Cartographic Perspectives

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IN THIS ISSUE

LETTER FROM THE EDITOR

PEER-REVIEWED ARTICLES

CARTOGRAPHIC COLLECTIONS

VIEWS ON CARTOGRAPHIC EDUCATION

REVIEWS

Cartographic Perspectives

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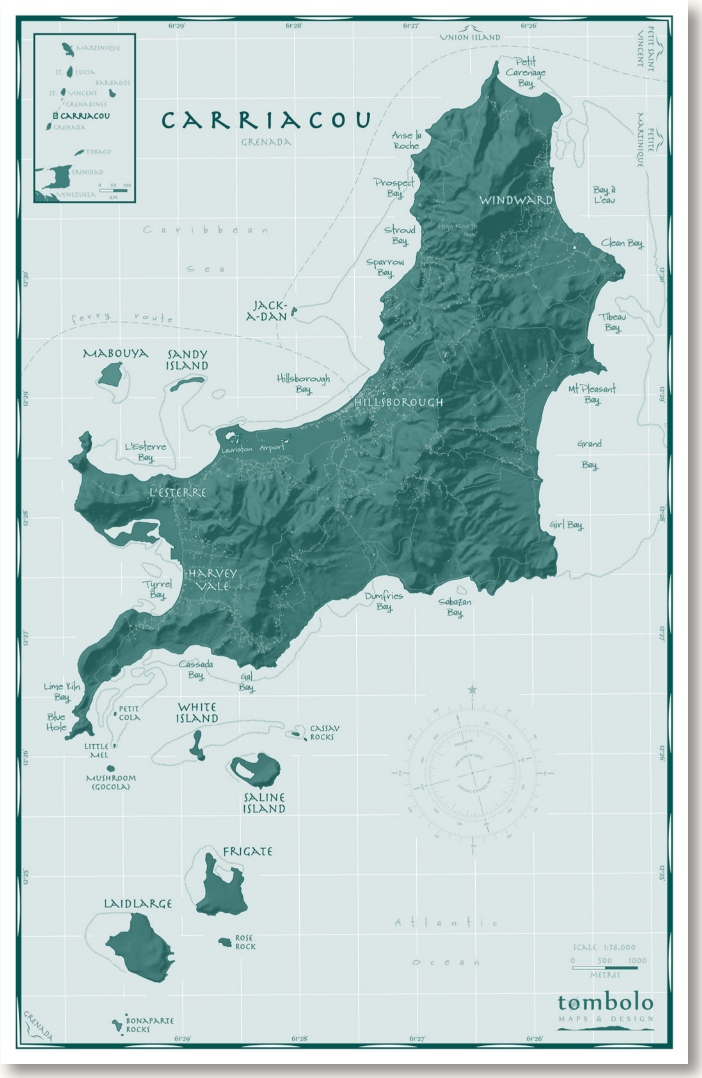
ABOUT THE COVER

This issue features a detail from a wall map of Carriacou, Grenada, by Alison DeGraff Ollivierre. This map is part of a series of wall maps, which together cover the terrain and settlements of the transboundary Grenadines. You can see more of Aly's work at www.tombolomapsdesign.com.



Cartographic Perspectives

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LETTER FROM THE EDITOR

Dear *Cartographic Perspective* readers,

I wanted to welcome you to issue 102 and keep you abreast of what's been happening behind the scenes as we prepare for an exciting 2024 for our journal.

First, the issue itself has content that will be of interest to the wide section of readers. From contract cartographers to research librarians to academics, this issue contains entries that speak eloquently across the breadth of our community and readership. We have two peer-reviewed articles in this issue. In the first, Jenny Marie Johnson and Nicholas R. Chrisman trace the history of the General Land Office's (GLO) "National Map," showing how the map series "records the development of the United States of America from its foundation through its imperial ambitions" (7). Their intimately detailed retelling of the rise (and fall) of the GLO highlight both an important period in the history of the United States, but also how the nation has historically claimed space, rendered it legible and exchangeable (a core aspect of the early GLO being the sale of claimed territory), and built a "unified territory from sea to sea" (19).

Our second peer reviewed piece is from Andrei Kushkin, Amy Griffin, Alberto Giordano, and Alexander Savelyev, and tackles the thorny nexus of emotional cartography, cognition, and color. Color is one of my favorite topics in cartography and here the authors deftly entwine two concerns: that cultural and affective associations with color can conflict with map intent *and* the growing nature of emotional data in cartography. Taken together, they present, first, the results from a user study on color association and emotion and, second, a tool for cartographers and other data visualization practitioners to consult when trying to represent emotional data. In keeping with the spirit of NACIS, they note that their tool is likely to be "important both for academic and commercial contexts" (55). Perhaps most exciting, for me, are the future avenues of research opened up through this study. The authors clearly acknowledge the scope and limits of their study—for example, restricting participants to persons within the United States who speak English as their first language—which leaves open wonderfully intriguing questions of how "cognitively congruent" colors may differ within other contexts and how mapmakers (and data visualizers writ large) might accommodate these differences.

This issue also contains entries in our *Views on Cartographic Education* (VCE) and *Cartographic Collections* (CC) sections. In VCE, Carl Sack recounts his experiences using the 30 Day Map

Challenge to teach cartography in a community college environment. Sack raises important questions around how traditional cartographic education models intersect with privilege and positionality. While Sack is careful to frame the outcomes of his pedagogical experiment in cautious terms, the questions he raises around how cartographic educators can better serve the needs of varied student bodies is one worthy of significant attention. Meanwhile, in our CC section, Benjamin Meader recounts the fascinating lives—and cartographic productions—of the Phillips Brothers of Maine. Held mostly in the Penobscot Marine Museum of Searsport, Maine, the brothers' maps are often viewed through the lens of folk art; here, Meader draws our attention to their lives as independent illustrators that produced pictoral maps by hand. I suspect these maps will be of particular interest to our readers that enjoy hand-drawn mapping techniques.

The issue also contains four book reviews on a variety of topics. Veronica Penney reviews Sparrow's *Phenomena: Doppelmayr's Celestial Atlas*, finding it well worth visiting both for how it demonstrates the historical spread and acceptance of scientific knowledge as well as—and in line with our CC piece—offering much to consider with respect to "more artistic and creative forms of visualization" (89). Kate Thornhill reviews Miller's *Metadata for Digital Collections* and finds it an "invaluable resource for anyone interested in working with digital collections" (81), while Glenn O. Humphress examines Black's *A History of the Second World War in 100 Maps* and finds it well worth recommending to those interested in the history of cartography during and around the Second World War. Finally, Jörn Seemann reviews Altic's *Encounters in the New World: Jesuit Cartography of the Americas*. A "very dense and descriptive" book (84), he describes it as "a great reference book, especially for map historians and scholars specializing in Latin America and religious studies" (85).

What stood out to me in the latter three reviews was how each reviewer found a lack of engagement with alternative voices by the book authors. Thornhill notes the absence of much discussion around the labor and costs of archival work, as well as a lack of engagement with criticisms of the dominance of "white heteronormative metadata practitioners who work at predominantly white institutions" within the field (81). Humphress notes the "serious omission" of maps both focusing on the Pacific theater or made by Asian or Pacific creators (91). Perhaps most reflectively, Seemann notes Altic's work is likely to "provoke diverse reactions" that range from wholeheartedly praise for such a substantive work on Jesuit cartography to "categorical condemnation (as downplaying the devastating impacts of European colonialism in the region)." My intent in highlighting these somewhat parallel concerns is not to offer a solution, but rather to highlight how their continued presence within our collective inquiries speaks to our ongoing need for reflexivity and care. No work can cover every perspective, but which perspectives we choose to elevate—what data we put on the map and how—matters.

In addition to the excellent content of this issue, I also wanted to update folks on where *Cartographic Perspectives* is heading. First, we're absolutely delighted to welcome Garrett Dash Nelson of the Norman B. Leventhal Map & Education Center at the Boston Public Library as a co-editor of the Cartographic Collections section beginning this year. His work as head curator there will be invaluable for us. In 2023, we discovered a few hiccups in our production line that, if left unaddressed, could cause ongoing issues in terms of delivery of the journal. Daniel Huffman and I, as well as the Editorial Board, have been working behind the scenes to strengthen *Cartographic Perspectives* for the foreseeable future. If you are a student, or advise students, please keep your eyes out for a couple student positions we'll be advertising in the coming months, they'll be great opportunities to learn about journal editing and publishing (and to get more involved with NACIS!).

As always, I am honored to serve as editor of *Cartographic Perspectives*. 2024 is shaping up to be a fantastic year for the journal and I look forward to working with our incredible team to bring the journal to you.

Let's keep mapping,

Jim Thatcher

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PEER-REVIEWED ARTICLE

Tracing the Development of the General Land Office's "National Map": From Lands Surveyed to Territorial Acquisitions

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From the foundation of the republic, the government of the United States promoted western expansion through the surveying and sales of the public domain. The agency responsible over most of this period, the General Land Office (GLO), produced maps of the progress of surveying and sales on an annual basis. This article reviews a notable series, from the first "connected" map (i.e., one showing all the public lands in a single view) in 1864 until the last in 1953. In each period, the national map produced by the agency reflects the concerns of the time, as it records the preparations for the sale of the public domain for settlement. In the first decades of the connected maps, the primary thematic elements documented the work of GLO in surveying what is now called the Public Land Survey System (PLSS). These maps evolved to include a treatment of "territorial acquisitions," which eventually became the most prominent thematic element, while still including a representation of the PLSS grid. The series' first depictions of territorial acquisitions included an exceptional error, one of several, indicating that the Oregon Country was part of the Louisiana Purchase. Commissioner Binger Hermann expounded his understanding of the United States' territorial history in an eighty-seven page monograph, an unusual recognition of a cartographic error, which led to corrections. The long history of this map series provides material to understand the role of maps in the history of the country.

KEYWORDS: history of cartography; national mapping; American expansion; territorial acquisitions of the United States; General Land Office; Louisiana Purchase

From 1864 to the 1950s, the United States General Land Office (GLO), succeeded by the Bureau of Land Management, created and published a national map that first showed the growing nation's progress in controlling territory from sea to sea and later incorporated a representation of its overseas territories. While Short (2001) recounted part of this story in a general coverage of mapping the United States from 1600 to 1900, we will add greater detail regarding one of the longest series of annual maps produced by the United States federal government.

Our examination adds to a steady accumulation of cartographic understanding of the circumstances under which maps have been produced. Initially, Harley and Blakemore (1980) set out the argument to move away from the specific map artifact to its historical context. Subsequently, a number of scholars have contributed studies of the institutional and political backgrounds involved in map series of British India (Edney 1997), Egypt (Godlewska 1988), Canada (Taylor 1994), and the United States (Short 2001).

The first part of the story we will tell regards the process that led the agency to produce an annual map that showed GLO activity across the whole national territory. GLO had the task of dividing the public domain into saleable parcels, then selling them to provide revenue to the early republic. As a part of an annual report to Congress, the GLO's maps record the westward expansion of settlers moving into what had been aboriginal lands. In the second part, at a key moment in the agency's history, these detailed maps of new "townships" become overlain by a bold theme recording "territorial acquisitions," largely from European imperial claims. In this manner, this map series records the development of the United States of America from its foundation through its imperial ambitions of the late nineteenth century. This record can be used to support or question prior work on the politics and public concerns of the era.

The story of these national maps enfolds a massive mistake, something that had to be confronted with an eighty-seven page retraction/explanation. The error was not due to a slip of the wrist or an act of forgetfulness. It arose from the same sources as the truth in the maps. The story of these maps needs to be encased in the sweep of institutional and historical context it deserves, following the administrative and institutional setting that called for these maps and realizing that prior to this national series the United States government, and private consumers, relied on commercially produced maps of the nation. While this story raises parallel questions about other mapping efforts, with ninety years to cover, the focus must remain on just one agency, the General Land Office, and its mapping efforts.

MAPS OF STATES, TERRITORIES, AND DISTRICTS

Prior to the 1812 establishment of the General Land Office within the Department of the Treasury, surveying of lands available for distribution or purchase was undertaken by state surveyors or the geographer of the United States, who initially was mandated to supervise the surveying of the seven ranges of the Northwest Territory and to communicate the resulting plats to the board of the Treasury (Figure 1).

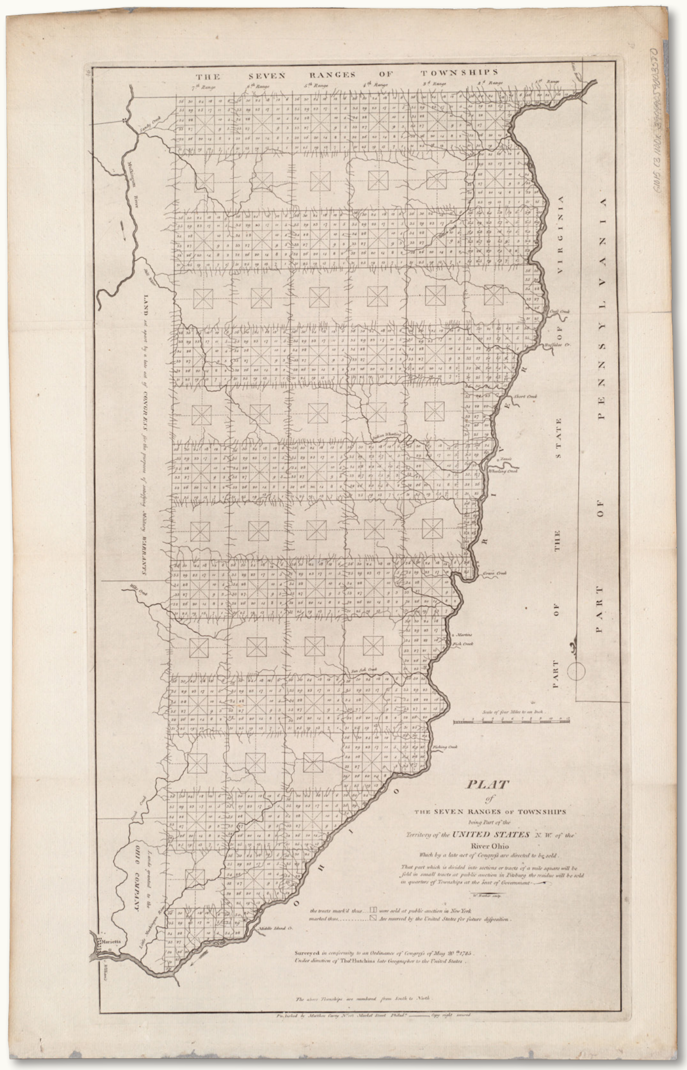

Figure 1. *Plat of the Seven Ranges of Townships Being Part of the Territory of the United States N.W. of the Ohio River which by a Late Act of Congress are Directed to be Sold* (Hutchins, Carey, and Barker 1800). Courtesy of the Norman B. Leventhal Map & Education Center, Boston Public Library.

The Department of the Treasury was directly responsible for the way that the Northwest Territory, the Louisiana Purchase, and other land accessions were integrated into the public domain and for the process of land sales both to those interested in purchasing large expanses and to individuals and families who made much smaller purchases. The public domain was a heavy, and ever increasing, administrative burden for the Department of the Treasury. A request by the secretary of the treasury for additional funding to handle land matters led the Senate Committee on the Public Lands to recommend establishing a bureau within the department to handle all aspects of land business. President James Madison signed the bill establishing the General Land Office on April 25, 1812.

The General Land Office was charged to

> superintend, execute, and perform all such acts and things, touching or respecting the public lands of the United States, and other lands patented or granted by the United States, as have heretofore been directed by law to be done or performed in the office of the Secretary of State, of the Secretary and Register of the Treasury, and of the Secretary of War (US Congress 1812, 716)

When created, the General Land Office was placed in the Department of the Treasury because of the anticipated revenues that it would be collecting. Edward Tiffin, the first commissioner, gathered clerks with applicable experience from other departments to staff his office: clerks from the War Department who had worked with military land bounties, clerks from the Department of

State with experience in land patents, and clerks from the Department of the Treasury to provide continuity in record keeping (Rohrbaugh 1968, 54).

The role of the commissioner of the General Land Office was primarily administrative. He had control of all the books and records about public lands and provided information about public lands to the president or to Congress upon request. An oversight of the 1812 act is that no clear reporting or supervisory roles were established between the surveyor general in each district and the commissioner of the General Land Office. Congress and the secretary of the treasury largely continued to direct the work of each surveyor general. The surveyors general, and their contracted deputies, remained autonomous and separate from the General Land Office until 1836, when the General Land Office was re-organized.

The General Land Office's draftsmen were critical to the bureau's mapping enterprise. They compiled maps from plats submitted by field operatives that were later sent back out to the district offices, marked sales of public lands on maps maintained in the office, and prepared maps for Congress and department heads. Maps showing lands surveyed, sold, and available hung in land district offices (Figure 2).

Figure 2. *Map of the Bounty Lands in Illinois Territory* (Gardiner 1812). Courtesy of the Map Library, University of Illinois Urbana-Champaign.

The General Land Office's portfolio of responsibilities ballooned over time from its initial charge. Beyond surveying and selling public lands, and collecting the proceeds, the GLO administered preemption acts and homestead laws, responded to land claims made through military warrants, issued land grant patents for railroads, and handled the sales of lands specifically for timbering and mining. Additionally, because of speculative buying and the government's policy of extending credit to land purchasers, the GLO became a mortgage holder. The General Land Office ended up with the same problem as its parent department—too much work and not enough hands.

In 1849, the same year during which Congress created the Oregon Territory, the General Land Office, along with the Patent Office (from the Department of State), Indian Affairs Office (War) and military pension offices (War and Navy), was transferred to the newly created Department of the Interior, as was the surveyor general. The new department had a broad-ranging set of responsibilities, all focused on the internal development of the nation or on the well-being of its inhabitants. The GLO operated under a number of congressional acts, many of which referred to specific states or territories or even smaller areas. The role of the GLO within the new department further emphasized its mission to provide surveys of the public domain in support of land grants to states, corporations, and individuals. Maps remained the central tool to communicate this work.

The annual report of the commissioner of the General Land Office, submitted as part of the secretary of the treasury's (after 1849 the secretary of the interior's) annual report to Congress, habitually included separate maps of states and territories, sometimes ten or more, showing areas that had been surveyed (Figure 3). The maps accompanied reports submitted to the commissioner by state and territorial surveyors general. Usually there was one map per state/territory report, covering the entire region, but occasionally additional maps would be included focusing on specific areas of interest. In bound copies of the *Congressional Record*, the maps tended to be bound

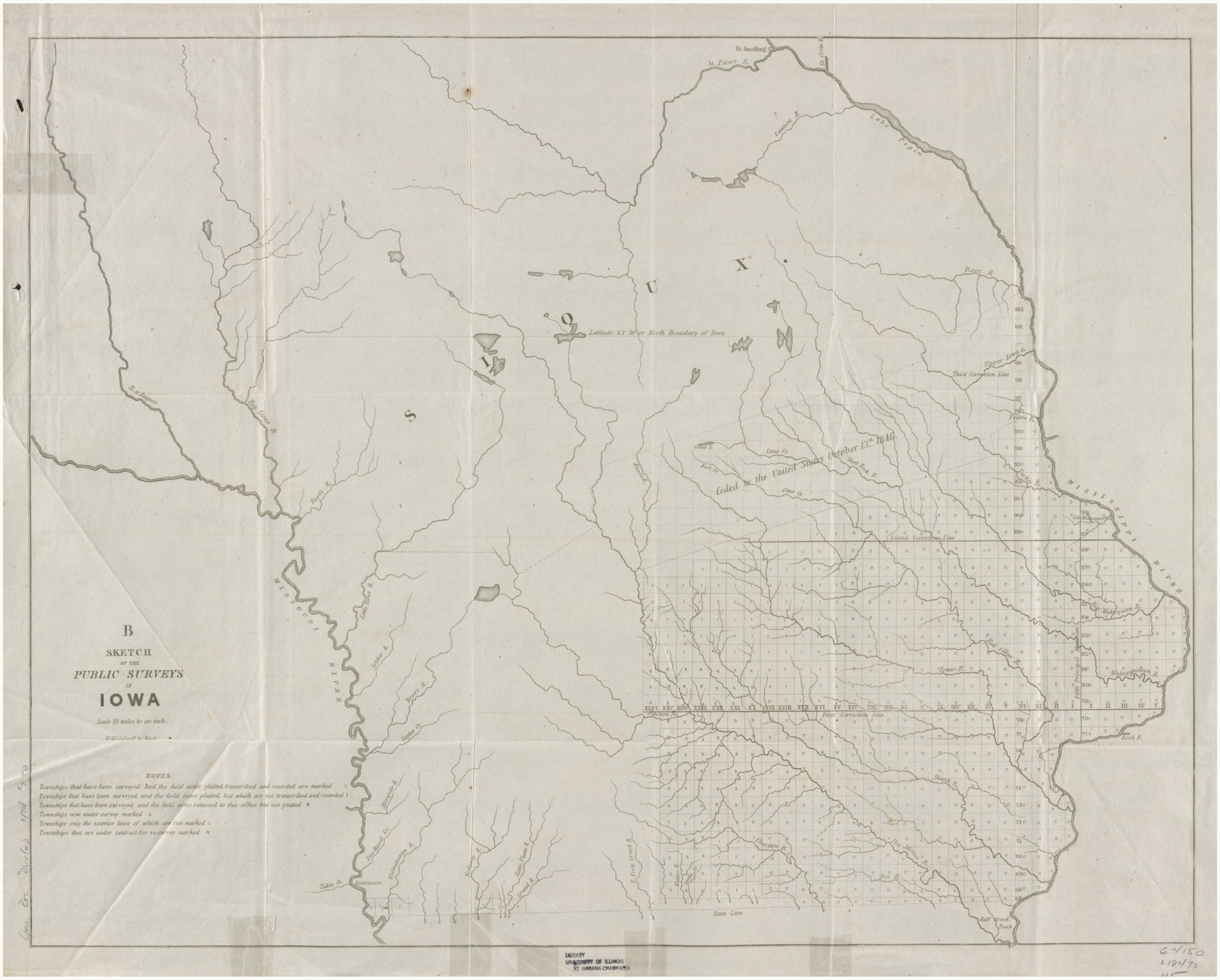

Figure 3. *Sketch of the Public Surveys of Iowa* (GLO 1847). Note the large area titled "Sioux" and the diagonal zone "Ceded to the United States October 13th, 1846." Courtesy of the Map Library, University of Illinois Urbana-Champaign.

immediately after the corresponding report. This arrangement would have made using the maps cumbersome.

As Figure 3 demonstrates, the district maps provide a snapshot of the procedures followed by the GLO concerning treaties with Indian tribes. It is part of a long and complicated history of the piecemeal destruction of native sovereignty. Up to 1832, Iowa had been part of "Indian Territory." It was opened to settlement following the Black Hawk War. The required pre-settlement surveys began when the government had concluded treaties with the local tribes; many of these lopsided treaties were followed by continued pressure to remove the Indian population further away, west of the Missouri River. The text "Sioux" on the map and the map's mention of specific treaties shows the attention paid at a district level to the removal procedures. The group referred to as "Sioux" are more properly referred to as the Lakota.

While surveying and land distribution continued to be fragmented because of the separate mandates in each district, the context of the work became increasingly national in scope because of a number of developments that cut across state and territorial boundaries. Railroad development, spurred by the Pacific Railroad Act of 1862, created a national focus, along with railroad grants managed by GLO. In the short period of twenty years after the 1847 publication of the map in Figure 3, railroad grants came to cover most of Iowa (Figure 4). Additionally, there is no remaining trace of any native groups in Iowa. Through the 1851 Treaty of Traverse des Sioux, the Lakota ceded 24 million acres, including an area in northern Iowa, to the United States federal government in exchange for cash, goods, education, and a reservation.

The GLO's work also exploded with the Homestead Act of 1862. 270 million acres in 30 different states were settled in fairly small transactions, all handled by the GLO. The Homestead Act in conjunction with railroad land grants and events of the Civil War may have led to a demand for a more national view.

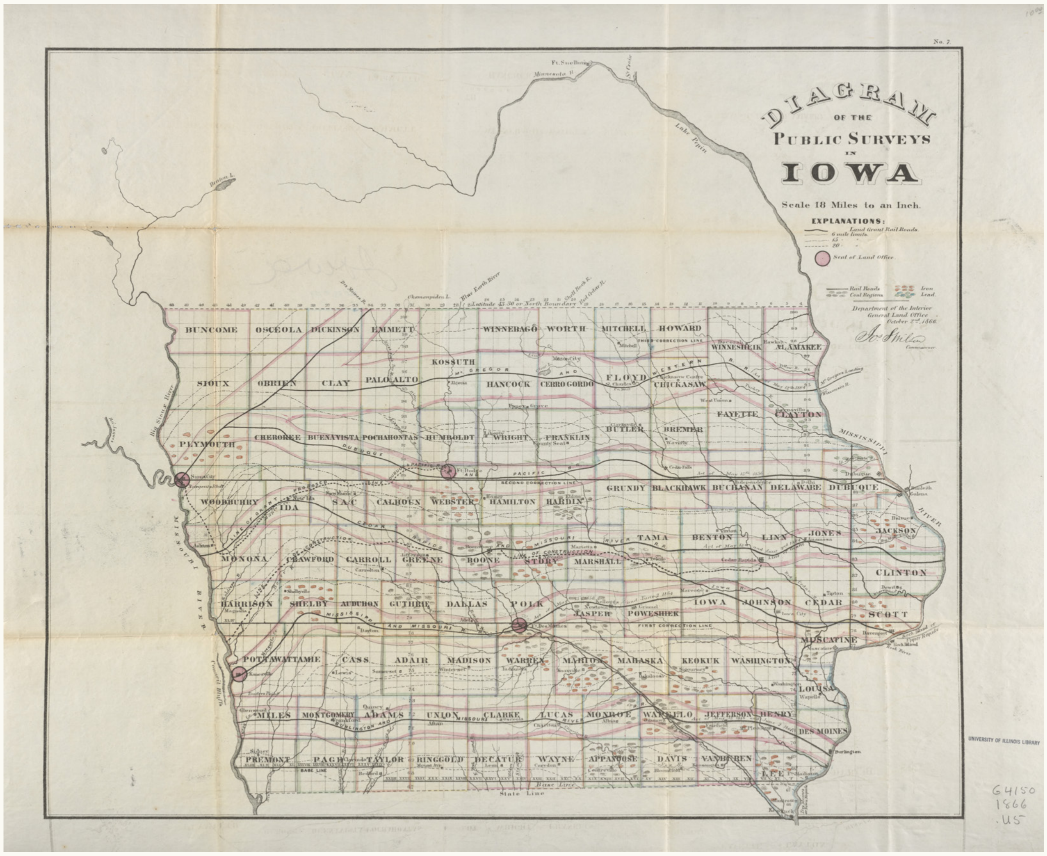

Figure 4. *Diagram of the Public Surveys of Iowa* (GLO 1866). Note the rapid progress since 1847 (Figure 3) and the near saturation of railroad grants. Courtesy of the Map Library, University of Illinois Urbana-Champaign.

CONNECTED MAP

Through a joint resolution on January 6, 1863, Congress made some specific changes to how the General Land Office produced maps. Most of the state and territory maps that accompanied reports would now be produced commercially, under contract, instead of by General Land Office personnel. Additionally, the office was directed to create an annual map showing all of the lands in the public domain to accompany the year-end report of the commissioner of the General Land Office.

> With a view of expediting the issue of the annual report of the general land-office, the public printer is hereby authorized to contract for the lithographing of the maps of the several states and territories, . . . except in regard to the connected map accompanying the last annual report of the public lands east and west of the Mississippi, in regard to which the commissioner of the general land-office is hereby authorized to procure an engraved plate thereof, to be perfected by adding from time to time the further surveys that may be made. (US Congress 1863, 822)

From the record in the *Congressional Globe*, it appears that this joint resolution (Senate No. 110) had its beginning in a Senate committee on printing; it was introduced to the Senate on December 10, 1862, by Senator James Harlan of Iowa, Chair of the Senate Committee on Public Lands. In his introduction, Harlan indicated that "they [the General Land Office] have been using a map prepared in the War Department, but they have all been exhausted, and are not very well adapted for the purposes of the office." The resolution was "for the purpose of engraving a map connected with the surveys, to which they may add from year to year an exhibit of the additional surveys. This is now done by hand, by the clerks in the office, draughtsmen, and costs the Government doubtless ten times as much as it would have to have them engraved" (Congressional Globe 1863, 52). The resolution seems to have been read in the Senate and passed without further discussion before it was sent to the House where it was read three times and approved without any recorded discussion.

It is important to remember the distinction between printing technologies of the period. Lithography was less expensive, for a single image. However, once the image was traced onto the stone, it could not be easily changed. Engraving, by contrast, etched the surface of a copper plate chemically, and new linework could be added incrementally. The printing office had been recently established, and had become a specialist in engraving for currency, and thus provided a means to print maps. Congress has a long history of cost-cutting, and this Senate committee seems to dive deep into the details of GLO's operations.

Of course, Congress in 1863 was not in full control of the national territory that would be shown on this "connected map." By that year, eleven states had seceded from the Union and established a rival government. Maintaining the Union's claim to the whole could have been one possible motivation to create a map of national extent. Another motivation may have been the number of changes to territories and states, as Congress was no longer locked into sectional division that had plagued the prior decades. Without the southern senators, new states were admitted, some of them before they had the required population. Each year saw some change in status, boundaries, or both.

There was no mention of the required "connected map" in the annual report submitted for the GLO at the end of 1863 as either a completed work or a work in progress. The maps included with the report were only the state and territory maps following prior convention.

The first connected map, *Map of the Public Lands and Territories, Constructed from the Public Surveys and Other Official Sources in the General Land Office*, at a scale of 1:3,801,600, accompanied the commissioner's 1864 report (Figure 5). Within the text of the report, the map is listed as the final accompanying item or report: "Connected map of the public land, States and Territories compiled from the diagrams accompanying the reports of the surveyors general." It is curious that this map shows Virginia at its pre-war extent, as West Virginia had been admitted to the

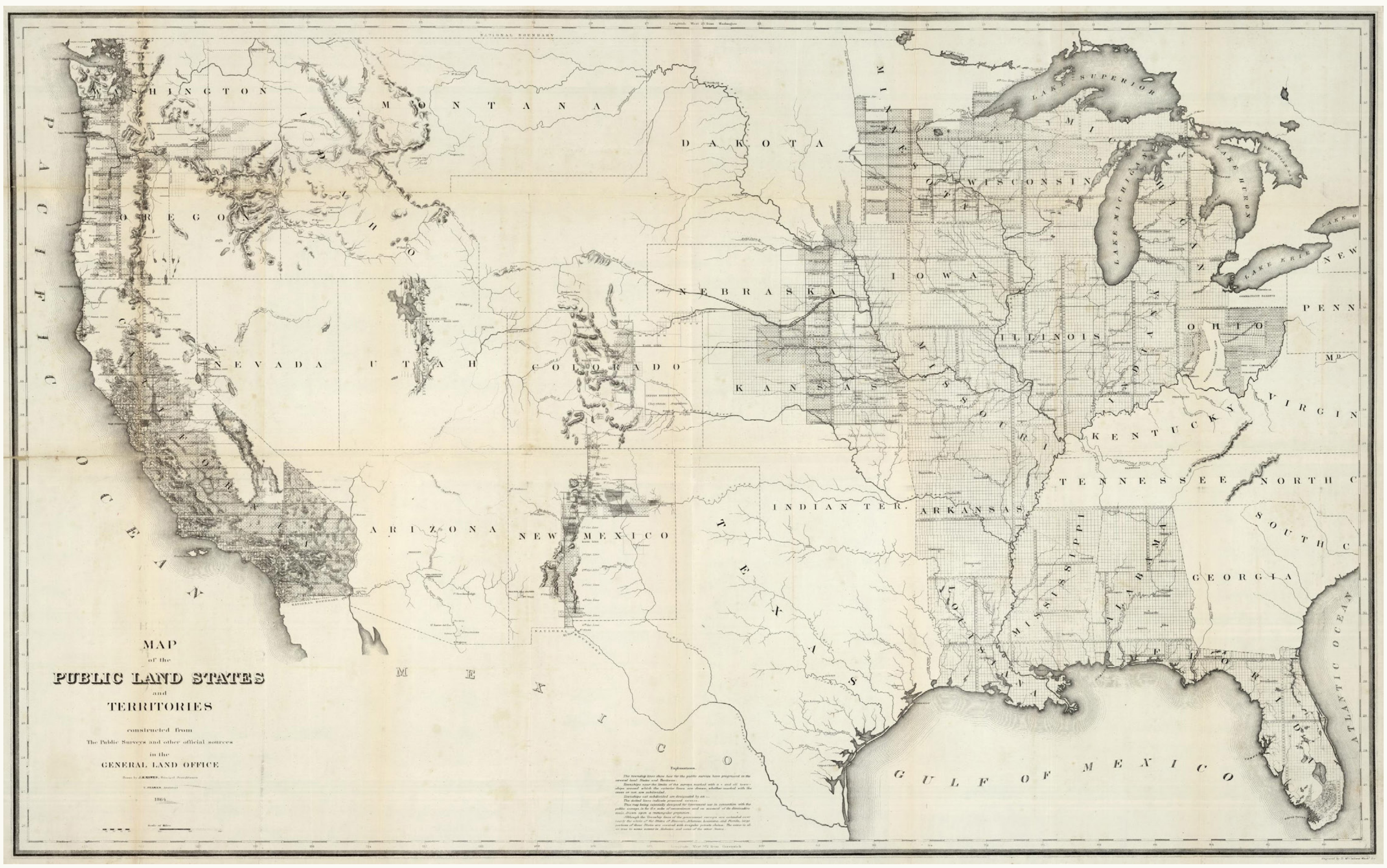

Figure 5. *Map of the Public Land States and Territories, Constructed from the Public Surveys and Other Official Sources in the General Land Office* (Hawes 1864). Courtesy of the David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

Union in June 1863. Yet, it shows the Montana Territory, which was not created until May 1864. GLO could have updated the map to include West Virginia, but it was neither in its region of operations nor a public land state.

The list's entry for the connected map is followed by a statement regarding the multiple state/territory maps that had previously been distributed with the commissioners' reports.

