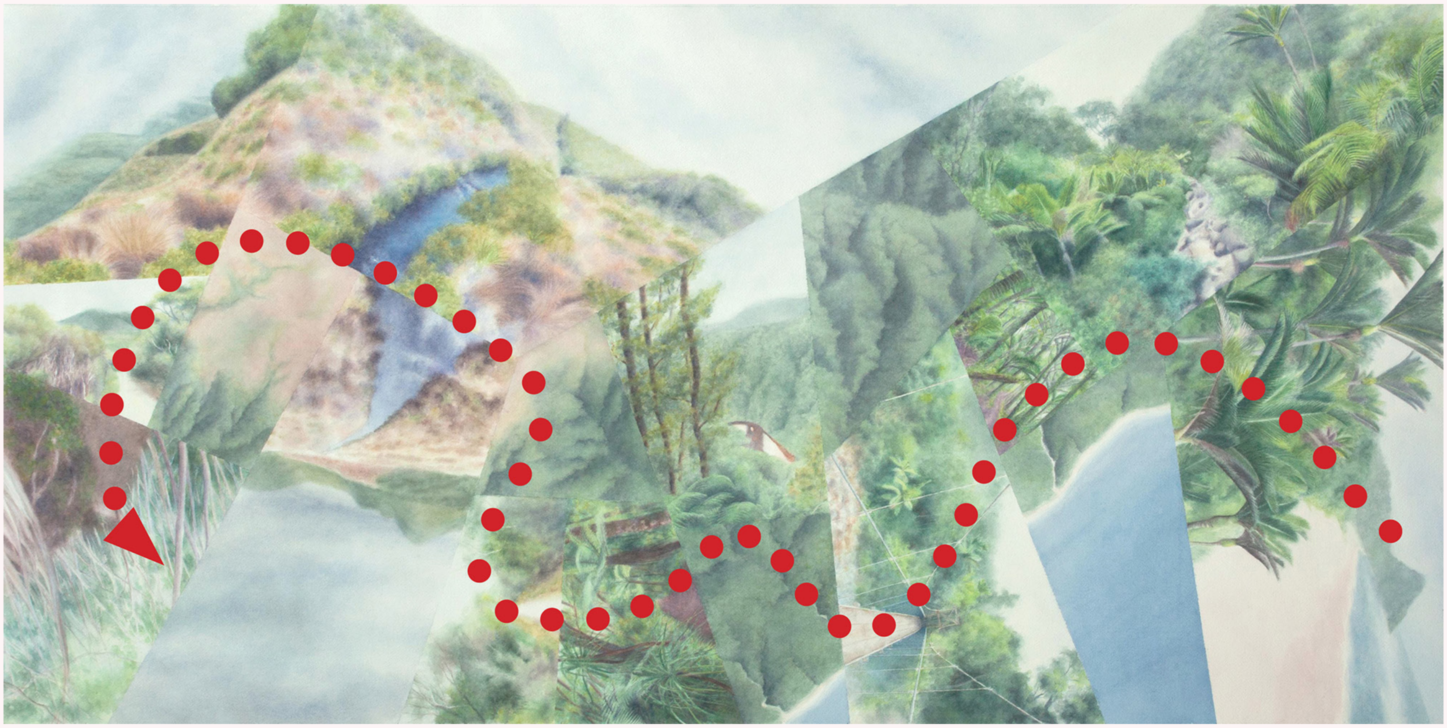


High Desert (2012), an imaginary juxtaposition of Death Valley in California with the Alakai Swamp on Kauai. Oil on canvas, 48"×48".

Peaks (2020), inspired by Twin Peaks in San Francisco. Watercolor on paper, 42"×37".

"world" —the full experience of a place—rather than an individual snapshot or a purely bird's-eye perspective. They are different from most maps in having this experiential quality, preserving some of that "lived" aspect. Yet I no longer think of them as paintings per se: the term *worldviews* also references the particular way that I view the world, namely in spatial rather than scenic terms. An individual landscape means little to me unless I can journey to where it ends and beyond, just as knowledge of darkness gives meaning to light. Depicting a landscape in isolation holds no interest for me—even the process of painting the individual perspectives making up each *worldview* is much less engaging than designing the relationships between them—essentially, drawing the map.

Some of the *worldviews* depict roughly linear "journeys" through a sequence of landscapes, while others convey less-directed "wanderings." So far they draw on my memories and photographs from about fifteen countries on six continents, with a current focus on my recent travels in Oceania and South America. The representations



Great Walk (2019) overlaid with an abstracted hiking route, inspired by a trek along the Heaphy Track in Kahurangi National Park, New Zealand. Watercolor on paper with digital overlay, 24"×48".

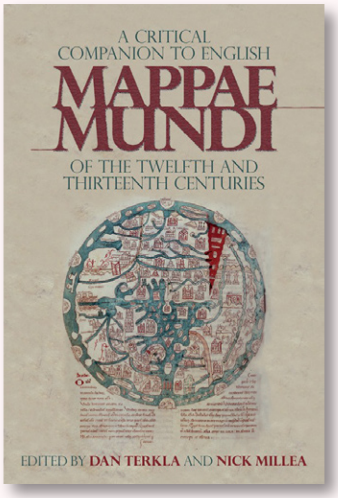
Pearl Isle (2018), an imaginary island combining elements of the Kimberley region of Australia. Watercolor on paper, 8"×8".

Floreana (2019), inspired by Floreana Island in the Galápagos. Watercolor on paper, 24"×21".

range from accentuated versions of the real thing to completely imagined, invented by mixing and matching pieces of real locales. Lately I have taken a greater interest in the truer-to-experience variety, given the engaging challenge of mapping my recollections and idealizations onto something resembling the real geographical relationships, plus an aim to overlay the "compression" narrative with an expression of my distress at the growing ecological fragility of these places. It is not coincidental that the complex ecological zonation patterns and tiny natural relicts that I find so inspiring are particularly susceptible to climate change, invasive species, and other environmental threats. But I think of my urge to further compress them in 2D, into something I can intellectually grasp and control, as a protective impulse rather than a desire to make them any more fragile than they are.

Fog Meadows (2020), inspired by the Lomas de Lachay, a fog-fed oasis in the coastal desert of Peru. Watercolor on paper, 36"x48".

DOI: 10.14714/CP97.1657



A CRITICAL COMPANION TO ENGLISH MAPPAE MUNDI OF THE TWELFTH AND THIRTEENTH CENTURIES

Edited by Dan Terkla and Nick Millea

The Boydell Press, 2019

347 pages, 10 full color maps, 30 black and white figures or images

Hardcover: $90.00, ISBN 978-1-78327-422-2

Review by: Gillian Bailey, University of California Los Angeles

Dan Terkla from Illinois Wesleyan University and Nick Millea of the Bodleian Library have brought us *A Critical Companion to English Mappae Mundi of the Twelfth and Thirteenth Centuries*, a compendium of essays on mappae mundi from this prolific period of Anglo-French cartography. The term *mappa mundi* (plural, *mappae mundi*) refers broadly to any medieval European world map, and in the twelfth and thirteenth centuries these maps were at their peak of production and design. Over the course of thirteen chapters, this collection's ten contributors strive to provide new contexts for, and examinations of, this most significant genre of medieval map. While this volume "cannot claim to be a comprehensive revamp" (2) of Harley and Woodward's work in Volume 1 of *The History of Cartography* (1987), it does seek to provide a forward-looking study highlighting nine significant, but little studied, Anglo-French world maps. The essays build on the scholarly conversation begun by Harley and Woodward—a conversation that has expanded over the past three decades in light of the sometimes startling results afforded by new technologies.

The Preface and Introduction ("Where to fix Cadiz?") set up one of the editors' objectives: to approach their study as spectators into the late medieval mindset. The Introduction begins with a discussion of the source books and maps held, copied, and circulated in monastic houses, and then goes on to describe the materials, tools, and skills used by the medieval cartographers, revealing their shared history with medieval book making. The Introduction also focuses on the uses for these maps, which were as varied as the maps' commissioners, ranging from religious teaching—with the maps' imagery as a means for the transmission of knowledge—to non-clerical displays of status or power. All the maps nonetheless shared the same basic formatting and conventions; conventions that were largely grounded in the theological writings of Hugh of St. Victor (d. 1141), particularly *Descriptio Mappa Mundi* (c. 1128).

In Chapter One, "Making Manuscripts and *Mappae Mundi*," contributor Michelle P. Brown describes these maps in their broad chronological and socio-historical contexts and discusses the formal, stylistic, art-historical, and paleographical features upon which the genre would build over time. For example, world maps had tended toward circularity since the Babylonians, and by Greek and Roman times, depiction of the tripartite division of the world into Asia, Africa, and Europe had settled into a schema resembling a capital T—the familiar "T in O" map. Brown firmly locates these world maps in the complex histories of book production and publishing, art, and cartography, even if, on occasion, they sometimes strayed into other media such as murals.

In the second chapter, "Books and Maps: Anglo-Saxon Glastonbury and Geospatial Awareness," Dan Terkla takes Brown's views, as presented in Chapter One, and applies them to pre- and post-Conquest (1066) English religious houses that both owned mappae mundi and had significant manuscript collections. Terkla describes

Glastonbury Abbey (now a ruin) as the first such major monastic house in England, and suggests ways in which its particular books and maps might have been used together to develop a visual understanding of the world—a coupling that would indicate the first case of English geospatial awareness. The earliest catalog of Glastonbury's collection (1247–1248) inventories a now-missing map that Terkla tentatively identifies as the Anglo-Saxon Map contained within the *Cotton Tiberius B.v.* codex (c. 1050), a manuscript that is now in the British Library's collection, and of which a number of copies appear in the Glastonbury catalog.

Following a similar path, in Chapter Three, "Books and Maps: Anglo-Norman Durham and Geospatial Awareness," Terkla demonstrates how library holdings and clerical education flourished in religious houses across Anglo-Norman England in the twelfth century. This leads him to expand and deepen the story he outlined in Chapter Two regarding the burgeoning geospatial awareness and curiosity of English clerics.

Chapters Four through Ten, written by various scholars, are each devoted to an individual map. Contributor Nathalie Bouloux penned Chapter Four, "The Munich Map (c. 1130): Description, Meanings and Uses," detailing a map that appears in an early twelfth-century manuscript written in the north of France and consisting primarily of works by Isidore of Seville (d. 636); the map appears at the opening of Isidore's *Etymologies*. Bouloux argues that the Munich Map is the map that Hugh of St. Victor describes in his *De Mappa Mundi*, pointing out that the then-ubiquitous religious elements missing from the map—like the Earthly Paradise, or the placement of the City of Jerusalem at its center—shows its connection to Hugh's belief in the value of objective knowledge of the inhabited world.

In Chapter Five, Alfred Hiatt discusses the history and content of the Sawley Map (c. 1190). After a review of the evidence suggesting that this map is related to a mappa mundi left to Durham Cathedral by the Bishop of Durham, Hugh de Puiset, Hiatt sets the map in the context of the manuscript to which it is the frontispiece—a copy of the *Imago Mundi* of Honorius Augustodunensis (c. 1080–1157). His detailed analysis shows the map to be a synthesis of classical sources—presented with a decidedly Christian slant—and various references to Old Testament history and the Biblical account of the Apocalypse. Hiatt also explores the connection of the Sawley Map to the Hereford Map (c. 1300), as well as its similarities to, and differences from, earlier maps. Altogether, this chapter allows us to glimpse many of the complexities of the transmission and development of medieval mappae mundi.

Asa Simon Mittman unveils some new information about the Vercelli Map (c. 1217) in Chapter Six. This map has not hitherto received the level of attention paid to other maps of this period—largely due to its poor state of preservation. However, multispectral images captured by the Lazarus Project (**lazarusprojectimaging.com**) team have produced new visual information for further examination. Mittman assesses the previous scholarship on the Vercelli Map, and performs a close visual analysis of the map and its layout to set it in context with other major works in the same period, and to reveal important differences in its presentation of Europe, Asia, and Africa.

Up until the thirteenth century, mappae mundi typically employed a tripartite scheme—epitomized by the "T-O" configuration of Europe, Africa, and Asia. However, as Daniel Connolly points out, in his chapter "In the Company of Matthew Paris: Mapping the World at St Albans Abbey," the mappa mundi in Paris's *Chronica Majora* (1240–1253) looks almost nothing like this. Connolly argues that it is, in fact, more like the pilgrimage itinerary maps for which Paris is also known, and that this unusual style actually suits the *Chronica Majora*—Paris's history of the world from creation to the year 1253—better than would a tripartite map.