> The diagrams accompanying the annual reports of the surveyors general are omitted, and the connected map of the public land States and Territories, brought up to date therefrom, is bound with this report in lieu of them." (US GLO Annual Report 1864, 29)

This statement appeared in the commissioner's reports in 1864 and 1865. The connected map was intended to serve as an aggregator or distillation of data that appeared on the individual state maps. By 1866, the materials accompanying the annual report included the connected map and, once again, maps of individual states and territories, 22 individual areas in 1866.

Relief on the map from 1864 was shown by hachures; townships were coded as divided or not divided into sections by symbols. The small amount of text included a disclaimer about the use of a rectangular projection and explained that patterns of previously surveyed areas, such as long lots in Louisiana or Spanish and Mexican land grants in California, were not specifically depicted on the map. The map does not cover the entire eastern seaboard, omitting Maine through North Carolina and including no details for South Carolina and Georgia. It covers only the parts of the United States in the public domain, the areas relevant to GLO operations. The focus was clearly westward facing. A mostly regular square grid pattern represents areas surveyed, using the actual townships, baselines and meridians. Railroads extending diagonally from population centers are visually emphasized. The map issued with the commissioner's annual report was black and white, a blank canvas that could be used to depict information about mineral resources.

Two years later, the map distributed with the commissioner's report included complete coverage of the east coast, though some of the boundaries (such as Vermont-New York) look rather dubious to modern eyes. Its title changed to reflect the full national scope of coverage: *Map of the United States and Territories, Shewing the Extent of Public Surveys and Other Details Constructed from the Plats and Other Official Sources of the General Land Office*, and it remained at a scale of approximately 1:3,900,000 (Figure 6).

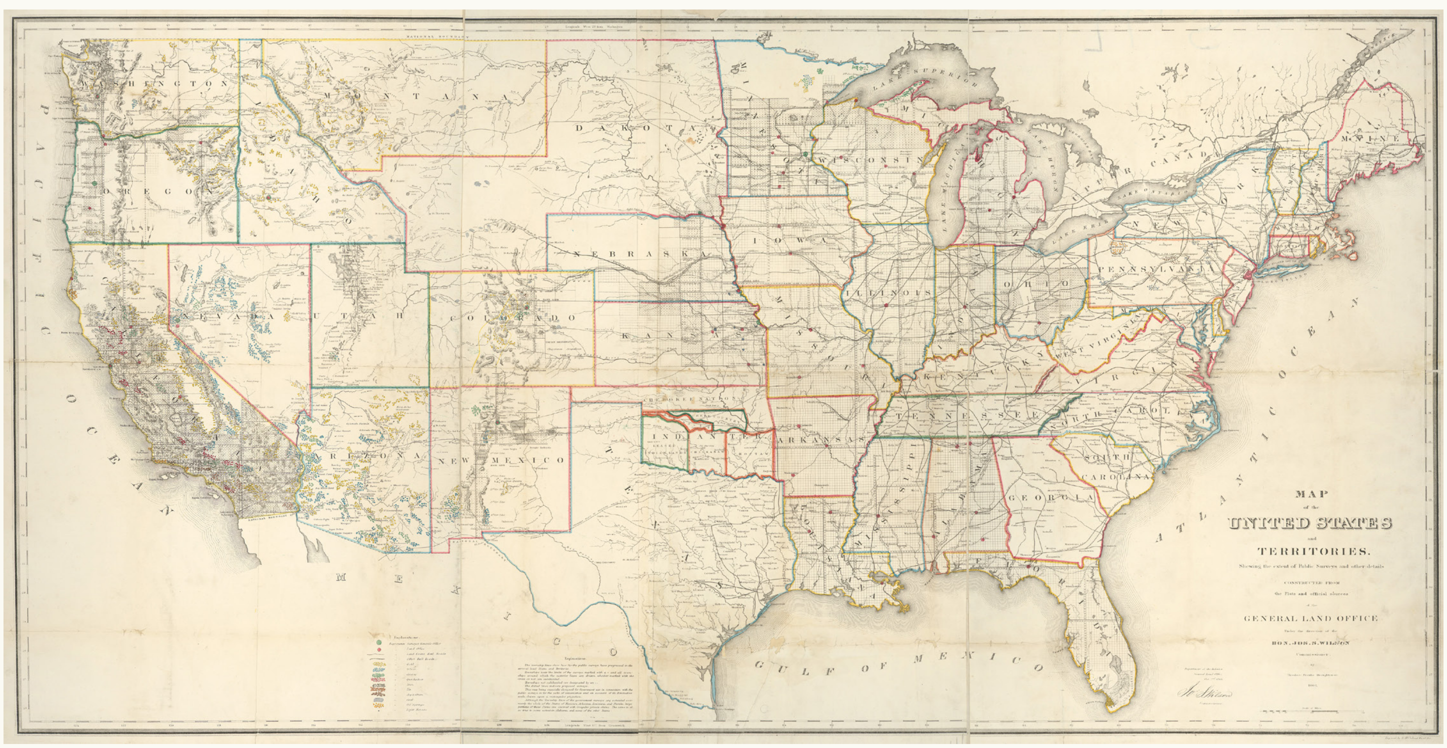

Figure 6. *Map of the United States and Territories, Shewing the Extent of Public Surveys and Other Details* (Franks 1866). Courtesy of the Lionel Pincus and Princess Firyal Map Division, New York Public Library.

The description of the map in the list of accompanying items in the annual commissioner's report was quite fulsome; item 16 was "Connected map of the United States from ocean to ocean exhibiting the extent of the public surveys, localities, land districts, seats of surveyors general's offices and district offices; also localities of railroads of general interest and mineral deposits" (US GLO Annual Report 1866, 40). Oil springs and light houses were also indicated. State and territory boundaries are picked out in color. GLO put a date of 1866 on this map, although it shows the expanded boundaries of Nevada that were not approved until January 1867.

Just as the state maps had shown the status of treaties with Indian nations, this 1866 map uses the garish colors of state boundaries for six nations inside the Indian Territory. The spatial arrangement of the territory and the groups in the area are a product of the work of the Southern Treaty Commission which met beginning in the fall of 1865 with resulting treaties ratified in spring and summer of 1866. A number of tribes had aligned with the Confederacy making any prior treaties with the United States null and void, thus new treaties had to be negotiated. As a penalty for aligning with the Confederacy, the "Five Civilized" tribes, Cherokee, Creek, Choctaw, Chickasaw, and Seminole, all lost approximately half of their territory in Indian Territory. The relinquished territory was used to provide rights of way for railroad construction and to create space for Great Plains tribes that were being moved from their traditional lands into the Indian Territory. There are a few other black outlined Indian reservations noted in some other areas. Due to the reduction of scale, the level and amount of detail on the state maps regarding Indian claims and treaties could not continue on the national map.

The map from 1867 is very similar to the 1866 map except that states and territories were shown by color fill. For some reason, West Virginia shares the same color as the residual Virginia, although they had been separated officially for four years. The color fill allowed a line symbol, in the same color but a more saturated shade as the states and territories, for showing the boundaries of land office districts inside of states and territories. This technique to show land office districts was also used to show different tribal areas in the Indian Territory; they are not as easily differentiated from each other as they were on the 1866 map (Figure 7).

The 1867 map was described in the commissioner's text as "a connected map of the United States, as it existed prior to the Russian purchase" (US GLO Annual Report 1867,

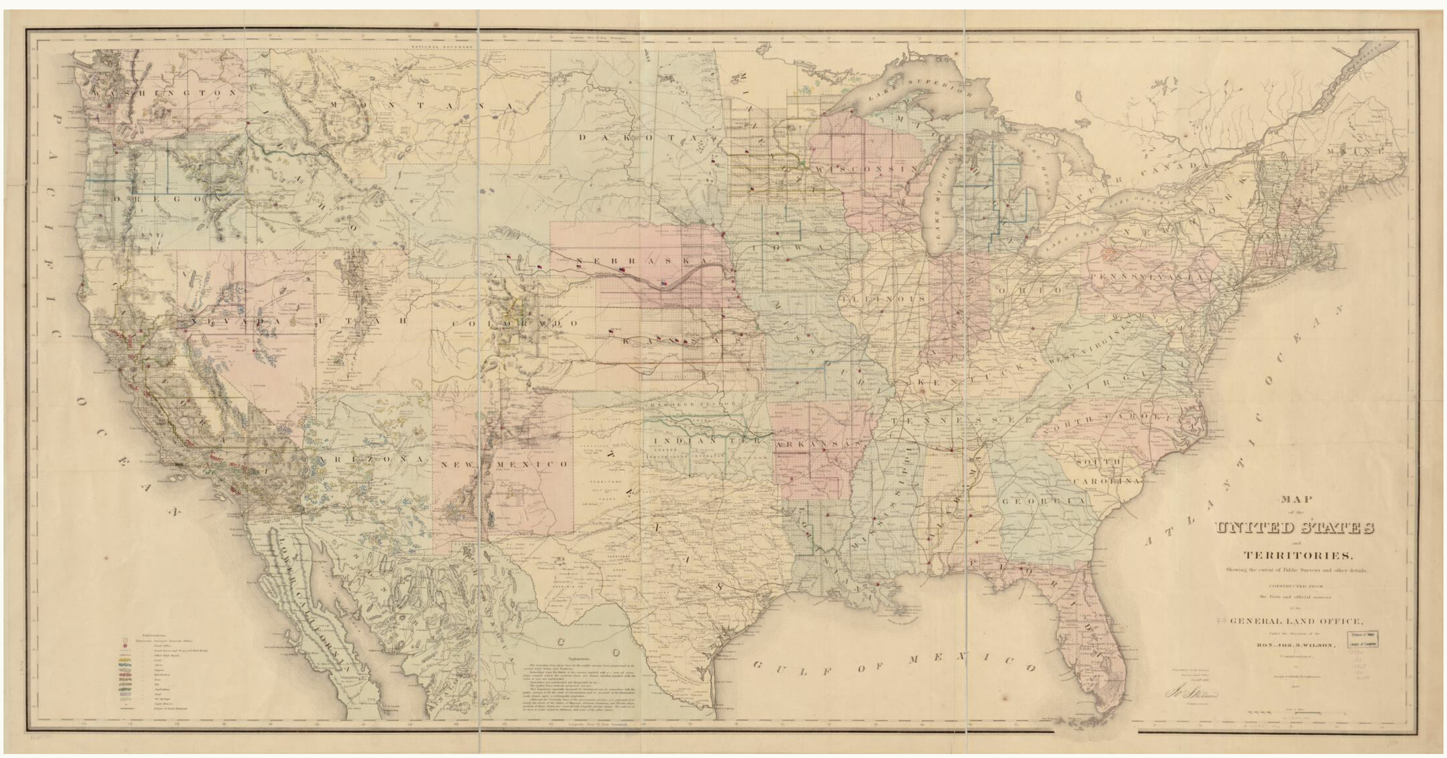

Figure 7. *Map of the United States and Territories, Showing the Extent of Public Surveys and Other Details* (Gorlinski 1867). Courtesy of the Geography and Map Division, Library of Congress.

6). The map would be referred to as a "connected map" or, in conjunction with the state maps, "connected and separate United States maps" in either the text of the GLO annual report or its budget request through 1900.

For the next five years, the maps created and distributed by the General Land Office followed a similar pattern to the 1867 map. They were approximately 71 × 139 cm (28 × 56 inches), at a scale approximately 1:3,800,000, and of a size appropriate for and printed on paper suitable for folding and inclusion in the General Land Office commissioner's report to the secretary of the treasury, and later of the interior, for transmission to the president and Congress. The 1868 map recorded the creation of the Wyoming Territory and the boundary change for Idaho Territory.

A footnote appears in the Estimates of Appropriations budget section in 1870 and 1871 to explain the request made "For constructing the connected map of the public lands States and Territories:"

> The map prepared in 1862, and the engraved plate thereof authorized by joint resolution of January 6, 1863, having proved by subsequent actual surveys during eight [or nine] years to be imperfect, and not susceptible of being corrected, and, besides, the map not embracing Alaska, acquired by subsequent treaty, this estimate is submitted in order to acquire a correct map of the public domain, greatly needed for Government purposes. (US GLO Annual Report 1870, 322; 1871, 334)

Indian Territory was not public land or in the public domain and thus not in the purview of the General Land Office for surveying. But, it is interesting to note that as early as the 1871 map evidence of surveying appears in Indian Territory. Unlike territories on the path to statehood, a surveyor general was not appointed for Indian Territory. Surveying was done directly by the General Land Office commissioner through separately issued contracts. The first survey was contracted in July 1870.

The map changed radically in 1873 without further comment or explanation in the commissioner's annual report. The root title of the map remained *Map of the United States and Territories*, but its physical nature changed extensively.

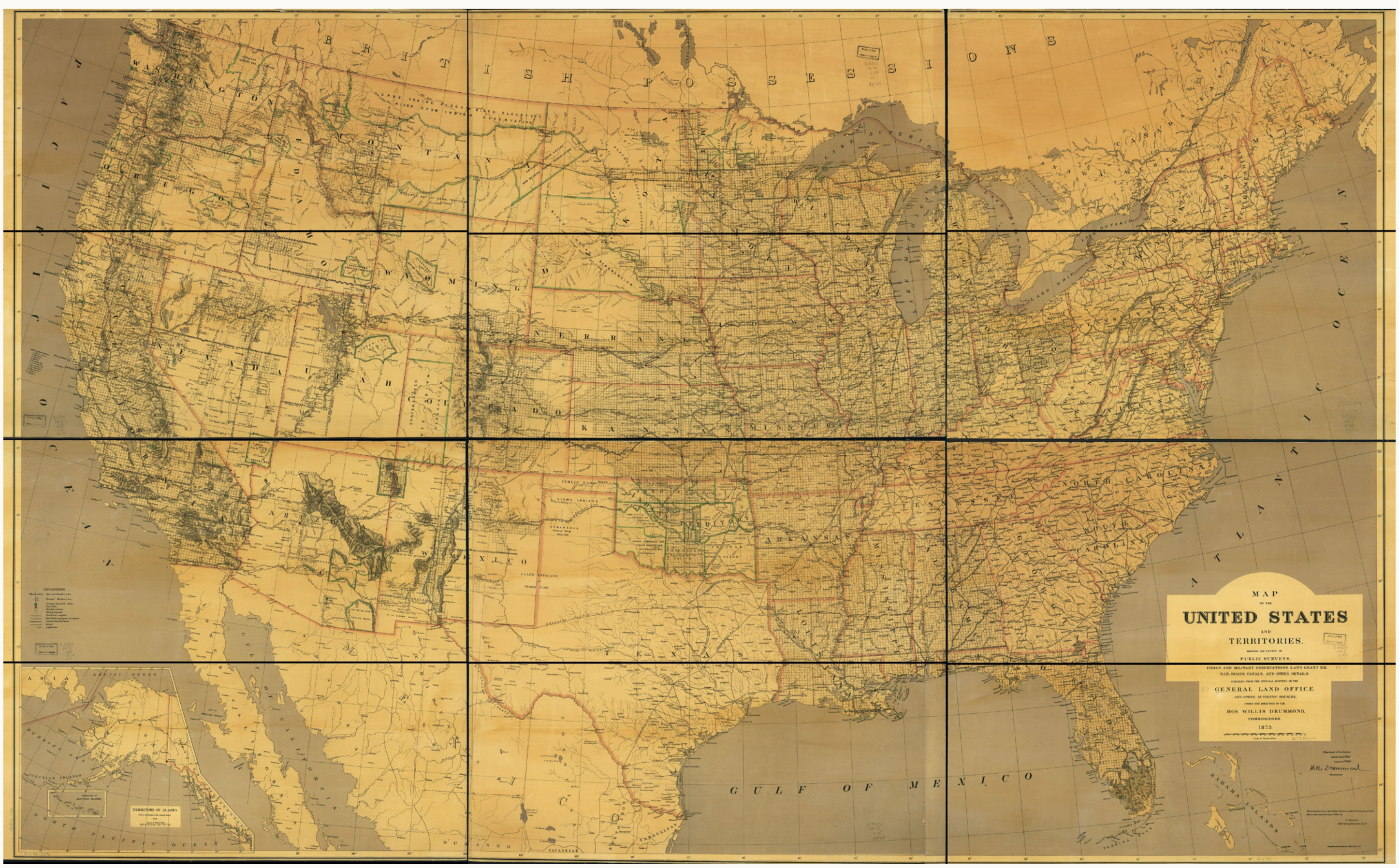

Figure 8. *Map of the United States and Territories, Showing the Extent of Public Surveys, Indian and Military Reservations, Land Grant R.R.; Rail Roads, Canals, and Other Details* (Roeser 1873a). Courtesy of the Map and Geography Division, Library of Congress.

The map more than doubled in area, now measuring approximately 122 × 197 cm (49 × 79 inches) at a scale approximately 1:2,500,000. In the new format, the GLO abandoned the earlier rectangular (cylindric) projection for a conic projection. By this date, the states and territories had taken on boundaries that have proved to be stable up to the current day, with the exception of the division of Dakota Territory into two states in the spree of statehoods of 1889 (Figure 8).

Figure 9. *Alaska and Baja California as shown on Map of the United States and Territories, Showing the Extent of Public Surveys, Indian and Military Reservations, Land Grant R.R.; Rail Roads, Canals, and Other Details* (Roeser 1873a). Courtesy of the Map and Geography Division, Library of Congress.

On this larger map, the treatment of Indian nations and reservations shows much more detail, in part due to the creation of a number of new zones for the federal government to manage. Indian Territory shows a different set of boundaries for the individual nations and substantial survey activity in the Cherokee and Arkansas sections. The Oklahoma Panhandle has been separated from the Indian Territory as "Public Land." Outside Oklahoma, the reservations are shown with a similar green boundary, including a Sioux reservation that essentially covers all of modern South Dakota west of the Missouri River. Most show no surveying activity, although the Navajo reservation is completely laid out in townships and ranges, spanning northwest New Mexico and northeast Arizona Territory. Established the year before, Yellowstone National Park has the same green boundary treatment as the reservations. Through the use of color fills and outlines for various forms of federal control, the public survey element of the map was visually diminished. These changes continued incrementally.

The spatial scope changed as well. Alaska, purchased from Russia in 1867, and with most of its 586,412 square miles of land in the public domain, finally appears on the new larger format map in an inset off Baja California (Figure 9). The inset's subtitle reads, "Ceded by Russia to the United States 1868." The statement and inset map set the style for including future acquisitions. There is no indication of any surveying activity in the Alaska Territory, in contrast to the conterminous United States, as none had yet happened, but including Alaska on the map could be seen as the first acknowledgement of a United States empire.

There appear to be two versions of this wall map. The title blocks differ in shape even though both copies are photolithographed and printed by the same company. Color is also used differently, with the copy held by the Library of Congress (Figure 8) having no blocks of color but showing federal lands, such as reservations and the newly established Yellowstone National Park, outlined in green, as described above. The copy from the New York

Public Library uses varying hues of color fill to highlight reservation lands but gives no color to the boundaries of Yellowstone (Figure 10).

The GLO's next version of the annual map was issued in 1876/1878 as the "centennial map" of the United States, at a scale of 1:1,267,200. The map does not seem to have completely originated within the GLO. It was produced under the direction of the House Committee on Public Lands. If joined, the sixteen sheets would create a map 2.43m × 3.64m (8 × 12 feet). For the most part, this map is the same as the previous ten years' worth of maps, just much larger. The color variants observed in 1873 are replaced by a grey to demonstrate areas where surveys have been completed (including the western part of Indian Territory). Military reservations are colored rose. An index map to accompany the full-size map is seen in Figure 11. While this index to the much larger sixteen-sheet map does not highlight Indian lands, they do appear prominently in green on the map sheets.

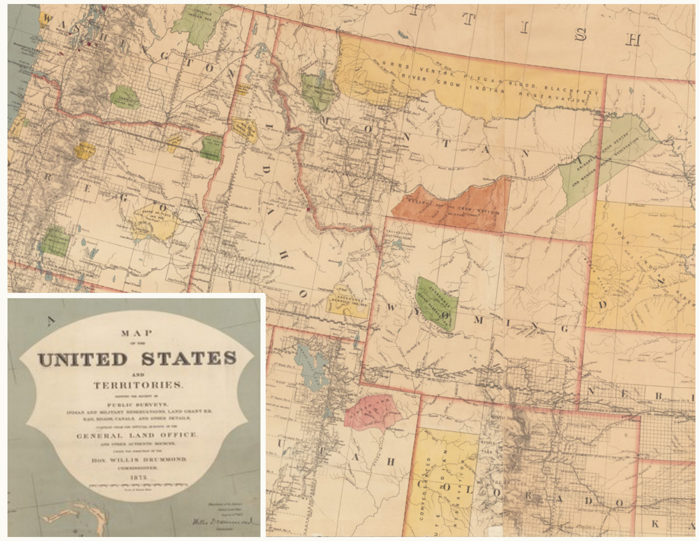

Figure 10. Title block and northwestern United States as shown on *Map of the United States and Territories, Showing the Extent of Public Surveys, Indian and Military Reservations, Land Grant R.R.; Rail Roads, Canals, and Other Details* (Roeser 1873b). Courtesy of the Lionel Pincus and Princess Firyal Map Division, New York Public Library.

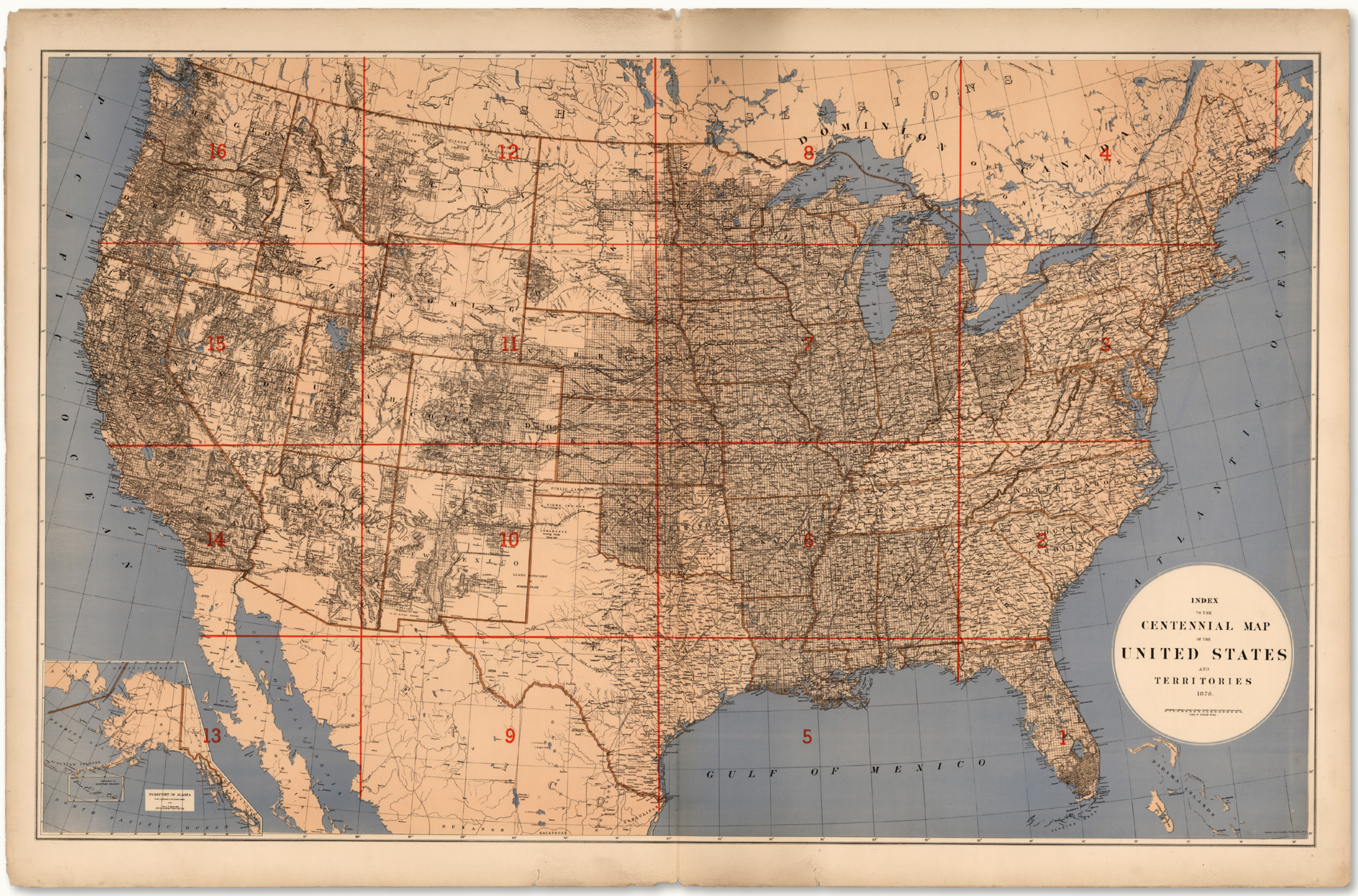

Figure 11. *Centennial Map of the United States and Territories, Showing the Extent of Public Surveys, Indian and Military Reservations, Land Grants R.R., Rail Roads, Canals, Cities, Towns & Other Details* (Roeser 1878). This image shows the index sheet to a 16-map set, sheets numbered in red. Courtesy of the David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

Figure 12. *Map of the United States and Territories, to Accompany the Annual Report of Hon. N.C. MacFarland, Commissioner, General Land Office for Fiscal Year which Ended June 30, 1884* (US GLO 1884). Courtesy of Barry Lawrence Ruderman Antique Maps.

In 1884, the General Land Office prepared two maps, both titled *Map of the United States and Territories*. The first followed the established pattern of the wall map at a scale of approximately 1:2,500,000, was printed on multiple sheets of paper, mounted on linen and features the expected content for the wall map, "the extent of public surveys, Indian and military reservations, land grant R.R.; rail roads, canals, and other details." The second (Figure 12) clearly is intended to accompany the commissioner's annual report given the title, *Map of the United States and Territories, to Accompany the Annual Report of Hon. N.C. MacFarland, Commissioner, General Land Office for Fiscal Year which Ended June 30, 1884*. It has a smaller scale of approximately 1:3,500,000 and smaller dimensions of 61cm × 96cm (24 × 38 inches).

The sole purpose of this map is to identify public domain states and territories. Although surveying of Indian Territory had begun through contracts from the office of the General Land Office commissioner, Indian Territory was not a public domain territory and is indicated as such. The Oklahoma Panhandle, "Public Lands," clearly is part of the public domain. The extent of surveys has disappeared as have other details such as railroads, reservations, or national parks. Interestingly, mountain ranges are visually prominent. Similar maps illustrating public domain states appeared in later annual reports but they were page-sized rather than printed on an oversized, folded sheet that had to be tipped into the volume.

The wall map's title changed in 1886. No longer *Map of the United States and Territories, Showing the Extent of Public Surveys, Indian and Military Reservations, Land Grant R.R.; Rail Roads, Canals, and Other Details,* the new title is *Map of the United States and Territories, with Adjacent Parts of Canada and Mexico, also Part of the West India Islands, Showing the Extent of Public Surveys, Indian and Military Reservations, Rail Roads, Canals and Other Details* (Figure 13). This map displays greatly increased amounts of Canada and Mexico in comparison to earlier editions. In an era of burgeoning empires, the map boldly establishes the United States as the core of North America with a title that places emphasis on location. This moment establishes the visual for the United States as a unified territory from sea to sea.

Cuba, but not Puerto Rico, and all of Baja California appear. Alaska pays the price for Baja California and is constrained in a very small box. Although Alaska is small, the Aleutian Islands are not treated as an inset within an inset as they were in 1873, nor is the archipelago truncated as it was on the map that accompanied the 1884 and 1885 annual reports. The inset also shows the distance to the other Pacific coast states. As before, Indian reservations are shown in a green fill, and Yellowstone is not filled. Military reservations are in a bold red, while a lighter reddish tint covers areas of Spanish land grants in California and New Mexico.

The 1886 report (US GLO Annual Report 1886, 358) indicates that 3500 copies of the map were received. Without a significant change in format, the print run expanded to 14,000 copies for 1890 and to 11,000 for 1891 (US GLO Annual Report 1890, 247; 1891, 224). In 1893, 16,224 copies were printed (US GLO Annual Report 1893, 206). It is not clear where all these copies ended up, but these press runs were far above the number needed for Congress itself. The records are incomplete, and the next reported production numbers do not appear until 1902. However, the appropriations continued, and the maps were updated each year.

Besides obscuring Indian reservations by indicating them with a beige-pink, the 1890 map shows an administrative

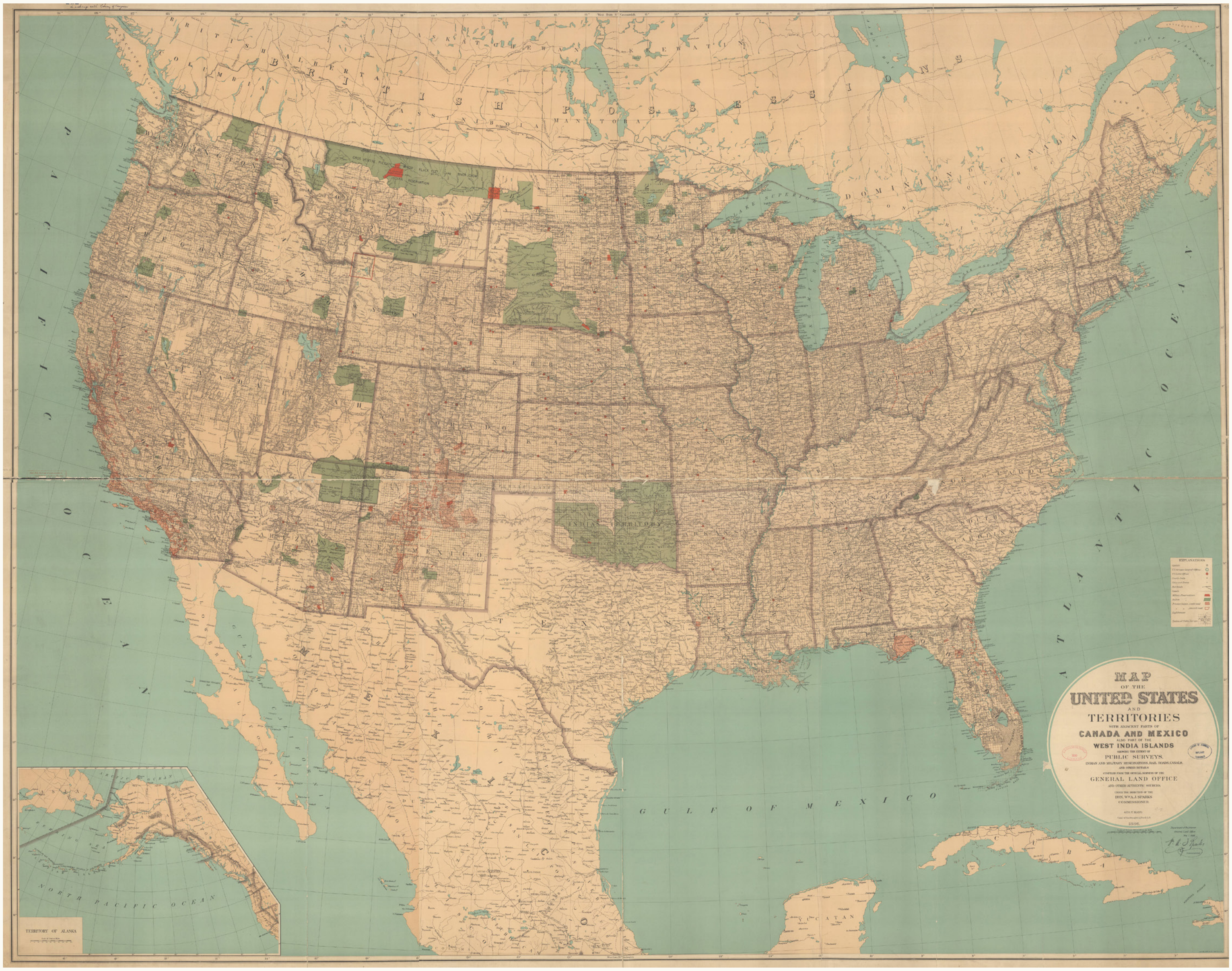

Figure 13. *Map of the United States and Territories, with Adjacent Parts of Canada and Mexico, also Part of the West India Islands, Showing the Extent of Public Surveys, Indian and Military Reservations, Rail Roads, Canals and Other Details* (US GLO 1886). Courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries.