In Chapter Eight, "The Psalter Map (c. 1262)," Chet Van Duzer discusses the Psalter Map. This piece is unique, both for having been bound into a psalter—a volume containing the Book of Psalms and other devotional material—and for featuring two maps—one one either side of its sheet. On the recto (front) is a familiar mappa, and on the verso (back) is what is sometimes called a "list map." This list map has an overall form, design, and marginal decoration similar to the recto, but is made up of text descriptions of the important provinces and cities, which appear on the verso. Although other mappae are found bound into books—a circumstance that is a contributing factor in their survival—no others are in psalters, and after his examination of this unique context and the relationship between the two maps, Van Duzer notes the strong visual emphasis on the central element of Jerusalem. There is a popular theory that the Psalter Map was based on the roughly contemporary mural mappa mundi at Westminster Abbey (now lost), but Van Duzer argues that the description of the latter left by Matthew Paris shows them to have been very different. His findings further show that the map's visual emphasis on France suggests that the model for this map was more likely French than English.

In the following chapter, Dan Terkla takes up the first deep study of "The Duchy of Cornwall Map Fragment (c. 1286)" with a full transcription and translation of the fragment's inscriptions. He compares the fragment to its nearest surviving analog, the Hereford Map (c. 1300), to reveal similarities in design and theology—similarities which in turn generate new insights into the fragment's original appearance, placement, and use. Terkla shows how the map's patron must have been Edmund of Cornwall (d. 1300), who would have commissioned it as a display of authority and spectacle.

Marcia Kupfer writes in Chapter Ten, "The Hereford Map (c. 1300)," that the earliest records of the Hereford Map document its installation in a carved wooden case with painted shutters of near life-sized figures enacting the Annunciation. However, she notes, previous scholars have yet to discover the purpose of the map's purported triptych housing. She, herself, focuses on the physical and iconographical aspects the map itself—a large piece of vellum stretched on a wooden frame and decorated with depictions of both geographic and pietistic natures. Kupfer shows a correspondence between, for example, the physical embodiment of the artwork as a skin stretched and nailed to wooden cross-arms and the image of the Crucifixion painted at its center, and she further shows how this identified the fabric of creation with the Virgin's role in God's plan for human redemption.

The final chapter, "Digital Mapping, Spectral Imaging and Medieval *Mappae Mundi,*" brings our medieval pilgrimage through this *Companion* to a fascinating close. As Helen Davies and Gregory Heyworth write so eloquently, "Today, with the advent of imaging technologies that can return damaged or overwritten manuscripts to legibility, maps are themselves the undiscovered country at the bourne of innovation" (253). The authors examine the ways in which digital technologies assist different types of projects related to medieval maps, using several of the maps discussed in previous chapters as examples. They open with an examination of current digital approaches to mapping medieval cartographic information, describing digital mapping projects such as The Pelagios Project (**pelagios.org**), Mappa Mundi: Hereford Cathedral (**themappamundi.co.uk**), The Digital Atlas of Roman and Medieval Civilizations (**darmc.harvard.edu**), and Digital Mappa (**digitalmappa.org**; formerly Digital Mappaemundi). Each of these exciting projects is focused on compiling and annotating maps in a scholarly medium, and in a format that allows for closer inspection of text and iconography, as well as an analysis of the materials used to create them.

Part of this process is the translation of analog mappae mundi into the digital realm, using multi- and hyperspectral imaging, which may also be used as a method of digital recovery or preservation. The chapter includes an overview of the differences between, and particular uses of, each type of spectral imagery and continues with a discussion of deep mapping as a digital humanities paradigm. Deep mapping seeks to capture and incorporate the full range of discursive, material, and imaginative geographies that inform the conception of a location's topography and sense of place for the variety of social groups and individuals that encounter the landscape. The authors conclude with a discussion of significant new directions and lines of inquiry opened up by both of these methods and paradigms.

Nick Millea's fully annotated bibliography of resources from the past thirty years, including *The History of Cartography*, completes the volume. He draws resources from key publications and presents the reader with a multilingual collection ranging from general studies of the period to more focused works on specific maps, and includes resources on the new scientific methodologies that seem set to further upcoming research on medieval mappae mundi.

Together, the essays in the *Critical Companion to English Mappae Mundi* make a strong case for a fresh look at medieval mapmaking—filling a void in scholarship on medieval Anglo-French cartography of the period and expanding what we know about this style of mapmaking. They argue the need to go beyond the traditional classification of these works solely as a stage or cul-du-sac in the history of mapping, by conceptualizing them instead as deep mapping artifacts: integral products of medieval book production, manifestations of catechismal instruction, practical instruments of geographic awareness, displays of wealth, influence, and power, and a unifying framework for a holistic theology, among others. The essays call for a classification predicated not upon conventional similarities—which are, in truth, widespread—but upon significant differences. These differences point to unique humanistic elements that can, upon examination, provide insights into the humanistic concerns that underlay the intentions of the mappae mundi makers.

The delight and enthusiasm the contributors and editors have for their subject comes through on every page of *Critical Companion to English Mappae Mundi*—starting right from the Preface, and continuing throughout. The writing style of every contributor is highly approachable, making it easy to delve into the intriguing, if somewhat Latin-heavy, subject without a dictionary. All Latin phrases are translated, either inline or in footnotes. The organization of the essays and presentation of the color map plates and black and white images are clear and very readable throughout this *Companion*, with one small caveat: I would have liked to have the color plates of the map associated with each chapter displayed at the chapter's head instead of collected in a single group in chapter three. This is, however, likely a limitation imposed by the economics of the book's binding process rather than a fault with the volume itself.

REFERENCE

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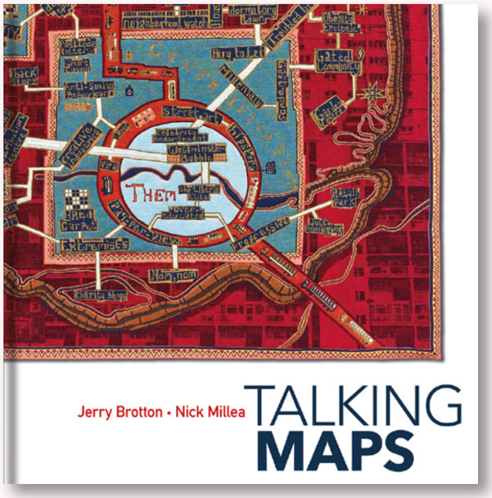
DOI: 10.14714/CP97.1659



TALKING MAPS

By Jerry Brotton and Nick Millea

Bodleian Library/University of Oxford, 2019

208 pages, 120 color plates

Hardcover: $55.00, ISBN 978-1-85124-515-4

Review by: Rhiannon Jakopak

In *Talking Maps*, Jerry Brotton and Nick Millea set out with the ambitious goal of exploring how maps function as a conversation between the mapmaker and user, through a recounting of the origin stories of several selected maps. The authors use in-depth research to situate maps in the historical and cultural milieus in which they were produced, while encouraging the reader to question whether these examples (and by implication, *all* maps) serve primarily as cultural artifacts—reflecting the time and place of their making—or as strictly unbiased scientific documents depicting the world. *Talking Maps* is an accessible, engaging, and casual read that would be most appropriate for readers who are relatively new to cartography and wish to know more about the cultural connotations that accompany any map.

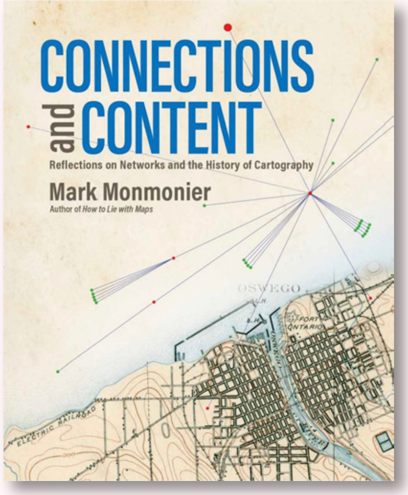
Talking Maps walks its readers through multiple categories, functions, and styles of maps, using examples of both well-known and sometimes-overlooked maps from around the world and across centuries. The book features high-quality images of nearly 100 maps, accompanied by detailed descriptions discussing specific elements of each map, why it might have been produced, what it suggests about the time and culture of its origin, and more. The 10 chapters of the book cover a range of topics, including the changing conventions of map orientation through time, the rise of *qibla* maps (which show the devout the direction of the Kaabah in Mecca, and which became ever more important as Muslims moved beyond the Arabian Peninsula), explanations of J. R. R. Tolkien's drawings of the Battle of Helm's Deep in the *Lord of the Rings*, and how maps were used strategically in World War II. Multiple times throughout the course of reading this book, I found myself excitedly showing whoever happened to be near me an image of a given map and sharing with them the history I had just been reading.

The authors have extensive experience with cartography, map curation, and history. Brotton is a Professor of Renaissance Studies at Queen Mary University of London and has published numerous books and articles on various topics related to history and cartography. Millea has been Map Librarian at the Bodleian Library since 1992 and has himself published numerous books and articles on cartography. The authors' expertise is on display throughout the book, which offers detailed documentation of the specific historical context of the place a map details, anecdotes about the predilections of the mapmakers, and more. These same gentlemen also curated the *Talking Maps* exhibition at the Bodleian's Weston Library (July 2019–March 2020). The Bodleian, at the University of Oxford, holds over 1.5 million maps, of which only a select few are featured in this book.

Perhaps the most compelling aspect of *Talking Maps* is the high-quality reproduction of such an impressive range of maps—from twelfth-century world maps to modern human population cartograms. The page layouts allow the reader to reference both the descriptions of the maps and the maps themselves with ease, without being overcrowded by too much text on a single page. The maps are printed on at least an entire page, and some maps are spread generously over two pages. The book itself is large, providing space for the maps to be reproduced in considerable detail. The authors guide the reader's attention to specific features of the maps, occasionally resulting in an exercise resembling *Where's Waldo*, as the reader searches for the mentioned features. The rich combination of context, comment, and contents that the authors provide for each map show the reader fine details that would otherwise be unknown or unsuspected, allowing for a deeper understanding and appreciation of each map.

My major criticisms of this book concern the strangely uneven selection of maps and the lack of any concluding remarks. There is such a focus on United Kingdom maps—with an entire chapter devoted to maps of Oxford—that the inclusion of other maps seems, in a way, a bit haphazard. For example, the few Islamic maps featured are mixed in with various other maps and scattered over several chapters. Perhaps the selection reflects the interests of the authors and the location of the exhibition upon which this book was based, but it is hard to tell. The selection criteria might have been clearer if there was a summary chapter or conclusion, but the book just unceremoniously ends. This lack of a conclusion is a missed opportunity to culminate the various enlightening conversations between mapmakers, users, and societies that had been playing out throughout the book. Instead of concluding remarks about how maps through time have always been artifacts that reflect the values and interests of the cultures that produce them, the authors just leave the reader to draw conclusions for themselves. Neither of these shortcomings are devastating, but they do leave the reader with a sense of imbalance and unresolved curiosity.

All in all, *Talking Maps* is an enjoyable and informative read. With its high-quality images and accessible explanations of the special features of each map, it serves as exciting introduction to the complexities of maps, their histories, and their places in society.



CONNECTIONS AND CONTENT: REFLECTIONS ON NETWORKS AND THE HISTORY OF CARTOGRAPHY

By Mark Monmonier

Esri Press, 2019

275 pages, 90 figures

Softcover: $39.99, ISBN 978-1-58948-559-4

Review by: Marissa Wood, International Mapping

In *Connections and Content*, Mark Monmonier provides a historical analysis of the evolution of modern cartography through an exploration of the development of "networks," which he defines as the "indispensable geometric framework[s]" (1) from which maps are derived. Starting from this purposefully broad and vague definition, he goes on to examine the build-out of such networks—from the days of early United States coastal and topographic mapping efforts through to modern-day election mapping—focusing on both the challenges posed and possibilities afforded by the technologies of the day.

The book contains seven chapters, each related to a broad technological development and the corresponding evolution it prompted in the mapping sciences: transportation infrastructure with topographic maps in Chapter 4, for example, and the telegraph with weather mapping in Chapter 5. The book moves through these developments chronologically, and is focused primarily on United States history and cartography. The paired topics in the other chapters include: baselines with early survey networks (Chapter 1); methods of deriving location, from early astronomical techniques to the Geocentric Datum of Australia 2020 (Chapter 2); the evolution of topographic map symbols for canals and railroads (Chapter 3); computers and mapping technology (Chapter 6), and lastly, a thoughtful discussion of the influences of cartographic manipulation on daily life (Chapter 7).

Monmonier's primary aim is to present a view of historical cartography in the United States that is predicated upon the establishment and widespread use of reliable geometric frameworks (his "networks"), and to show that without those frameworks, in whatever form they took, cartography could not have developed as it did. He proposes, for example, that it was the early nineteenth century networks created for detailed and precise mapping of the eastern coast of the United States that led to the networks later created by the United States Geographical Survey (USGS) to map, albeit with less accuracy and more artistry, the entire interior of the country. The USGS surveys then led to the westward march of rail and telegraph lines, which spurred development of the first geodetic datums, which in turn formed the base network underlying early American topographic mapping. It was the infrastructure networks of rails, telegraphs, and survey fabrics that made possible the mapping of the west to east movement of storms across the continental United States, an activity that matured into the most prolific of all cartographic genres: meteorology and weather maps. Today, computer technology facilitates map manipulation for political control, and there remains the potential for still greater influence of maps—for better or worse—on our daily lives as technology relentlessly pushes forward.