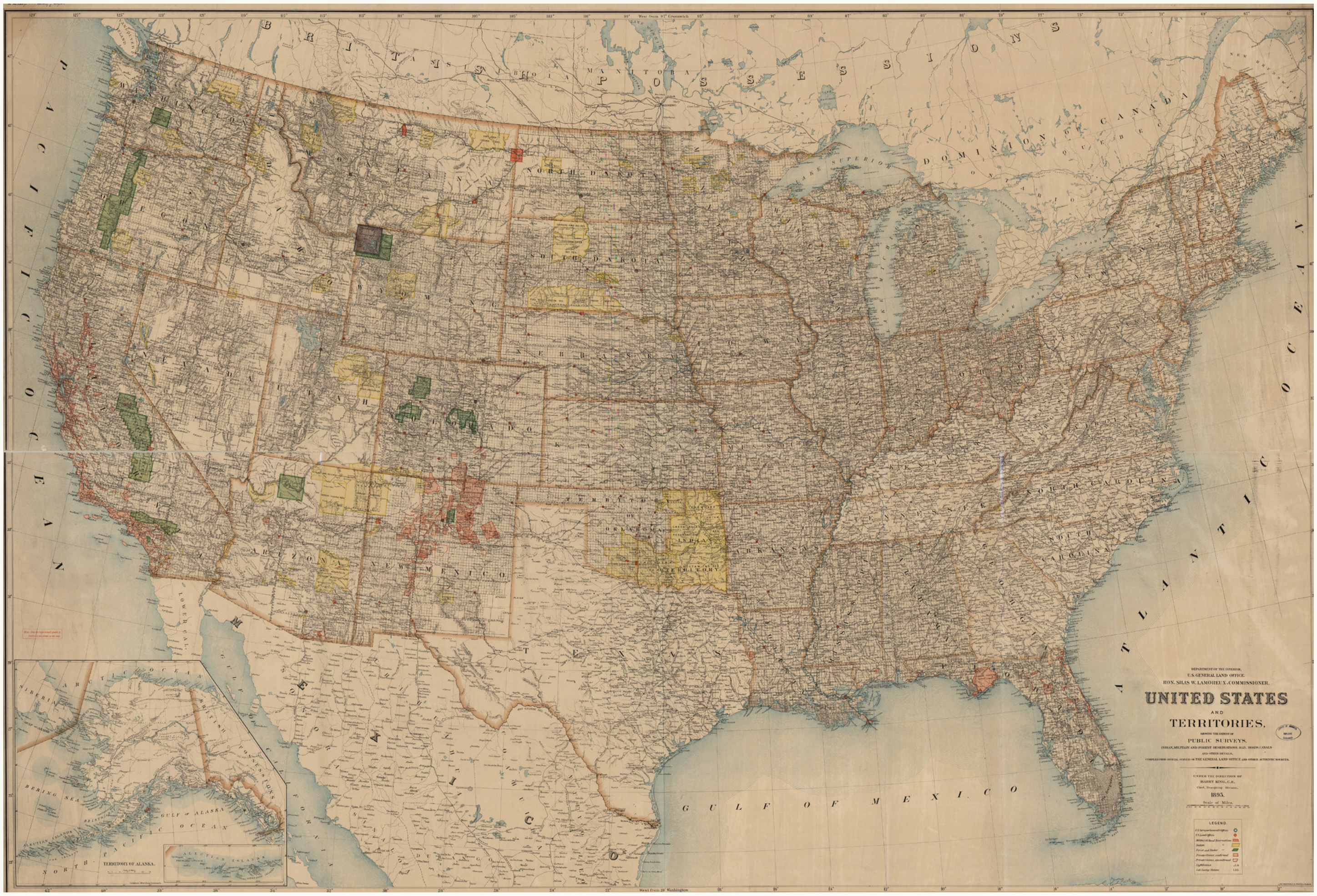

Figure 14. *United States and Territories, Showing the Extent of Public Surveys, Indian, Military and Forest Reservations, Railroads, Canals and Other Details* (US GLO 1895). Courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries.

resolution for the area now known as the Oklahoma Panhandle. Originally part of the Republic of Texas, the area was separated when Texas joined the United States because the strip of land was north of the Missouri Compromise line. The early GLO maps of the United States showed the strip attached to Indian Territory, which was not subdivided. The 1866 map shows Indian Territory divided into six units with the panhandle attached to the lands of the Cherokee Nation. It was separated from the Cherokee Nation on the 1868 map and remained separate, and labeled "Public Land," on the maps until 1890 when the Oklahoma Territory, the western half of the current state of Oklahoma, was organized.

In 1895, the layout of the map changed again. As reported in the 1894 commissioner's report, "A new and effective coloration of the United States and Territorial maps has been adopted" (US GLO Annual Report 1894, 330). The map, with a scale of 1:2,217,600, focuses more narrowly on the United States, with smaller areas to the north and south of the international borders included (Figure 14).

Cuba has disappeared, and Alaska's inset is over Baja California with, again, the western portion of the island chain inset within the inset. The map's geographical extent is similar to that of maps prior to 1886. The changes in "coloration" continued the shift of thematic content away from the public surveys. Federally held lands expanded beyond Indian (yellow) and military (red) reservations to include forest and timber reservations (green), many of which later became national forests and parks, making the narrative about federal lands more nuanced. Indian reservations are not as visually present in yellow as they had been in green. Yellowstone National Park is the only holding marked in purple. Purple does not appear in the legend.

TERRITORIAL ACQUISITIONS—ERRORS AND CORRECTIONS

The reformatting that occurred with the 1895 edition led the way for a most notable change in content—and thus possible change in purpose and audience—that occurred in 1896. The title and legend stayed the same but an entirely new thematic layer appeared: when, and from whence, territory had been acquired, shown by brash text and bold boundary line treatment, on top of the continued public land survey representation (Figure 15).

There is no indication in the commissioner's annual report from 1896, or any prior year, that the change was happening or why it was made. The standard language that appeared in all other reports is used to report on this particular annual map: "The map of the United States for [year] revised, corrected up to date. . ." (US GLO Annual Report 1896, 272). The same map appeared in 1897.

Possible motivations for the GLO to make this particular change at this particular time need to be considered. Some of the reasoning may be internal. The GLO had been promoting its importance for decades to Congress using the inexorable march of rectangular surveys across the map. While surveying continued for various reasons, the annual report of 1895 makes the rear-guard statement "public land surveys must continue for some years, at least, with numerous resurveys sooner or later" (US GLO Annual Report 1895, 60). By 1896, much of the public domain (80%, excluding Alaska) had been surveyed, at least at some preliminary level. Twelve of the thirty public land states and territories, again excluding Alaska, were completely surveyed, and of the remaining eighteen, three were more than 90% complete, ten were more than 50% complete, and the remainder were close to 25% or more surveyed. Alaska was an extreme outlier with less than 1%

Figure 15. *United States and Territories, Showing the Extent of Public Surveys, Indian, Military and Forest Reservations, Railroads, Canals and Other Details* (US GLO 1896). Courtesy of the Map Collection at the University of Chicago Library.

surveyed (US GLO Annual Report 1896, 197–198). Many of the less surveyed states were states with treacherous and less than desirable terrain that was not conducive to occupation via individuals taking advantage of homestead acts. The unsurveyed areas are scattered, and maps would no longer be showing large annual additions to zones of surveyed lands. The map's primary mission of communicating about the extent of surveying may have run out.

Additionally, sales of public lands, another General Land Office bailiwick, had diminished greatly and no longer played a substantial part in the nation's revenues and receipts. Public land sales were a significant, but not dominant, source of revenue early in the United States' history. Their zenith was in 1836, when revenue from public land sales made up over 32% of the nation's entire receipts. The financial importance declined until the early 1850s with a secondary peak of nearly 15% of the year's revenue in 1853. By 1896, public land sales were making up only 0.3% of the annual revenue and never exceeded 1.6% after 1896 (Wallis 2006).

Just in itself, the logic of the map could have justified some new direction. Moving outward from the GLO, the main audience for these maps lay in Congress. In this period, half of the print run was dedicated to the House of Representatives and another quarter to the Senate. Over the decades, the GLO made the map bigger and bigger, perhaps in part to occupy a more prominent place on the walls of congressional offices. The move to a big, bold patriotic message might have been related to an urge to maintain prominence in this select location. In addition, the GLO had a rival for congressional appropriations. The upstart Geological Survey, and its charismatic leader John Wesley Powell, claimed attention for programs of topographic mapping with wider application than the legal process and products of land surveying.

Leaving the interagency conflict aside, the GLO was located in a larger society where the issue of westward expansion was quite prominent. Frederick Jackson Turner had presented his "Frontier Thesis" in 1893 at a session of the American Historical Association during the Chicago Exposition of that year. Turner (1894) struck a chord outside the world of scholarship, with much debate and publicity. Much of the scholarship about the era points to this moment as a pivot towards a more imperial view of the country's role in the world.

In the 1880s and 1890s, the globe was carved up by imperial powers. The United States had occupied its swath of North America from east to west, Russia had expanded from the Urals eastward to the Pacific Ocean, Latin America was firmly in the spheres of influence of European powers, and Africa had been carved up amongst the European powers at the Berlin Conference of 1884–1885. This map, prominently displaying United States title to its territory, could be seen as a statement of place and prominence in the global theater, declaring the United States equal to other nations with imperial aspirations.

The obvious, massive error on the 1896 and 1897 map is the inclusion of the Pacific Northwest as part of the Province of Louisiana. This may have happened because of a misunderstanding about the mandate for Lewis and Clark's voyage to travel through the Louisiana Purchase and, beyond the territory of the purchase, onward to the Pacific Ocean. Some earlier maps produced by the GLO and Census Bureau had portrayed Oregon in this way; perhaps the error was not seen as an error at the time. Smaller missteps include the border in Minnesota between the original territory of the thirteen states and Louisiana, which should have swooped northwest through North Dakota to exclude the Red River of the North drainage from Louisiana. The very complex situation of West Florida is ignored as are overlapping territorial boundaries occurring in the Rocky Mountains of Colorado. Additionally, the map treats all of the eastern seaboard (except Florida) as part of the original territory. This is incorrect for northern Maine's boundary with New Brunswick, established in 1842.

The presidential election of 1896 saw a change from Democrat to Republican administration. The position of commissioner of the General Land Office was, as ever, a political appointment made by the president, since it had considerable opportunities to hire and contract in dispersed locations. With the election of William McKinley, Binger Hermann was appointed commissioner of the General Land Office in March 1897.

Hermann, who had immigrated to Oregon Territory as a teenager with his parents, quickly turned his attention to the largest error in his agency's recently published national map, writing a monograph entitled *The Louisiana Purchase and Our Title West of the Rocky Mountains* to address

> an error which I conceive exists upon the map of the United States as published under the direction of my predecessor, and which goes forth with the official indorsement of the Department. The error to which I refer is in the representation that the

> cession of Louisiana from France in 1803 comprised territory west of the Rocky Mountains, now known as Oregon, Washington, Idaho and portions of Montana and Wyoming. Believing that such domain was derived by the United States based on the right of discovery, exploration and occupancy by our own people, together with the cession from Spain, by treaty of February 22, 1819, of such adverse rights as that nation claimed to possess, I have assumed the liberty of representing these facts on the new edition of the United States map soon to be published by the Department. (Hermann 1898, 11)

Hermann's eighty-seven page monograph, which includes a pair of sketch reductions of pre-eighteenth-century maps as its only historic cartographic background (Figure 16), reviews the course of territorial ownership and control, beginning with early attempts to define the Province of Louisiana; territorial actions of Spain, France and Great Britain; followed by acquisition of the territory by the United States; a short discussion of natural resources and economic value; and a concluding examination of annexation's role in the United States with specific attention paid to Hawaii.

Documents cited include treaties, correspondence, early maps, and commercial publications. Hermann's monograph was written to support his recommendation to correct the map when it was next republished. Interestingly, both Hermann's July 1898 letter of transmittal and the response received from Cornelius Bliss, secretary of the interior, appear to only specifically reference the error contained on the 1897 map; there is no indication that the prior year's map initiated the error. Bliss gave permission for corrections to be made on the next map published "upon careful consideration of the matter, as so ably presented by [Hermann]" (Hermann 1898, 9). The monograph included a tipped in, very small scale, simple map showing Hermann's corrected depiction of territorial growth, at least where the Pacific Northwest is concerned (Figure 17).

In his report, Hermann did not acknowledge a long history of sporadic misrepresentation of the territory included in the Louisiana Purchase. The "error" on the 1897 (and 1896) map was not so much an error but an oversimplification of a very complex situation.

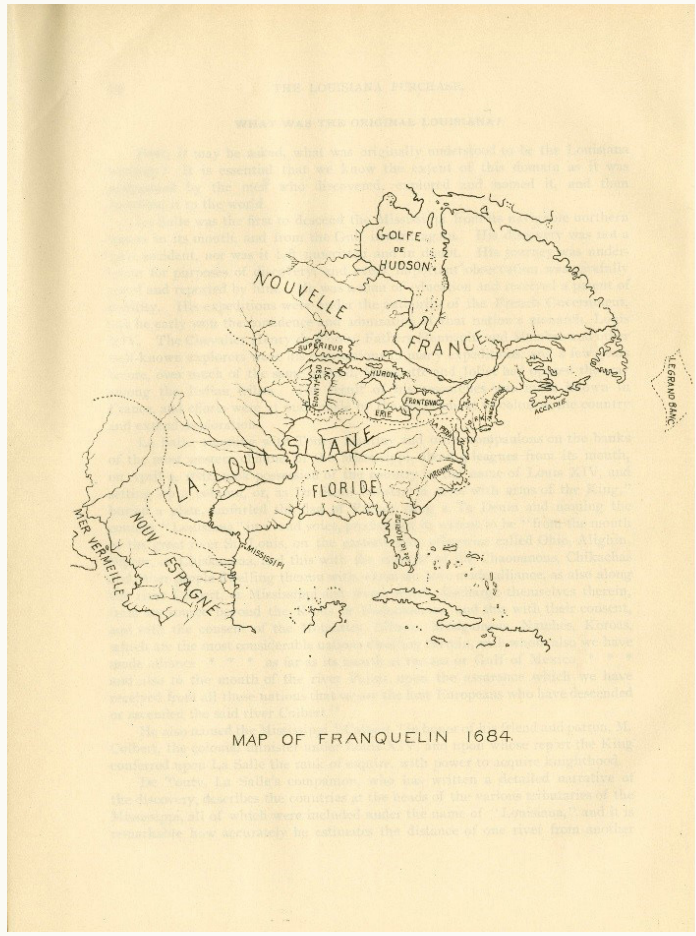

Figure 16. *Map of Franquelin 1684* and *Part of Map by Herman Moll, English Geographer, Published in London About the Year 1710* (Hermann 1898a & b). Courtesy of the Map Library, University of Illinois Urbana-Champaign.

Figure 17. *Territorial growth of the United States* (Hermann 1898c). Courtesy of the Map Library, University of Illinois Urbana-Champaign.

AFTER 1897

The 1898 map correction corrected only the Pacific Northwest (Figure 18). The Red River of the North, northern Maine, and West Florida remain unacknowledged. The story is still overly simple: territory was acquired only once in unambiguous manner; territories abut but do not overlap. Although the graphic portion of the story has been somewhat cleaned up, the text on the Pacific Northwest is highly abridged, sanitized, or incomplete. There is no mention of treaties of 1819, 1828, or 1846, all of which were key in establishing international boundaries, or of the confusion in previous federal narratives.

While the United States had bought Louisiana from France, it had previously been ceded by France to Spain and then returned. The imprecise boundaries in the purchase had to confront the reality of other claims. The Spanish provinces of Tejas and Santa Fe included territory in the Mississippi basin. The treaties of 1819 and 1828 with Spain and Mexico had confirmed these boundaries.

Figure 18. *United States and Territories, Showing the Extent of Public Surveys, Indian, Military and Forest Reservations, Railroads, Canals and Other Details* (US GLO 1898). Courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries.

The simple graphical account of United States territorial acquisitions focused on the conterminous United States appeared—with slight changes and overlain on the representation of public land surveys—on all subsequent versions of the map, and distant territories were added and removed as political change occurred. These political changes occurred rapidly, beginning with annexation of Hawaii in 1898 and the outcome of the Spanish-American War in the same year. Changes to the map followed on quickly as an overseas empire accumulated.

The commissioner's report for fiscal year 1900 states "Owing to the delay incidental to the inclusion of the recently acquired insular possessions as insets, the map of the United States for 1899. . . was not completed during the fiscal year ended June 30, 1899. It is now in the hands of the contractors, however, and will soon be ready for distribution" (US GLO Annual Report 1900, 278). Those insular possessions included the Philippine Islands, the Tutuila Group of the Samoan Islands, Guam, the Hawaiian Islands, and "Porto Rico" [*sic*], plus an inset "Index map showing relative position of Alaska and recently acquired islands to the United States" (Figure 19). Far from hiding an empire (as Immerwahr [2019] contends), the new possessions were displayed in prominence, at vastly differing scales.

The United States had become an empire. It is interesting to note that Cuba has reappeared, and although it is neither boxed nor marked with a cession date, it would be easy to mistake Cuba for one of the insular possessions alluded to in the new title of the map: *United States, Territories and Insular Possessions*. The design of the 1899 map, with insets showing extra-continental territories along with a small map showing the geographical relationship between the continental United States and its territories, became the standard layout for the remainder of the map's production.

In 1903, an inset appeared showing the Panama Canal Zone. The annual commissioner's report for that year

Figure 19. *United States, Territories and Insular Possessions, Showing the Extent of Public Surveys, Indian, Military and Forest Reservations, Rail Roads, Canals and Other Details* (US GLO 1899). Courtesy of Murray Hudson — Antique Maps, Globes, Books & Prints.

indicated only that the plates for the annual map of the United States were updated and the map produced:

> The most important work of this division is technical in character and embraces the compilation of maps of the United States and insular possessions, and of the various States and Territories in which public land is located. These compilations demand the careful computations of the mathematician and the highest skill of the draftsman. An engraved copperplate base for the maps of the United States and insular possessions, now completed and owned by the Interior Department, insures an uniformity, accuracy, and workmanship not heretofore reached in the publication of these important maps. (US GLO Annual Report 1903, 26)

Figure 20. *United States, Including Territories and Insular Possessions, Showing the Extent of Public Surveys, Indian, Military and Forest Reservations, Railroads, Canals, National Parks and Other Details* (US GLO 1904). Courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries.

The then commissioner of the General Land Office, William A. Richards (appointed January 1903), who had experience as a surveyor, clearly placed importance on the production and distribution of the annual national map. His report for fiscal year 1904 indicated problems in production and delivery, for reasons outside of the printer's control.

> The completion and delivery of the 1902 United States map was prevented, after the receipt of only 200 copies, by the Baltimore fire, and on March 1, 1904, the lithographers were advised of their release from further liability under the contract. By act of Congress approved March 28, 1904, the unexpended balance under this contract was made available for the 1904 edition. Steps were immediately taken to hasten the completion of the 1903 edition, and about 3,000 copies of this map have been received up to June 30, 1904. (US GLO Annual Report 1904, 210)

The fire referenced, the Great Baltimore Fire, occurred on February 7 and 8, 1904.

The report goes on to describe the anticipated production and delivery schedule for the 1904 edition (Figure 20).

> The work of bringing the copperplate base of the United States map up to date for the 1904 edition is being pushed as rapidly as may be. Contract for lithographing 63,000 copies of the 1904 map, more or less, has been entered into with a Philadelphia firm, which has expressed its readiness to take up the work promptly, as soon as transfers are delivered to it, which will be in a few weeks. The contract for printing this edition provides that within five weeks after order is received to print, the first 10,000 copies are to be delivered; that four weeks shall be allowed for the delivery of

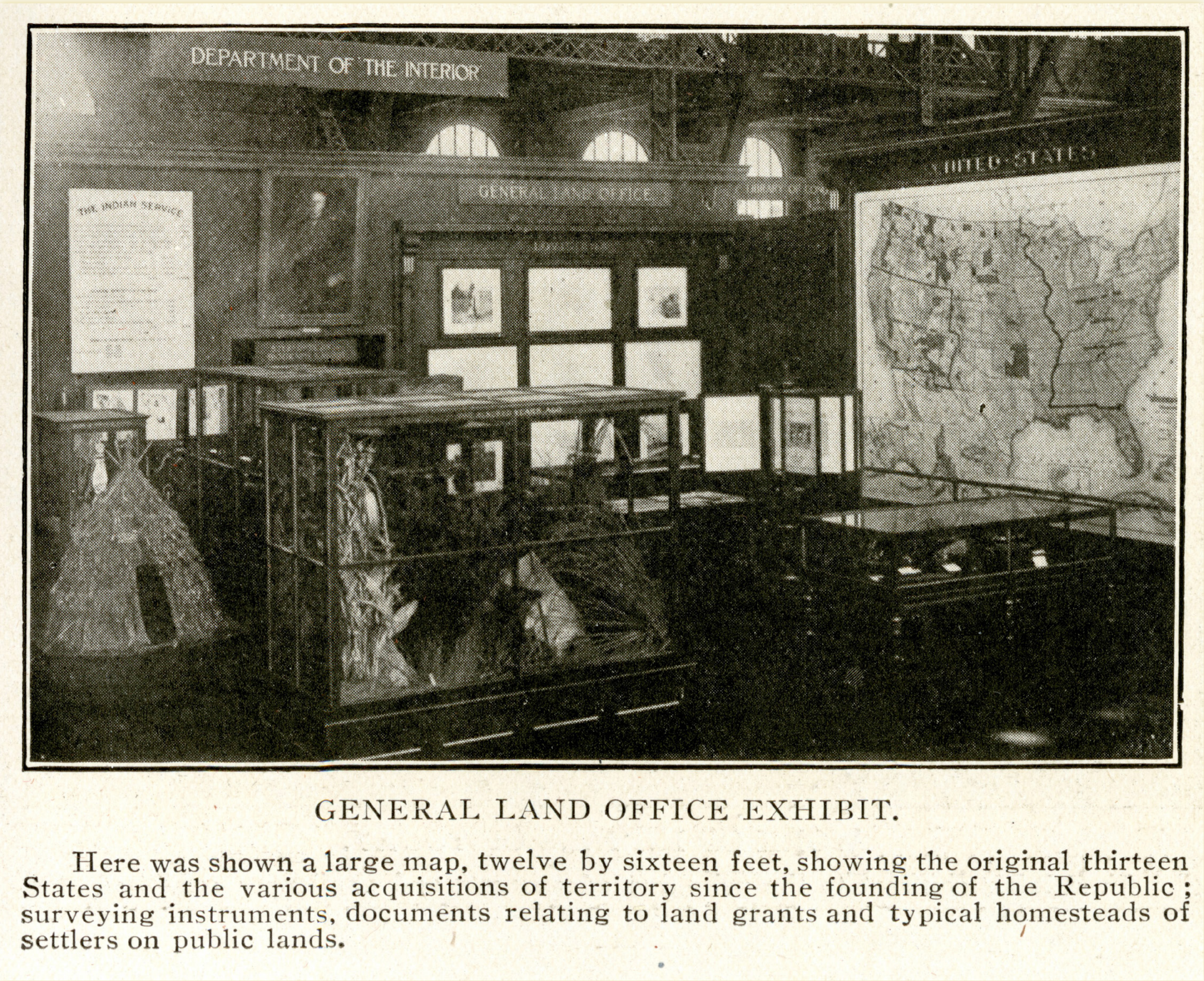

Figure 21. Photograph of General Land Office Exhibit at the Louisiana Purchase Exposition/St. Louis World's Fair of 1904 (Bennitt and Stockbridge 1905, 335). Courtesy of the University Library, University of Illinois Urbana-Champaign.

> the second and that each succeeding 10,000 copies, and that the entire edition is to be completed within twenty-five weeks after the work of printing is begun.

By the 1904 map, the story of continental territorial acquisitions has become more complex, with overlapping acquisitions boundaries. The boundary for the Red River of the North has been corrected so that the region is not part of Louisiana. The Mississippi watershed boundary meanders through Texas, showing that the treaties with Spain had granted land to Mexico that were part of the Louisiana claim. As with all maps in this series, the northern portion of the Mississippi watershed north of the 49th parallel is omitted. Yet still, the story of northern Maine is not represented. West Florida has been changed so that only the Florida Panhandle was acquired from Spain in 1819, again still simplifying a much more complex situation. The text regarding the Pacific Northwest is also greatly simplified to "Oregon Territory: American Title established in 1844."

This was not the only nationwide map created by the General Land Office during 1904. The office also created a set of five maps showing territorial acquisitions and a 20-sheet map of the United States (Figure 21), which was 3.64m × 4.85m (12 × 16 feet) when mounted, for the office's exhibit at the 1904 Louisiana Purchase Exhibition

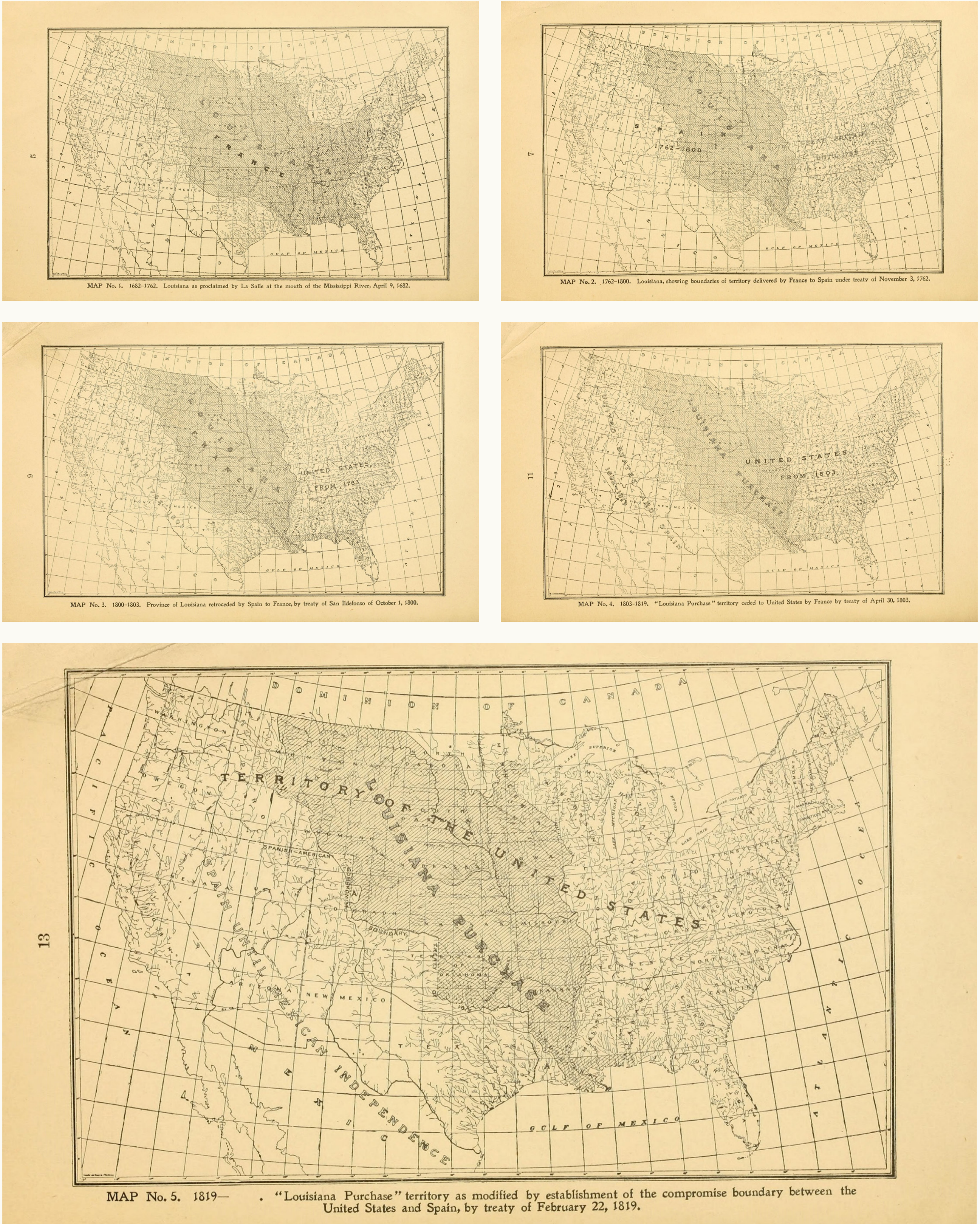

Figure 22. Five maps showing the Province of Louisiana/Louisiana Purchase between 1682 and 1819. From *Historical Sketch of "Louisiana" and the Louisiana Purchase* (US GLO 1904a). Courtesy of the Geography and Map Division, Library of Congress.

(St. Louis World's Fair). The five maps were reproduced in a pamphlet published in 1904 by the General Land Office, *Historical Sketch of "Louisiana" and the Louisiana Purchase with Illustrative Maps reproduced from the Exhibit of the General Land Office, Department of the Interior* (US GLO 1904; Figure 22).

These maps, along with additional maps that brought the chronological coverage into the early twentieth century, were later reproduced with extensive historical text—text which appears to be mostly the same as in the 1904 pamphlet—in an often-republished monograph by Frank Bond, who served as chief of the General Land Office's Drafting Division as well as the office's chief clerk.

Interestingly, Hermann's 1898 monograph correcting the 1896 and 1897 editions of the national map was extensively quoted in a commercial publication which was published contemporaneously with the fair, Murat Halstead's (1904) *Pictorial History of the Louisiana Purchase and the World's Fair in St. Louis.*

It is not entirely clear where all of the 63,000 copies of the 1904 map went, but it seems logical that the exhibition provided a platform to disseminate them widely. For the next five years, GLO printed 25,000 copies each year, a huge number of wall maps for official offices and perhaps also for schools.

Between 1904 and 1906, there was a substantial change in the center of the map. Oklahoma was on the path to being admitted to the United States as a state in 1907. The 1906 map already reflects the changes that would be made through the 1907 Oklahoma Enabling Act. The border between Indian Territory and Oklahoma Territory has been removed, and the soon-to-be former Indian Territory is no longer predominantly shown as Indian reservations. The only reservation indicated is the Osage reservation directly below the territory's northern border.

The layout of boxed insular possessions marching along the bottom trailed by Cuba remained the format of the annual map, with surveys continuing to fill in the township grid, for the remainder of its production life with small changes. The 1915 edition of the map included a revised version of the Panama Canal Zone inset map that shows a much more detailed view of the region's surface water than previous versions and removing proposed routes for the canal leaving only the completed route (Figure 23).

The commissioner in 1915, Clay Tallman, wrote that the copper plates for the 1916 edition were being revised and that "that part of Mexico appearing on the map will be revised and other new features will be added" (US GLO Annual Report 1915, 28). "New features" might have been referencing the list of guano islands that was first included on the 1916 map but removed in 1930 or 1931. Guano was important to the increasingly chemicalized agriculture of the United States. The list is an indication of the United States' global positioning on the pre-World War One world stage. Interestingly, the far-flung guano islands themselves are never graphically represented on the large map of the United States, except on the very small inset map showing the United States with its territories. Creating a large map showing the United State with its territories would have minimized the continental United States and its representation of power and place. Still, the spread of empire was not at all hidden.

PRINT RUNS AND COSTS

Tallman's report for the year ending June 30, 1917 indicated that the copper plates being prepared for the 1918 map would include an inset of the Virgin Islands, formerly the Danish West Indies, which had been acquired from Denmark by purchase on January 17 and formally possessed on March 31, 1917 (US GLO Annual Report 1917, 27). The actual issue of the 1918 edition was delayed. The map had been printed by the lithographer within the usual timeframe but because of restrictions placed on the use of flour by the Food Administration—flour being a component in the adhesive used to mount the maps on canvas—and difficulties in obtaining labor, the delivery of the map to Congress was delayed (US GLO Annual Report 1918, 28).

Reading the annual reports of the commissioners of the General Land Office, it is obvious that the number of copies of the national map printed each year fluctuated greatly. In 1919, Tallman complained about the lack of funding allocated to map production.

> One of the most important functions of the office is exercised in the preparation of the annual issue of the United States map by which much of the field work of the office for the preceding year is graphically recorded and made accessible to the general public. Each year, the progress of public-land surveys, establishment of new national

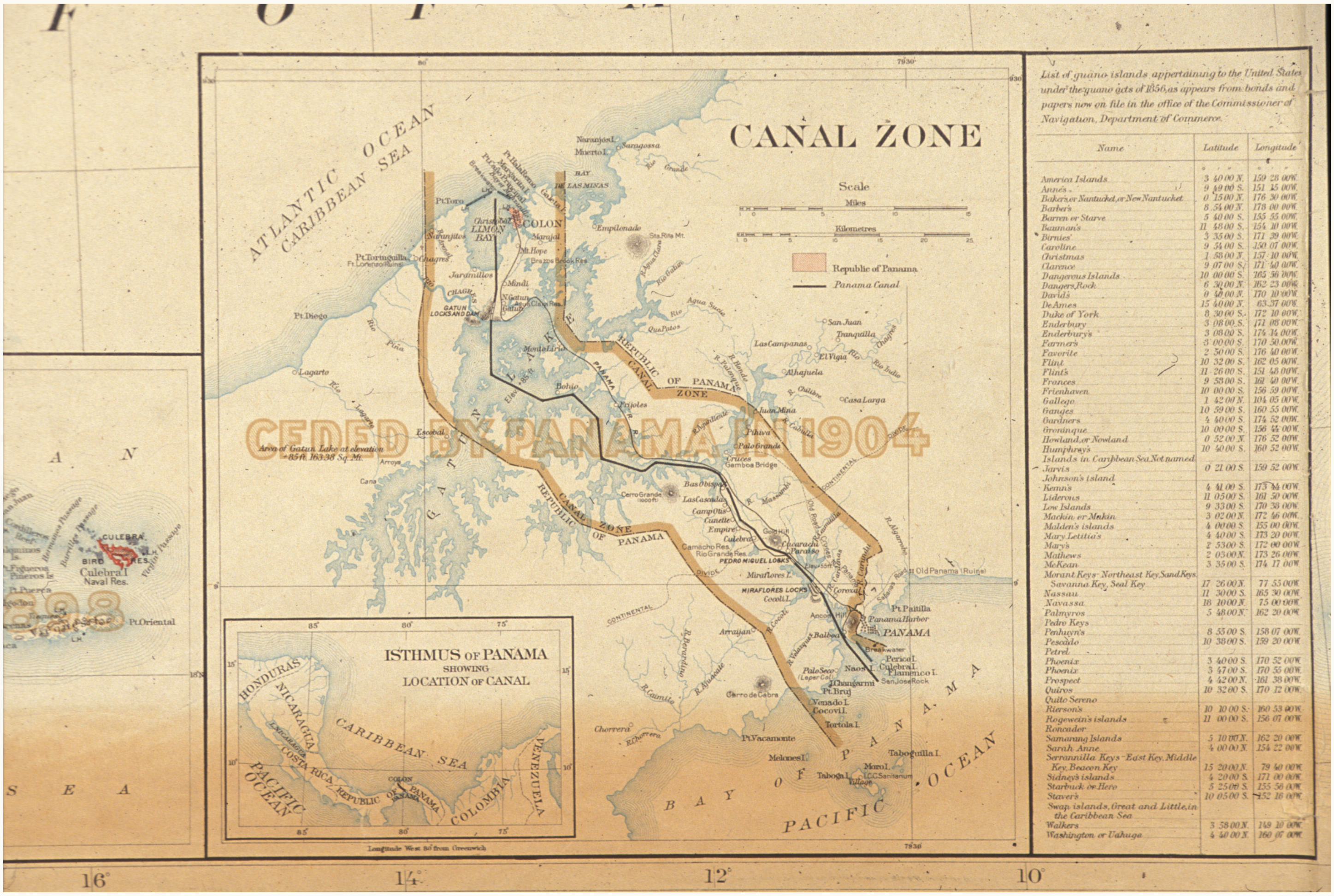

Figure 23. Canal Zone. From *United States, Including Territories and Insular Possessions, Showing the Extent of Public Surveys, Indian, Military and Forest Reservations, Railroads, Canals, National Parks and Other Details* (US GLO 1916). Courtesy of the American Geographical Society Library, University of Wisconsin–Milwaukee Libraries.

> parks and reservations, changes in the boundaries of existing reservations, county-seat locations, new lines of railroads, as well as towns and cities that have attained substantial importance during the year, are faithfully noted in addition to the general basic features of the map. The edition of the 1919 United States map was only 8,519 copies, while that of the 1918 edition was 15,000 copies, the difference being due to increased cost, owing to the advanced outlay for labor, muslin, paper, and other materials. The cost of the 1918 edition was $1.04 and that of the 1919 edition $1.90 per map.
>
> The number issued did not permit in either instance of providing the usual number to the Senate and House of Representatives and Commissioner of the General Land Office—7,200, 14,400, and 500, respectively.
>
> The demand for this map is increasing, especially for Government uses; a larger appropriation is desired to provide the required number for Congress and the Commissioner's use. (US GLO Annual Report 1919, 31)

At the time he wrote, the long-established budget for "Maps of the United States" was $20,000. It had been at that amount since 1910 and would stay at that level until 1924 when funding began to be decreased.

Examining GLO annual reports, Senate and House executive reports, and *the Digest of Appropriations for the Support of the Government of the United States* (US Department of the Treasury 1880–1940), the appropriation "For connected and separate United States and other maps prepared in this office" often stayed at the same level for as many as 12 or 14 years, regardless of changes in costs of production or difficulties in obtaining needed production materials (Figure 24).

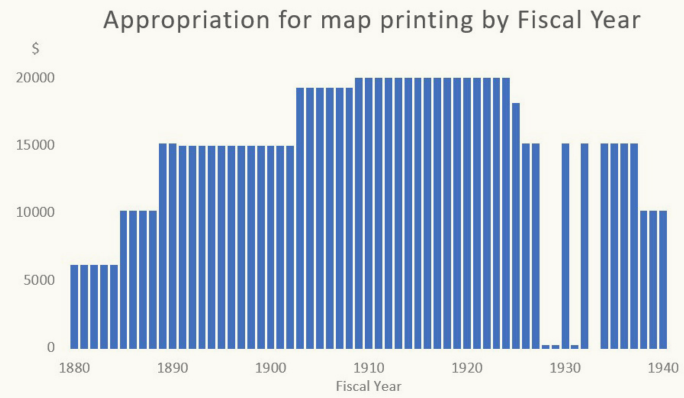

Figure 24. Chart of appropriations for "Maps of the United States" in General Land Office budgets, 1880–1943.

The number printed varied widely. Only 5,400 copies of the 1921 map could be printed for the allocated $20,000 (US GLO Annual Report 1921, 21); in 1904 that level of funding supported a contract for 63,000 copies (US GLO Annual Report 1904, 210).

CHANGING SYMBOLISM AND THE FINAL MAP

The 1930 annual report, submitted by Commissioner Charles C. Moore, describes the 1929 version of the map as "[differing] from previous publications in that the different acquisitions of territory are shown in solid colors" (Figure 25; US GLO Annual Report 1930, 9).

Figure 25. *United States, Including Territories and Insular Possessions, Showing the Extent of Public Surveys, National Parks and Monuments, Indian, Military, Bird and Game Reservations, National Forests, Railroads, Canals, and Other Details* (US GLO 1929). Courtesy of Harvard Map Collection, Harvard Library.

The colors are somewhat transparent to demonstrate the ambiguity over the boundary of the Mississippi watershed and the treaties with Spain and Mexico, as well as allow for identifying smaller areas such as Indian reservations and federal land holdings. The public surveys component has again diminished in prominence, yet it continues to appear. Additionally, there are three areas obviously blank in the layer of territorial acquisition colors: the Red River of the North (Minnesota and Dakotas), the western portion of the state of Louisiana, and a sliver in the Colorado basin east of the northern extension of the Texas claim. There is no acquisition explanation; the stories of these areas are simply untold.

In the era immediately before the beginning of the Second World War and the United States's eventual entry in the conflict, it appears that a national map of the United States was funded biennially, 1934/35, 1936/37, 1938/39, and 1940/41. 1941 was the last map published until after the war. In 1946, the GLO was merged with the Grazing Service, under the new name "Bureau of Land Management." *Surveying and Mapping's* new publications list greeted the 1953 printing (Figure 26) with "After a lapse of some 14 years (mostly war years), the Bureau of Land Management has issued a new edition of the map of the *United States including Territories and Insular Possessions*" (Ristow 1953, 368).

This would be the last time that the map was produced by the Government Land Office's successor agency. The Philippine Islands inset has been removed, as the Philippines had gained full independence from the United States in 1946. The Alaska inset has moved toward the right, creating enough space so that the Aleutian Islands are no longer truncated or boxed as an inset within an inset. A subjective, visual change has also happened. On previous editions, the boundary line of the original territory and the boundary lines of the acquired territories

Figure 26. *United States, Including Territories and Insular Possessions, Showing the Extent of Public Surveys, National Parks, National Forests, Indian Reservations, National Wildlife Refuges, and Reclamation Projects* (US Bureau of Land Management 1953). Courtesy of the Map Library, University of Illinois Urbana-Champaign.

seemed to have the same weight. On this map, the acquired territory boundaries appear lighter, of less importance. The line symbol has been changed. As on the 1929 map, the Red River of the North is shown as part of neither the original territory nor the Louisiana Purchase. Maine's story is still untold; west Florida remains simplified. Cuba hangs in ambiguity as background but aligned with the possessions.

In 1964 and 1965, the United States Geological Survey, "in cooperation with the Bureau of Land Management," published *United States of America: Showing the Extent of Public Land Surveys, Remaining Public Land, Historical Boundaries, National Forests, Indian Reservations, Wildlife Refuges, National Parks and Monuments*. The title essentially reiterates the contents of the legend and a break in authorship. Listing "extent of public surveys" and "remaining public lands" as the first and second content elements is certainly a nod to the map's antecedents, but the visual hierarchy does not reflect the title. The depiction of "historical boundaries" is done through boldly colored text and line work. State boundaries, remaining public lands, and national forests grab attention. The depiction of public land surveys has faded into the background, and the United States Geological Survey asserts its mandate in producing maps of and for the nation. Powell's agency had won the long-standing battle.

CONCLUSION

The complex history of territorial expansion has different significance at different periods in United States history. The maps of the General Land Office series manifest that transformation, choosing to hide certain details and to proclaim others. Map and territory get entangled. The footprints of the GLO tell one "official" story as it emerged. It is a story written in a positive direction only. Areas conceded to Canada are not included in the narrative; some acquired areas are never explained. The content of the maps changed as the focus of the society shifted. As many scholars have noted, this history totally fails to record the shrinking domain of the native peoples who held perfectly valid title to their traditional lands. To some extent, this was the express mandate of GLO. Surveys were only conducted once lands had passed out of Indian ownership and occupation.

In this complex story, a large and notable shift occurred—when the agency actually rejected its own map. This kind of action is unusual, and therefore worthy to revisit. Commissioner Hermann cuts an unusual figure in the operations of a rather prosaic organization. His long and detailed review of the Oregon Country, from the vantage point of an original settler, rejected the unsubstantiated story about Louisiana extending to the Pacific; Oregon Territory was treated as a distinct historical entity. A complex history was condensed into an unambiguous non-overlapping set of polygons.

The subsequent maps in the series show the shifting tides of the American empire, what were called Insular Possessions during the period. The story depicted on GLO maps stayed close to the actions as they occurred. The annual production cycle provided enough resolution to detect these shifts and the return of some ambiguity about the acquisitions. While in some sense of retrospect, the United States continues to focus its cartographic image on what are now 48 contiguous states, there was a period in which each "insular" possession was clearly proclaimed in annual maps. The empire was far from hidden in those days. Immerwahr's (2019) argument about a "hidden empire" is not apparent from this series, as it ends in 1953 with all elements fully accounted for, though at massively divergent scales in their insets.

When the series began, the process of surveying and selling the public domain was one of the principal activities of the United States federal government. This process left its mark across the country with the almost square layout now called the Public Land Survey System (PLSS). This rectilinear form, with its curious little deviations, has simply become an infrastructure, little noticed. Similarly, the story of territorial acquisitions no longer occupies the position in national discourse that it did in the nineteenth century.

Full and additional images can be viewed at: ***www.ideals.illinois.edu/items/116868***.

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AUTHORS' NOTE

In this article, we have chosen to retain the usage in the period documents that refer to "Indians," "Indian tribes," and similar wording for the native peoples who were displaced in the expansion of the United States. We did not want to import current terminologies to cover up the events of the past.

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Cognitively Congruent Color Palettes for Mapping Spatial Emotional Data. Matching Colors to Emotions.

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Emotions are touchstones of humans' everyday life experiences. Maps of emotions inform a variety of research from urban planning and disaster response to marketing studies. Emotions are most often shown on maps with colors. Previous research suggests that humans have subjective associations between colors and emotions that impact objective task performance. Thus, a mismatch between the emotion associated with a color and the emotion it represents may bias the viewer's attention, perception, and understanding of the map. There are no guidelines that can help cartographers and designers choose matching colors to display spatial emotional data. This study aimed to address this gap by suggesting cognitively congruent color palettes—color sets matched to emotions in a way that is aligned with color-emotion associations.

To obtain the set of candidate congruent colors and identify appropriate color-to-emotion assignments, two user experiments were conducted with participants in the United States. In the first, participants picked a representative color for 23 discrete emotions. In the second experiment, for each candidate color from a set derived from the results of the first experiment, participants selected the best-matching emotions. The probability of the emotion being selected served as a measure of how representative the color is of that emotion. Due to the many-to-many nature of associations between colors and emotions, suitable color choices were incorporated into a dynamic palette generation tool. This tool solves the color assignment problem and produces a suitable color palette depending on the combination of selected emotions.

KEYWORDS: cartography; emotions; color; mapping emotions; cognitive congruence; color palettes

INTRODUCTION

PROBLEM

Emotions are inherent to every human being and play a significant role in our life experiences, social interactions, and well-being. Psychological research provides evidence that emotions can impact our cognition and behavior and affect attention, memory, action, and decision-making (Coppin and Sander 2016). Thematic cartography has a long history of mapping different geographic, economic, and social phenomena, including visible and intangible features. Nevertheless, one of the defining characteristics of every human being—emotions—has only recently gained the attention of cartographic researchers (Griffin and McQuoid 2012; Caquard and Cartwright 2014; Caquard and Griffin 2018).

Advances in technology have made it possible to automate the collection of spatial emotional data by for example, extracting location information from social media posts, and inferring emotional data from their contents. The growing amount of spatial emotional data provides new opportunities to investigate human relationships and experiences with a place. Emotional maps are gaining popularity and have already been employed in various research areas such as tourism (Kim and Fesenmaier 2015; Mody, Willis, and Kerstein 2009), navigation (Gartner 2012; Huang et al. 2014), urban safety and planning (Pánek, Pászto, and Marek 2017; Pánek and Benediktsson 2017; Resch et al. 2015; Zeile et al. 2015), natural disaster studies (Caragea et al. 2014; Lu et al. 2015), and business intelligence (Hao et al. 2013). Social scientists use emotional maps to investigate the relationships between ethnic communities within a city and to study perceived levels of comfort and fear (Curtis et al. 2014; Matei, Ball-Rokeach, and Qiu 2001). Cultural geographers build maps of grief to provide insights into relational spaces and therapeutic environments (Maddrell 2016) and maps of happiness to learn how happiness levels correlate with demographic characteristics (Mitchell et al. 2013).

Color is the visual variable that is most often used for showing emotions on maps. For example, point symbols are placed over a base map, with different colors standing for a different experienced emotion or sentiment (Caragea et al. 2014; Lu et al. 2015; Mitchell et al. 2013). Colors are also used to represent emotions in non-spatial visualizations, like psychological self-report probes (Sacharin, Schlegel, and Scherer 2012) or interactive charts of emotional response taxonomies (Cowen et al. 2021). Usually, authors use categorical color palettes with randomly assigned colors or design their own color schemes based on their subjective understanding of what color is most suitable to show each emotion. For example, a typical example of a map that shows spatial emotional data (Figure 1) uses a color wheel scheme to represent eight types of emotion (Meenar, Flamm, and Keenan 2019). The use of color to show emotions, both within cartography (Griffin and McQuoid 2012; Caquard and Griffin 2018) and within data visualization generally (Lin et al. 2013; Setlur and Stone 2015), makes consideration of the colors used to display emotional data an important aspect of map design.

It is well known that colors have strong psychological effects. Psychological research suggests that humans have subjective associations between colors and abstract notions, including emotions (D'Andrade and Egan 1974; Hemphill 1996; Mohammad 2013). These associations can affect user performance even when color is not task-relevant (Goodhew and Kidd 2020; Lin et al. 2013). The results of empirical color research provide evidence that different dimensions of color (hue, saturation, and lightness) influence the emotional responses of the viewer and that affective connotations of color should be considered in

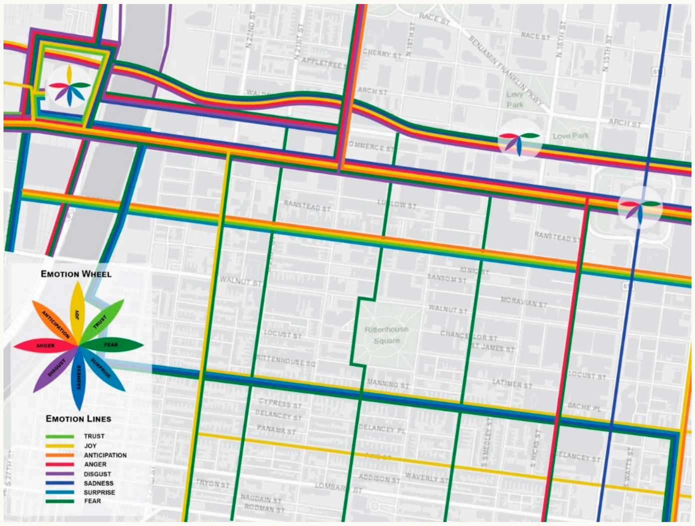

Figure 1. Map by Meenar, Flamm, and Keenan (2019) presents the city as an emotional space. Points of interest are mapped as petals of a graphical flower—each petal represented one emotion—and routes are mapped as one or more colored lines representing different emotions. Licensed under CC BY 4.0.

map design (Anderson and Robinson 2021; Suk and Irtel 2010; Bartram, Patra, and Stone 2017). It is also recognized that choosing an appropriate color palette for a particular dataset is not just a matter of choosing a visually attractive representation. When mismanaged, the use of color can lead to an impaired reaction to the visual stimuli and thus cause user confusion and hinder visual data analysis (Schloss et al. 2018; Silva, Santos, and Madeira 2011). At the same time, interpreting color meaning becomes easier when colors assigned to concepts in visualizations match people's expectations (Lin et al. 2013; Schloss et al. 2018; Setlur and Stone 2015). That research suggests that semantically-resonant color palettes provide significant performance benefits in data reading tasks.

The lack of universal, transferable map design guidelines for different mapping contexts is considered one of the main problems of modern cartography (Griffin et al. 2017). Silva, Santos, and Madeira (2011) outlined the need of knowledge and guidelines for the use of color in data visualization. This lack of map design guidelines is particularly topical to emotional cartography. For example, the latest editions of the *GIS Cartography: A Guide to Effective Map Design* (Peterson 2020) and *Thematic Cartography and Geovisualization* (Slocum et al. 2022) provide suggestions on mapping features such as elevation, climate, water bodies, geology, and hazards, but make no mention of mapping emotional data. Dent, Torguson, and Hodler (2008) touch on the connotative meanings of color and suggest possible connections between color and various notions including emotions. These authors also emphasize that further cartographic research on color meaning is needed to inform practical map design applications. Despite the large body of literature on color palette design and optimization, there are no guidelines for choosing colors for mapping emotions. Using default palettes from GIS and design software or palettes generated by cartographic color-picking tools to show emotional data on maps may lead to a conflict with subliminal associations between colors and emotions. In other words, it can cause the conceptual equivalent of the Stroop effect, hindering visual data analysis (MacLeod 1991; Stroop 1935). Conversely, showing emotions on a map using a cognitively congruent color palette where colors are matched to emotions in a way that is aligned with human associations, has the potential to improve semantic coherence and reduce the cognitive load of using the map.

PURPOSE

The purpose of the present study was to address the lack map design guidelines by identifying appropriate color choices for showing emotional data on maps. To this end, we have tried to discover a set of cognitively congruent colors for emotional data. Designing cognitively congruent color palettes requires the estimation of human color-concept associations. Thus, our first objective was to identify colors that are associated with each of the selected emotions. Schloss et al. (2018) suggest that there is no one-to-one correspondence between colors and meanings and that people interpret color-coding systems based on the simultaneous association strengths between all presented objects and colors. Given this, the second objective of the study was to assess the interpretability of the colors associated with particular emotions and solve the color-to-emotion assignment problem to maximize the interpretability of all colors in the set.

This research contributes to the literature on categorical colormap design (Lee, Sips, and Seidel 2013; Lin et al. 2013; Schloss et al. 2018; Brewer 1994), to studies of color-emotion associations (Demir 2020; Hanada 2018; Jonauskaite et al. 2020; Fugate and Franco 2019), and to the general body of emotional mapping research (Griffin and McQuoid 2012; Caquard and Griffin 2018).

STUDY OVERVIEW

There are different approaches to color palette design based on color-concept associations (Lin et al. 2013; Rathore et al. 2020; Schloss et al. 2018; Setlur and Stone 2015), but they generally involve two steps: quantifying color-concept associations, and assigning colors to concepts, using the associations from step one. We use the same approach in this research, as these steps are well aligned with research objectives 1 and 2, mentioned above.

A direct and reliable way of estimating human color-concept associations is by human judgments. Such user studies usually involve rating the strength of association between colors and concepts (Schloss et al. 2018), selecting colors that fit concepts best (D'Andrade and Egan 1974; Ou et al. 2004), or naming concepts associated with colors (Demir 2020; Hanada 2018). There is an alternative approach of automatically deriving human color-concept associations from large, user-generated datasets like tagged images (Hauthal and Burghardt 2013; Rathore et al. 2020) or textual data (Bostan and Klinger 2018; Mohammad 2016). Despite the advantages of automation and the use of publicly available data, this approach is computationally intensive and still requires manual data annotation for training the algorithm. As we were limited in computational and time resources in this study, the connection between emotions and colors was established by collecting human judgments in a user experiment. In this experiment, participants picked a color for each emotion in a list from a continuous, perceptually uniform color space.

There are several theories and multiple taxonomies of emotions, which can be generally divided into two major groups: discrete and dimensional emotion theories (Barrett 2017; Gerrig and Zimbardo 2008; Hamann 2012; Sander 2013). Discrete emotion theory suggests that there are distinct emotions that people can experience and identify. Dimensional theories conceptualize emotions as combinations of several fundamental factors or dimensions (Sander 2013). The question of whether emotions are better conceptualized in terms of discrete categories or underlying dimensions has been much debated in the psychological literature and a consensus has not been reached (Hamann 2012; Harmon-Jones, Harmon-Jones, and Summerell 2017; Barrett 1998). Research on the association of color and emotions typically employs the model of discrete emotions, which we also follow by selecting 23 discrete emotions based on established emotion classification models derived from the literature (Plutchik 2001; Scherer 2005; Scherer et al. 2013; Kim and Fesenmaier 2015; Keltner et al. 2016; Cowen and Keltner 2017; Cowen, Elfenbein, et al. 2019; Demszky et al. 2020; Cowen and Keltner 2020).

To understand how reliably each color is interpreted as representing a particular emotion, a second user experiment was conducted. During this experiment, we asked participants to solve the task backwards and match each color to the emotion(s) they thought it represented. The colors used in Experiment 2 were the congruent color candidates defined during Experiment 1. Based on the results of the two experiments, a final set of cognitively congruent colors was defined, where each color-emotion pair had a value showing how well they matched. In alignment with the previous research, color-to-emotion associations followed a many-to-many relationship. Thus, color assignment can differ depending on the number and combination of emotions in a palette. To automate the process of assigning colors for each possible set of emotions, we designed an interactive tool that generates cognitively congruent color palettes depending on the selected emotions to maximize the interpretability of all colors across the set.

METHODOLOGY

OVERVIEW

This study is based on two user experiments and used a quantitative methodological approach. Each experiment was a separate online user study that followed a within-subjects design. The experiments were conducted consecutively, with Experiment 2 built on the results of Experiment 1. Participants for each user study were recruited separately using an online crowdsourcing platform.

The use of crowdsourcing platforms for behavioral data collection is common in social science research and has been successfully implemented in color and emotion-related research (Christen, Brugger, and Fabrikant 2021; Cowen, Elfenbein, et al. 2019; Mohammad 2013). Heer and Bostock (2010) replicated existing laboratory experiments on Amazon Mechanical Turk (AMT) to demonstrate the validity of crowdsourcing for graphical perception experiments. Their crowdsourced results show higher variance but are consistent with laboratory findings. Other research outlines that crowdsourcing often lacks sufficient data quality control and should be used with caution to acquire meaningful data for behavioral research (Pe'er et al. 2022). Crowdsourcing approaches to visual perception experiments lead to a lack of control over conditions like display type, lighting, viewing angle, and distance. At the same time, crowdsourcing conditions more closely mimic real-world data visualization scenarios (Heer and Bostock 2010). Based on the comparison of different crowdsourcing platforms, it appears that Prolific outperforms other competitors, including AMT, in terms of data quality and cost per observation (Gupta, Rigotti, and Wilson 2021; Hulland and Miller 2018; Pe'er et al. 2022; Sheehan 2018). Thus, Prolific was used for both user experiments in this research.

Both studies were reviewed and approved by the Texas State University Institutional Review Board (project 8076). Data collection was implemented using the Qualtrics online survey software. Only participants located in the United States, speaking English as their first language, were recruited to participate in each study, to reduce the possible impact of cultural differences on associations between colors and emotions. All participants were 18 years of age or older. Each participant participated only in one experiment of this study. To ensure that collected data were not affected by color vision impairments, participants were required to pass an online version of the Ishihara color vision test (Marey, Semary, and Mandour 2015) and to complete the survey on a laptop or desktop computer to provide sufficient screen size. Stimuli were presented to viewers on a Munsell neutral value scale N7 background to minimize the influence of simultaneous color contrast on the perceived colors.

Sample size plays an important role in testing for statistical significance. A fairly large difference between the sample means will not be statistically significant with a small sample size, and even a small difference between sample means with a very large sample size can produce a statistically significant result (Urdan 2016). Statistical power analysis can be used to determine the sample size that is necessary to detect statistical significance at a specified confidence level α with a hypothesized effect size (Cohen 1992; Dean, Voss, and Draguljić 2017). In this research, the required sample size for each experiment was estimated by *a priori* power analysis solved for a medium effect size using the G*Power software, indicating that between 80 to 90 participants were necessary, depending on the target statistical test (Faul et al. 2007).

EXPERIMENT PROCEDURE

At the beginning of each user experiment, after providing informed consent, participants took a 12-plate version of the Ishihara color vision test. Following the Ishihara test instructions (Ishihara 1974), if participants gave a correct response in at least 10 of the 12 plates, their color vision was regarded as normal, and participants proceeded to the next step of the study. Information about sex and age of the participants was downloaded from the Prolific participant database, for later assessment of the basic demographic characteristics of the sample. Experiments included training tasks and questions with known answers for additional data quality control. After the main trial, at the last step of each user experiment, there was an optional free text question asking participants to provide general feedback about the study.

EXPERIMENT 1. IDENTIFY CANDIDATES FOR CONGRUENT COLORS

METHODS

Experiment 1 aimed to identify colors associated with each of the 23 discrete emotions selected for the research. Human judgments were collected to estimate the color-emotion associations and obtain candidate cognitively congruent colors.

The set of 23 emotions includes Ekman and Frisen's (1971; 1986) seven so-called basic emotions of anger, contempt, disgust, fear, happiness, sadness, surprise. These seven are widely used in research and were included to make the results of this study more easily comparable with others. However, their ability to describe the spectrum of human emotional experiences is limited (Cowen, Sauter, et al. 2019), and to address this we added sixteen additional emotions: amusement, annoyance, awe, boredom, confusion, contentment, disappointment, grief, elation, embarrassment, interest, joy, pride, relief, serenity, and shame. These were taken from elsewhere in the literature; specifically we looked for those emotional concepts that were mentioned frequently and that, together, provided a wide range of different emotions (Plutchik 2001; Scherer 2005; Scherer et al. 2013; Kim and Fesenmaier 2015; Keltner et al. 2016; Cowen and Keltner 2017; Cowen, Elfenbein, et al. 2019; Demszky et al. 2020; Cowen and Keltner 2020). The list of 23 emotions selected for this research is not comprehensive and presents only a limited perspective on all possible emotional experiences. Nevertheless, the list extends prior work that focused only on the basic emotions.

Participants submitted their color judgments using a color picker that enabled them to select colors from a continuous perceptually uniform CIELuv color space (Schanda 2007). This color space, developed by the International Commission on Illumination, approximates human vision and is commonly used for applications where color is produced by emitted light, such as computer displays. CIELuv uses lightness (L) and chromatic coordinates (u and v), which can be challenging for non-expert users to understand and manipulate. To address this issue and increase the usability of the color picker, we utilized HSLuv (**hsluv.org**). HSLuv utilizes a modified color space that incorporates CIELuv within the dimensions of the HSL color model, which includes hue, saturation, and lightness. In Experiment 1, we combined the JavaScript implementation of HSLuv with the "d3-color" and "d3-color-difference" JavaScript modules to seamlessly convert user-selected colors between different color spaces, derive alternative color representations, and calculate color distances.

PARTICIPANTS

A total of 95 participants were recruited for Experiment 1 through the Prolific crowdsourcing web service. The general demographic characteristics of the sample were as follows: 51 females and 44 males with a mean age of 36, ranging from 19 to 76 years old. Participants were compensated with USD 1.10, which, when pro-rated for the average duration of the task, was equivalent to a USD 7.00 per hour rate.

DISPLAYS AND PROCEDURE

In Experiment 1 participants used an interactive color picker that allowed them to choose any color from a continuous color space. To ensure that participants understood how to use the color picker and were able to select a specific color, a training task (Figure 2) was included before the main trial. In this task, participants were asked to set the color of at least three out of four white rectangles to be as close as possible to the color of the sample rectangle on their left.

The user-selected colors were automatically compared to the target color using the CIEDE2000 version of the

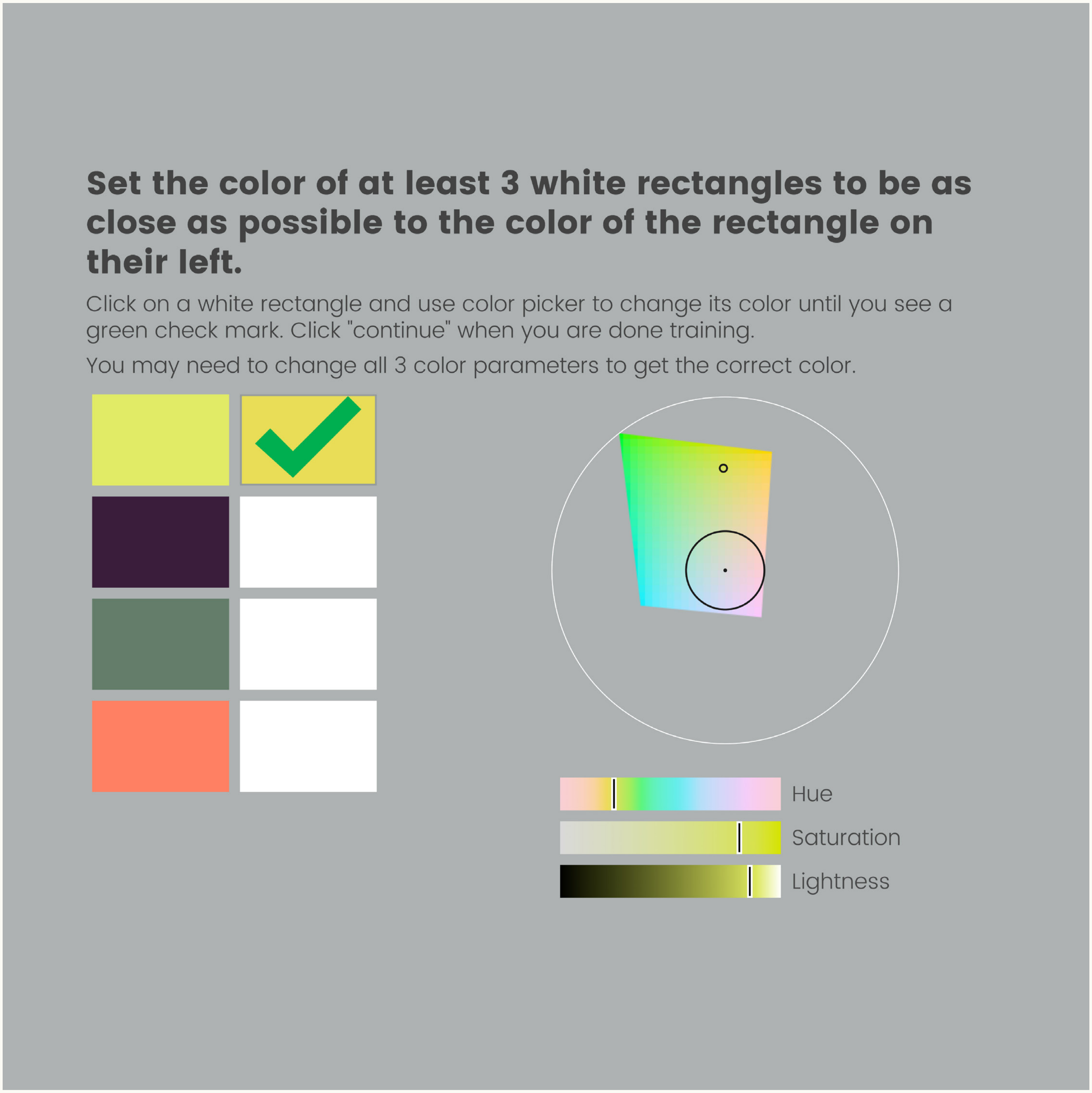

Figure 2. Training task in Experiment 1.

CIELab ΔE color distance formula. We checked several values of ΔE to select a suitable threshold value for comparing user selections with the sample colors. It appeared that a color distance of 5.5 provides a sensible level of difficulty in matching the color to the sample swatch. The color distance between the sample color and the user-selected color was calculated in real-time as the user was modifying their selected color. When it dropped below 5.5, a green checkmark indicated a successful matching of the colors. This value is consistent with the findings of Stone, Szafir, and Setlur (2014), who suggest that the minimum step in CIELab needed to make two colors visibly different is between 5 and 6. When three colors were matched, a "next" button appeared, allowing the participant to proceed to the main trial. In the main trial of Experiment 1 (Figure 3), participants selected a color for each emotion. Emotions were displayed one by one in a randomized order.

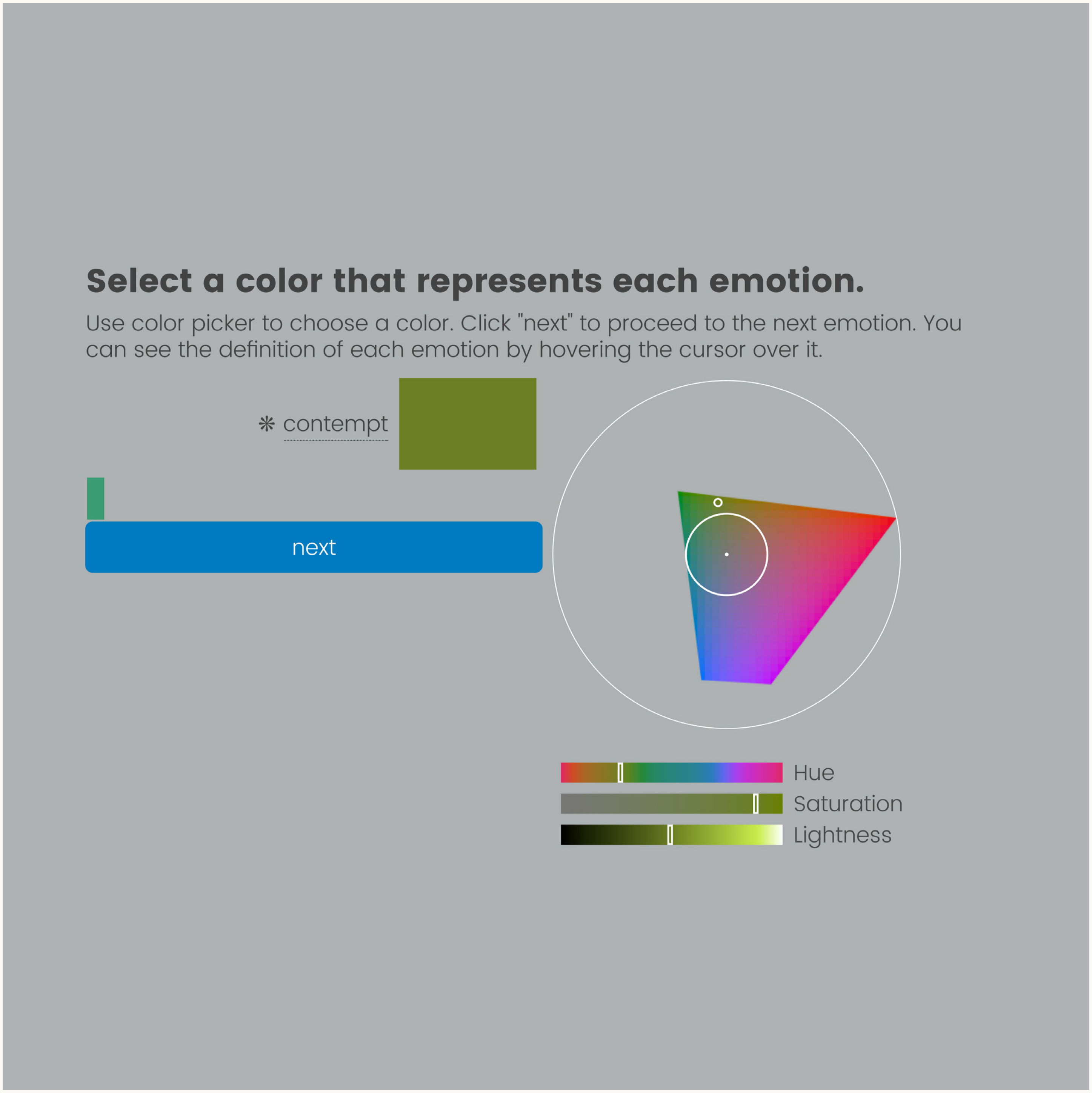

Figure 3. Experiment 1, main trial.