Overall, the case the author puts forward is convincing, but his argumentation is at times over-strenuous. For example, in the first two chapters—"Baselines" and "Geometry," respectively—Monmonier describes the painstaking process of developing triangulated networks anchored on precisely measured baselines. He dwells for pages on end on how early surveyors struggled with minutiae like the tiny but accumulating errors caused by the thermal expansion of their metal measuring tubes, but the author fails to justify the necessity of the repetitive extent of these details. In fact, Monmonier emphasizes his relentless perusal of particulars in the opening of the second chapter with the warning that "if you're put off by details, you might hate" his painstaking review of the mathematical calculations for latitude and longitude. Thirty pages into *Connections and Content*, the reader has been warned.

There is a fair amount of overlap between Chapters 3 and 4—"Symbols" and "Infrastructure." The first concerns topographic map symbols and their relation to infrastructure, and the second relates infrastructure to topographic maps. More specifically, both chapters focus on canals and railroads, with the first describing mapping the features and the other discussing the use of maps to plan and construct the features. Similar to Chapters 1 and 2, beautifully constructed sentences that manage to convey nothing at all abound. A fine example appears on page 108: "Because extensive transport networks of all types typically evolve step by step, maps have always had a role in advocacy, news reporting, and historical narratives," which comes after the reader has already worked through pages and pages on the subject.

Despite these problems, Monmonier offers in these first four chapters, and throughout the book, an incredible amount of interesting information on the history of mapmaking in the United States. While I was familiar with the process of astronomical cartography, I had never before considered how the telegraph, in providing precise details and timings of known astronomical events, could be used to determine location. Monmonier describes the process of observing a celestial event at a known location and comparing the timing of the same event elsewhere and using the difference in time to calculate latitude. He then directs the reader to "sketch an example or two on paper, to make certain you understand the principle," just in case his ill-prepared reader misunderstood the details of the science and math (34). As technology improved and allowed the area of the Earth occupied by the United States to be better and more precisely defined by, among other things, these astronomical observations, features on all of the old topographic maps had to be shifted to fit the new, more accurate, datum (51).

Somewhere in the middle of Chapter 4—after the author is at last ready to move on from canals and railroads—it starts to become more clear just how the linkages between networks and cartography illuminate the role of maps in modern society and how they have contributed to, and benefited from, the development of science and technology. The fifth chapter, "Telecommunications" offers a beautiful narrative of the progressive development of telegraph infrastructure in tandem with weather science. It includes examples of early live maps, such as one managed by the Smithsonian Institution in the late 1850s, which was updated daily with hanging cards representing weather patterns from across the continent (136). Monmonier also points out the impact the Civil War had on the development of meteorological sciences, describing how civilian telegraph lines, which were formerly transmitting weather data multiple times a day across the country, were co-opted by military authorities or had their activities disrupted (139). For example, after the withdrawal of the Confederate south from the United States, southern telegraph stations stopped communicating weather data to the Smithsonian Institution and other contemporary meteorology hubs in the north, gravely reducing the accuracy of storm movement predictions.

Chapters 6 ("Topology") and 7 ("Control") recount the development of computer mapping technology and look ahead to project future possibilities in the field. Monmonier describes digitization efforts at the United States Census Bureau—which began as early as 1890—and how their Topologically Integrated Geographic Encoding and Referencing (TIGER) base map files lent themselves to partisan gerrymandering by those seeking to maintain political power (202). Finally, he imagines maps in a world where "Social Media meets the Driverless Car" (189). It is introduced with an anecdote about his own difficulties as a driver deviating from a GPS-prescribed route to do some sightseeing.

Connections and Content is illustrated with a multitude of figures—some by Monmonier himself—and historical maps and drawings enlarged for clarity or reduced to fit the page. The figures relate to, and help clarify, various points, such as the depiction of valleys and ridges on contour maps (Figure 3.3), and the evolution of the Internet (Figures 7.1 through 7.5). All of the illustrations are in black and white, a curious choice in view of the fact that the book's pages are bordered in full color, with snippets of a different historical map for each chapter. It is especially odd when color itself is the topic under consideration, such as the discussion in Chapter 3 of the colored symbols used in USGS topographic maps, where he refers to "'heavy Prussian blue', . . . India ink, . . . and burnt sienna" (64). Throughout, Monmonier offers readers constant reminders that he has, for example, converted a color map to greyscale before he "manipulated the relative darkness of shades of grey to emphasize some features more than others" (70). The book is peppered throughout with editorial evaluations of its illustrations—those the author drew and others he chose to include. Among the comments are such insights as: "indeed, its lack of precision is an enigma" (132) and "most cartographic purists would excuse the rounded coastlines" (198). He spends an entire page in Chapter 4 reviewing his own two-panel Erie Canal map (Figure 4.1), which he quite proudly calls "a graphic paragraph of sorts" (101). I found these frequent, and sometimes lengthy, asides jarring digressions from the book's primary, historical focus.

The final chapter covers the symbiosis of cartography with networks of control, such as in the case of maps used to manipulate electoral outcomes. This chapter contains a series of bold statements about the 2016 Presidential election that, while based in fact, may generate some controversy in the current political climate. For example, Monmonier sums up the role of the Russian government's use of social media to influence the election outcome with, "Clinton was strongly disliked by Russian president Vladimir Putin, who apparently believed that pejorative posts and forwarded fabrications would benefit her opponent, Donald Trump. . . ." On page 200, Monmonier provides a proposal of his own for fixing the broken electoral college system—one that involves awarding electoral votes proportionally, based on the popular vote count in each state, rather than the current winner-take-all system. But he also notes that until the problem of widespread partisan gerrymandering is addressed, even this bold and progressive voting system reform will not solve the underlying problems. I have to agree with Monmonier that this is an "awkward" place to end the book (206).

Although the author is largely successful in presenting his thesis, it never becomes clear just who Monmonier sees as the intended audience for *Connections and Content*. Much of the book delves deeply, perhaps unnecessarily so, into specific examples and invitations for you to "try it yourself" (13) as if you were a student in a network-focused cartographic history class. The first two, math-heavy chapters were interesting but something of a chore to get through, and most of the next two chapters get a bit bogged down with steel rails and water-filled ditches. *Connections and Content* is an interesting and informative read but might have had a broader appeal as a series of essays, commenting on cartographic history, development, and the current problems in mapmaking. The use of the broad idea of "networks" to string the various essays together has instead led to too much awkward overlap between sections. This book has an identity crisis. Is it for surveyors interested in the historical development of mapping technology? Is it for students whose eyes are on the future role of cartography in daily life? It is surely not for the average reader casually interested in the history of mapping in the United States, unless they can appreciate quite a bit of obscure math and a deep dive into cartographic/communication design analysis.

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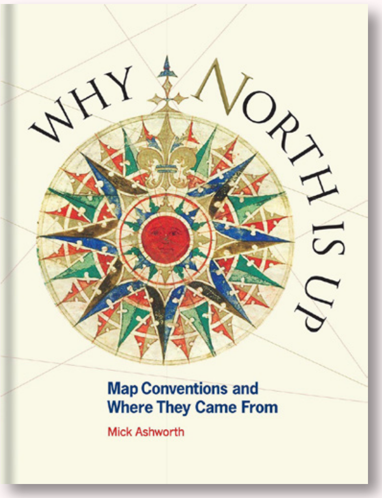

WHY NORTH IS UP: MAP CONVENTIONS AND WHERE THEY CAME FROM

By Mick Ashworth

Bodleian Library/University of Oxford, 2019

224 pages, 109 maps

Hardcover: $30.00, ISBN 978-1-8512-45192

Review by: Sarah Kelly, University of Colorado Boulder

Why North Is Up: *Map Conventions and Where They Came From*, by Mick Ashworth is not the dry, textbook-style history of cartographic conventions I expected, but is instead—to my delight—a quite elegant telling of "how widely accepted mapping conventions originated and evolved" (cover blurb), and is beautifully adorned with 109 maps from throughout history.

The book begins with an introduction that provides background information on the various types of maps found throughout the volume, and the many difficulties faced by cartographers in making quality maps—difficulties such as determining an appropriate scale, representing a spherical planet on a flat piece of paper, and selecting map symbols. Ashworth explains how each of these choices can lead to map features being misrepresented, and why readers should exercise caution when interpreting maps. The introduction concludes with a note explaining that (unspecified) emerging conventions are changing the way we interpret and interact with maps.

The book is divided into seven Parts: "Map Structure," "Symbols," "Representations of Relief," "Names and Boundaries," "Thematic Maps," "Specialized Conventions," and "Post-Convention Mapping." Each Part contains between two and seven short, easily digestible chapters. At the end of the book are "Notes and Further Readings," credits for all the maps, and a handy index.

The book takes its title from the topic of the first chapter of Part I: "Map Structure," which discusses why most maps today are oriented with north at the top. Clearly, "the Earth doesn't have a top and a bottom" (7), and there is no rule that explicitly states that north must be at the top of the map, so how is it this practice has become uniform? Ashworth focuses on the factors that may have influenced the adoption of this convention, and his discussion is supported with many south-up map examples. These range from al-Idrīsī's world map from the sixteenth century to *McArthur's Universal Corrective Map of the World* from 1979. The chapter concludes with mention of technological advances, such as Google Maps, which, when zooming out, offers users a globe that they can spin to whatever orientation they please, helping make the "north up" convention less imperative in daily map use.

The second chapter is dedicated to latitude and longitude—how, and by whom, such lines were defined, when we first saw such systems used, and what it was that spurred the development and use of prime meridians. Early maps, such as the "map of the world published by Donnus Nicolaus Germanus, circa 1460, based on Ptolemy's *Geographia*, circa 150 CE" (14) compliment the text (Ptolemy had been the first to use the terms latitude and longitude when describing grid coordinates). In the third chapter the author deals with map projections, beginning with the classic orange peel example, demonstrating the impossible task of transforming a spherical surface to a flat one without disruptions and distortions. Important concepts such as projection families, map scale along the line of tangency, rhumb lines, and projections that preserve metric properties (such as equidistance) are touched upon, but there is a lot left out or glossed over. For example, insufficient information is provided about the main properties of map distortion (shape, area, distance, direction) to allow them to be understood in any meaningful way, and the chapter lacks any mention of projection aspect or geodesy, although, admittedly, geodesy may well be beyond the scope of this popular-level book.

The fourth chapter in Part I opens with a grim example of how grids were used in World War I to record body counts, but it then goes on into the wider history of grid use. Early examples include a Chinese map dating from the twelfth century (*Yu ju tu*, circa 1137) and John Norden's *Myddlesex* (1593), the first map to use an alphanumeric grid index system much like the ones we often see in present-day atlases. More recent developments such as the British National Grid (BNG) and the Universal Transverse Mercator (UTM) systems are also discussed, along with an explanation of the concept of *eastings* and *northings* used by these and similar systems.

Scale, an important concept often overlooked by amateur cartographers, is presented next. Ashworth accurately states that "with reduced map scale come limitations both on what it is possible to show and how it can be represented" (35). In addition, he describes the three methods for representing scale—graphical (scale bars), mathematical (representative fractions), and descriptive (*this* to every *that*; for example, one inch to every mile). Map examples include some with very ornate graphical scale representations from the sixteenth and seventeenth centuries and a beautiful topographic map of Mont Blanc from 1865 that uses all three methods to represent scale.

The last two chapters of Part I, "Legends: What does it all mean?" and "Ornament: Art meets science," together speak to the features of a map that support its usability and lend it an air of authority—by providing a key to the map symbols used and by stylistically signaling to the reader the professionalism of the maker. In earlier times, for example, map legends were presented in very ornate cartouches or decorative panels—Christopher Saxton's *Norfolciae* (1579) is the example shown—but since that time mapmakers have more and more tended to "adopt the much simpler, functional styles with which we are familiar today" (53)—as is seen in the *Former Yugoslavia Series M709 1:50,000 Sheet Vareš* (U.S. Defense Mapping Agency 1995). Along with ornate legends, early maps often had elaborate borders and map symbols that, to modern eyes, at least, made these maps look more like works of art than scientific documents. This effect is shown with some magnificent examples, such as Willem Janszoon Blaeu's *Nova totius terrarum orbis* (circa 1606).

Part II of the book has six chapters dedicated to map symbols and their use. The first chapter focuses on the symbols themselves in their three basic forms—points, lines, and areas—and their basic styles—pictographic and geometric. The concept of visual variables such as shape, size, and

Nova totius terrarum orbis, Willem Janszoon Blaeu.

hue is introduced, with examples of how they are used. The variables of orientation and position in the plane are not included, presumably because they are less commonly used.