During the color assignment trials, participants had access to the definition of each emotion, which appeared when hovering the cursor over the word. The definitions for emotion terms were obtained from the online version of the Cambridge English Dictionary (**dictionary.cambridge.org/dictionary/english/**). The time required to select a color for each emotion, and the total time for the whole task was recorded for data quality assessment.

At the beginning of each trial, the color picker was reset to a random color to avoid bias being introduced to the color selections by the data collection instrument. The starting color of each trial was recorded along with the final user choice to check that participants did not submit the randomly preset color as their selection. A total of seven submissions with unreasonably short completion times or where these two colors were systematically similar were excluded from the study and replaced with new participants additionally recruited on Prolific.

RESULTS

Data collected in Experiment 1 were sets of colors defined in a perceptually uniform color space that were identified by participants as associated with each emotion. Color selections from all 95 participants, as well as the detailed results of the statistical tests, are provided in supplementary materials. A subset of the reported colors is presented here in Figure 4. The distribution of selected colors was consistent with the many-to-many nature of associations between colors and emotions that has been suggested in prior research. Participants selected different colors to represent the same emotion, and similar colors were associated with different emotions. Some emotions demonstrated more uniform color associations than others. Bright and saturated colors were generally assigned to positive emotions, while negative emotions were more often associated with darker colors.

Figure 4. A subset of colors reported as associated with emotions. Each column represents one participant with nine out of ninety-five participants shown here.

The analysis of the data from Experiment 1 consisted of the following steps. First, color selections were inspected visually using interactive 3D scatterplots in the CIELab color space for all responses grouped by emotion (Figure 5). Visual inspection of these interactive charts suggested that the distributions of color choices in CIELab color space were different for different emotions.

Next, a repeated measures ANOVA test was conducted for each color dimension (L, a, b) to check that colors were not selected randomly and there is a statistically significant difference between colors selected for different emotions. This was then followed by multiple pairwise paired *t*-tests to identify which emotions were significantly different in terms of their corresponding color parameters. Then cluster analysis was applied to identify the candidates for the most representative and thus, most congruent colors for each emotion. As a result, one representative color was extracted from each cluster. Last, the strength of association with the corresponding emotion was quantified for each cognitively congruent color candidate. Based on this value, a final selection of the thirty-two cognitively congruent colors was made (Table 2).

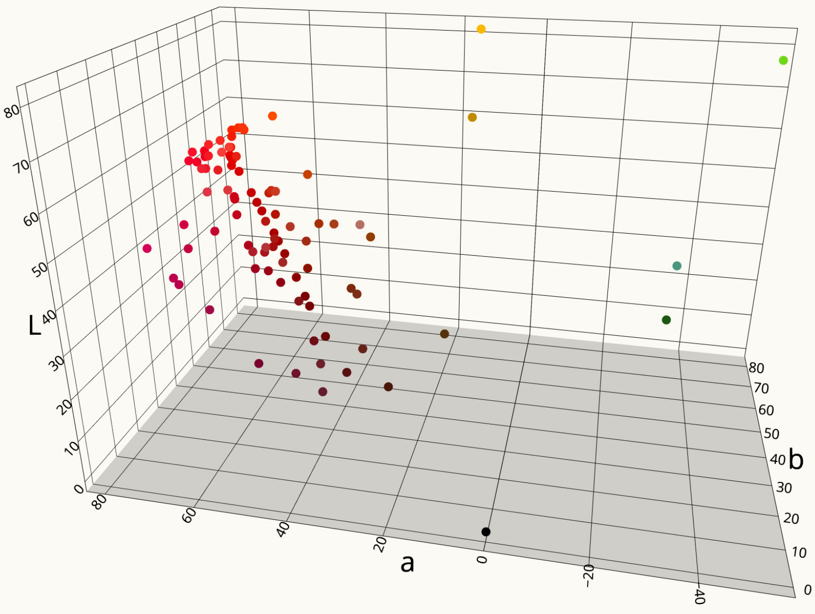

Figure 5. 3D scatter plot of colors selected for anger in the CIELab color space.

A repeated measures ANOVA was conducted to determine whether there was any effect of emotion (independent variable) on the "L" color dimension (dependent variable). The assumption of normality was checked using QQ plots that draw the correlation between the given data and the normal distribution. Outliers were identified using the box plot method and removed. The assumption of sphericity was automatically checked using Mauchly's test during the computation of the ANOVA. The Greenhouse-Geisser sphericity correction was automatically applied to factors violating the sphericity assumption. The mean values of the "L" color dimension were statistically significantly different for at least two emotions, $F(12, 411) = 33$, $p < 0.0001$, $\eta_g^2 = 0.45$. Given that the ANOVA results showed a significant difference, post hoc pairwise comparisons using paired *t*-tests were applied, with *p*-values adjusted using the Bonferroni multiple testing correction method. The results for a total of 253 t-test comparisons (provided in supplementary materials) demonstrate that the mean "L" values are significantly different for 164 pairs of emotions.

Repeated measures ANOVA for the "a" and "b" color dimensions as the dependent variables followed the same procedure as did the analysis for the "L" color dimension. The mean values of the "a" color dimension were significantly different for at least two emotions, $F(11, 387) = 8$, $p < 0.0001$, $\eta_g^2 = 0.19$. Post hoc pairwise *t*-test comparisons demonstrate that the mean "a" values are significantly different for 87 out of 253 pairs of emotions. The mean values of the "b" color dimension were statistically significantly different between at least two emotions, $F(11, 389) = 9$, $p < 0.0001$, $\eta_g^2 = 0.19$. Post hoc pairwise *t*-test comparisons demonstrate that the mean "b" values are significantly different for 91 out of 253 pairs of emotions.

Cluster analysis was applied to organize color choices for each emotion into sensible groupings. This approach follows the method of Setlur and Stone (2015), who applied *k*-means clustering to quantize input colors into visually discriminable clusters using CIELuv Euclidean distance. Since there are thousands of clustering algorithms and none of them has been shown to outperform the others (Jain 2010), we tested different algorithms with varying parameters to see which produced more meaningful results. A simple *k*-means clustering and two density-based spatial clustering algorithms, DBSCAN and OPTICS, were used (Ester et al. 1996; Ankerst et al. 1999). Density-based algorithms proved to be more suitable for this study as such algorithms perform better with irregularly shaped clusters of varying density (Duan et al. 2007; Liu et al. 2012). Both density-based clustering algorithms required manual fine-tuning of their parameters for the best performance.

The cluster analysis was implemented using "Scikit-Learn," a free machine learning library for the Python programming language (Kramer 2016; **scikit-learn.org**). An interactive 3D scatterplot was produced for each algorithm, where each point is assigned to a color-coded cluster (Figure 6). These scatterplots were then visually inspected, and the one with more meaningful clusters was selected for further analysis. The results of DBSCAN were used for 13 emotions, and the clusters for the remaining 10 emotions were obtained with OPTICS.

After finishing the cluster analysis for each emotion, one candidate congruent color was extracted from each identified cluster with a geometric median algorithm described by Vardi and Zhang (2000). The position of each extracted candidate color was inspected using another series of interactive 3D scatterplots to make sure it was located inside the corresponding cluster (Figure 7).

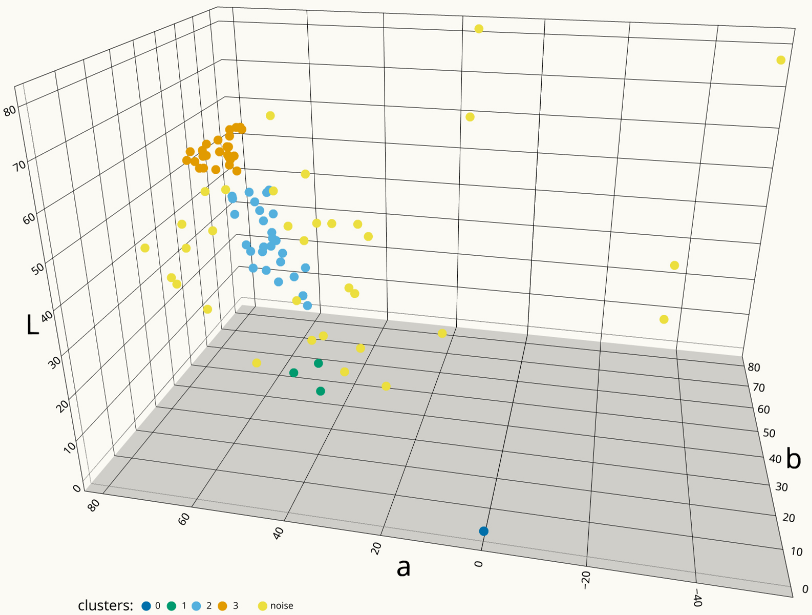

Figure 6. 3D scatter plot of classified dots for anger. The values identify the different clusters.

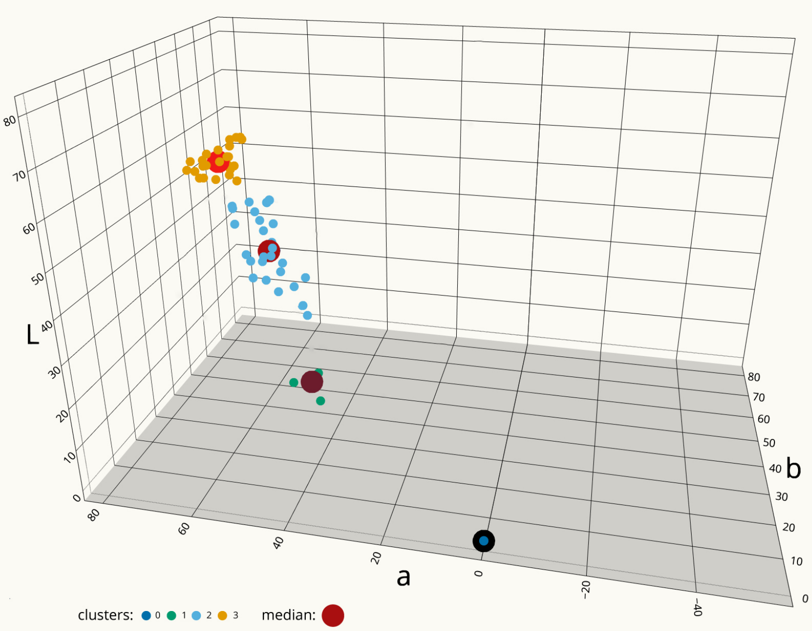

Figure 7. 3D scatterplot with classified dots and candidate colors for anger. The large dots show the actual color represented by the median point of each cluster.

Since clusters varied by the number of color points, size, and shape, it was necessary to quantify the degree of association between an extracted candidate color and the corresponding emotion. This congruency rating (r) was calculated as the ratio of the number of points in the cluster (n) to the median distance ($\tilde{d}$) from the color points to the geometric median of that cluster ($r = n \div \tilde{d}$). A candidate color coming from a cluster with more points placed closer to each other will have a higher rating than a candidate color from a cluster with fewer points or with the points being farther away from each other. For clusters where colors are very close or identical, the median distance $\tilde{d}$ will be close to zero, leading to an infinite congruency rating.

The total number of cognitively congruent color candidates was 100 (Table 1). Some colors identified as congruent for different emotions turned out to be very similar to each other. Similar colors less than 5 ΔE apart were aggregated to a single color using the geometric median to

pride	awe	joy	happiness	elation	surprise	interest	amusement
0.79	0.60	1.37	1.86	0.71	0.78	0.39	0.72
0.50	0.80	0.57	0.72	0.95	0.67		1.01
	0.30	0.60		0.70	0.81		0.70
0.49	0.48	0.56	0.48	0.42	0.48	0.55	0.43
0.71	0.57	0.55		0.51	0.60	0.66	
0.52	0.83	0.39		0.54			0.36

annoyance	contempt	embarrassment	anger	fear	disappointment	shame	disgust
1.83	0.53	1.18	3.18	0.63	1.00	0.65	1.63
0.55	0.62	0.68	2.46			0.52	0.87
0.53	1.24	0.53	0.80	0.87	0.80	0.70	
0.47	0.67	0.47			0.58	0.91	0.71
0.44	0.65					0.85	0.57
0.41			inf	1.39	1.04		1.16

serenity	relief	contentment	boredom	confusion	grief	sadness
1.19	0.84	0.78		0.94	1.23	2.18
0.73	0.83	1.18	3.33	0.71		0.94
0.88	0.80	0.61				
0.40	0.66	0.62		0.59		
0.81	0.65	0.54	1.15	0.55	3.35	

Table 1. Congruency ratings of cognitively congruent color candidates based on the cluster analysis. Emotions and colors are grouped by similarity. An infinite score for anger indicates a cluster of identical colors.

#e23dc2	#f080f1	#eda4b3	#eeb8e0	#62202b	#9b1c45	#ac1011	#dc2265	#ef2119	#eee3e8	#204c6e
#c94949	#f07723	#e5914e	#f9b308	#ebe049	#4290ac	#34b0f4	#8ce7f7	#c9f1ec	#40718f	#282a36
#91a3cf	#ada8ff	#424326	#465838	#767928	#3fad41	#6e6c68	#838586	#a0a1a5	#070808	

Table 2. The final set of cognitively congruent color candidates.

improve the discriminability of colors in the complete set and to minimize the variability in brightness and saturation among the candidate colors because this is useful for qualitative color schemes. The remaining set of colors was reduced further by selecting only colors with the highest congruency ratings while preserving as much difference in hue as possible. The resulting set of 32 congruent color candidates (Table 2) was then tested in Experiment 2 to estimate the interpretability of each color.

DISCUSSION

Our review of the color-association literature suggested that some emotions would have more consistent and distinct color selections than others; there would be stronger similarity in the colors associated with similar emotions than of those associated with dissimilar emotions; and that there would be some variability in color-emotion assignments, but the colors would not be selected entirely at random (Fugate and Franco 2019; Demir 2020; Gilbert, Fridlund, and Lucchina 2016; Schloss et al. 2018).

The results of Experiment 1 support the findings of prior studies. For some emotions, like anger, happiness, and disgust, participants demonstrated more consistent color selections, while for the others, like awe, confusion, and surprise, color choices show higher variability (Figure 4). Colors selected for positive emotions are generally brighter and more saturated than colors picked for negative emotions.

Despite the variability in color selection and similar colors being chosen to represent different emotions, the overall distribution of color choices does not appear random. This conclusion is supported by the results of ANOVA comparisons conducted for each color dimension of the CIELab color model. The results showed that at least two emotions were significantly different from each other on each color dimension between the 23 tested emotions ($p < 0.0001$). According to Cohen (1988), the reported η_g^2 of 0.19 for "a" and "b," and 0.45 for "L" indicate a large effect size. According to the follow-up t-tests of all possible 253 pairs of emotions (provided in supplementary materials), only 39 of the pairs were not significantly different at least on one color dimension. Emotion pairs that did not show a significant difference consisted mainly of similar emotions like sadness-grief and joy-surprise. However, a few pairs included dissimilar emotions. For example, the pair embarrassment-pride did not demonstrate a significant difference in any of the color dimensions. This could happen because the distribution of color choices for these emotions in CIELab space produced similar mean values of color dimensions, even though the shapes of the distributions were different (a link to all 3D scatter plots is provided in the supplementary materials). Alternatively, these might be the cases of type 2 errors happening due to multiple comparisons. In other words, the emotion pairs might in fact be significantly different, but the statistical test failed to detect this difference. Overall, the results of the statistical tests for the data collected in Experiment 1 could be considered to provide strong evidence that there is a relationship between colors and emotions, and it is possible to characterize emotions by assigning each one a unique, specific color.

Color selections obtained in Experiment 1 are well aligned with those previously reported in the literature. In particular, they are very similar to the color-emotion associations presented by Fugate and Franco (2019) and Gilbert, Fridlund, and Lucchina (2016). For example, different shades of red were a popular choice for anger, gray for boredom, and dark blue and black for sadness. Color selections from Experiment 1 also match with the general color-emotion associations summarized by Demir (2020). Our empirical data demonstrate fairly low specificity (one color being selected exclusively for a particular emotion) and consistency (only similar-looking colors being selected for an emotion), consistent with the findings of Fugate and Franco (2019).

In most previous investigations, participants were asked to indicate color-emotion associations using color swatches or color words. Because of this, the identified color-emotion associations are sometimes critiqued as having been imposed by the limited range of answer choices. Other authors have argued that the use of categorical representations of color limits our ability to identify exact color-to-emotion associations (Tham et al. 2020). For instance, many English speakers might agree that anger is associated with red, but is this association with a range of colors categorized as red or with more specific exemplars of red?

Following the methodology of Gilbert, Fridlund, and Lucchina (2016), the present study addressed the limitation of the constrained color-matching method by using an interactive color picker that allowed participants to choose any color from a perceptually uniform continuous color space. The color picker used in the current study provided controls for three color parameters, while dynamically displaying the range of available colors at the currently selected level of lightness. This provided more accurate control of the selected color than a color wheel with a single light/dark slider, the method used by Gilbert, Fridlund, and Lucchina (2016).

Even when participants were not restricted by a limited number of available choices, the obtained color-to-emotion associations aligned well with the results of previous studies. This suggests that identified color-emotion associations are not entirely task-specific or imposed by the data collection instrument. Selecting colors from a continuous color space also helped in understanding which exact color is considered more suitable for a corresponding emotion, such as which "red" is more associated with anger and which "red" is more associated with surprise. Aggregating the collected data with clustering algorithms allowed identification of colors that demonstrate more reliable associations with the corresponding emotions.

The main practical application of the outcomes of Experiment 1 for this study was to provide a basis for identifying cognitively congruent colors. The resulting color candidates still required evaluation in terms of their ability to represent corresponding emotions. At the same time our efforts and methodology in Experiment 1 could easily be extended in future research. More data can be collected for the same set of emotions to see if it is possible to refine the most congruent color choices. The same methodology can be applied to a population from a different country or using a different language to see how the color selections compare to each other, a point of particular interest given Feldman Barrett's hypothesis that language structures emotional learning and concepts and that in the discrete emotion model, emotions are described by language (Barrett 2017). Our method and test instrument can be applied to collect data on other discrete emotions, expanding our knowledge about color-to-emotion associations in a systematic and more comparable way.

EXPERIMENT 2. QUANTIFY THE INTERPRETABILITY OF CANDIDATE CONGRUENT COLORS

METHODS

The purpose of Experiment 2 was to quantify the interpretability of the colors obtained in Experiment 1 to generate the appropriate color assignments for a given set of emotions. In other words, we wanted to see which candidate colors from Experiment 1 are more reliably interpreted as representing a particular emotion. Knowing this can inform the creation of cognitively congruent color palettes for any combination of the 23 emotions. To this end, the participants of Experiment 2 were asked to solve the task of Experiment 1 backwards and pick matching emotions for a presented color. Quantification of the color's interpretability was based on the frequency of each emotion being selected as matching to a corresponding color.

A total of 32 colors came out as a result of Experiment 1 (Table 2). The task of matching emotions to these colors could be formulated in two ways: the best fit for an individual color and the best fit for a set of colors. Since color-concept associations usually demonstrate many-to-many relationships (Schloss et al. 2018; Fugate and Franco 2019), different combinations of emotions would likely result in different sets of assigned colors. Some colors would be interchangeably used for different emotions. Given this, testing a single set of emotions for the best set of colors would be only representative of that particular assignment case. Testing all possible combinations that could be made from 23 emotions was not feasible. Thus, Experiment 2 was designed to estimate the best fit for each individual color.

PARTICIPANTS

A total of 99 participants were recruited for Experiment 2 through the crowdsourcing platform Prolific. The general demographic characteristics of the sample were as follows: 50 females and 49 males with a mean age of 38, ranging from 18 to 78 years old. Participants were compensated with USD 1.10, which, when pro-rated for the average duration of the task, was equivalent to a USD 9.00 per hour rate.

DISPLAY AND PROCEDURE

During Experiment 2, the participants saw all 32 colors one by one in a randomized order and selected all emotions they thought each color represented (Figure 8). Emotions and their definitions were the same as those used in Experiment 1. Emotion choices were presented in individual containers with the emotion term and a checkbox to indicate if it was selected or not. These containers were ordered alphabetically in each trial to make it easier for participants to find the emotion they wanted to select. A definition of each emotion was available to participants by hovering the cursor over the corresponding container. An additional option, "none," was included in each trial to avoid forced replies when participants did not feel an association of the current color with any emotion. The time spent selecting emotions for each color and the total time for the whole task were recorded. A total of six submissions with unreasonably short completion times or contradicting emotions selected for the same color were excluded from the study and replaced with new participants additionally recruited on Prolific.

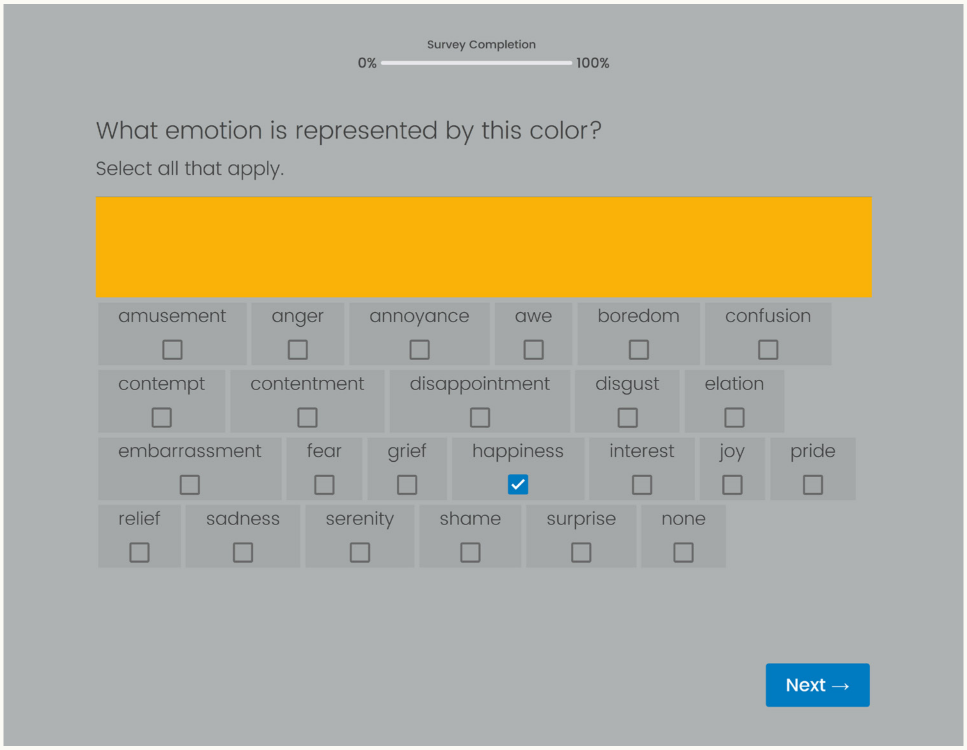

Figure 8. The color interpretability assessment instrument.

RESULTS

Data collected in Experiment 2 were arranged in the form of a two-way contingency table of counts for each color-emotion pair. A chi-square test of independence was used to check for the presence of a relationship between an emotion and a selected color (Hanada 2018; Lutabingwa and Auriacombe 2007; Olsen and St George 2004). It has been argued that the standard chi-square test is unsuitable for data collected with multiple-choice questions where participants select all answers that apply (Mahieu et al. 2021; Loughin and Scherer 1998). Since this was the case in Experiment 2, a multiple-response chi-square test version implemented in the R statistical software package "MultiResponseR" by Mahieu et al. (2021) was applied. It was followed by a multinomial logistic regression analysis to estimate how suitable each color was for representing an emotion. The calculated probabilities of each emotion being selected depending on the color served as a measure of interpretability.

The results of the chi-square test (χ^2 = 6981, p = 0.0005, and effect size Cramér's V = 0.22) indicated a relationship between at least one color-emotion pair. In addition to the chi-square test, the "MultiResponseR" package allows determining the significance of associations between each pair of the tested variables by conducting multiple-response hypergeometric tests per cell. In particular, it showed for a given color-emotion pair whether this emotion was cited for this color in a proportion that differs significantly from the overall average citation proportion for this emotion in all colors combined (Mahieu et al. 2021). The detailed results of the hypergeometric tests per cell and multinomial logistic regression are provided in the supplementary materials.

DISCUSSION

As proposed by Schloss et al. (2018), people interpret color-coding systems by solving a decoding assignment problem. They make inferences about how colors are mapped onto concepts. Given this, Experiment 2 aimed at testing the cognitively congruent color candidates from Experiment 1 in terms of their interpretability as corresponding to a particular emotion. A statistically significant relationship between the color and emotions selected as represented by that color was expected. Hypothetically, the probability of an emotion being selected as matching to a color should be different depending on the strength of association between that color-emotion pair. These probabilities were calculated and served as interpretability ratings, with higher values meaning that this color is more reliably identified as showing a particular emotion.

A chi-square test of independence was conducted to determine whether two categorical variables of color and emotion were likely to be related. The results suggest that the null hypothesis should be rejected, and the variables are not independent of one another. The estimated effect size indicates a large effect size or strong association between colors and emotions (Volker 2006; Cohen 1988). Thus, the color candidates used in Experiment 2 are likely to be suitable colors for creating cognitively congruent color palettes.

The probabilities of each emotion being selected depending on the color were estimated with a multinomial logistic regression. The resulting values were generally quite low. This could be explained by the total number of emotions, as the probability of 1 is divided between 23 possible outcomes. However, a pattern can still be identified in the distribution of probabilities. The emotions can be divided into three groups. First are emotions (such as anger, boredom, disgust) that have a few colors with high probabilities and very low probabilities for the rest of the colors. The second group includes emotions that demonstrate medium probabilities of similar values for multiple colors (such as happiness, joy, serenity). In the third group, emotions (like confusion, shame, embarrassment) have low probabilities for a few colors and almost zero probabilities for the rest of the colors. This might happen due to the nature of the color to emotion associations, meaning that some emotions are strongly connected to one or two specific colors, while the others are more "colorful" and demonstrate higher variability in associated colors. The presence of the third group may also indicate that some emotions do not have any solid or stable color associations. The observed probabilities of an emotion being selected depending on the color still follow the many-to-many kind of relationship outlined in the literature. Pairs with the highest probabilities match the top-scoring color assignments from Experiment 1 and the color choices presented by Fugate and Franco (2019) for the corresponding emotions.

LIMITATIONS

Experiment 1 had several limitations. The first one is the variability of lighting conditions and of the screens used to take the survey. This should be considered a confounding factor, introducing additional variability to the responses since different monitors can show the same colors differently, and the same color on identical screens can look different depending on the surrounding lighting. It is worth noticing that Fugate and Franco (2019) claim that participants' judgments are not influenced by perceiving the colors differently based on the device on which they take the survey. They report that the top-indicated color across the majority of emotions was the same between the laboratory control study and the results reported from an online crowdsourcing platform. Another limitation originates in the nature of online studies. Researchers must rely on the honesty of the self-reported demographic data, and although the data from our study were examined carefully, there is no reliable way to entirely exclude low-effort or completely random submissions.

There were also some methodological limitations. First, the total number of emotions studied in Experiment 1 was 23. This is only a fraction of all existing emotional concepts, and thus, the results of Experiment 1 provide a limited view of color-emotion associations. Second, the use of only the English language is another methodological limitation. In other languages there are emotional concepts that are not present in English and vice versa. Third, the candidates for the cognitively congruent colors were determined using specific clustering algorithms with manual parameter tuning. The use of different algorithms or different parameters may have produced other colors that could be more or less congruent than those that were identified.

Finally, it is important to note that both experiments were limited to United States residents, which afforded a degree of experimental control but at the same time limits the generalizability of the results. Communities with different cultural backgrounds may have noticeable differences in color preferences and associations (Cyr, Head, and Larios 2010; Jacobs et al. 1991; Or and Wang 2014). Because of this limitation, one should be careful when extending them to all populations in order to avoid an improper color-emotion assignment. In such cases, the proposed cognitively congruent colors may serve as a starting point for making informed decisions about choosing and assigning colors to display emotions.

Experiment 2 shares the limitations described earlier for Experiment 1 and has some limitations of its own. First, when selecting emotions represented by a given color, participants did not have a way to rank the suitability of each choice. Thus, each selected emotion had the same contribution to the overall probability, which might not be the case with actual color to emotion associations. Including an additional weighting procedure could help to calculate more precise probabilities for each color-emotion pair and, by doing this, achieve a more optimal final color assignment. Another limitation of Experiment 2 was the total number of colors tested. Having 32 colors tested is comparable to the number of colors used in the other studies with some authors having fewer (Fugate and Franco 2019; Jonauskaite et al. 2020), and others having more (Schloss et al. 2018; Tham et al. 2020). At the same time, including the other possible candidate colors may provide additional information about color to emotion associations and possibly reveal some other patterns that remained unnoticed in the current set of tested colors.

COLORS4EMOTIONS COLOR PALETTE GENERATOR

To turn the findings of Experiments 1 and 2 into a practically usable tool, we constructed an interactive color palette generator. Here we describe the construction of this tool, provide examples of color palettes generated by the tool, and discuss its potential use and limitations.

Quantification of color-emotion associations allows us to apply mathematical methods to solve the color assignment problem. Following the approach of Schloss et al. (2018), our tool generates suggested colors for each set of emotions by solving the color assignment problem as a linear program. Assignment problems, also known as maximum-weight matching problems, are mathematical models describing how to pair items from two categories (Kuhn 1955). For example, such models can optimally assign employees to jobs in a company, machines to tasks in a factory, and trucks to routes in a shipping network (Williams 2013). Linear programming, also called linear optimization, is a method to achieve the best outcome (such as maximizing profit or minimizing cost) in this matching process and can be used when its requirements are represented by linear relationships (Williams 2013; Schrijver 1998). The values of probabilities of each emotion being selected for a particular color were derived from the multinomial logistic regression model from Experiment 2, and when combined with the results of the hypergeometric tests per cell, formed the basis for solving the color-to-emotion assignment problem. Only color-emotion pairs with probabilities that demonstrated a statistically significant relationship were included when generating the palettes.

Because different colors demonstrate a similar degree of association with multiple emotions, it is possible to create multiple combinations of congruent color assignment. Our interactive tool offers two options: an isolated and a balanced assignment of colors suggested by Schloss et al. (2018). The isolated algorithm for color-emotion assignment is straightforward and maximizes the color-emotion associations among all color-emotion pairs for the chosen emotions. The balanced algorithm mitigates conflicts due to many-to-many relationships by simultaneously maximizing the association between all paired items while minimizing the association between unpaired items. An additional optional constraint of the minimum allowed color distance between the assigned colors in CIEDE2000 ΔE units was added to the algorithm to improve the discriminability of colors assigned to different emotions. If possible, the algorithm assigns the colors to emotions ensuring the minimum distance between the colors in the suggested palette is not less than the specified value.

The color palette generator was implemented using the "PuLP" linear programming toolkit and the Python programming language (Mitchell, O'Sullivan, and Dunning 2011). It can be used to automatically generate cognitively congruent palettes for any possible combination of the 23 emotions. This script was then turned into a web app

(Figure 9) that produces two cognitively congruent palettes for the selected emotions. It also displays an extended set of colors with top-scoring options for each emotion to give the users more flexibility in terms of available color choices because, depending on other aspects of the map design, cognitive congruence of colors and emotions may be only one of many design considerations. These colors are presented with the corresponding probability scores to help users manually adjust the suggested palette without reducing the overall suitability of the palette too much. The final color palette for emotional data is expected to be a color-coding system that is easier for map readers to use and understand. The app is available at **colors4emotions.tk**.

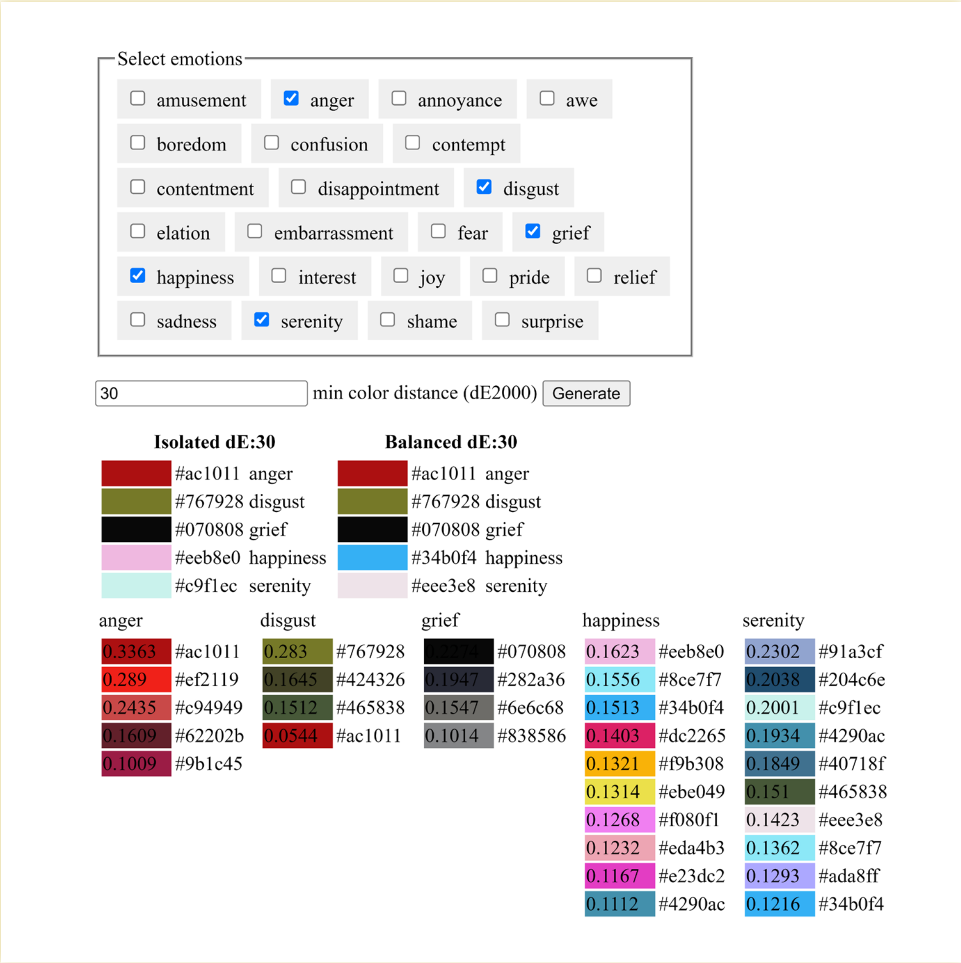

Figure 9. Example of palettes generated by the cognitively congruent color palette generation tool.