Each of the next three chapters are devoted, in turn, to the various ways each of the basic symbol forms can be employed—starting with points. Point features can be represented by either geometric shapes or pictographic symbols. Ashworth, however, proposes that while geometric symbols are generally easier to find, the use of pictographic symbols allows for faster interpretation. I would disagree with him on this. It is true that pictographs can carry more connotative detail—perhaps aiding *feature* interpretation—but this individuality is usually at the expense of a larger symbol size. Large point symbols can quickly clutter the map, often making interpretation of the *map* (as opposed to the *feature*) more difficult. Similarly, Ashworth also feels that the variable of shape, along with that of size, is appropriate for indicating a hierarchy among point features. This view, however, contradicts the orthodox convention that dictates that while shape can be used effectively for grouping features of different types, it cannot be used to establish hierarchy.

The next chapter, "Line Symbols: Keeping on track," focuses on transportation networks, with examples such as Harry Beck's *London Underground* (1933). Only one line symbol map produced prior to the nineteenth century is included—an extract from the *Book on Navigation* by Piri Reis (1525)—and I was surprised that W. R. Gardner's 1823 *Comparative Heights of the Principal Mountains And Lengths of the Principal Rivers in The World* was not, although John Ogilby's *Road from London to Aberistwith* (1665) is referenced in a sidebar. The text mentions, and provides examples of the use of, different textures and hues to represent different types of line features, and of widths for indicating quantitative differences.

Ashworth then moves to area symbol representation, where he emphasizes their importance in a discussion of the *Map of Eastern Turkey in Asia, Syria and Western Persia* (Royal Geographical Society, 1916), which identified how the British and French intended to divide the Middle East between them once World War I concluded. Many maps representing area features include political divisions, but they often also show natural features such as ecosystem classifications, or statistical information such as COVID-19 cases by country. Area color was a problem for early maps—often having to be applied by hand—but the introduction of lithographic printing in the nineteenth century made printing areas of nuanced color variation much simpler and cheaper. This discussion of color segues into the next chapter—"Colour: Deep blue sea?"—which briefly discusses how color use has evolved, the emotive connotations implied by color, and the role our "understanding of light, electromagnetic radiation and optics" (88) has played in evolving mapping practice. The author points out that current color conventions were well established by the mid-nineteenth century, and he speculates that the advent of online mapping may lead to the development of further styles and conventions.

The final chapter in Part II is on generalization, an important topic that is often overlooked by both map readers and makers. It starts by discussing the importance of scale and map purpose relative to generalization and then moves into generalization techniques, though no comprehensive list of these techniques is provided. The author stresses that in generalization there are no rules or conventions that apply across the board. He chooses to illustrate the potential for generalization techniques to be used in the manufacture of propaganda with *England's Raids over 5 Continents 1605–1940*, a 1941 map by Alois Moser, although many better examples of propagandizing generalization exist.

Part III is all about the "Representation of Relief," with five chapters that explore the various ways that elevation can be portrayed. Spot heights and soundings come first, and the author is careful to point out the difficulties encountered in trying to represent, or read, the overall character of terrain with discrete measurements alone. The next technique is hachures—lines that run downslope in order to portray relief and slope. First used in the seventeenth century, hachures are no longer commonly employed, although Ashworth writes that "there is still room in cartography for the[se] more subjective and artistic methods" (109). This chapter includes some beautiful examples of both landscape and nautical maps employing hachured terrain. A chapter on "Contours and Isobaths: On the level" follows, and provides background on when, where, why, and by whom contour lines were first used. The various types of contours are explained, and early map examples are presented.

The next chapter in Part III is about the use of "layer colors" to depict elevations and depths—also known as hypsometric or bathymetric tints, respectively. The early history of their use is explained, but the most interesting aspect covered is that of the debates surrounding the sometimes very different color gradation schemes that have been used for representing relief. A rundown of the various confusions that can arise when using color to portray landscape elevations, along with the potential complications that can occur when these colors are used in conjunction with other relief portrayal techniques, closes out the chapter. The final chapter in Part III, "Hill Shading: Out of the shadows," examines this mimetic technique that strives to give the perception of a three-dimensional landscape through the use of idealized shadowing cast by a hypothetical light source illuminating the terrain from an oblique angle. The sample maps the author included to accompany this chapter bear out his remark about "the best examples [of hill shading] being the perfect blend of art and science in map-making" (127).

Part IV, "Names and Boundaries," has three chapters, with the first being "Place Names: Putting a name to it." The chapter begins by providing a place name—in this case, *Paris*, *France*—along with its geographic coordinates, and then proceeds to demonstrate that there are multiple ways in which we can name what is at that location. Ashworth is quick to point out that place names on maps can be quite subjective, and can vary by language and by political agenda. The conventions pertaining to the placement of text associated with map features are discussed briefly as well. The second chapter, "Boundaries: Drawing the line," discusses how line texture and color can be used to represent different types of boundaries, and includes a look at the significantly different ways lines representing boundary features can be drawn, depending on, among other things, a mapmaker's viewpoint or the geopolitical standing of the area being depicted. The third and final chapter is entitled "Typography: Keep it clear," and it deals with the various styles and forms that text on a map can take. Ashworth focuses on the main principles of typography—text positioning, font style, size, weight, and relative hierarchy. One of the example maps presented is a T-O map from 1472, but no modern maps are included.

Part V, "Thematic Maps," has only two chapters, "Qualitative Thematic Maps: What do we have here?" and "Quantitative Thematic Maps: How many are there?" In the first chapter, Ashworth discusses the difference between general (reference) and thematic maps, and discusses the common pitfalls encountered by makers of thematic maps (for example, using overly complicated pictorial symbols and/or mapping too many phenomena). Unfortunately, this chapter (along with the next one) proved to be the biggest disappointment of *Why North Is Up*, as the reader is misinformed on a few topics. One example regards the first graphic presented in this chapter: John Snow's famous *Map of Soho, London*, showing cholera deaths in 1855. Ashworth claims that this map is qualitative, ignoring the fact that it uses small black bars to show the count of individual deaths occurring at each address. Counts are quantitative in nature and, even if no mortality numbers are written directly on the map and no comparative statistics with deaths in adjoining areas are given, the map is still representing numerical information and should therefore be included in the chapter on quantitative maps.

The quantitative chapter goes into some detail on methods for mapping numerical thematic information, such as choropleth maps and graduated symbol maps. Cartograms, too, are discussed briefly in a sidebar, but no examples of such maps are included. Unfortunately, the author inappropriately conflates proportional symbols with graduated symbols, and furthermore, he incorrectly states that the visual variables of shape and orientation can be used to represent differences in relative value. Unreliable information of this sort seriously undermines the real value the rest of this book delivers.

Part VI is about "Specialized Conventions," and includes chapters on geologic maps, hydrographic charts, military maps, and global mapping (in particular, Albrecht Penck's vision for the *International Map of the World* in 1891 and the difficulties that the venture encountered), with some beautiful examples accompanying each topic. While each of these topics have come up previously, these chapters go into more detail and elaborate on the history of each.

The final part of the book, Part VII, "Post-Convention Mapping," has three chapters on some of the more recent advances in cartography. The first chapter, "Different Perspectives: Picture this," is all about maps that portray features with a "bird's-eye view." The exquisite examples include Heinrich Berann's *Yellowstone National Park* (1991), along with some other, older, examples. The development of aerial photography, satellite imagery, and light detection and ranging (lidar) are mentioned as well. The second chapter focuses on the development of digital mapping technologies such as GPS and GIS, along with online mapping systems, and how such technology requires mapmakers to consider cartographic conventions in relation to digital map functionality (for example: dropping pins, URL links to other data sources, route tracking), but does not make any mention of the concerns around locational privacy. The final chapter covers what the author terms the democratization of cartography—crowdsourcing, open source data, and how we are all contributing to digital maps even if we are not aware of it.

The book ends abruptly, with no closing remarks, but it does provide a succinct list of resources for further reading.

Overall, I believe Ashworth has met his goal of providing a background on the origins and role of mapping conventions, and he does so with interesting stories, beautiful maps, and a comprehensive list of topics presented in succinct chapters. I have pointed out a few issues I found with some of the information he presented such as those related to map symbols and thematic mapping. I also found that not all of the many maps included in the book are referenced in the text, and that there are other maps that are mentioned without reference to a page or figure number. Despite these shortcomings, I am not at all deterred from recommending *Why North Is Up*: *Map Conventions and Where They Came From* to both novice and experienced mapmakers. It provides the reader with the very interesting history of map conventions, accompanied with many gorgeous illustrations that are not typically presented in cartography textbooks. This book can serve as a reference for cartographic scholars while also being an enjoyable read for anyone interested in the history of maps and mapmaking.

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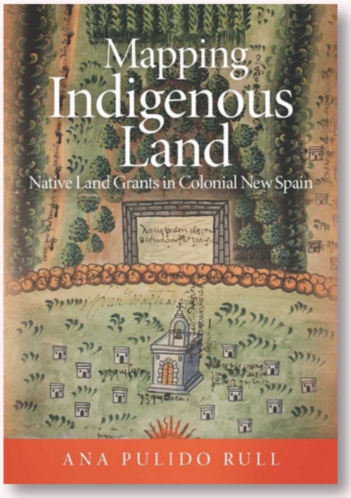

MAPPING INDIGENOUS LAND: NATIVE LAND GRANTS IN COLONIAL NEW SPAIN

By Ana Pulido Rull

University of Oklahoma Press, 2020

216 pages, 52 black & white and 27 color illustrations, 2 maps, 4 tables

Hardcover: $45.00, ISBN 978-0-8061-6496-0

Review by: Jörn Seemann, Ball State University

In pre-Columbian times, the Aztec, Maya, Mixtec, and Zapotec peoples of Mesoamerica—the region that historically extended from central Mexico to Costa Rica—all brought forms of visual communication to a high level of development. Included among these forms were sophisticated mapmaking practices. Art historian Barbara Mundy affirms that this kind of mapmaking was a genuinely American achievement that evolved independently from traditions in the Old World, and writes that "these cultures of Mesoamerica took the production and use of maps to a level unparalleled elsewhere in the New World" (Mundy 1998, 183). There are at least four different map types among the surviving artifacts: celestial maps of star constellations and the night sky, cosmographical maps that explained the universe, cartographic histories that visually projected communities and their territories in space and time, and large-scale plans of individual properties (Mundy 1998, 187).

This last category is the object of investigation for Ana Pulido Rull's study of land grant petition maps in the Viceroyalty of New Spain. Created shortly after the arrival of the conquistadors in 1521, the Viceroyalty controlled the Spanish Crown's lands in Mesoamerica. As Spanish colonizers began to seize more and more Indigenous lands for agriculture and cattle herding, Spain became concerned about unlawful occupation, and eager to regulate property holdings. Through its overseas representation, the Viceroyalty, Spain aimed to officially register and control land titles through specific legal proceedings, beginning in 1536. The first step for a Spaniard interested in using land for economic activities was to file a petition for a *merced*, a land grant, with the Viceroyalty. The request was then sent to the local authorities, who would announce the details about the proposed property, the petitioner, and his intents in a public hearing. Interested parties, both Spaniards and Indigenous, had the right to manifest their support or objection to the request, and this was followed by a field inspection and the questioning of witnesses before the judge pronounced his verdict on the case.

The *Archivo General de la Nación* in Mexico City holds about 7,500 legal documents on land titles produced during the first two centuries of Spanish colonization. These records include verbal testimony (conversations, attestations, and accounts of conflict), written documents, and over 700 maps with details on measurements, place names, and specific locations, drawn by Indigenous painters or Spanish draftsmen to visualize the land covered by the grant petition. This archival source provides the primary material for Pulido Rull's study, specifically "the corpus of paintings known as land grant maps, or *mapas de mercedes de tierras*, kept today in the map gallery (Mapoteca) of the Mexican National Archives" (3). Pulido Rull's focus is on the more than 200 works produced by Indigenous artists. This is the first thorough examination of this peculiar set of maps that specifically addresses local land grant disputes, and it parallels Mundy's more general official survey of the *Relaciones Geográficas* between 1579 and 1585 that aimed to collect population data and to map territories in New Spain (Mundy 1996).

Unlike other Spanish territories, land proceedings documentation in New Spain commonly featured a painting of the area where the property was situated. This practice followed the tradition of the Aztec legal system, which used drawings and paintings as narratives and proofs in litigation. In pre-Columbian times, a *tlacuilo*, or painter-scribe, undertook the recording of all sorts of historical, genealogical, and geographical knowledge, and, as Pulido Rull notes, "there was no distinction between painting and writing: those who created manuscripts wrote using images" (66). This pictorial approach is deeply embedded in the many Mesoamerican visual cultures that commonly emphasized images, pictures, and glyphs as "alternative literacies" over verbal forms of expression (see Leibsohn [2009] and Boone [2010] for fascinating examples).

Within this context, Pulido Rull sets out to read between the lines of these pictorial representations of places and properties, and the accompanying documentation, to find out about how these maps were used as accepted visual arguments, forms of contestation, and strategies of negotiation between Indigenous people and the Spanish colonizers. She argues that these maps by unknown authors served as "cross-cultural communication" (4) and "persuasive and rhetorical images" (5) that expressed distinct views and understandings of the contested lands and were accepted as statements of truth by all participants.

The book is divided into five chapters. In the first, the author provides the historical context for the legal proceedings in land grant processes in New Spain. In theory, the Spanish Crown only allowed requests to be filed for demonstrably vacant lands, as a form of protection for the Indigenous population that had cultivated fields and herded animals in this region for a long time. However, the court records show that the application of land grant laws had many loopholes and a lot of room for corruption, fraud, and dishonesty—to the great disadvantage of Indigenous landowners. The chapter describes in detail how judges, scribes, translators, painters, and involved parties communicated and interacted from the moment of the official reading of the request—which frequently occurred after Sunday mass—to the final decision about the land ownership.

Chapter 2 focuses on the Indigenous artists and the painting process itself. The land grant maps blended pre-Columbian Indigenous pictorial traditions with elements of Renaissance art introduced by European monks from mendicant orders, who came to Mesoamerica to catechize and educate the Indigenous people, and who also taught them to paint religious motifs on church and monastery walls. As a result of this cultural encounter, the maps frequently contained both conventional Indigenous glyphs and European elements and techniques, such as human figures, scale, and perspective. Many of the resulting maps included pre-Columbian pictographs for houses, paths with human footprints for designated roads, whirlpools for water bodies, bell-shaped hill symbols for elevations, and trees with exposed roots. These sophisticated, colorful paintings in Pulido Rull's study were painted with locally available pigments extracted from flowers, seeds, insects, or minerals on paper either imported from Europe or made from local fig-bark or agave fibers.

The remaining three chapters of the book discuss particular land dispute cases in different stages of the process during which grants were requested, opposed, and negotiated. Pulido Rull presents detailed narratives of the court documents and the property maps. Chapter 3 tells about the case of Andrés de Arellano, the Indigenous governor of Pahuatlán, who requested two ranches for small cattle herding in the proximity of the town. The colorful pictorial land grant map depicts hills and mountains (in green, with tree symbols), a standardized church symbol for all settlements, and brown tones for roads. The plains between the elevations are painted in light yellow, "which creates a sense of depth" (85). The two properties for the land grant are at the bottom of the map (west), and are less carefully drawn in the form of rectangular fenced areas. Arellano's petition was approved within two days, because the ranches "would not bring harm to a third party." (83)

Many cases did not reach the quick resolution of the example above. In Chapter 4, Pulido Rull sheds light on multiple processes through which Indigenous people opposed requests by Spaniards because the proposed herding grounds were too close to Indigenous properties, and they feared damage to their crops or the contamination of their water sources. In the case of a petition in the town of Coatlinchan, a Spaniard requested lands for two small animal ranches—claiming that these lands were vacant, even though the Indigenous people declared that they had used them for a long time and even had received a property title signed by a former mayor. A few days after the initial hearing, another Spaniard submitted a request for lands close to the area of the first petition. The maps used in this dispute show heavy reworking. Places crucial to the argument of the Spanish petitioners were amended: patches of paper were glued on top of the original map, farms were displaced to "safe" positions, and an entire cornfield even disappeared from the map—all in order to make points for the Spaniard's argument. Infrared photos clearly show palimpsest evidence of this meddling with the map's contents. The result of the lawsuit was the unanimous approval of the petition by both Spanish and Indigenous witnesses—an outcome that could indicate collusion, coercion, or even bribery (118).

Unfortunately, many cases were decided in favor of the Spanish petitioners, despite the questionable quality of their evidence or argument. This systemic partiality induced many Indigenous people, who at first contested the requests, to attempt to negotiate, and, ultimately, to withdraw their veto, as the author shows in Chapter 5. Five years after the decision about the land grants in Coatlinchan, the Spaniard Diego de Villegas also petitioned for land to open two cattle farms. His request was approved swiftly, despite the fact that another Spaniard who had applied for the same lands four years earlier had been rejected. In this particular case, Pulido Rull can only speculate on the chain of events that made witnesses change their mind, suggesting that giving in might help them to receive "some benefits and establish a good relationship with the new landholder" (160).

Pulido Rull's account is very engaging and reads like a collection of detective story plots with cartographic crimes and historical "story maps." Her patient deciphering of court documents allows her to reconstruct crucial parts of the judicial proceedings and the more than 50 black-and-white illustrations and 27 color plates showing complete maps or zoomed-in details give what seems likely as clear an understanding of the issues and arguments as was available to the judges. Altogether Pulido Rull shows not only that these cross-cultural maps were powerful tools to represent reality, but also how that representation could be altered or reworked to reflect changes in how someone wishes that reality to be presented. Cartographic palimpsests—that is, areas on a map that have been scraped off, overwritten or covered with other pieces of paper—were not uncommon among the land grant maps, and clearly represented shifts in a petitioner's argument in order to gain or maintain advantage.

It would have been useful for the author to devote some time early in the book to discussing the theoretical framework within which she places her cartographic study, but it is only in the book's conclusion that the author alludes to the work of J. B. Harley and his ideas about the rhetoric of maps and their propositional character. Presenting this discussion earlier would have set the stage for her analysis of the land grant maps and how these were used as visual arguments, albeit most frequently in favor of the colonizers. Although Pulido Rull's intention is to point out that there was a distinctly Indigenous dimension in the mapping process for land grants—one that is still visible in the archives despite the widespread erasure of historical Indigenous traces in the Americas—the reader may gain the impression that she tries to extract more facts on Indigenous mapmaking from the documents than what she could, in fact, find. Due to the scarcity of original Indigenous records, and to the almost overpowering presence of the "paper bureaucracy" of the Spanish colonial administration, information about Indigenous society in general and mapmakers in particular is scarce. Nonetheless, her study shows the powerlessness of the Indigenous population suffering encroachment on their traditional lands, and the partiality of the legal system that very frequently dismissed their concerns. On the other hand, signs of hope can also be found. For example, she discusses one of the few lawsuits decided in favor of the Indigenous people, when a land grant for a limestone quarry was subsequently revoked and the public prosecutor requested that the Spanish petitioner and his workers "be taken in custody and formally charged" (17). The court documents do not tell if this request was executed, but it seems clear that the Indigenous landowners were able to secure their lands.

I feel that the author could have engaged with the issues and questions surrounding postcolonial and decolonial cartography more deeply than she did (see, for example, Akerman [2017]). Engaging these issues would have helped contextualize her study and make a stronger statement about the importance of Indigenous maps and cultural perspectives in the history of cartography—a history that for a long time has maintained a biased view of non-Western or "primitive" maps.

Mapping Indigenous Land includes glossary of more than one hundred Spanish and Nahuatl technical terms with explanations of their specific meanings, some of which can be difficult to understand from a modern Western perspective. The illustrations of historical paintings are fascinating, but I have a minor complaint about some of the contemporary maps used in the book. It would be useful to add a general map showing the locations of the land grant cases and documentary paintings discussed. This would have been of tremendous help for those readers not already familiar with the historical geography of Mesoamerica; more help than the catalog of land grant maps that is included in the appendix. Although there were two location maps with a relief background (Figures 5.1 and 5.4), they are disproportionately large and not very informative, adding very little to the text. Nonetheless, these small issues do not take away any of the merit of this captivating study. In conclusion, *Mapping Indigenous Land* is a pleasant and entertaining read that provides insights into stories of mapmaking at the contact zone between Mesoamerican and European cultures. The book will definitely spark the interest of those readers who are not only curious about historical maps from New Spain, but also about maps as storytelling devices and as visual arguments.

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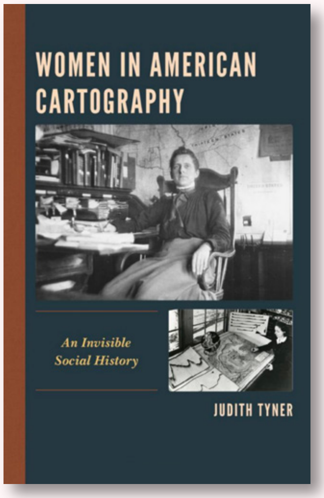

WOMEN IN AMERICAN CARTOGRAPHY: AN INVISIBLE SOCIAL HISTORY

by Judith Tyner

Lexington Books, 2020

131 pages, 24 illustrations

Hardcover: $85.00, ISBN 978-1-4985-4829-8

Review by: Jenny Marie Johnson, University of Illinois at Urbana-Champaign

Judith Tyner is a master teacher, researcher, and author, and her new book—*Women in American Cartography: An Invisible Social History*— is an approachable and seamless read. In this, it is much like her other works, which includes titles such as *The World of Maps* (2015), *Principles of Map Design* (2010), and two chapters in *The Routledge Handbook of Mapping and Cartography*, "Designing Maps for Print" (2018a) and "Persuasive Map Design" (2018b). *Women in American Cartography* focuses on women mapmakers in the United States from the late eighteenth century to the end of the twentieth. Tyner's background and research, each broad and deep, gives her a platform of substantive content to distill and present to her readers.

Women in American Cartography is comprised of six somewhat chronological chapters that are proceeded by an introduction and followed by a conclusion. The front matter includes a list of abbreviations, and each chapter, as well as the introduction and conclusion, has its own set of endnotes. A list of colleges and universities that hosted Army Map Service military mapmaking classes, a bibliography of cartography dissertations and theses by women 1966–1982, and a consolidated bibliography are all found at the end of the volume.

The introduction contains an extensive and valuable literature review, one that places Tyner's work in the context of both other works on women cartographers and of more general works on the history of cartography. *Women in American Cartography* highlights individual, named women cartographers within their work environments, organizations, or institutions, deftly balancing descriptions of the societal and organizational contexts in which women cartographers worked with often highly personal (or personable) descriptions of the women themselves. Tyner has not written a "bibliographic dictionary;" she instead tells "the story of how women fit into various cartographic cultures." (7) There has been a noticeable lack of coverage of women cartographers in histories of cartography, but, as Tyner writes, "To be fair, there has also been less done on male cartographers than their maps as histories of cartography have focused on maps not chaps" (2).

The question "Who is a cartographer?" played a critical role in shaping the scope of *Women in American Cartography* and in selecting which individuals to include. As the author explains:

> In this work, I have cast my net wide and I include all women who were involved in the mapping field. Some women were not cartographers per se in the sense of conceiving and drawing maps, but contributed by researching, editing, engraving, and printing. They were all part of the "map trades" or what van den Hoonaard [in *Map Worlds: A History of Women in Cartography* (2013)] has designated the "map worlds." (6)

Tyner lists six questions that she kept in mind while writing (7):

- What were the roles of women in American cartography?
- What kinds of maps did they make?
- How did women fit into the overall history of American cartography?
- How did individual women learn to make maps or get involved in the field?
- How did women's roles differ from those of men?
- Did women's maps differ from those of men?

Readers will see evidence of these questions and their answers throughout the book.

The six chapters—"Pedagogues and Students;" "Activists, Persuaders, and Travelers;" "Pictorial and Illustrated Maps;" "Millie the Mapper and Maps of the Second World War;" "Women Professors and Researchers: Their Role in an Emerging Discipline;" and "Government Girls and Company Women"—vary in length and in the depth to which specific women are discussed.

The first chapter, "Pedagogues and Students," begins the story of American women cartographers in the late eighteenth and early nineteenth centuries with a brief description of the educational opportunities and resources available in the United States at the time. The chapter includes robust descriptions of female teachers, highlighting Emma Willard who was a pioneer in teaching geography through map drawing; textbook authors; schoolgirl maps (a particular interest of Tyner's); and globes as pedagogical instruments. Chapter two, "Activists, Persuaders, and Travelers," explores how nineteenth- and twentieth-century women and women's organizations in the United States created maps supporting their causes and movements. Additionally, three women travelers/explorers, who documented their travels with published works that included maps, are highlighted.

Women cartographers are viewed through the lens of "Pictorial and Illustrated Maps" in chapter three. The attributes and uses of these maps, as well as places that examples can be found, are a frame for descriptions of the work of nine cartographers who created maps between the 1920s and the late twentieth century. Chapter four, "Millie the Mapper and Maps of the Second World War," is the most chronologically focused of the chapters. The bulk of the chapter describes women cartographers in three United States government agencies, with particular attention paid to mapmaking programs established by the Army Map Service at a number of colleges and universities. Tyner also discusses the attitude toward women in these workplaces and their postwar experiences.

Because cartography was not a recognized academic discipline prior to the Second World War, most of the women with PhDs in cartography whose professional paths are highlighted in chapter five, "Women Professors and Researchers: Their Role in an Emerging Discipline," were active in academia only post-war. This chapter also touches on the use of cartography as a research tool, through the pioneering work of Marie Tharp, and as illustration, Tyner uses her own experiences, both as a graduate student and as a faculty member in a geography department, as a case study to typify the experiences of women in academic programs.

The final chapter, "Government Girls and Company Women," surveys women's cartographic roles in the latter half of the twentieth century: independently creating custom maps to order or as employees of United States government agencies, non-governmental societies and organizations, and commercial firms. Tyner ties the entire volume together in her conclusion with a discussion of the "culture" of women's cartography.