The practical applications of the cognitively congruent color palette tool that we built based on the results of Experiment 2 are diverse. It may be helpful to cartographers who need to choose colors for mapping emotions, for designers who need to color-code emotions in their visualizations, or for scientists who develop stimuli or measurement instruments that may benefit from using cognitively congruent colors. It should be noted that the tool doesn't consider lightness/saturation differences when producing a palette. Taking this into account could be way to build upon the conducted research and would help generate color sets without some colors being noticeably brighter or darker than the others.

CONCLUSION

This study builds upon and extends existing knowledge about color-emotion associations in the domains of psychology, cartography, and data visualization. It provides much-needed empirically-based guidelines for the informed use of color and for the design of more effective visual representations of spatial emotional data that facilitate comprehension and analysis of this information (Silva, Santos, and Madeira 2011). We aimed to solve a pragmatic problem of identifying the cognitively congruent colors for suitably displaying emotional data on maps. The congruent colors were defined as matching subliminal color-emotion associations. To identify these associations, we conducted a user experiment where participants chose colors that represented each emotion. Color candidates for each emotion were calculated as geometric medians of clusters in the reported colors plotted in the CIELab color space. The interpretability of each congruent color candidate was quantified with another user experiment.

Given the many-to-many nature of the relationship between colors and emotions, the congruent color for an emotion will need to differ, depending on the combination of emotions. The color assignment problem was solved mathematically, using the linear programming approach. This solution was implemented as a web-app that generates cognitively congruent color palettes for the selected emotions. It is expected that the use of congruent colors will provide advantages for user task performance, will reduce the perceived difficulty of the tasks as compared to when undertaken with non-congruent colors, and will probably influence decisions users make with the emotional data.

This research did not try to identify whether there are any universal color-emotion associations. Indeed, some psychologists have suggested it's unlikely that universal emotions even exist (Barrett 2017), much less universal color-emotion associations. Investigation of individual or cultural differences and understanding the underlying mechanisms and patterns of color-emotion associations were outside of the scope of the present research. Possible differences in color-emotion associations between male and female participants or between younger and older participants were not considered. Two primary contributions were made: (1) an empirically derived set of cognitively congruent colors for 23 emotions and (2) an interactive web-app tool that suggests cognitively congruent color palettes for emotional data, which can serve as a guideline and starting point for researchers, designers, and cartographers who need to create effective visualizations of emotions.

By estimating the associations between colors and a set of discrete emotion concepts, this study mainly contributes to our knowledge of color-emotion associations and the emotional mapping branch of thematic cartography. The presented findings can be important both for academic and commercial contexts. The literature outlines that color-concept associations should be considered when designing color-coding systems for categorical data. The application of this idea to emotional mapping is a useful contribution to existing knowledge because maps of emotions are valuable tools for studying human experience with space and place. Mapping of emotional landscapes, as advocated by human geographers and critical cartographers, makes geospatial practices more relevant to real-life decisions (Kwan 2007; Pearce 2008).

The broader impact of the outcomes of the current study is twofold. First, our tool for choosing colors for visualization of emotions may help researchers, cartographers, and designers create visualizations of emotions that put a lower cognitive load on the viewers. This could facilitate exploratory visual analysis and help emphasize and communicate the necessary information more accurately. Geographers who use emotional mapping for collecting data can use the color palette generator tool to provide the participants with color-coding systems that are easier to use. Researchers and geovisual analysts who explore big spatial datasets for extracting emotional information could benefit from data visualizations that more effectively convey information and insights from such complex data. Designers of user interfaces and human-computer interaction (HCI) specialists can use cognitively congruent palettes for emotional data in development of web-based or mobile applications. The provided palette generator tool can be used as a guideline and assist nonprofessional cartographers and people dealing with emotional data visualization in diverse disciplines such as medicine, psychology, and graphic design. It can help with color choices for making their visualizations easier to read, explore, and understand.

Second, an empirically tested cognitively congruent color set for visualizing emotions can serve as a basis for further research. As emotional mapping is a relatively new area of thematic cartography, there are no well-established design methods for showing emotions on maps. The effectiveness of different symbolization approaches could be evaluated in future work, using the provided color suggestions as a baseline for comparison. Investigation of the influence of cognitive congruence of the color palette on user performance and preference for different kinds of emotional maps (e.g., choropleth) could provide further guidance to designers and cartographers. As demonstrated by Fuest et al. (2021), differences in cartographic designs can influence user decision-making. Thus, the suggested cognitively congruent colors can be used to research the influence of symbolization on the opinions and decisions of emotional maps' viewers'. This could be of especial importance for maps made for and used by policymakers.

In closing, it is important to note that existing color conventions and principles of color mapping should not be ignored in favor of facilitating cognitive congruence; design considerations are always multifactorial. This study, however, advocates that connoted color meanings in general and color-emotion associations, in particular, should be among the essential design considerations in cartography and data visualization.

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Drawing Maine: The Pictorial Maps of the Phillips Brothers

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THE PHILLIPS COLLECTION

Two days before Thanksgiving in 1973, a father and son lost control of a small, backyard brushfire in Northeast Harbor, Maine. The fire destroyed a small art studio containing much of the inventory of two of Maine's most prolific pictorial cartographers, the brothers Luther Phillips (1891–1960) and Augustus Phillips (1898–1975). The father was the younger brother, Augustus, better known as Gus. Despite the fire, many of the brothers' works survived with family members, on the walls of stores, sporting camps, and homes throughout Maine.

In 2017, the late Mary-Jane Phillips Smith, Gus's daughter, donated the remaining Phillips maps, along with hundreds of postcards and the 35 mm slides used to print them, to the Penobscot Marine Museum, a historical museum located in the small, coastal town of Searsport, Maine. In addition to the largest photography archive in the state, the Penobscot Marine Museum includes historic Maine wooden boats, a sea captain's house, a fisheries building, art galleries, and a library. Under the direction of Kevin Johnson, the museum's photo archivist, and aided by Cathy Jewitt, Gus's granddaughter, the Penobscot Marine Museum has collected and curated the definitive Phillips Collection.

THE PHILLIPS BROTHERS

Born to a farmer's family of modest means on Mount Desert Island, neither Gus nor his brother Luther would have exclusively identified themselves as cartographers, but in retrospect, both are best known through their maps. Luther, the older brother, was a draftsman by profession and received his education from MIT in architecture. During the 1940s he developed a series of postcards and illustrated maps as a side business in Maine's summertime economy. After some success, he began to involve his younger brother Gus to color and paint a handful of these early maps.

Gus's life, in contrast, was more typical of coastal Maine's rural working class. Although the Phillips family had traditionally been mariners, Gus grew up amid the transformative years following industrialization. Mount Desert Island's influx of rusticators—the wealthy summer vacationers seeking simpler, rustic lifestyles—throughout the end of the nineteenth and beginning of the twentieth centuries provided Gus with various service and labor jobs throughout his life. In addition to cartographer, Gus would have described himself variously as a hunting guide, vegetable farmer, draftsman, handyman, ice cutter, or carpenter. But to look at his life through the volume of creative work he made, it becomes evident that he lived his life for his passions—most of which derived from physical arts and crafts.

It is impossible not to compare the brothers' work. Looking at their maps, Luther's work is crisper, with the exemplary penwork of a professional draftsman, with compositions and linework that are neater overall. Gus's earlier maps are undoubtedly rougher, but his later maps show a nuanced view of local geography and terrain representation. Taken with the added context of Gus's exploration of painting and wood carving, his pictorial maps and mural paintings reveal the crowning work of a folk artist who realized his signature style.

PENWORK AND PICTURING PLACES

LUTHER CREATED THE FIRST DRAFT of *A Map of Mount Desert Island* in the early 1930s. The island was by far the brothers' most reworked and longest published subject. This map depicts many colonial romanticisms of interest to white Americans of the time: the European exploration of the Maine coast and the stories surrounding the voyages of Samuel de Champlain. The map includes fine penwork, illustrations of historically significant ships, quotations in French, an inset reproduction of Samuel de Champlain's historical map, and a cartouche depicting indigenous Americans framing another locator map that shows the pre-Columbian/European conception of the Americas.

The ocean calls the most attention. In addition to the use of waterlines to delineate land from water, it includes a notable pictorial wave-hatching pattern to fill the marine areas. Whether conscious or unconscious, this style echoes several sixteenth-century Renaissance maps—like those found in *The Mariner's Mirror* (1586), for example. The version of *A Map of Mount Desert Island* shown in Figure 1 is relevant to the arc of the Phillips collection because it represents Luther's early penwork and includes Gus's first color washes, possibly their first collaboration. Gus re-published this map in the 1960s with completely different colorations.

Figure 1. *A Map of Mount Desert Island.* Luther Phillips, 1932. Courtesy of the Penobscot Marine Museum.

Luther's maps usually included precise illustrations of historical figures of interest. In his *1941 Map of Pemaquid*, he highlights Fort William Henry and the surrounding villages. The map blends American colonial narratives with local context: houses were carefully located with the help of resident Walker Gilbert and annotated with family names.

One of Luther's best-known maps is probably *A Decorative Map of Penobscot Bay Region*, a detailed representation of the upper part of Penobscot Bay and the surrounding towns. Here are all of Luther's strengths on display: a commitment to geographically sound and heavily patterned hydrography, numerous, well-executed lettering styles, tightly organized insets, an intricate cartouche, and many naturalistic historical diagrams. Even though variations of this map were reprinted, occasionally colored by Gus, the content was never significantly altered from the original.

In almost every case, Luther's maps follow a common pattern. He frames an extent around a region or locale

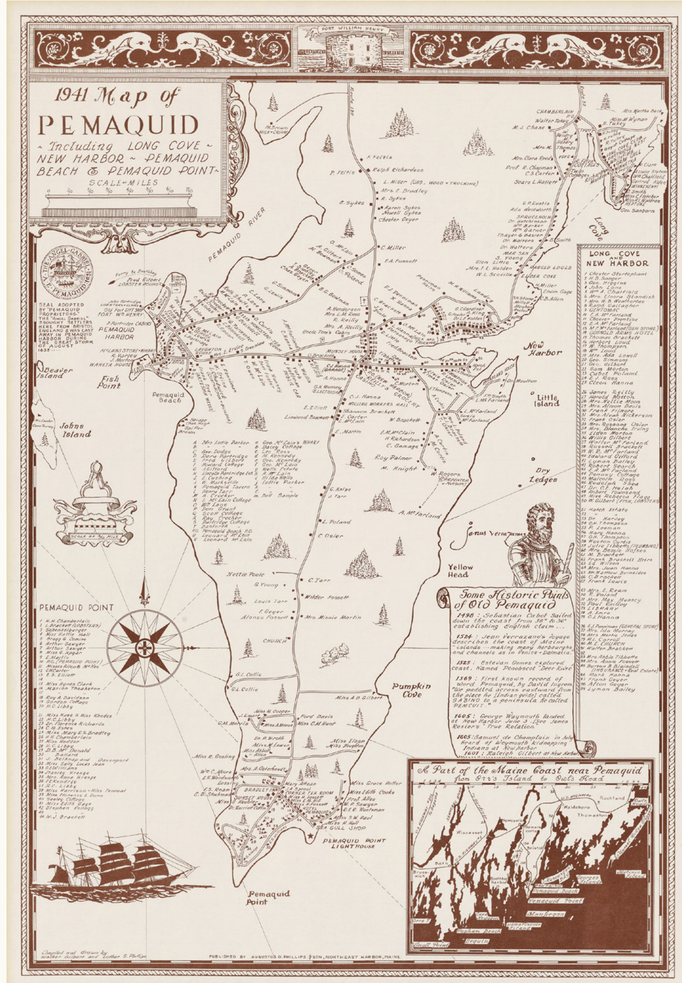


Figure 2. *1941 Map of Pemaquid.* Walker Gilbert and Luther Phillips, 1941. Courtesy of the Penobscot Marine Museum.

of interest, usually coastal, and then highlights subjects of interest. The overall drama of the composition derives from attractive penwork. The visual strategy is to incite the viewer to explore. His maps bear a similarity in subject and style to those of Ruth Rhoads Lepper Gardner (1905–2011), another prolific and renowned pictorial cartographer of the Maine coast. The themes of Lepper Gardner and Luther's maps are resonant throughout the coast: historical ships and buildings dominate the maritime landscape.

Moosehead Lake (1953) is likely Luther's last map, but it is his first map—apart from a few small-scale global and state maps—to frame an area of interest away from the coast. Almost two decades later, Gus painted a new version, *Moosehead Lake* (1971). The differences in the brothers' styles are immediately apparent when comparing the two maps. Even though Luther has abandoned the cartouche and much of the pen ornamentation of his early

Figure 3. *A Decorative Map of Penobscot Bay Region.* Luther Phillips, 1940. Courtesy of the Penobscot Marine Museum.

Figure 4. *Moosehead Lake.* Luther Phillips, 1953. Courtesy of the Penobscot Marine Museum.

Figure 5. *Moosehead Lake.* Augustus Phillips, 1971. Courtesy of the Penobscot Marine Museum.

maps, he retains many of his signature design choices: callouts on parchment banners, copperplate-like lettering, and naturalistic sketches. In contrast, Gus employs illustrative figures more as imaginative flourishes than exemplars of geographic interest. His figure painting is also less naturalistic than Luther's and more caricaturist. Gus never quite matches Luther's skill with a pen, but his use of paint gives the terrain representation a unique dynamism, allowing for the landscape itself to become the focus.

The most interesting comparison between the brothers' styles is that their work exemplifies differences in their respective eras and abilities. Luther's productive years were between 1932 and 1953, an era marked by the Great Depression and the Second World War. Patrons of Luther's maps were likely wealthier cottagers who sought cultural memorabilia as wall art, and Luther was not solely dependent on the maps for his income. Gus's primary years of production were between 1960 and 1975. During this time, vacationers typified a burgeoning middle class; in addition to the cottagers, visitors now included a much higher number of tourists, outdoor enthusiasts, and day-trippers. For the final years of Gus's life, the map and postcard business was his primary source of income. It is no surprise, then, that his maps span a wider range of geographic extents and scales, were prolifically produced and distributed, and show broader experimentation in terms of media.

FROM WALL ART TO WAYFINDING

At age 62, Gus began republishing his late brother's maps and adding new extents of his own. Several of these first extents mimic Luther's style: an iconic region or locale is identified and then illuminated with annotations and sketches. But Gus also began to create a series of maps to explore a small niche market. Before David DeLorme first published the now iconic *Maine Atlas and Gazetteer* in 1976, there were very few well-organized reference maps for planning recreation trips. Throughout the 1960s and 1970s, Gus developed 8–10 extents depicting popular outdoor areas. While these maps were not intended for use on the trail, they were in demand at many stores and sporting camps for the regional overview they provided outdoor enthusiasts.

This *Phillips' Map of Northern Maine's Moosehead-Allagash Region* (1963), is most likely Gus's first outdoor map of this kind. There are several major departures from earlier Phillips maps worth noting. First, unlike the previous maps, this includes the self-referential title *Phillips' Map*, and demonstrates a fresh style of locators and color palettes. Second, the base details and layers were traced directly from USGS topo maps on separate transparencies—these were shipped directly to the printer to be registered and shrunk to the correct publishing dimension. Lastly, the map represents local geography with the purpose of being an accurate reference for locations of boat ramps, roads, campsites, gates, and other key infrastructure for planning outdoor trips.

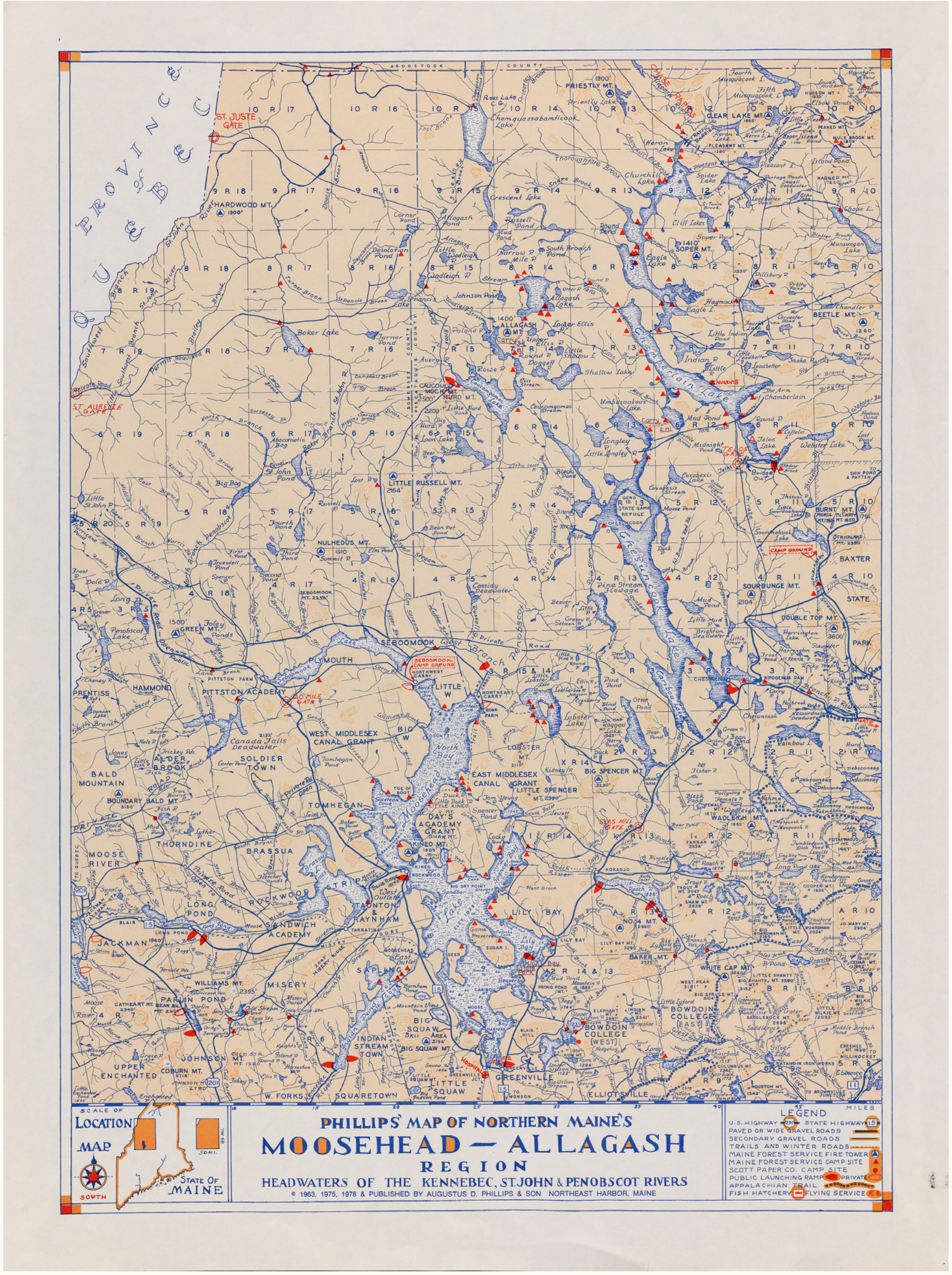
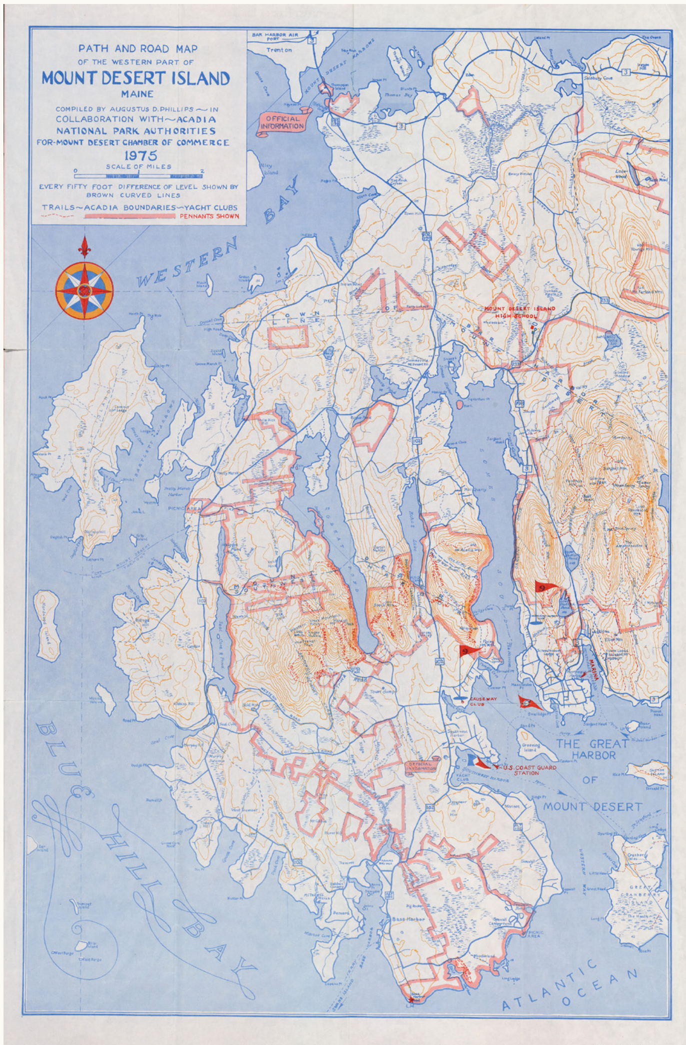


Figure 6. *Phillips' Map of Northern Maine's Moosehead-Allagash Region.* Augustus Phillips, 1963. Courtesy of the Penobscot Marine Museum.

Gus's only wayfinding trail map was developed on commission for Acadia National Park in 1973. Split into east and west extents, it was the only known Phillips map to be printed double-sided. In *Path and Road Map of the Eastern/Western Part of Mount Desert Island*, we see a few notable deviations from his other recreation maps: more care has been taken with contour accuracy; conserved lands are precisely represented, including enclaves and exclaves; the symbology is simple and unornamented; and copperplate-style lettering is restricted to the ocean. Some Phillips flair remains with a showy compass rose and a few parchment callouts, but otherwise, this map is designed to highlight trails and points of interest with little extra. Although this may be the Phillips map that required Gus to work hardest to ensure geographic accuracy, it represents primarily trace work. As an artist who loved to use color and embellishment, we truly see Gus's unique eye emerge through his painted landscape representations.



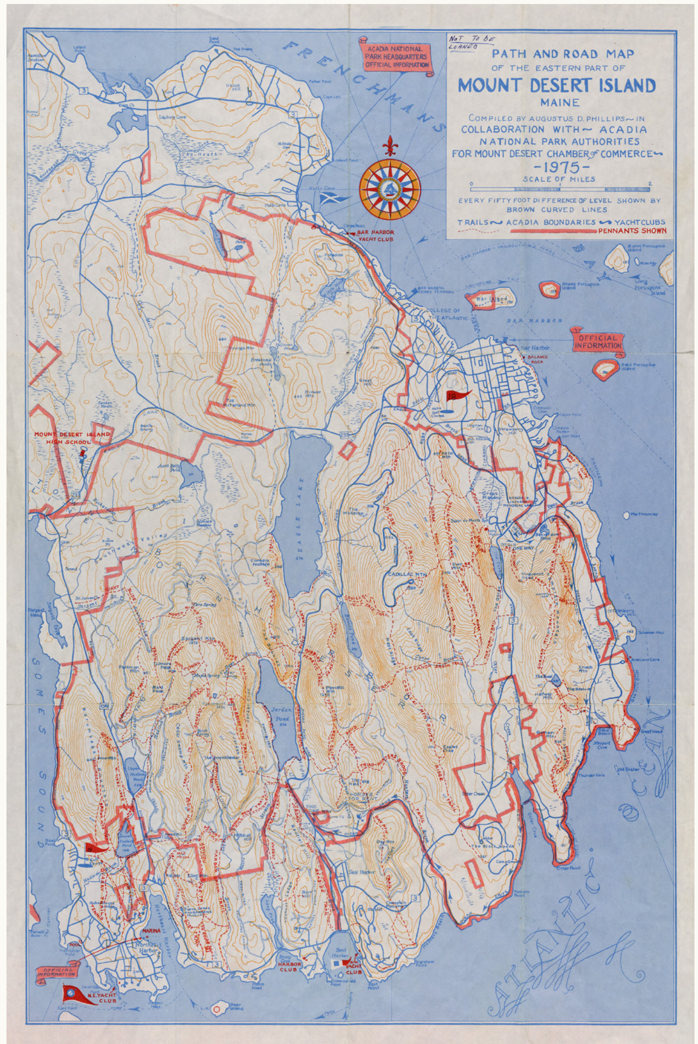


Figure 7. *Path and Road Map of the Western/Eastern Part of Mount Desert Island.* Augustus Phillips, 1973. Courtesy of the Penobscot Marine Museum.

PLEIN AIR CARTOGRAPHY

Gus spent thousands of hours looking at the landscape, and one of his great passions was painting outdoors, en plein air, as the style is called. While delivering groceries in Mount Desert Island's Asticou neighborhood, Gus met renowned plein air painter Carroll Tyson in 1912. Gus struck up a good friendship with Tyson, who took him under his wing as an informal apprentice. Tyson, heavily influenced by the impressionists that preceded him, clearly influenced Gus's work. His subsequent paintings reflected the stylistic color, mood, and depth of Tyson and the enclave of Mount Desert Island's plein air painters. Gus never made a living with his paintings, though a dozen or more survive in the hands of various family members.

Figure 8. *View to Northeast Harbor.* Augustus Phillips, c. 1930s. Courtesy of Mary-Jane Phillips Smith; photo by John Meader.

In 1965, Gus painted a large mural to honor several major contributors to Acadia National Park: George B. Dorr, Charles W. Eliot, and John D. Rockefeller, Jr. This map, *Sunrise on Acadia*, still hangs in the Northeast Harbor library, and at approximately 6 feet wide and 4 feet tall, it is truly an impressive painting to behold. Modern digital cartographers, who know the difficulty in achieving attractive terrain representation, labeling hierarchy, color balance, and visual harmony, will appreciate how Gus's map coheres. The relief, for instance, breaks tradition from the typical northwest illumination and instead suggests sunrise lighting by illuminating the landscape from the east-southeast.

In addition to painting outdoors, Gus spent hundreds of hours in an airplane, taking pictures that informed his knowledge of the landscape and later became postcards. Of the 600-plus postcards Gus developed, over 120 were aerial landscapes and about half a dozen were small map prints.

Alongside *Sunrise on Acadia*, Gus produced at least six other painted maps. He also made a novel oblique-perspective layout, *Aerial View — Casco Bay, Maine to the Longfellow — Blue Mountains*, which could have been created only through imaginative spatial interpretation from reference maps and familiarity with the coastline from his time in the air.

At the end of his life, Gus began to develop several large-format, mural maps in this same oblique perspective. Two extant works were of Mount Desert Island, looking northward to Maine's interior. One of these was very large, approximately 4½ feet tall by 10 feet wide. The other was smaller and can be found at the Northeast Harbor Library, hanging over the mantel in the reading room. The plaque reads: "*Mount Desert to Katahdin: a Bird's Eye View* (1982) by Augustus D. Phillips. Donated by Bob and Miriam Pyle. Illness prevented Mr. Phillips from completing this,

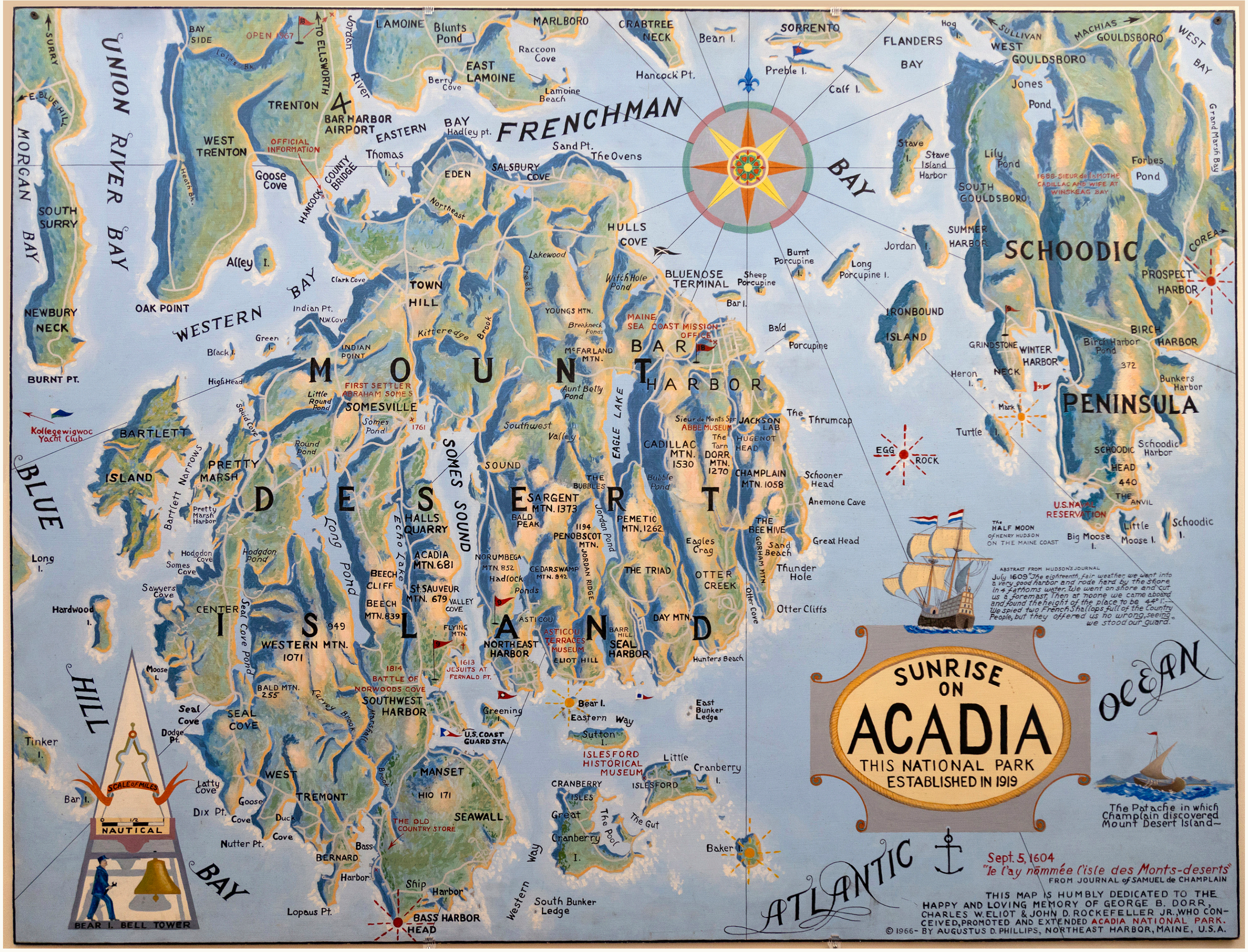


Figure 9. *Sunrise on Acadia.* Augustus Phillips, 1965. Courtesy of Northeast Harbor Library; photo by John Meader.

his final map. It was given by Donald Phillips, his son, to Bob Pyle in 1985."

Although sadly unfinished at the time of his death, it does represent the best of what Gus had to offer in terms of cartographic vision: a fully formed geographic imagination unhindered by any lack of technical resources, fully able to express his love of place through paint.

FINAL YEARS AND TODAY

Gus spent the final ten years of his life carving out a unique niche as a self-employed, pictorial cartographer in rural Maine. Instead of working for an illustration company, Gus and his brother Luther were part of a small cohort of independents who painstakingly illustrated maps by hand. Once an extent had been developed, the Phillips brothers traced, inked, painted, and lettered their maps from scratch. The maps were published and distributed by the authors themselves—often covering hundreds of miles across Maine and sold directly from the back of a station wagon.

Luther, who was responsible for approximately 10–15 maps, died in 1960. Gus independently created 20–25 maps after his brother's death. Gus inherited the entire business at age 62 and adapted and republished many of

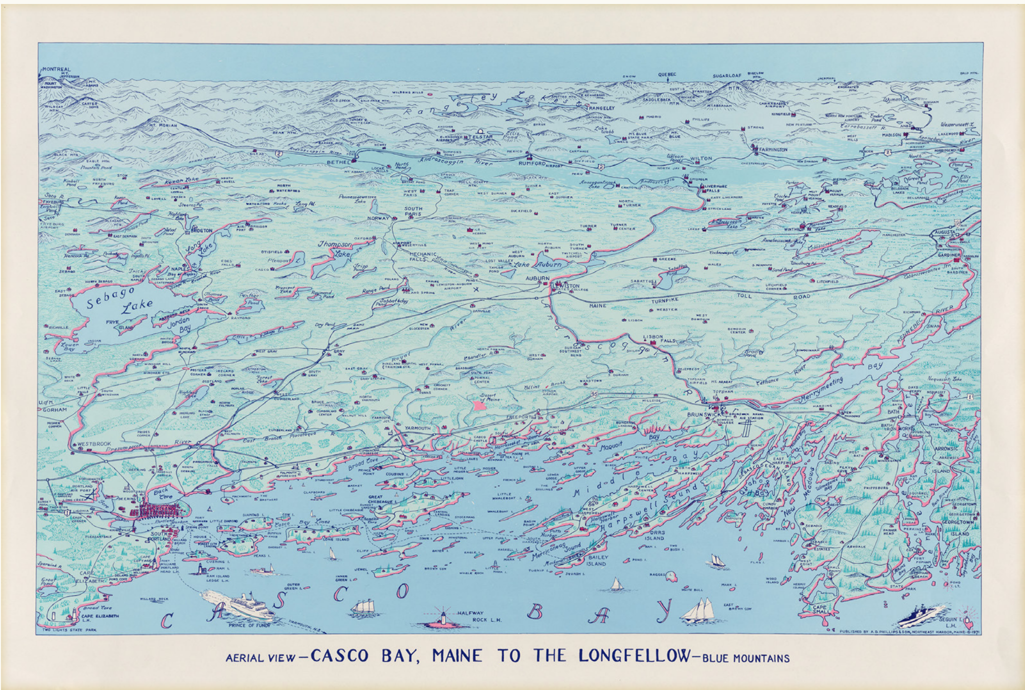


Figure 10. *Aerial View — Casco Bay, Maine to the Longfellow — Blue Mountains.* Augustus Phillips, 1971. Courtesy of Penobscot Marine Museum.