Tyner is considered the leading expert in this field in the United States, and *Women in American Cartography* compiles and integrates decades of scholarship for delivery to future researchers and readers. Those who have the privilege of hearing Tyner speak will know that the content of *Women in American Cartography* has been a passion of hers and that she has presented much of this work in papers delivered at numerous professional meetings over the years. Tyner's straightforward prose, grounded in her deep research, makes *Women in American Cartography* an easy, informative, and enjoyable read. The black-and-white illustrations include photographs of women cartographers and samples of their work, and Tyner often states in the text where she has found these elusive documents, giving readers direction should they wish to explore any of the maps further.

There are two other fairly recent monographs on women and cartography, *Women and Cartography in the Progressive Era* by Christina E. Dando (2018) and *Map Worlds: A History of Women in Cartography* by Will C. van den Hoonaard (2013). Tyner's work covers a broader historical period than Dando's and is more tightly focused in time and place than van den Hoonaard's. While Tyner touches on the Progressive Era and associated movements and societal changes in the second chapter of *Women in American Cartography*, Dando exclusively examines women's use of, and related production of, maps during that very specific period in United States history. On the other hand, van den Hoonaard's essentially sociological work encompasses cartographic developments in the Western world from the thirteenth to the late twentieth century, as well as including biographical sketches of twenty-eight twentieth-century women geographers and cartographers (mostly western European or North American) with little regard to whether the women were making, using, or curating maps. Tyner, by contrast, is concerned with the whole history of women's place in the American cartographic creation experience.

At the close of her introduction, Tyner writes that her work is neither an analysis of the types of maps created by women cartographers nor a critique of women's cartography. When specific maps are discussed, it is to put the women who created them into the context of their work. With its focus on the creators—rather than the artifacts they produced—*Women in American Cartography*: *An Invisible Social History* will be of interest to students and researchers in women's and gender studies, as well as the history of cartography, and should be on the shelves of libraries supporting these programs.

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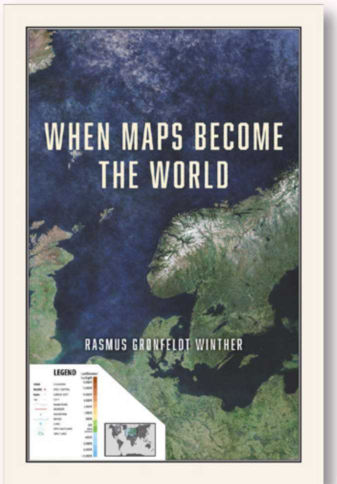

WHEN MAPS BECOME THE WORLD

By Rasmus Grønfeldt Winther

The University of Chicago Press, 2020

318 pages, with maps, satellite imagery, photography, and 10 color plates

Softcover: $37.50, ISBN 978-0-226-67472-8

Review by: Daniel G. Cole, Smithsonian Institution

Reading this book, I could not help but be reminded of *All Possible Worlds* by Preston James (1972), the book we were required to read for a class in the history and philosophy of geography that I took back in my graduate school days. Of course, James was a geographer, writing about the philosophic history of his speciality; Winther, on the other hand, professes philosophy at University of California, Santa Cruz, and it was his love of maps that prompted him to write philosophically about cartography. Fully aware that he is exploring waters that may at times be deeper than some of his readers care to plumb, Winther provides helpful "swimmer's depth" ranking icons, "philosophical deep diving or philosophical snorkeling … or easy reading" (xii) for each section of his text. These humble guideposts allow readers with differing interests and nuance tolerances to judge which passages they might safely plunge into or wisely avoid. There are also extensive footnotes throughout the book, supplying much needed information to aid readers who have done little wading in philosophy.

The first chapter, "Introduction: Why Maps?" presents the fundamental importance of maps for "finding our way in the world" (1), and continues with a short discussion about maps in both real and fictional worlds. Winther then lines up one of the central theses of his book: "… maps are abstractions discarding detail, focusing only on essential features of the territory. What is essential depends on one's purpose. … In order to realize that a map is not the territory, we can, for instance, consider multiple points of view on—multiple maps of—the same territory" (3). Winther further posits that "this book is about the power and limitations of maps and mapping, including those ambitious and interconnected maps that we call scientific theories" (3).

From this beginning, the author addresses the history and philosophy of map thinking up until the present day (including GIS), and then compares and contrasts what he sees as the implicit worldviews of three maps: Waldseemüller's 1507 world map; Guaman Poma's Andean map included in his late sixteenth-century critique of Spanish colonial rule—which Winther identifies as a counter-map; and Tom Van Sant's 1990 geosphere map. The author concludes this introduction with a short discussion of Google Maps and Google Earth, and his hope that future cartographers will "reconstitute" the world in a new map, though Winther's meaning is unclear.

Chapter 2, "*Theory* is to *World* as *Map* is to *Territory*," presents a typology of map analogies—basic, general, extreme-scale, state-space, literal, causal, model, and paradigm map. Most of rest of the chapter involves some of the ways the philosophies of other disciplines employ map analogies or otherwise tie into maps. Winther shares the concern that Robinson and Petchenik raised in their classic 1976 book, *The Nature of Maps* "about what a map *is* or *is good for*," because, he writes, "maps do not just make the world. They help make *other* worlds, and the worlds of *others*" (52).

Chapter 3, "From Abstraction to Ontologizing," looks at "cartographic practices to explore how representations are produced," with the goal of examining "the internal workings of abstraction and ontologizing practices" (59). Winther sees the abstraction of the world as taking place "via measurement and conceptualization to a representation" on paper or on a screen, and takes *ontologizing* to mean "deploying representation to do work in the world" (60). In this regard, the author takes particular note of the work of Robinson and Petchenik (1976) and that of Alan MacEachren (2004) in advancing cartographic communication. He then goes on to discuss the various "stages" of abstraction—calibration of units and coordinates, data collection and management, and generalization—and in this last mentioned stage, he covers the five "protocols" of generalization—selection of scale and projection, simplification, classification, symbolization, and exaggeration. The last pages of this chapter cover a broad range of topics. These include drawing parallels between his five cartographic generalization protocols to analogous practices in the social sciences, and a discussion of two broad approaches to abstraction—perspectivizing and partitioning—before finishing with "ontologizing representation testing," by which he means: changing the world, understanding the world, and classroom communication.

Chapter 4, "Long Live Contextual Objectivity!" deals with the what Winther calls the "pernicious reification" of maps, through which they cause readers to imagine the Earth as being the same shape as the map. He offers, as an example, a Ming dynasty map of China, that shows the Middle Kingdom placed in the center of the map, which may lead readers to believe that it truly is the center of the world. This is followed by a discussion on "contextual objectivity"—which he defines as "the quality resulting from good and proper application of a representation" (95)—with examples of county maps to show boundaries and a geologic map to illustrate prehistoric connections. Winther then provides some worthwhile quotations from other writers such as Ronald Giere (1999, 82): "The fit between a model and the world may be thought of like the fit between a map and the region it represents." The last seventeen pages of this chapter deal with the history of the Mercator projection and criticisms of its sometimes inappropriate use. He rightfully bemoans the use of Web Mercator as the default online map projection used by Google, Bing, and ArcGIS, but he does point out that "finding a projection that satisfies critiques of all perspectives . . . is impossible. No single map can fully represent the world" (103).

Chapter 5, "Projecting Maps into Our Worlds," deals with the concepts of isomorphism (equal form) and similarity. Winther points out that "scale makes map space and world space isomorphic" (122), and that this state "is achieved with the equation characterizing the map projection" (125). Under the heading of similarity, the author discusses three types of symbols: abstract / geometric, mimetic, and pictographic. He later notes that both the metric and symbolic layers he sees maps as possessing "are concerned with assumptions about how to interpret and present the world in the map itself . . ." (127). Further to this, he declares that "mapmakers perspectivize reality. That is, they impose a holistic, consistent perspective to make sense of a complex and finicky world" (128). Winther goes on to describe the experience of a map reader's abstracted viewing versus the direct cognitive cartography developed by a pedestrian traversing the same ground. This leads to a warning that "a map's cartopower can lead to its pernicious reification" (129)—a danger for which he declares counter-mapping to be the savior, as it brings light to alternative maps and minority viewpoints. At the chapter's end is a discussion on modeling climate change.

Chapter 6, "Mapping Space," covers a variety of topics, from mapping the universe in 3D, to geologic mapping. On the latter subject, it includes a history of the theory of continental drift, culminating in the ocean floor maps Marie Tharp created between the 1950s and 1970s. Winther also presents sections on state-space maps in physics and physical chemistry, and analogous maps in mathematics. He concludes this section with a note that mapping "is a transformative process of establishing robust relations between representations, or between a representation and an ontologized world" (174).

Chapter 7, "Mapping Ourselves," is something of a catchall. It starts with a discussion of cartographic reification via European explorations from 1492 onwards. From this point, he covers a variety of topics, including migration maps, brain maps, and statistical causal maps. He wisely points out that the flow arrows found in migration maps "treat all people in a particular migration as similar" (181). This is due, at least in part, to a number of limiting cartographic parameters, but that it can be overcome has been shown through recent challenges posed by counter-mapping practices. In his section on brain maps, one subsection deals with counter-maps of the brain, or "cognitive ontologies." Surprisingly, while Winther briefly discusses cognitive mapping elsewhere in *When Maps Become the World*, it is not directly addressed here—nor is there any citation of Gould and White's *Mental Maps* (1974), or of any other similar work on cognitive cartography. The last section on statistical causal maps covers topics such as linear model assumptions, correlation and causation, genetic and environmental diseases, path diagrams as statistical causal maps, and when causal maps become the world. Needless to say, in this last subsection, the author points out how we shouldn't be defined by statistics, and that counter-mapping is possible.

Chapter 8, "Mapping Genetics," starts with Gregor Mendel's ground-breaking study on peas. From this point, Winther notes that genetic maps use a partitioning frame to track events over space and time. He then describes several types of genetic maps, before finishing with a look forward to mapping genetics as a "paradigmatic integration platform." Because of the technical scientific nature of this chapter, the author includes a glossary of genetic terms to assist any non-genetics-oriented readers.

The ninth and final chapter, "Map Thinking, Science, and Philosophy," serves as a summary for the rest of the book. In it, Winther states that "maps provide an intuitive window into how humans think and act, and steer their hopes and fears" (243). In the first section, titled "Existence, World Making and Responsibility," he addresses the concepts of constructionism, empiricism, and realism, and notes that "undeniably, map thinking invites us to entertain a plurality of philosophical projections" (248). Later, he follows with the observation that "just as there is no single correct map or map projection, or even a single correct and universal map abstraction and ontologizing practice, so there is no single way of interpreting or of practicing scientific methodology" (251). Winther concludes with a discussion of how map thinking "gives additional clarity to standard philosophical accounts of ethical thinking" (252). From this, he proposes what maps are good for: they provide what-if scenarios for imagining new kinds of worlds.

While *When Maps Become the World* is an engaging and informative work, its execution nonetheless has a few factual errors that tend to disrupt the flow of Winther's presentation. Many of these issues crop up in Chapter 3.

In the "Abstraction" section of that chapter, he makes several mistakes that might confuse a neophyte. It seems likely, for example, that his subsection title "Geodesic Surveying" (63) should more properly have been "Geodetic Surveying" instead. Similarly, on page 67 he refers to the Defense Mapping Agency as if that agency had not ceased to exist in 1996—despite showing, on page 24, that he clearly knows about its current successor, the National Geospatial-Intelligence Agency. Winther's text also shows his inadequate investigation of certain cartographic fundamentals. One wonders why he even brings up the topic of hillshading, for example, when his only note on it—note 48 on page 78—is an outdated reference from 2002. More seriously, the only equal-area projection he discusses is the little-used and widely panned Gall-Peters. For example, an exercise in the Appendix features two blank continental world maps—one in Mercator and the other in Gall-Peters. While I understand the choice of Mercator, why did he choose to ignore all of the other available (and widely used) equal-area projections such as Mollweide, Eckert IV, Equal Earth, and so on? Juxtaposing the Mercator and Gall-Peters seems just a little too much like a rehashing of Arno Peters's straw-man argument.

Finally, at the end of Chapter 6, on page 139, there is a discussion of climate change, but the pertinent figure referenced (Figure 5.1) is on page 118— twenty-one pages away, and at the start of this chapter!

Nonetheless, I recommend this book to graduate students taking a class on the history and philosophy of geography, along with anyone else interested in this field. While I presented a number of problems with the book, they are essentially quibbles about minor confusions that can easily be puzzled out with careful reading. One hopes they will be dealt with in the next edition.