Figure 11. *Mount Desert to Katahdin: a Bird's Eye View.* Augustus Phillips, c. 1975. Courtesy of Northeast Harbor Library; photo by John Meader.

Luther's pieces throughout the 1960s and 1970s. When doing so, he updated the copyright but retained Luther's name posthumously, inscribing his own in a shared co-authorship. The total collection of currently inventoried maps—discounting a wide array of aerial postcards, a handful of map postcards, and a few reprints of historical maps not authored by the Phillips brothers—comprises approximately 35–40 unique designs.

Tucked into the small town of Searsport, the Penobscot Marine Museum hosts the largest digitally available collection of Phillips maps, along with other unique and historically significant collections: manuscripts, logbooks, journals, area maps, and over 3000 nautical charts. It offers a large online database as well as licensing and reproductions of photographs, archives, and maps, including the Phillips Collection.

The Phillips maps may be enjoyed as folk art, but the collection is also worth attention for its breadth of style and methods, conveyed by two brothers in an era when pictorial maps were popular. We know from their writings that Gus and his son were devastated when their map studio "burned flat," but their inventory was never truly lost. With the Penobscot Marine Museum's support, the Phillips maps will attract viewers and decorate walls for many years to come.

ACKNOWLEDGMENTS

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Quantity Over Quality? Teaching Cartography Through the 30 Day Map Challenge

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I used the 30 Day Map Challenge as a framework to structure my Spring 2023 Cartography and Visualization community college course. Students were tasked with a new mapping assignment following the themes of the Map Challenge to complete during each class meeting throughout the semester, as an alternative to a more traditional project-based lab structure. I sequenced lecture topics to accompany and elucidate the Map Challenge prompts, and used Socratic prompts on Google Jamboard slides to spur collaborative class discussions. As a whole, the ten-student class completed 80% of submissions for 27 required mapping prompts, submitting a total of 218 maps that fulfilled the prompts. Short, thematic mapping activities entailed greater repetition of software workflows as well as more opportunities for independent problem solving.

INTRODUCTION: CARTOGRAPHY AT A COMMUNITY COLLEGE

How can an instructor in an undergraduate cartography course best engage their students, given the heavy cognitive load of such a course? Modern cartography is a discipline rooted in both technical skills and visual design chops, and thus requires an active learning curriculum that allows students hands-on experiences to build their mapping skills (Harvey and Kotting 2011). The standard curriculum model involves a mixture of lecture on the principles of map design and project-based lab assignments in which students apply those lecture concepts to constructing their own maps (Huffman 2018). This course structure requires a high level of student engagement, including many hours of work on lab projects outside of facilitated classroom lab hours.

The standard cartography course design works for highly motivated, upper-level undergraduate students. However, I have found it a challenge to implement in an open enrollment community college environment. Community college GIS offerings are typically two-year associate degree programs. The most advanced courses must therefore be taught at a sophomore level, whereas they are often junior or senior level courses in the university setting. Further, most community college students have off-campus work and/or family obligations that reduce their capacity for working on lab assignments outside of class time (Sockin 2021). It's worth noting that a substantial minority of four-year university students also face such challenges, and classes that require large amounts of project work outside of class time may inadvertently enroll and favor more advantaged students.

After five years of teaching a community college cartography course with low enrollment and mediocre success at fulfilling the intended learning outcomes, I decided that minor tweaks to the directions of multi-week lab assignments were inadequate improvements. I needed a radically new model. Fortunately, an alternative model of cartographic skill development existed and was being practiced by thousands of cartographers each year, albeit outside of formal education channels: The 30 Day Map Challenge.

THE MAP CHALLENGE

The 30 Day Map Challenge was created by Finnish cartographer Topi Tjukanov in 2019. It consists of a set of 30 themes of one to a few words each, one for each day in November (Figure 1). Participating involves making a map that fits the day's category and posting it to social media with the hashtag *#30DayMapChallenge*. Participation is thus entirely voluntary and free for anyone with a social media account. Some cartographers strive to complete daily maps for all prompts, while others may complete only part of the list. The Map Challenge has generated thousands of publicly shared maps, exposing cartographers worldwide to a rich array of new data sources and design ideas.

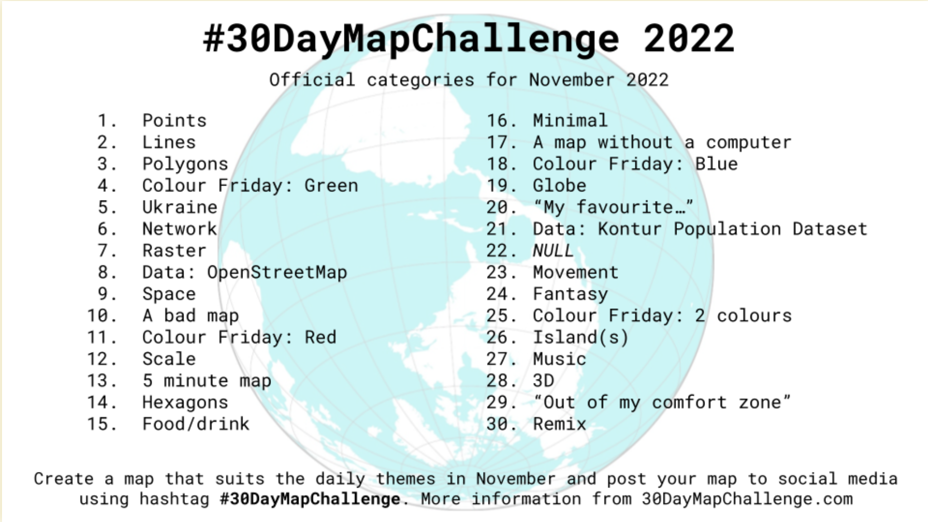

Figure 1. Daily themes of the 2022 edition of the 30 Day Map Challenge, from 30daymapchallenge.com (Topi Tjukanov).

To adapt the Map Challenge to my curriculum, I first examined how it could fit with the class schedule. I typically teach my cartography course in a block schedule, meeting for two hours and 40 minutes twice a week. In my institution's 16-week spring semester, this schedule works out to exactly 30 class meetings, including the final exam period. Thus, it was a simple matter to convert the 30 Day Map Challenge into a single mapping activity each class day, following the Challenge themes.

From a pedagogical perspective, trading a few multi-week lab assignments for daily mapping challenges invokes a concept best known as the "parable of the pottery class." The parable, as told by Bayles and Orland (1993), states that a ceramics instructor divided their class into two groups: in the first, students were graded based on the total weight of finished pots produced by the end of the term; in the second, they were graded based on the quality of a single final pot. The result was that the "quantity" group outperformed the "quality" group in the artistry of their final works. This ironic finding is attributed to the former students' lack of insecurity regarding experimentation and greater opportunity to learn from their mistakes. The parable is ostensibly based on a true story pertaining to a photography class, and is applicable regardless of the medium (Kleon 2020).

To adopt the lesson of the parable, rather than grade each individual map activity on quality, I simply counted each submission as complete or incomplete, depending on whether the student had turned in something that fulfilled the challenge prompt. I also gave narrative feedback on each map submitted. Each completed activity earned the student one activity point. At the end of the semester, I tallied all points to assign the activity grade for the course (worth 50% of the overall course grade). I initially considered 26 points equivalent to an "A," but later reduced this to 25 points, as I made one activity (Activity 22, "NULL") optional due to an illness-related class cancellation.

An obvious challenge of assigning daily mapping activities to an introductory cartography course with no prerequisites was the lack of students' prior technical knowledge of how to make a map. The 30 Day Map Challenge was intended mainly for professional cartographers. Beginners with no prior knowledge required guidance and scaffolding to complete each daily theme (Harvey and Kotting 2011).

A source of inspiration to address this challenge was *The Great British Baking Show* (or, as it's known outside of the United States, *The Great British Bake Off*). In this reality television series, participants are all amateur bakers, and are given three baking prompts, or "briefs," each episode, and a set amount of time to complete each brief. The second brief is always a Technical Challenge, in which contestants are given a pared-down recipe and a set of ingredients, and must use their prior knowledge of baking principles to complete the challenge.

Like the *Baking Show*'s Technical Challenge recipes, I addressed the need for scaffolding around each daily Map Challenge theme with a corresponding activity prompt tailored to the skills and concepts that had been previously introduced during the course. For several of these prompts, I provided students with a sample dataset (the "ingredients" for the map), as taking the time to find and process data would have made the activity impossible to complete in the time allotted. In some cases, I gave students a set of explicit instructions for procuring data from an online repository, with the intention of teaching them how to access and process such datasets in the most efficient way possible (Figure 2).

In keeping with the *Baking Show* format, I assigned time limits to the mapping activities. These ranged from five minutes (for Activity 13, "5 minute map") to two-and-a-half hours, based on my best estimate of the complexity of the activity prompt. The time limit was intended to motivate completion during the class period, while I was available for immediate assistance. I also encouraged students to assist one another in class, as some students had already completed an introductory GIS course and were thus already familiar with the GIS software interface and key concepts, while others were delving into digital mapmaking for the first time. Unlike the *Baking Show*, I allowed students who did not complete the activity within the time limit to submit it late via email with no penalty, to avoid too much stress on students.

All but two activities required the production of a map. The exceptions were Activity 1, "Points," which was a group exercise in adding points to an existing web map, and Activity 10, "A bad map," which prompted students to critique an existing map. Activities 16, 20, and 30 prompted students to change or improve a map they had made during a previous activity. All other activities asked for a unique map submission. Activities 14, "Hexagons," and 30, "Remix," were incorporated into midterm and final exams, respectively.

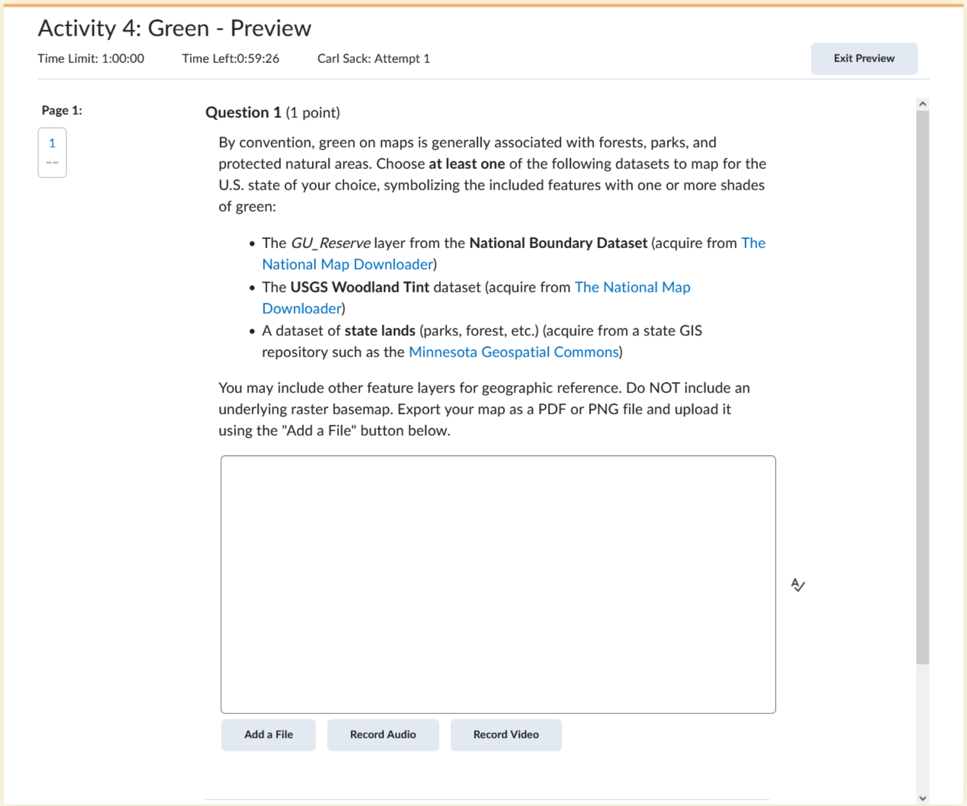

Figure 2. An example activity prompt provided through the course's learning management system.

LECTURES, DISCUSSIONS, AND DELIVERY FORMAT

As in previous, more traditionally structured iterations of the course, I imparted cartographic theory and concepts via classroom lectures. However, I reordered the lecture sequence away from prioritizing scaffolding of theoretical constructs toward delivering the content most useful for the next Map Challenge theme. I also sought to increase the amount of active learning in class by using Google Jamboard as a platform for collaborative class discussions (Harvey and Kotting 2011). Jamboard is a web app that simulates a flip chart, allowing anyone viewing it to add movable notes and sketches. Rather than having to raise their hands to contribute to the discussion verbally, students can contribute written notes anonymously, making it easier for shy or tongue-tied students to participate and limiting the space taken up by more vocal students. I created a total of 31 Jamboard pages with Socratic questions meant to draw out students' understanding of, and stimulate critical thinking about, a mapping topic. I held a discussion on a set of topic slides either right before or right after a related activity or lecture (Paul and Elder 2007; Figure 3).

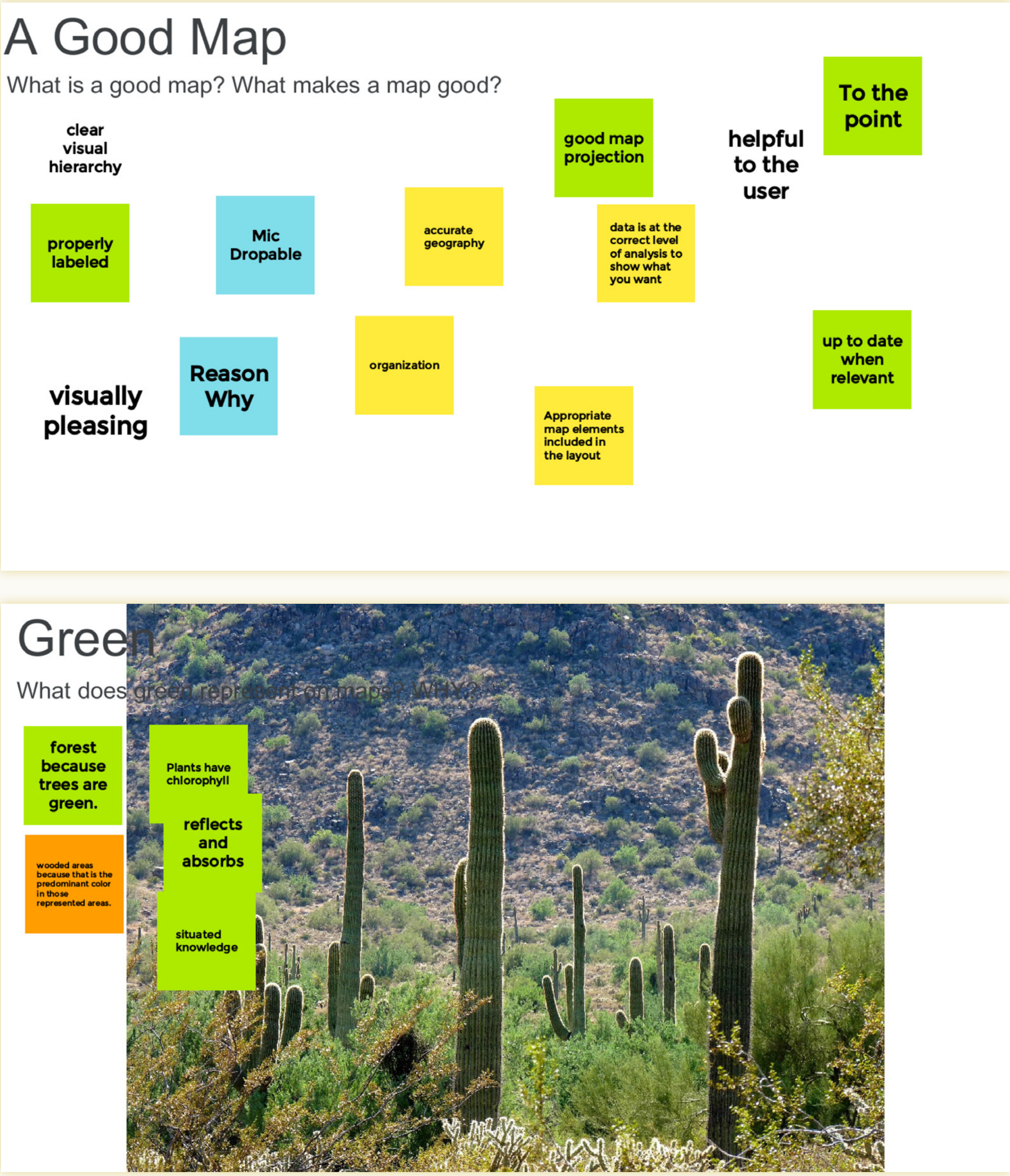

Figure 3: Examples of Jamboard slides with content generated by students during class discussions.

The course was delivered in a student choice hybrid format, whereby students could choose on a day-to-day basis whether to join the class in person or remotely via a videoconferencing connection. This allowed students who were ill, had transportation problems, or needed to care for family members to participate in classes they were unable to attend in person. The disadvantages of this delivery method were that remote students could not easily get help from their peers or unsolicited advice from me looking over their shoulder. All of the learning tools used in the course were either online tools (such as Jamboard and the course learning management system) or software that students could download to their home PCs or use on a borrowed school laptop.

PARTICIPATION AND PROGRESS

The revised course format resulted in satisfactory student participation. With ten students finishing the course, the Map Challenge activities resulted in 238 completed submissions, 218 of which were unique maps created by students, or an average of 22 maps per student. The lowest rate of completion for an individual student was 17 out of the 30 activity prompts (15 out of 28 maps). Four students completed the 25 or more activities required for an "A" activity grade. Only eight submissions, and no more than one for any activity, were considered "incomplete" because they did not fulfill the prompt. Later in the semester, as activity prompts increased in difficulty,

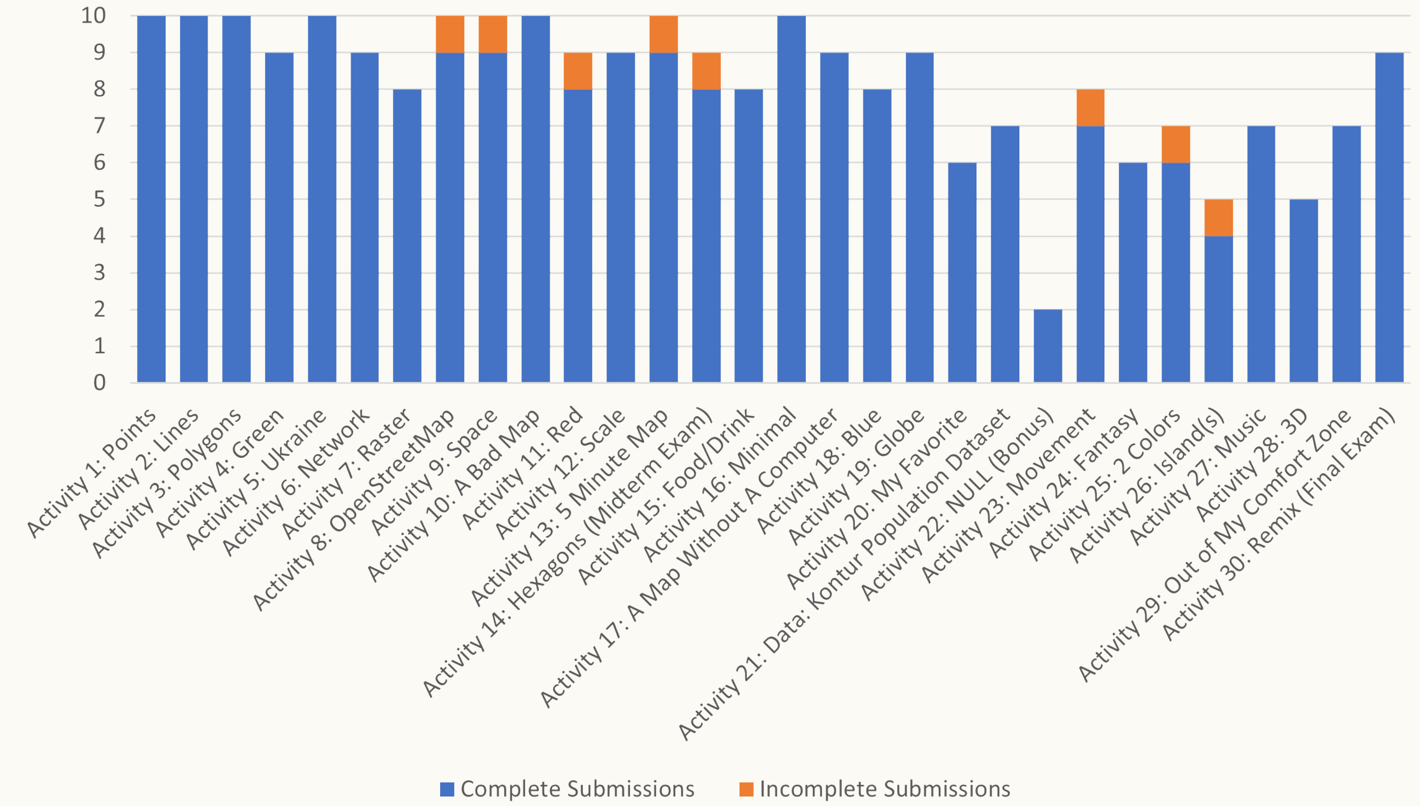

Figure 4. Completion rates for each Map Challenge activity

the activity completion rate fell. However, other than the bonus activity (Activity 22), only one activity had a completion rate below 50%, and two-thirds of the activities had a completion rate of 80% or better (Figure 4).

The maps that students submitted were not, of course, professional quality. Nonetheless, they showed the results of repetitive practice with mapping software tools and numerous opportunities for experimentation. The refined maps created for the final exam prompt (Activity 30, "Remix") were simpler than final project maps in previous iterations of the course, but comparable or better in overall design quality. They showed marked improvement from early submissions among both beginners and students with some prior GIS experience. Figure 5 compares examples of first and final digital maps from students with and without prior map-making experience.

Two bonus questions on the final exam surveyed students as to what skills and concepts were the most difficult for them to learn during the course, and what learning they expected to use in future work. The most common difficulty was figuring out Adobe Illustrator, with four out of the seven students who submitted responses mentioning it. Other difficult topics included data normalization, raster symbolization, file organization, and web map creation, each mentioned by one student. Two students each cited learning ArcGIS Pro and learning Adobe Illustrator, respectively, as the most useful course outcomes. Others felt they benefitted from learning map layout principles, symbolization, and thematic data visualization, and gaining confidence in their own ability to learn computer skills.

LESSONS LEARNED

Overall, integrating the 30 Day Map Challenge into my cartography course was a modest success. The use of smaller daily activity prompts increased repetition of map creation tasks in GIS software, such that by the

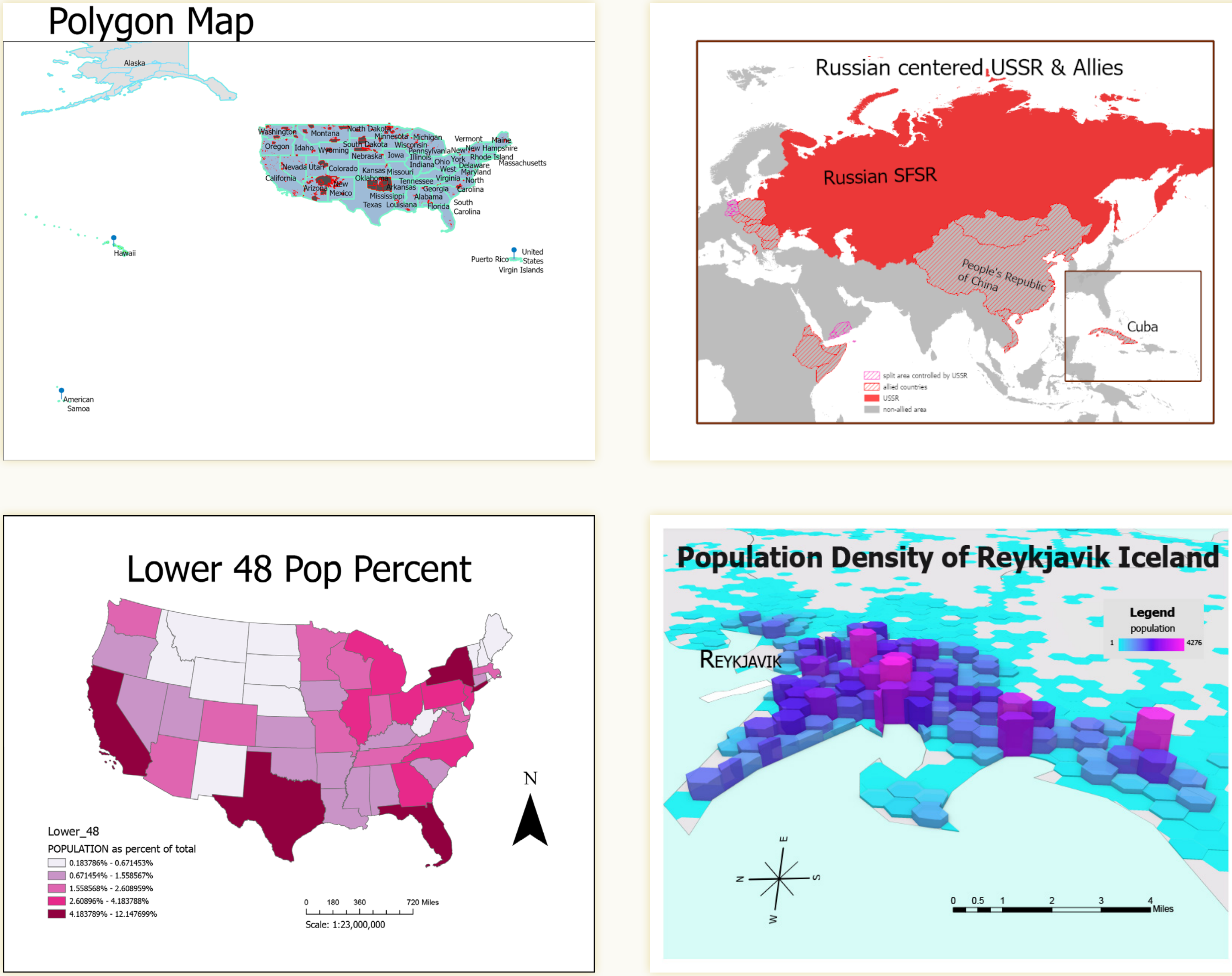

Figure 5. Comparing submissions from Activity 3 (left) and Activity 30 (right), from a student with no prior GIS experience (top) and a student who had taken an introductory GIS course (bottom).

end of the course, students were adept at the basic steps of adding data, changing the map projection, symbolizing features, and creating layouts. The structure of activity prompts—a single customizable end goal with few step-by-step instructions—allowed for independent problem-solving, creativity, and self-discovery.

Perhaps the most positive outcome was that students did not fall behind on lab assignments, necessitating due date delays and reducing the amount of time for new learning content. Since all activities were timed for completion in a single class period, late work was almost a non-issue. This led to more available class time for lecture and discussion, as no class time needed to be dedicated to allowing students to play catch-up on big mapping projects. As a result, I was able to introduce new topics that I had not been able to cover in previous iterations of the course, and I did not have to cut any content for time at the end of the semester. Since there was little activity-based homework, students could dedicate more out-of-class time to lecture review and studying for exams.

Nonetheless, exam scores did not significantly improve from prior iterations of the course, so it was unclear whether students better internalized cartographic design concepts covered in the lectures. Although the majority of students completed enough activities to earn an activity grade of A or B, three students received a D, indicating that they had not been able to complete several of the prompts despite the class time dedicated to them. The drop in activity submissions during the final third of the course was concerning and may indicate a need to simplify or clarify some of those activity prompts.

Under the student choice hybrid delivery format, the number of students physically in the classroom varied each class period, averaging about 50% of the class on any given day. Despite conscientiously checking in with remote students, I was not able to easily monitor their progress and provide unsolicited advice the way I could with students in the classroom. It was often the remote students who were unable to finish their maps during the class period.

QUANTITY → QUALITY

Whether using the 30 Day Map Challenge improved learning outcomes in my community college cartography course is uncertain. In future iterations, more scaffolding may need to be provided for later prompts. An additional challenge may be the time involved in rewriting activity prompts and reordering lecture content to fit the new themes of the next 30 Day Map Challenge, which changes every year. However, the format encouraged on-time activity submissions, and thus opened up more class time for additional learning content and fruitful class discussions. The Map Challenge provided an engaging way for students to learn mapmaking through experimentation and problem-solving. The notable improvements between students' early map submissions and their later ones showed that in cartography, quantity can lead to quality.

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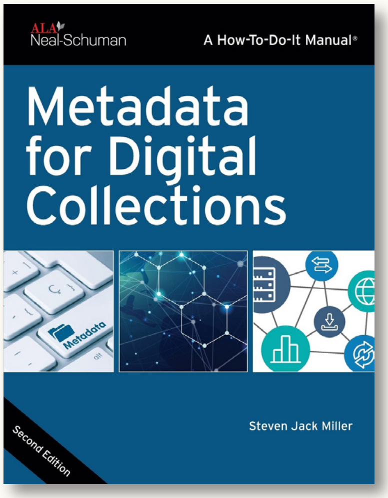

METADATA FOR DIGITAL COLLECTIONS: A HOW-TO-DO-IT MANUAL, SECOND EDITION

By Steven Jack Miller

ALA Neal-Schuman, 2022

505 pages, 212 figures and tables

Softcover: $69.99, ISBN 978-0-8389-4748-7

Review by: Kate Thornhill (she/her), University of Oregon

This how-to textbook published by the American Library Association's Neal-Schuman imprint is the much anticipated second edition of a volume originally released in 2011. This review will focus on the new edition's scope and arrangement, and how it represents today's metadata best practices. Although this manual is primarily geared toward developers and managers of cultural heritage digital collections, its approaches to data design and interoperability are also relevant to those whose work intersects this field. That could be cartographers seeking foundational knowledge of, or advice about, object-oriented cultural projects and other digital collections stewarded by galleries, libraries, archives, and museums (GLAMs). It also includes anyone with little formal data science training, including beginner data creators and those who digitize print maps, who wants to learn how to describe and structure data so that it's accessible to others, and are looking to learn some significant good data hygiene practices, too.

The book's author, Steven Jack Miller, is an emeritus faculty member at the University of Wisconsin–Madison. He is an expert in information knowledge and organization, resource description and access, and linked data ontologies. He was a metadata and cataloging librarian from 1991 to 2006, when he led library materials acquisitions and cataloging, and he has also taught graduate courses in library and information sciences. Miller's professional and pedagogical experiences have made him an authority on a wide range of metadata-related topics. His extensive teaching experience has also heavily influenced his approach to metadata—treating it as *data* instead of *annotation*—and it is this approach that makes his text so valuable, accessible, and applicable.

The over five hundred pages of *Metadata for Digital Collections* are divided into twelve chapters that can be followed step-by-step or cherry-picked by readers, depending on the need or predilection of the user and the particulars of the collection and data retrieval system in use. Each chapter starts with a brief introduction, followed by in-depth explanations, real-world examples, and a summary with references. The book is designed to provide a structured learning experience, building on foundational metadata practices established in the 1990s and 2000s. As the author, Steven Jack Miller, explains in the preface, every chapter has been reworked to some extent, but perhaps most noticeable are the structural changes apparent when comparing this second edition's table of contents to the earlier book's. Chapters have been reordered, and both new and updated material added to reflect recent developments in the cultural heritage field, such as the Linked Data movement.

Chapter 1, "Introduction to Metadata for Digital Collections," showcases the ups and downs typically faced by metadata designers and covers the rationale for constructing cultural heritage digital collections in ways that allow users to browse, search, navigate, identify, and interpret. It also gives a very brief overview of how digital collections are planned, developed, digitized, and hosted. The purpose and functional distinctions between the various types of metadata are illustrated, as are the different metadata topologies, such as structural, content, and data value. Data encoding and exchange standards are touched upon as well. Again, it is important to note that Miller's metadata-is-data approach to framing these concepts supports the designers of data-driven projects who are intent on using digital collection platforms like ContentDM (**oclc.org/contentdm**), Samvera (**samvera.org**), CollectionBuilder (**collectionbuilder.github.io**), Islandora (**islandora.ca**), and Omeka (**omeka.org**).

Chapter 2, "Introduction to Resource Description," is about how to approach metadata creation, cataloging, indexing, and resource description, and it lays out foundational concepts and practices that GLAM digital collection metadata managers utilize to communicate and implement interoperable data. It demystifies terms like *description*, *digital objects*, *resources*, and others typically used by cultural heritage data workers, and sorts out what is involved in choosing between, say, collection-level and item-level; metadata and the data makeup for simple, compound, or complex digital objects; element repeatability and element functionality; or what constitutes a property-value pair. It also expands on strategies for dealing with content and carrier descriptions for digitized cultural objects.

Chapter 3 focuses on one of the most important, shared, and internationally used metadata standards, Dublin Core. It provides a general yet comprehensive overview of the standard, a description of how to apply the Dublin Core schema when designing a project, and instructions for how readers can align project-specific metadata elements or non-Dublin Core elements to the scope covered by either Simple or Qualified Dublin Core.

Chapter 4, "Resource Description: Identification and Responsibility," and Chapter 5, "Resource Description: Content and Relationship Elements," continue and extend discussions opened in the previous chapters. Both investigate and explain what information is commonly needed to give access to, and to describe, digital cultural objects, and how to make that information interoperable and retrievable from digital collection-oriented software systems. These two chapters also dive deep into the nuances of working with intellectual and artistic content descriptions such as resource type, genre, and subject. Two commonly used controlled vocabularies, MODS (**loc.gov/standards/mods**) and VRA Core (**core.vraweb.org**), are introduced here, although each schema is covered in detail in Chapter 8, "MODS: The Metadata Object Description Schema," and Chapter 9, "VRA Core: The Visual Resource Association Core Categories."

Chapter 6, "Controlled Vocabularies for Improved Resource Discovery" describes how resource interpretation through categorical groups is affected in a metadata system. Such a system, like a database, needs a way to allow users to search and browse objects, and it is through controlled lists of terms and controlled vocabulary topologies that this is provided. The chapter describes different controlled vocabulary topologies and established controlled vocabularies typically used by GLAMs, as well as where to find human-readable linked open data vocabularies published by the Library of Congress.

Chapter 7, "XML-Encoded Metadata," Chapter 8, "MODS: The Metadata Object Description Schema," and Chapter 9, "VRA Core: The Visual Resource Association Core Categories," are devoted to other technical topics and how-tos about encoding metadata. They offer introductions to XML and to using the MODS, Dublin Core, and VRA Core technical standards to markup resource descriptions. Similarly, Chapter 10, "Metadata Interoperability, Shareability, and Quality," also emphasizes how the terms in the chapter's title are essential for data exchanges and sharing, and how they facilitate the efforts of data providers and services to bring digital objects together for better discovery, use, reuse, and preservation opportunities. This chapter also highlights the concept of data quality and introduces the commonly used data cleanup and remediation software, Open Refine (**openrefine.org**).

Chapter 11, "Linked Data and Ontologies," demystifies and explains linked data and ontologies—not just with textual explanation, but also lots of data modeling illustrations as well. Miller systematically breaks down the many aspects of how linked data and ontologies are configured and structured, while emphasizing how this scaffolding backstops the digital collections that exist in the foreground. In a lovely foundational and technical way, this chapter brings home the importance of what was covered in all the previous chapters about metadata schema, resource descriptions, controlled vocabularies, and XML markup.

The twelfth and final chapter "Metadata Application Profile Design," provides a step-by-step process for assessing and documenting (in useful and usable guides) all aspects of user and digital collection system communication. Miller presents multiple examples of these types of guides from the University of Washington and the University of Wisconsin–Milwaukee. The system employed by the American Geographic Society Library and Digital Collection, which contains a browsable world mapping feature, is prominently highlighted.

What stands out most about this book is Miller's ability to explain highly technical data concepts in straightforward and illustrative ways, and it is evident that he has a great deal of experience in systematically explaining their application. The technical nature of the text will leave readers with a solid, practical knowledge base for working with cultural heritage digital collections, and a real appreciation for Miller's understanding that working with metadata for digital collections is not just a science but an art. Even though the book does not target digital mapmakers, cartographers seeking to use historical and contemporary cultural materials while building or adding to databases, or while creating interactive data-oriented maps, will appreciate this how-to publication's step-by-step and reference nature.

Although this book focus on digital collections and standards deployed by library and information scientists, it prepares all researchers in the foundations of data curation and provides a conversance with how metadata is made usable and shareable. The understanding it provides about crucial concepts, like resource description and encoding data with interoperable standards, positions researchers to make reproducible and shareable projects. Those working in interdisciplinary teams striving to tell geospatial stories with cultural materials, or with research objects captured in the field, will find the educational tone, approach, and structure taken in this book convivial for learning. The author's ability to shine light on the meaning and use of technical terms and methods gives project teams a common vocabulary and method for planning how data is to be collected, described, structured for interoperability and sharing, and reviewed for quality, all of which can ensure that their data is responsibly documented and cataloged.

Although the second edition of *Metadata for Digital Collections* is a solid technical manual, there remain some areas where its coverage could have been elaborated. Its illustrations and examples are drawn almost entirely from academic libraries supporting digital collections, something that makes the book feel less open to, or appropriate for, other types of GLAM workers or people from other disciplines. The book could also be improved by highlighting current trends and criticisms about resource descriptions that are coming from certain GLAM communities like libraries and archives. These trends and criticisms are relevant to any data practitioner concerned with, or curious about, the way cultural, institutional, and societal oppressions impact metadata creation and reuse. For example, there is little to no discussion about the invisibility of metadata creators' labor—although it is briefly mentioned in Chapters 1 and 2 when Miller writes about creating a digital collection and the need for research when describing objects. It is surprising to not see even a passing reference to the Digital Library Federation's Digitization Cost Calculator (**dashboard.diglib.org**), which lets anyone estimate how much time and money a project to catalog digital objects would require. Nor does Miller reference recent thought pieces or scholarship such as Stacie Williams's 2016 "Implications of Archival Labor" (**medium.com/on-archivy/implications-of-archival-labor-b606d8d02014**), which sparked critical conversations in the digital libraries community about who supports resource discovery and does archival labor.

Beyond his mention of efforts by the Library of Congress (using Flickr) over 15 years ago, Miller gives little to no attention to contemporary discussions about the implications of resource descriptions written by white heteronormative metadata practitioners who work at predominantly white institutions like academic libraries. For example, when discussing how metadata practitioners value end-user contributions, Miller might have also highlighted the work of Archives for Black Lives in Philadelphia's Anti-Racist Description Resources (**github.com/a4blip/A4BLiP**); Violet Fox, who started the Cataloging Lab (**cataloginglab.org**) in 2018; and Emily Drabinski's Queering the Catalog: Queer Theory and the Politics of Correction (**doi.org/10.1086/669547**). These people and organizations have been instrumental over the past ten years in trying to make metadata work more just, diverse, and inclusive so users feel seen and understood from their cultural and social contexts.

In conclusion, *Metadata for Digital Collections* is an invaluable resource for anyone interested in working with digital collections. Miller's expertise in metadata management and his ability to explain complex technical concepts in a clear and concise manner make this book a valuable asset to librarians, archivists, and other information professionals. While the book's focus is on digital collections and standards used by library and information scientists, its foundational principles of data curation and the importance of making metadata usable and shareable can be applied across disciplines. While there may be some areas where the book's coverage could be elaborated, Miller's focus on sound management practices and his practical approach makes this a must-read for anyone involved in digital collection management. Overall, *Metadata for Digital Collections* is an excellent resource that provides a solid technical foundation for working with cultural heritage digital collections and an appreciation for the art of metadata management.

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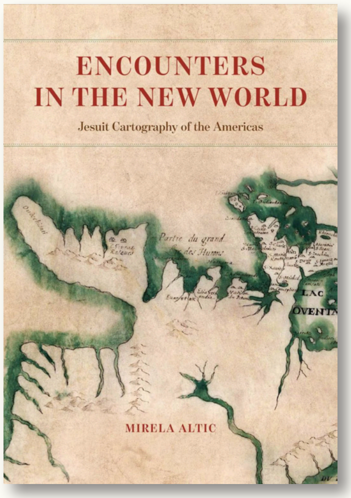

ENCOUNTERS IN THE NEW WORLD: JESUIT CARTOGRAPHY OF THE AMERICAS

By Mirela Altic

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433 pages, 47 colored plates, 121 illustrations and maps

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Review by: Jörn Seemann, Ball State University

The Society of Jesus, or the Jesuit Order, are an evangelical and apostolic order of Catholic clergy founded by Ignatius of Loyola in 1540. Although organized centuries later than most of the other well-known Catholic orders—such as the Franciscans, Dominicans, and Augustinians—their missionary work, contributions to science, and educational endeavors quickly made them the most influential and wealthiest order in the church. One of the fields in which the Jesuits stood out was that of cartography, and map historian Mirela Altic centers her new book, *Encounters in the New World,* on the maps many of them produced during the order's first two centuries in the Americas.

Altic set out to trace "the Jesuit contribution to mapping and mapmaking from their arrival in the New World [in 1549 in Brazil] until their suppression (in the Portuguese possessions in 1759, in the French in 1764, and in the Spanish in 1767)" (1), and does an impressive job of it. According to the author, besides excelling in their cartographic work, the Jesuits had a closer relationship with local populations than did representatives of the other orders. As "bearers of new cultural concepts and agents of new ideas," they "were the most important link bringing the two cultures together, and … successfully enabled transatlantic cultural exchanges between the Old and New Worlds" (1). Jesuits from many different European nationalities were sent to the Americas, frequently operating under false names to deflect the suspicions of colonial authorities fearful of spies from other colonizing powers. These missionaries were constantly on the move, creating new sites for missions, teaching indigenous populations, surveying lands, and making maps.

This book is the first comprehensive study to compare the characteristics, content, and cultural-political contexts of Jesuit maps from different parts of the Americas (7). In the process of writing it, the author compiled a large collection of more than one hundred fascinating cartographic examples from the Spanish, Portuguese, and French New World possessions, drawn from more than fifty libraries and archives around the world.

In the first of the book's four chapters, Altic situates the history and concept of Jesuit mapmaking in the broader context of colonial cartography and science during the Ages of Discovery and Enlightenment. She provides details on the institutional history of the Society of Jesus, and outlines some of the techniques, conventions, and characteristics typical of Jesuit mapmaking—a practice that, obviously, focused primarily on the location of missions and of their indigenous inhabitants, but that also addressed the physical geography and the natural resources found in specific places and regions (33). Jesuit mapmakers leaned on previously published maps and accounts, but added observations and updates based on their own travels and on direct contact with the land and life. Maps were most frequently composed for inclusion in progress reports directed to the upper administration of the order—very few were stand-alone products. While the maps were not standardized, many display common Jesuit features, such as the monogram IHS (the order's "trademark") and "figures of martyrs and saints" (43). Not unlike other cartographic representations of the Americas during this period, there was a constant confusion about the scale of the maps and the anchoring of the coordinate systems; largely because latitude was not always measured correctly and longitudes were both difficult to calculate and could use any one of a number of prime meridians as reference.

The book's remaining three chapters are of a regional nature. They discuss the Jesuit contributions to cartography in the possessions of the Spanish and Portuguese Crowns, and in what was known as New France—mainly the French territories in Canada and the region of the Great Lakes.

The longest chapter is on the Spanish sphere, and includes sections on New Spain (Florida, Mexico, and Baja California) and the Viceroyalty of Peru, which stretched from New Granada (present-day Colombia, Panama, Venezuela, and Ecuador) in the north to Paraguay and Patagonia at the southern edge of the Spanish Empire. Parts of some of the stories Altic tells may be familiar to the reader; for example, the myth that Baja California was an island—an error that persisted until the mid-eighteenth century—was finally busted, in part, by the explorations and mapping carried out by the Tyrolean Jesuit Eusebio Kino and the Croatian missionary Ferdinand Konščak (known in the Spanish world as Fernando Consag), who confirmed the peninsula as part of the continental mass (123–135). Another example is the mapping of the Amazon River by the Czech missionary Samuel Fritz, who compiled several maps that later served as a main reference for both Charles Marie de La Condamine's 1743 scientific exploration of its course, and for border dispute negotiations between Spain and Portugal.

The much shorter chapters on Jesuit maps of the Portuguese and French possessions in the New World make clear that each empire had different rules for mapmaking, use, and diffusion. In comparison to the Spanish maps, there are only a very small number of surviving maps of Brazil. This is largely due to Portugal's policies of secrecy that kept maps locked away from unauthorized viewers. Jesuit maps discoursed about border regions, the mining activities in the state of Minas Gerais, and the missions in both southern Brazil and the Sacramento colony along the banks of the La Plata River in present-day Uruguay. The first Jesuits in New France arrived in 1609, but their activity only began to thrive two decades later with the creation of new missions in Huronia—that land between Lakes Erie, Ontario, and Huron, today known as southern Ontario. There, they sustained their religious operations through the fur trade (293), and were in constant collaboration and conflict with indigenous nations such as the Huron and Iroquois. Most notably, it was a French missionary, Jacques Marquette, who, in 1673, drew one of the first maps of the Mississippi River in the lands between Lake Superior and the Gulf of Mexico.

The power of *Encounters in the New World* lies in its comparative analysis of the Jesuit maps. The author presents an insightful narrative of the complex processes of mapmaking and of the people involved in the process. Altic shares her enthusiasm about the maps, and writes: "I was particularly interested in the modalities of the transfer of information and the ways the information noted on Jesuit maps affected other maps—both within and beyond Jesuit cartography" (2). The meaning of this sentence becomes clear very quickly. The book's rich illustrations (47 color plates and 121 black-and-white figures) reveal that, in the process of being copied and printed, the original manuscript maps underwent heavy editing—sometimes resulting in completely different maps—and the author shows how these transformed maps were inserted in broader cultural and political contexts.

Be prepared! The book is very dense and descriptive. It contains many passages with very specific and detailed information, lengthy descriptions, and a lot of names of people and places that will likely not ring any bells for the reader not already acquainted with the era, landscape, and persons involved. There were moments that I felt overwhelmed by the abundance of place names and persons listed in long sequences, and further explanations, or even a glossary at the end of the book, would have been welcome additions. I became particularly curious about the biographies of some of the Jesuit mapmakers and wanted to read more about them—beyond what can be learned browsing through the book's 872 endnotes. It would also be useful for those interested in learning more about Jesuit cartography if there were an appendix with the complete list of maps used in the study, and the libraries and archives that hold them.

These days, writing almost anything on the activities of European missionaries in the Americas will court controversy and provoke diverse reactions and strong opinions, ranging from unconditional praise (as a substantial study on Jesuit cartography) to categorical condemnation (as downplaying of the devastating impacts of European colonialism in the region). Throughout this book—although always in the background—Altic keeps returning to one of the central points in her study, one also stressed in the title: *encounters*. She endeavors to examine the way that the Jesuits served as active agents connecting native peoples and European colonizers. Active connecting agents they surely were, but recollection of the brutality of the conquerors, and the fact that 90% of the native population of the Americas were wiped out by war and diseases in the first one hundred years after the arrival of the Europeans (Koch et al. 2019) may leave the reader with a bitter taste in their mouth.

Compared with other religious orders active in the New World, the Jesuits were skilled field workers and excelled in mapmaking, but the maps they made almost always served the colonial project: identifying, organizing, and controlling territories and peoples. Altic affirms that the fourth vow of the Jesuits—to spread Catholicism through their missionary work—played into the hands of the colonizers. It was "skillfully used by European imperial politics, so that the Jesuits, by spreading the gospel among the indigenous peoples of the New World and the maps they were to produce, would also become a powerful tool for establishing and maintaining the colonial authority of the European imperial powers" (17). It would be naïve to think that the Jesuits only ever wanted to know about space for the purpose of converting the natives to Catholicism when they were, in fact, so clearly an integral part of the larger colonial project.

Throughout her book, Altic frequently refers to "encounters" between natives and colonizers and stresses the Jesuits' role as active connecting agents between the parties to these interactions. However, while European viewpoints are well represented, the indigenous voices remain strangely silent. Perhaps this is due to the scarcity of surviving native sources or simply because the intended focus is on European cartographic history, but there seems to be little about actual cross-cultural encounters or connections. While this focus is fine with me, I would have liked to read more about the "real" encounters between the missionaries and the local populations and how, and how much, indigenous informants contributed to the mapmaking. Great examples of this approach are Barbara Mundy's path-breaking book *The Mapping of New Spain* (Mundy 1996) or, more recently, Ana Pulido Rull's *Mapping Indigenous Lands* (Pulido Rull 2020; reviewed in *Cartographic Perspectives* 97). Both books point out that indigenous people played important roles as information sources and were even involved in the mapmaking itself. Lastly, the title of Altic's book reminded me of two other books that focus on "cartographic encounters": Malcolm Lewis' 1998 anthology on Native American mapmaking and map use, published twenty-five years ago, and John Rennie Short's 2009 study of indigenous peoples and the exploration of the New World. It surprised me that these references were not mentioned in her bibliography. None of this, however, takes away the merit of Altic's exhaustive and meticulous work. As I mentioned above, her study is on Jesuits and their maps, not on indigenous peoples, although under the circumstances her title may be slightly misleading. An additional chapter on these intercultural encounters might have been in order, though I suspect that this theme would be worth a complete book by itself.

Altic's study is Herculean. She clearly put so much work into it. It is a great reference book, especially for map historians and scholars specializing in Latin America and religious studies, though it is not always easily accessible to the general readership without expertise in these topics (including myself). A great strategy for reading would be to start by examining the color plates or black-and-white figures—many never before published—and comparing one's own observations to the detailed analysis provided by the author.

In summary, *Encounters in the New World* is a valuable contribution to studies in the history of cartography and of the Americas, especially Latin America, between the mid 1500s and late 1700s. Besides being a thorough account of Jesuit cartography in the Americas, the book also literally invites the reader to an encounter with these fascinating maps.

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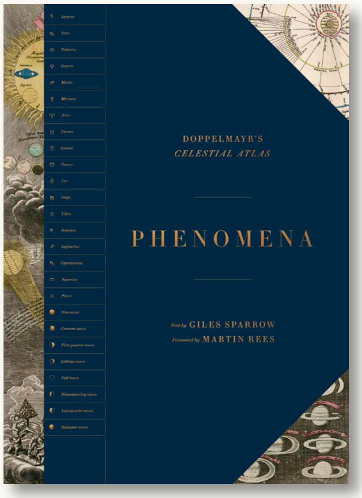

PHENOMENA: DOPPELMAYR'S CELESTIAL ATLAS

By Giles Sparrow

The University of Chicago Press, 2022

256 pages, 736 illustrations, 600 color plates

Hardcover: $65.00, ISBN: 978-0-226-82411-6

Review by: Veronica Penney, The Washington Post

We may think of progress in the science of astronomy as the product of a forward march of scientific discoveries to the present day, but *Phenomena: Doppelmayr's Celestial Atlas*, by Giles Sparrow, reminds us that history is never straightforward. *Phenomena* is an exploration and summation of Johann Gabriel Doppelmayr's 1742 *Atlas Coelestis* from the perspectives of both the eighteenth and twenty-first centuries. The *Atlas Coelestis* itself, a best seller of its day, summarized the then-current scientific understanding of planetary movements and physics, and depicted it in thirty "plates," or full-page illustrations, with captions and annotations that made the underlying theories and calculations accessible to a wide readership. Because Doppelmayr was epitomizing what was known about the field of astronomy—rather than introducing new concepts—author Giles Sparrow places Doppelmayr's work in the category of "popular science" (21).

Sparrow creates space to examine Doppelmayr's work and the evolution of astronomy in a way that is rarely offered in the long, sweeping arc of history courses—narratives that often bypass the details of scientific debates. These days, for example, the slow progress of planetary understanding that culminated in the wide acceptance of Copernicus' heliocentric model is easy to overlook. From our modern vantage point, any theories that predated the understanding that the planets orbit the Sun can appear quaint. Yet the widespread acceptance of heliocentric models of the solar system took hundreds of years and countless iterations. Sparrow explores such nuances in an engaging way and provides key context for the inclusion of some non-Copernican planetary models in Doppelmayr's *Atlas*.

Each section of *Phenomena* corresponds with one of the plates in the *Atlas Coelestis*. New technology and theories in the almost three centuries since the book's publication have advanced the field of astronomy, so the text in each section provides key context for why the theories portrayed on each plate were significant at the time. Sparrow begins each section with an overview of the diagrams on the plates and background on the theories they depict. He reproduces each atlas plate in full, at a slightly reduced size, followed by magnified sections showing the detail in the illustrations and images of other research and theories that inspired Doppelmayr's work.

Phenomena is visually stunning. It is printed on generously sized, 10½ by 14⅜ inch pages and bound in a handsome blue cover with gold foil text. Although these pages are only about two-thirds the size of Doppelmayr's, they still allow for large images of Doppelmayr's illustrations and the work that inspired his *Atlas*, all of which are filled with minute writing and intricate detail. *Phenomena* is equally well-suited for use as an historical reference or as a coffee table display to flip through for visual inspiration.

According to Sparrow, the *Atlas Coelestis* illustrations that are reproduced in *Phenomena* "provide an unrivaled insight into the Enlightenment view of the cosmos: a world that had shaken off many of the wrong-headed theories that had persisted since classical times, but for whom many questions remained unanswered" (12). The inclusion of mythical figures, gods, and references to the Zodiac in Doppelmayr's plates evoke a time when religious beliefs influenced scientific theories, and kings and emperors relied on astronomy and divinations to make important decisions. Sparrow writes that "the *Atlas* remains a salutary reminder that revolutions in the history of science and ideas are always more gradual, more tangled and more intriguing than the 'Just So' stories that we tell ourselves with the benefit of hindsight" (21).

Phenomena illuminates that point in recounting the debate over whether the Sun or Earth is the center of the solar system. In 1543, Copernicus famously published a treatise arguing that the Earth and the other planets in the solar system orbit the Sun. "History is written by the winners," writes Sparrow, "and it is often assumed that, despite his condemnation by the Church, Galileo's discoveries and arguments settled the matter in the mind of all rational thinkers from that point onwards" (12). Yet when the *Atlas Coelestis* published a century later, the debate had not yet been resolved.

A fundamental imperfection in the original Copernican model fueled the debate. Copernicus himself was "unable to break free from the shackles of circular motion at a uniform rate" (54), a carryover of Plato and Aristotle's belief in the perfection of the heavens, which left room for only perfect circles and spheres. A model employing circular paths and constant rates of motion could not adequately predict the observed positions of planets that were actually following elliptical paths. The original Copernican model, like its competing models, relied on complicated systems of epicycles, or smaller orbits imposed upon larger orbits. "For this reason," writes Sparrow, "the initial response to Copernicus's ideas was to treat them as a useful calculating tool, but not necessarily an alternative model that overthrew long-held notions of physical reality" (54). That ongoing debate led Doppelmayer to include some of Tycho Brahe's Earth-centric models in the *Atlas*.

The illustrations in *Phenomena* are exemplary pieces of draftsmanship, but slowing down to spend time with the text yields its own delights. Sparrow's descriptions are rich, filled with anecdotes and details that explore how astronomical findings progressed over time. Sparrow explains how theoretical models—like the idea that the cosmos forms a sphere that mirrors the sphere of Earth—came to be. If constellations rise in the east and set in the west, and if stars circle the poles over the course of twenty-four hours, one explanation could be that the stars are arranged in a spherical framework that rotates around the Earth.

Sparrow's recounting opens a window into the past, tracing how researchers communicated with each other and how knowledge slowly disseminated across countries and continents. He includes reminders of why some measurements were difficult to take and how discoveries were contingent on other technological advances—notably the "longitude problem," or the challenge of determining the relative east-west location of widely separated objects. Observers along the same line of latitude will see the same stars rising and setting at different times, and a measurement of that difference enables them to determine their separation in longitude. However, for centuries, observers relied on the Sun or stars to determine time. At best, they could record celestial positions in local time, but without a synchronized time keeper or rapid communication, they could not easily compare their recorded time with observations made at another location. This obstacle remained until the invention of the pendulum clock and portable chronometer in the seventeenth century.

The chapters that explore Doppelmayr's plates on comets again demonstrate the unresolved state of astronomical knowledge at that time. Sparrow explains that comets behave differently than planets and stars: they travel in straight lines across the sky and can vary widely in appearance and motion. This led to a spirited, centuries-long debate on their nature. Were comets part of the fiery sphere that Aristotle proposed, which hung above the air and below the realm of the stars? Or were they nearby phenomena, occurring within the upper atmosphere? Sparrow's explanation helps us see why, and how, the early stargazers who saw bright streaks of light across the sky struggled to categorize them.

In the centuries since Doppelmayr examined the field, astronomers built more powerful and capable telescopes and the understanding of physics progressed. Sparrow explains how those advancements refined or outright replaced some of the theories depicted in the *Atlas Coelestis*. That nonlinear process of research and refinement is equally applicable to contemporary scientific theories. Today, for example, it is thought that nearly ninety-five percent of the universe is composed of dark energy and dark matter—forces and masses that astronomers and physicists can neither observe nor completely explain. Could today's accepted models be, in some ways, as nascent as Earth-centric models governed by perfect, circular motion?

On the whole, *Phenomena* is an engaging read, and Sparrow's wit and humor shine through in his commentary. His anecdotes serve as moments of color, such as his story about how one lunar eclipse, accurately predicted, still elicited "much excitement" from astrologers for occurring at the same time as the French "Sun King" Louis XIV's defeat at Barcelona (119).

Phenomena includes two full pages of Maria Clara Eimmert's elegant, blue-and-white illustrations of the moon's phases, but otherwise, female astronomers and researchers are nearly absent from the book. This lacuna reflects the historical exclusion of women from science, and the systematic attribution of their work to male contemporaries. In the final chapter, Sparrow notes how Caroline Herschel's research advanced the field of astronomy in the years following the publication of Doppelmayer's *Atlas*. More than forty years after Doppelmayr's *Atlas* appeared, Herschel published her astronomical findings under her own name—making her the first woman to author a paper in the *Philosophical Transactions* of the Royal Society.

Most of the illustrations in *Phenomena* are of a good size and are well printed. For example, the reproduction of Doppelmayr's second plate shows the Sun with its planets orbiting on (what we now know to be incorrect) circular paths. The model is bordered by illustrations of zodiac constellations and individual labels for stars, and is large enough to be easy to read. However, images of the other detailed maps and charts that contributed to Doppelmayr's *Atlas* —such as Althanasius Kircher's *Typus Corpus Lunaris* map of the moon's surface—are printed in small sizes that make the text and details difficult to see.

Sparrow's descriptions of some of the three-dimensional models and tools of the celestial trade in use during Doppelmayr's time can be challenging to envision, despite the illustrations he provides. Admittedly, these models and tools are complex, unfamiliar to most readers, and challenging to describe in text, but these sections could benefit from more thorough descriptions and additional diagrams showing the instruments at different angles.

Phenomena's historical illustrations have a warmth and humanity that is rare in modern-day scientific communication and data visualizations. Centuries ago, any graphic, no matter how "scientific," had to be turned over to skilled illustrators to even appear in print. The clarity and beauty of the plates in Doppelmayr's *Atlas* are a product of that trade. As Sparrow observes, astronomy in particular lends itself to illustration and art: "The very nature of our place in the cosmos limits our ability to see it clearly," he writes. Even now, astronomers "turn to the talent of artists to bridge the gap and transform equations, digits, and data into visions of other stars and other worlds" (245).

In this age of big data and computer-generated graphics, modern scientists—and even cartographers—could benefit from a return to more artistic and creative forms of visualization. As Sparrow says, "the enticement of visual splendour can be a powerful tool for conveying scientific arguments" (245). *Phenomena*: *Doppelmayr's Celestial Atlas* demonstrates that using "visual splendour" in conveying scientific arguments can be both effective and inspiring, but the question for twenty-first century cartographers is how it can be appropriately used today.

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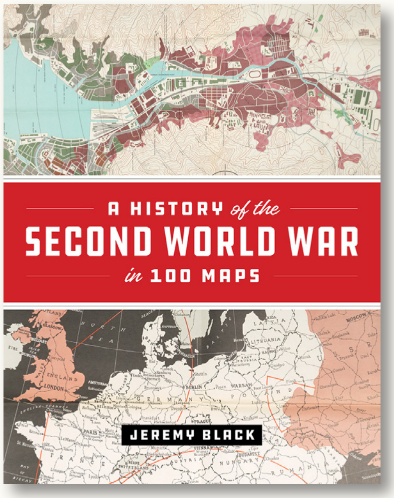

A HISTORY OF THE SECOND WORLD WAR IN 100 MAPS

By Jeremy Black

The University of Chicago Press, 2020

256 pages

Hardcover: $35.00. ISBN 978-0-226-75524-3

Review by: Glenn O. Humphress, Southeast Community College

A History of the Second World War in 100 Maps brings together three distinct publishing trends: (1) the relatively recent popularity of books with titles in the format of "A History of X in Y Objects," (2) the reliably prolific authorship of historian Jeremy Black, and (3) the continued public interest in information about the Second World War, nearly eighty years after the end of that conflict. This book follows Dr. Black's *Maps of War*: *Mapping Conflict through the Centuries* (2016) and *Mapping Naval Warfare*: *A Visual History of Conflict at Sea* (2017) with all three being stated precursors to his more analytically focused *The Geographies of War* (2022), which references the preceding three for their maps. Who needs trilogies when you can have a tetralogy of related books! While an argument can be made for reviewing all four books together, the scope of such an endeavor would quickly exceed the expected length of a typical book review, so I will focus on the most recent of the three books of maps as a relevant exemplar.

The goal of *A History of the Second World War in 100 Maps*, hereafter referred to as *100 Maps*, is to pull together a range of contemporary maps as artifacts from a complex conflict in which "mapping was required in a more comprehensive and multipurpose fashion than hitherto" (6) on both the battlefronts and home fronts. This is not a book of newly produced maps that accompany a historical story, but rather a book on the history of cartography that highlights the intertwining of cartography and the events that occurred in the historical moment.

100 Maps is divided into eight sections, consisting of an "Introduction" followed by seven numbered chapters. The "Introduction" effectively lays out Black's *raison d'être* for undertaking this work: "War inherently takes place in a spatial context and it is an activity that can only be conducted in that fashion. As a result, mapping is central to conflict, and at every level: from the most detailed (the tactical) to the most general (the strategic)" (7). He then uses this brief, seven-page preamble to run through a variety of cartographic concepts and issues. If any single section can be said to leave the reader wanting more, this is it. For example, Black claims "For most combat, we have no maps. Instead, mental mapping is the key . . . but any emphasis on mental mapping leads to the conclusion that the standard approach to war and cartography is teleological," (7) but at no point does he explain what "mental mapping" is. A professional geographer, cartographer, or historian can be expected to have had the opportunity to previously encounter and develop an understanding of this concept, but a World War II history buff coming across this book at a library, a local bookstore, or online most likely has not, and will have to make what will be, at best, vague assumptions as to its meaning. Black may discuss mental mapping more fully in his *Geographies of War,* mentioned above—a book that I have not, to date, had an opportunity to read beyond its Preface—but regardless, covering it elsewhere would not be helpful to the casual reader of *100 Maps*. He does better at explaining some of the technological innovations of the time, such as infrared aerial photography, as well as the nature of, and attempts to rectify, the persistent issue of map shortages felt by all the combatant states. Many other technical aspects of cartography are similarly addressed throughout the book, often in sidebar boxes.

The next six sections, Chapters 1 through 6, organize the bulk of the map artifacts into six thematic groupings: "Geopolitics," "Strategic," "Operational," "Tactical," "Reportage," and "Propaganda," followed by a seventh, concluding, "Retrospective" chapter. Each of the thematic chapters begins with a brief overview that includes discussion of the general theme as well as any included subthemes. Some sub-theme examples include "Ethnic and racial themes," "Hitler geopolitics" (which includes a sidebar box on Karl Haushofer and his concept of *Geopolitik*), and "Allied geopolitics;" all from the "Geopolitics" chapter. The maps included in *100 Maps* represent a wide range of cartographic styles, scales, levels of detail, and purposes, resulting in a book to delight any cartophile interested in the variety of possibilities available with cartographic communication—whether the intended audience was a soldier, a general, or a person at the home front. Some of the maps are expected ones commonly seen elsewhere; the perspective maps of Richard Edes Harrison and maps showing the arrangement of forces on a battlefield for example. Others are rarer, including ones made by prisoners of war while in captivity—with POWs at one camp even using a makeshift printing press process that Black describes in detail—and the hand-drawn map made by the Mitsuo Fuchida, the ranking Japanese commander present at the attack on Pearl Harbor, to communicate to his superiors his estimates of the damage inflicted on the American forces during the attack. The book has a very striking visual quality with excellent, generous-sized reproductions of the maps and images, as is to be expected from the University of Chicago Press. Black's accompanying discussions are succinct, yet both cartographically and historically informative, with generally at least half a page in this oversized book devoted to each discussion.

As much as I enjoy the presentation of *100 Maps*, there is an oversight that must be addressed. The term "Second World War" refers to a multiplicity of geographically dispersed conflicts that did not all start at the same time—with conflict in Asia beginning two years prior to the outbreak of war in Europe—but that, even as they progressed, came to be seen as essentially a single global conflict. To me, the use of that term in the title thus implies that the book will also be global in the scope of its coverage; however, throughout *100 Maps* there is a very strong focus on the European theater and associated areas of operations such as North Africa. For example, the "Geopolitics" chapter contains 10 maps, with their accompanying discussions, from the European sphere of the conflict but only one from the Asian-Pacific, and that is an American-made map (the Fuchida map mentioned above is in a different chapter). No map or discussion of Japan's geopolitical aims, such as the proposed Greater East Asia Co-Prosperity Sphere, is provided in this chapter, or anywhere else in the book, which in my opinion constitutes a serious omission. Chapter 2, "Strategic," likewise covers 10 maps from the European sphere and only one from the Asian-Pacific, and this later one is an American-made map of damage to Nagasaki made by the atomic bomb, accompanied with pre- and post-bombing aerial reconnaissance images. All told, only 24 of the 100 maps (taking the book's title at its word) cover the Asian-Pacific sphere of the conflict and are presented and discussed on only 41 of the 237 substantive pages. Even more representative of this disparity is that only three of the maps displayed in the book were of Japanese origin, the hand-drawn map of the results of the attack on Pearl Harbor mentioned above being one of them, and none are from any other Asian or Pacific polity. Maybe the disparity reflects the relative availability of maps that represent the particular themes Black emphasizes, or it could be due to a paucity of paper-based cartographic artifacts that have survived use in the largely tropical Asia-Pacific area; Black does not address any aspect of the uneven coverage in the text, so the reader is simply left with the impression that the Asian-Pacific theater of the Second World War was either not as important or not as well mapped compared to the European and associated theaters, although the latter implication would run counter to his statement in the "Introduction" about mapping being central to the conflict.

100 Maps may not be without flaws, but still has much to recommend it, particularly for anyone interested in the history of cartography. The Second World War marked an important moment in the development of cartographic tools and in the use of maps to communicate complex geographical and spatial information on a regular basis—arguably on a scale and with a scope never before attempted. The overall design of *100 Maps*, along with its accessibility to a general audience, makes it an important contribution that can also help raise awareness of the role maps have played in such historical events.

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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.

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

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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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