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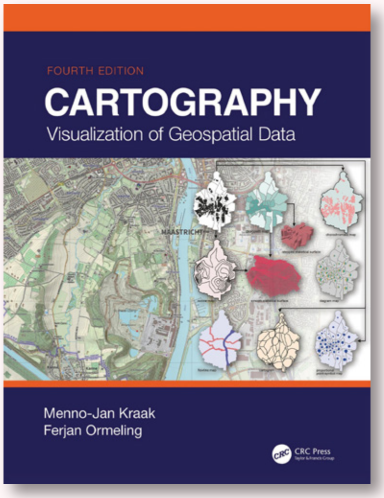


CARTOGRAPHY: VISUALIZATION OF GEOSPATIAL DATA, FOURTH EDITION

By Menno-Jan Kraak and Ferjan Ormeling

CRC Press, 2021

261 pages, 220 color illustrations

Hardcover: $130.00, ISBN 978-1-138-61395-9

eBook: $117.00, ISBN 978-0-429-46419-5

Review by: Timofey Samsonov, Lomonosov Moscow State University

This volume is the much anticipated update of Menno-Jan Kraak and Ferjan Ormeling's popular academic textbook—first published in 1996, with subsequent editions in 2003 and 2010. My review will focus mainly on how much the book has changed since its last incarnation, and how well the text reflects recent technological advancements in cartography, as readers are likely most curious about these aspects.

The structure and the overall layout of the book—basically an encyclopedia of mapping in eleven chapters—has remained unchanged. In Chapter 1, "Geographical Information Science and Maps," the authors draw a broad picture of GIScience and mapping, emphasizing their place in society and their role in scientific cognition. The spatial data sources and data processing technologies used to create maps are discussed in Chapter 2, "Data Acquisition." The next chapter, "Map Characteristics," dives into the conceptual matter of cartography—focusing on the unique properties of maps, their functions, and their types, as well as revealing what the authors consider the essence of cartography and the cartographic communication process. Chapter 4, "GIS Applications: Which Map to Use," discusses the appropriate applications of large- and small-scale mapping, as well as the role of geometric, attribute, and temporal data comparisons in the creation of change maps. Many of the basic processes of mapmaking are addressed in Chapters 5 through 8, which cover "Map Design and Production," "Topography," "Statistical Mapping," and "Mapping Time."

The book closes with three chapters showing how maps work as exploration and decision-making tools. Of these, Chapter 9, "Maps at Work: Presenting and Using Geospatial Data in Maps and Atlases," explains various approaches to organizing maps and delivering them into users' hands, as well as how to use an atlas as an organizational framework for data exploration. "Maps at Work: Analysis and Geovisualization" follows, with a discussion of techniques that can be used to facilitate the visual analysis of electronic maps by combining them with linked data representations such as interactive statistical graphics. Finally, Chapter 11, "Cartography at Work: Maps as Decision Tools," reflects on numerous aspects of the formal part of map use: legal issues, currentness, accessibility, and so on.

While the overall structure of the book has been preserved from previous editions, the content was substantially revised, with new material that reflects emerging trends and changes in technology. Specifically, several new sections were added:

- The International Cartographic Association's Cartographic Body of Knowledge (BoK) project receives attention for the first time in Chapter 1. The authors anticipate that the project's working group and accompanying website will serve as a forum, consolidating many concepts that have come to comprise modern cartography as academic research field.

- The list of data sources discussed in Chapter 2 has been extended by the inclusion of lidar, laser altimetry, Volunteered Geographic Information (VGI), and citizen science. All of these are notable for the increased attention they have received since the 2010s.
- Map machines and story maps now complement the overview given in Chapter 9, and, in that same chapter, map use is now reviewed in the context of atlases, instead of individual maps, in order to stress the increasingly widespread mode of interacting with cartographic representations through interactive atlas-like environments.

Many other updates were incorporated without explicitly altering the book's structure. Among the multitude of such changes are the following examples:

- The authors discuss the ubiquitous availability of maps delivered through electronic devices, and they touch upon issues of map usability and user-centered design in Chapter 3, "Map Characteristics."
- A discussion of the possible creation of real-time maps in a smart-city environment based on geosensor data is a new addition to Chapter 4.
- Chapter 5 has been updated to include an explanation of color reproduction on modern liquid crystal display (LCD) monitors that is as fully detailed as was the one found in earlier editions covering the old cathode ray tube (CRT) displays.
- Data formats and technologies used for interactive web map output—such as HTML5, CSS, SVG, WebGL and JavaScript—now figure prominently.
- The outdated Global Map and SABE mapping projects found in the previous version of Chapter 6 have been replaced with a brief discussion of contemporary OpenStreetMap and EuroBoundaryMap initiatives.
- Chapter 7 now devotes a significant place to the discussion of chorèmes—schematic representations purified of all aspects that are irrelevant to the main structures or relationships within the geographic region, including geometric accuracy. Chorematic diagrams offer a means of constructing an abstract thematic model of a region.
- There is a new discussion, in Chapter 8, of the implicit presence of temporal components in maps, using fascinating example maps of Iceland's airline flight networks.
- Chapter 9 features a significant reworking of the explanation of the principles of electronic atlases, with more focus on interactive web-based implementations.
- A discussion of geovisual analytics has been updated in Chapter 10, including a modern example of using an interactive analytical dashboard.
- The addition of useful information on the Creative Commons Licenses—often used to regulate the use of open data such as OSM—now rounds out the overview of copyright issues in cartography.

That fifty-four of the one hundred and forty-eight bibliographic references are new to this edition—thirty-five of them dating from 2010 or later—serves as one indication of the significant effort the authors made in bringing the methodological grounds of the book up to date.

Considering the scale of this effort, it is surprising that more attention was not paid to the all-too-briefly mentioned topic of 3D/VR/AR mapping—perhaps in Chapter 10. This is a rapidly developing area of geovisualization, where many questions about visualization and human-computer interaction are now being investigated.

One of the greatest improvements of the current edition is in the quality of the figures. This edition of the book is the first to be printed in color throughout—and it is needless to say how crucially important this is for a cartography text. Not only are almost all figures now colorful, but they have also been redesigned with a more modern look. The drop shadows and gradients that figured so prominently in the 1990s figures have been removed, replaced by plain, minimalistic graphics. There is a better balance between schematic and photorealistic figure elements, and the typographic work is more substantial and rigorous—all of which results in a much more unified visual look and, consequently, a more pleasing reading experience. Printing the entire text in color allowed more than fifty figures to be moved from the separate color plate section into the body of the book, which facilitates a seamless interplay between the text and the illustrative material. Perhaps most importantly, color-related issues of map design and the depiction of topography on maps are now illustrated alongside their discussion in the text.

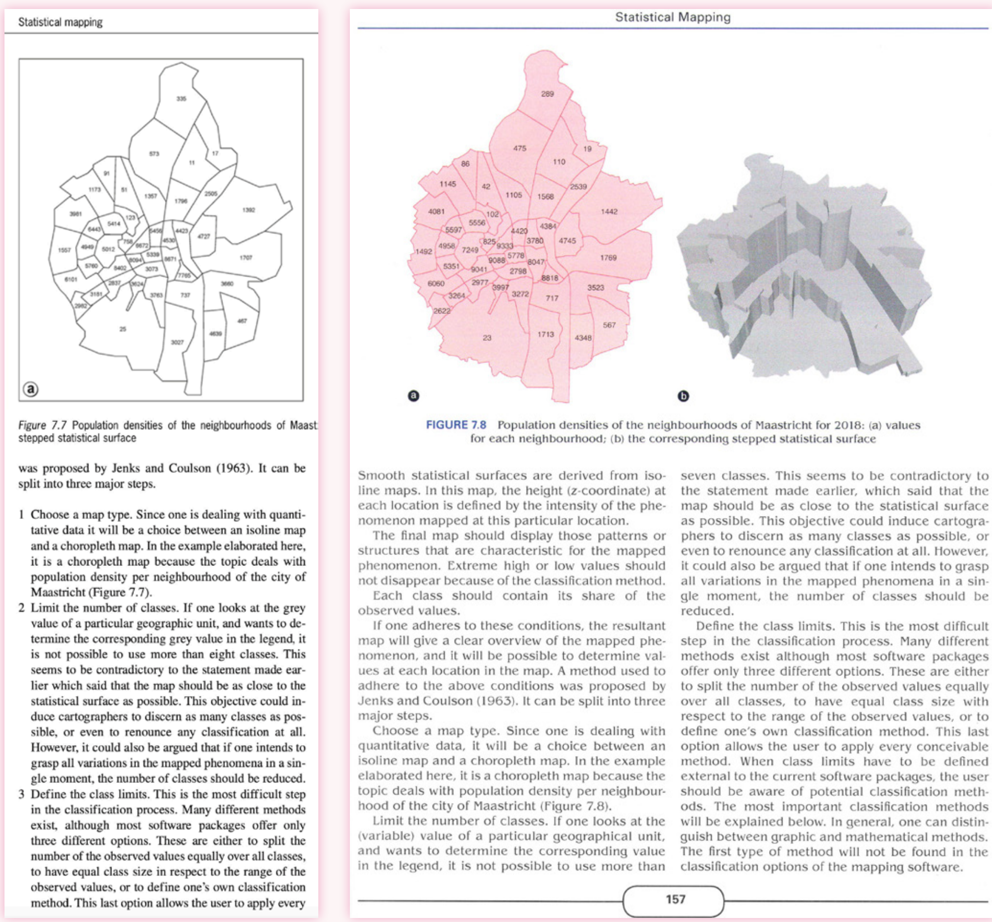
The authors have also taken the opportunity to employ updated and, in many cases, more timely and relevant map illustrations, taken from more widespread sources. For example, the 3D panoramic map visualization (Figure 9.4) was generated using a newer version of the Atlas of Switzerland (**www.atlasofswitzerland.ch**), while a figure illustrating multiscale topographic generalization (Figure 6.17) was created from OpenStreetMap, replacing the earlier one from Microsoft Encarta. Some of the images reflect the authors' updated views on specific conceptual questions of cartography. For example, the earlier version of Figure 3.1 placed cartography and related research disciplines in a two-dimensional spatial-nonspatial/exploration-presentation dichotomy, but the figure now includes information graphics as a third related domain—along with scientific visualization and information visualization.

Pages have retained their two-column layout, and this—on the roughly A4/letter width pages—continues to provide an optimum reading line-length. The typeface, however, has been changed from good old (but pretty boring) Times to ITC Benguiat—a face that is probably a poor choice for typesetting a lengthy, content-heavy, volume such as academic textbook, as it is somewhat fancy and hard to consume in large amounts.

The updated layout now represents some lists as plain text, which I perceive as a downgrade in content readability. This can be seen by comparing the explanation of Jenks and Coulson's classification approach as list on page 128 of the previous edition with its less explicitly delineated counterpart on page 157 of the new one (Figure 1).

Because the book's overall structure remains unchanged, all the questionable and subjective aspects of the book's arrangement and naming conventions remain unchanged as well. Any individual reader may chose to see this as a good thing or a bad thing, but there are at least some places where the authors' line of thought on these matters remains unclear to me. For example, one wonders why the conceptually important, theoretically driven chapter on map characteristics is not the second chapter—right after the introduction to GIScience and maps. Instead, the two topics are separated by highly practical material on data acquisition; something arguably much closer to the issues of map design and production that are explained in the fifth chapter. Similarly, I cannot think of any justification for discussing vector file characteristics *before* introducing the vector data model (Chapter 2)—surely it is the model that determines what file characteristics are desirable. Not all chapters have equally well elaborated hierarchies of content. For example, although chapters 8 ("Mapping time") and 10 ("Geovisualization") are of similar length (12 and 10 pages respectively), the former is subdivided into four named sections while the latter contains only one.

How Kraak and Ormeling came to name of some the chapters, and their choices of material to place in them, is



Statistical mapping

Figure 7.7 Population densities of the neighbourhoods of Maast stepped statistical surface

was proposed by Jenks and Coulson (1963). It can be split into three major steps.

1 Choose a map type. Since one is dealing with quantitative data it will be a choice between an isoline map and a choropleth map. In the example elaborated here, it is a choropleth map because the topic deals with population density per neighbourhood of the city of Maastricht (Figure 7.7).
2 Limit the number of classes. If one looks at the grey value of a particular geographic unit, and wants to determine the corresponding grey value in the legend, it is not possible to use more than eight classes. This seems to be contradictory to the statement made earlier which said that the map should be as close to the statistical surface as possible. This objective could induce cartographers to discern as many classes as possible, or even to renounce any classification at all. However, it could also be argued that if one intends to grasp all variations in the mapped phenomena in a single moment, the number of classes should be reduced.
3 Define the class limits. This is the most difficult step in the classification process. Many different methods exist, although most software packages offer only three different options. These are either to split the number of the observed values equally over all classes, to have equal class size in respect to the range of the observed values, or to define one's own classification method. This last option allows the user to apply every

Statistical Mapping

FIGURE 7.8 Population densities of the neighbourhoods of Maastricht for 2018: (a) values for each neighbourhood; (b) the corresponding stepped statistical surface

Smooth statistical surfaces are derived from isoline maps. In this map, the height (z-coordinate) at each location is defined by the intensity of the phenomenon mapped at this particular location.

The final map should display those patterns or structures that are characteristic for the mapped phenomenon. Extreme high or low values should not disappear because of the classification method.

Each class should contain its share of the observed values.

If one adheres to these conditions, the resultant map will give a clear overview of the mapped phenomenon, and it will be possible to determine values at each location in the map. A method used to adhere to the above conditions was proposed by Jenks and Coulson (1963). It can be split into three major steps.

Choose a map type. Since one is dealing with quantitative data, it will be a choice between an isoline map and a choropleth map. In the example elaborated here, it is a choropleth map because the topic deals with population density per neighbourhood of the city of Maastricht (Figure 7.8).

Limit the number of classes. If one looks at the (variable) value of a particular geographical unit, and wants to determine the corresponding value in the legend, it is not possible to use more than seven classes. This seems to be contradictory to the statement made earlier, which said that the map should be as close to the statistical surface as possible. This objective could induce cartographers to discern as many classes as possible, or even to renounce any classification at all. However, it could also be argued that if one intends to grasp all variations in the mapped phenomena in a single moment, the number of classes should be reduced.

Define the class limits. This is the most difficult step in the classification process. Many different methods exist although most software packages offer only three different options. These are either to split the number of the observed values equally over all classes, to have equal class size with respect to the range of the observed values, or to define one's own classification method. This last option allows the user to apply every conceivable method. When class limits have to be defined external to the current software packages, the user should be aware of potential classification methods. The most important classification methods will be explained below. In general, one can distinguish between graphic and mathematical methods. The first type of method will not be found in the classification options of the mapping software.

157

Figure 1. Explanation of Jenks and Coulson's classification approach in the 3rd (left, half-page) and 4th (right, full-page) edition of the textbook.

not always as evident as it might be. Chapter 4 is a notable example: entitled "GIS Applications: Which Map to Use," the chapter in fact discusses the differences between maps of different scales, along with other possible map comparisons. What have "GIS Applications" to do with what would seem to be straightforward cartographic issues—topics clearly lying outside of any GIS context? The title of the final chapter of the book, "Cartography at Work: Maps as Decision Tools," also seems somewhat misleading. It focuses not on the mechanisms for using maps as decision making tools, but rather on factors that affect the possibility and the reliability of such use—including various legal issues, data accessibility, relevance, and so on.

As in the previous editions, there are frequent references in *Cartography*: *Visualization of Geospatial Data* to specific software, websites, and contemporary cartographic products—an approach that makes it seem quite practical and down to earth, and rather less abstract and fundamental than one would expect in an academic cartography textbook. The authors, however, claim that their first objective was "to provide an overview of the role that maps will play both today and in the near future in the world of geospatial data handling" (ix), and from this point of view their engagement with the contemporary situation is quite justified. Data handling is a highly practical process that is heavily dependent on existing technological infrastructure, including the specific software products, and that infrastructure needs to be discussed despite the danger of specific information going out of date.

The authors acknowledge the teaching of map design and map function as the second and the third objectives of the book, and, while it is not a book specifically on map design, production and use, it explores these topics reasonably well.

Overall, the book makes generally positive impression. Its content fairly depicts the various sides of modern cartography, and has been brought up to date in almost every area it touches. This new edition is a significant improvement over the previous ones in terms of the quality of its graphics, which are now full color and are much more unified in style. The criticisms which I have outlined are relatively minor and subjective, and reflect only my own personal views. I am quite confident that the authors generally achieved their objectives with this edition of *Cartography*: *Visualization of Spatial Data*, and that it is worthy to be on the shelf of every modern academic researcher or teacher of cartography.

I would like to sincerely thank the editors of *Cartographic Perspectives* for their thorough and attentive comments, which helped to greatly improve the logic and wording of this review.

A PEOPLE'S ATLAS OF DETROIT

Edited by Linda Campbell, Andrew Newman, Sara Safransky and Tim Stallman

Wayne State University Press, 2020

352 pages

Paperback: $34.99, ISBN 978-0-8143-4297-8

eBook: $24.99, ISBN 978-0-8143-4298-5

Review by: Russell S. Kirby, University of South Florida

The editors of *A People's Atlas of Detroit* have produced a book that is spot-on for these troubled times. It's hard to imagine that they had the prescience to anticipate George Floyd's murder, the resurgence of the Black Lives Matter movement, and the broad national focus on structural racism that has emerged in this past year; yet that, in broad strokes, is the focus of their work. They have produced an interesting book, with an impressive pedigree and purpose that extends well beyond the primarily academic focus of most atlases. So well beyond, in fact, that many readers will take issue with calling it an atlas (a term typically defined as a book of maps or charts), as very few of its pages are devoted to maps, and many of those are used solely to designate the locations of those who contributed content to specific chapters.

A People's Atlas of Detroit unabashedly follows in the footsteps of William Bunge's legendary *Fitzgerald*: *Geography of a Revolution* (originally published in 1971 and now available in a 2011 softbound edition by University of Georgia Press). Both books call attention to the social geography of the Detroit metropolitan area through the lens of social justice, and both examine the spatial structures of commerce, social capital, amenities, and other resources with a focus on lived experiences, and personal and community histories. However, *A People's Atlas of Detroit* is much more personal, and conveys those experiences through numerous vignettes, interviews, and reflections from residents of disadvantaged neighborhoods throughout the city.

The book consists of six chapters and an epilogue. The first chapter provides historical context, with vignettes examining the history of slavery in Detroit; the Underground Railroad and resistance to slavery before the Civil War; labor struggles; conflict over housing; local events in the Civil Rights movement of the 1960s; and the uprisings in the summer of 1967. The chapter concludes with a reflective conversation between Grace Lee Boggs, a prominent community activist, and Sterling Toles.

Chapter 2 focuses on land ownership and the notion of community. At the outset, the authors seek to dispel the myth that Michigan's vacancy rates for residential housing are highest within the City of Detroit. Using data from the American Community Survey, a map creatively shows the names and approximate locations of other cities in the state with rates higher than the 28% reported for Detroit in 2008–2012. The chapter also explores patterns of land ownership, the physical divide of the river that forms an international border between the US and Canadian sections of a metropolitan region with numerous economic, social, and cultural ties, as well as how structural racism has affected disadvantaged communities through discriminatory practices related to freeway construction, urban "renewal," and redlining. This chapter also includes several vignettes, focusing on urban gardening and fishing as ways to connect community residents to the land they share. The chapter concludes with a poignant interview with Michelle Martinez, a woman of Mexican, Colombian, and Native American heritage who suggests the need for "a plan that honors people in this place, on this land" (111).

Chapter 3, "Growing a Revolution," focuses on opportunities for transformation in urban Detroit. Much of the emphasis is on the potentially transformative role of urban agriculture, not only as a source for food in a region with endemic food insecurity, but also as a source of economic livelihood, a way to reclaim inner-city neighborhoods and industrial districts lost in the global transition of heavy manufacturing from North America to less developed economies, and for its potential role in promoting Black self-reliance and transformation. This chapter consists largely of narratives and interviews, but also includes a brief cartographic essay illustrating some aspects of the history of urban agriculture in Detroit.

In Chapter 4, "Suspending Democracy is Violence," the authors focus on both the context for, and effects of, political and economic reform in Michigan generally and more specifically in the Detroit metropolitan area. The financial challenges of majority-Black Detroit are reflected in numerous communities across Michigan, many of which (such as Flint) have suffered the devastating consequences of poor decisions about municipal economics. The chapter details numerous actions taken for the ostensible purpose of cost-savings that have adversely affected Black residents of Detroit and describes community advocacy efforts to provide a larger voice for disadvantaged populations.

Race and the geography of displacement is the focus of the fifth chapter. As with issues explored in previous chapters, the authors demonstrate that gentrification is the visible face of much more complex social and economic processes at play in inner-city Detroit. The chapter explores spatial patterns of Black homeownership compared to Asian and Hispanic homeownership since 1960, and levels of housing insecurity in Detroit and other urban communities across the United States. Displacement effects of urban renewal are illustrated through a historical example from the Detroit Geographical Expedition and Institute. Discriminatory policies related to housing are described both graphically and in narrative form. The authors argue in favor of a broader-based approach to urban revitalization, one that incorporates the needs and aspirations of all Detroit's citizens, and illustrate this approach with vignettes describing several specific community-based efforts.

The final chapter is "The Right to the City." The authors provide a vision for the future, emphasizing five themes embodying the rights to: water, environmental justice, mobility, education, and freedom from crime and police harassment. Water shutoffs, for example, adversely affect the disadvantaged, and community-based efforts to prevent shutoffs and support those in danger of losing their water supplies are described in this chapter. Environmental racism is illustrated through an examination of the spatial distribution of asthma hospitalizations in the Detroit metropolitan region, while policies for expanding public transit are explored through a vignette describing plans to implement streetcar service on a main bus route. An interesting map displays the proportion of residents incarcerated per 1,000 population, accompanied by a map showing the locations of state prisons and the numbers of Detroit residents incarcerated in each. Not surprisingly, most of these prisons are located at considerable distances from the city, and visitation by family members is challenging. In the conclusion to the atlas, the authors argue that "Another city is possible" (296), and that making it so will require changing the structures of economic and political power, community engagement, activism, and both internal and external support.

Having briefly described the contents of *A People's Atlas of Detroit,* one can see that this is by no means a typical contribution either to the genre of atlases or to the field of urban geography. Like most atlases, the book does contain numerous maps, along with statistical graphics and photographs both in color and black and white, but while most atlases array maps around specific themes, here each map was carefully selected to illustrate specific points in the authors' narrative concerning the lived experiences of disadvantaged Detroit residents and their vision for a very different future from what may evolve if current policies and spatial dynamics persist. The narratives and interviews included with each chapter have poignancy and salience, but it is likely that the authors could have expressed the same sentiments and views in a more focused manner, or have captured a broader sense of the needs and challenges Detroit citizens face using more formal analytical methods with qualitative study designs.

This atlas was intended to open the eyes of readers to the past, the present, and the possible. From a pedagogical perspective, courses in social or urban geography might use this book to contrast with more conventional geographical and social science research on Detroit. Sociologists and anthropologists will find much of interest within these pages. Cartographers might explore themes introduced in this atlas in more depth, and consider methods for mapping spatial patterns and processes indicative of structural racism. Many communities across the United States have histories that are similarly worthy of this type of in-depth exploration.

As with its predecessor, *Fitzgerald*: *Geography of a Revolution*, *A People's Atlas of Detroit* marks not an endpoint, but a summation of collective work to date in documenting the major structural changes needed to improve the lives of the residents of Detroit. By promoting politics and practices that serve the needs of all, we can ensure that everyone is accorded basic rights in a meaningful way. Although the authors do not use the term explicitly, structural racism lies at the core of Detroit's problems, and must be disentangled persistently and systematically. *A People's Atlas of Detroit* makes this point extremely well, and it should be read by those interested in gaining a sense not only of the challenges that must be overcome, but what is at stake if we fail.

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ABSTRACT: An abstract of 250 words or less should summarize the purpose, methods, and major findings of the paper.

KEYWORDS: Five to ten keywords should be listed at the end of the abstract.

REFERENCES: References should be cited parenthetically in the text, following the author-date system found in *The Chicago Manual of Style,* 17th ed. (**chicagomanualofstyle.org**). When making a direct quote, include the page number. Example: (Doe 2001, 38).

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authors' names are listed in the order in which they appear on the title page, with the last author's name preceded by a comma and *and*. Note: With more than ten authors, invert first author's name and follow it with a comma and the words et al. without italics in the reference list.

The general format is: Name of author(s). Year. *Title in Italics*. City of Publication: Publisher Name.

Robinson, Arthur H., Joel L. Morrison, Phillip C. Muehrcke, A. Jon Kimerling, and Stephen C. Guptill. 1995. *Elements of Cartography, 6th Edition.* New York: John Wiley & Sons.

Articles in Periodicals: Author's or authors' names as in *Books,* above. Year. "Title of Article." *Title of Periodical,* volume number, page numbers, DOI if available. Follow punctuation and spacing shown in the following example.

Peterson, Michael. 2008. "Choropleth Google Maps." *Cartographic Perspectives* 60: 80–83. **http://doi.org/10.14714/CP60.237**.

Articles in edited volumes: Name of author(s). Year. "Title of Article." In *Title of Edited Volume*, edited by [Editor's or Editors' names, not inverted], page numbers. City of Publication: Publisher's Name.

Danzer, Gerald. 1990. "Bird's-Eye Views of Towns and Cities." In *From Sea Charts to Satellite Images: Interpreting North American History through Maps*, edited by David Buisseret, 143–163. Chicago: University of Chicago Press.

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Cartography Associates. 2009. "David Rumsey Donates 150,000 Maps to Stanford University." *David Rumsey Map Collection*. Accessed January 3, 2011. **http://www.davidrumsey.com/blog/2009/8/29/david-rumsey-donates-150-000-maps-to-stanford**.

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A Plan of the City of New York and its Environs. P. Andrews, sold by A. Dury in Dukes Court, St. Martins Lane, surveyed by John Montressor, 1775.

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