Cartographic Perspectives

Journal of the

North American Cartographic Information Society

Number 58, Fall 2007

From the President

Saint Louis, Missouri was the center of the map-making universe for three days in October. Our annual meeting brought 165 map-minded people together to share ideas about cartography. I continue to be amazed at the diversity of our collective works and the passion of our members. For me, it is the passion for map design that defines our craft. It has little to do with formal education and much to do with the more esoteric concept of talent. Talent is fueled by passion—and this combination is what makes beautiful maps, or prose, or art. Cartographers are often talented in all three disciplines. The semantic discussions of "is it a map?" or "is cartography dead?" or "is it an art or science?" all fall by the wayside when one sees a beautiful map. We know it when we see it. It is good design.

What separates NACIS from other organizations are two things: our comfortable size, and an overwhelming willingness to share ideas. As President, I'm asked about ways to grow the membership, yet I feel little reason to do so. Growth brings overhead and anonymity; neither is conducive to supporting a holistic network of map aficionados. The simple ability to all fit in one relatively small room benefits our ultimate goals of being able to meet and converse in a friendly manner. Our membership has grown steadily in recent years and now includes

(*continued on page 3*)

In this Issue

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North American Cartographic Information Society

©2007 NACIS ISSN 1048-9085
www.nacis.org

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(*letter from the president continued*)

over 500 people from ten nations. Our membership is not swayed by the geographical implications of our name.

Sharing ideas is at the core of our Annual Meeting. From map design to map sales, academic cartography and the education of cartographers, map libraries and the realm of on-line mapping—all of these topics are floating around in the conversation sphere of NACIS. Student cartographers can mix with seasoned professionals and meet some of the authors who have written their textbooks. Veteran cartographers can see the work of the next generation in our map galleries and poster contests, as well as get a glimpse of the future from presenters who are sharing their latest projects. Freelancers can network with other independent publishers or make introductions among our corporate cartographers who often hire outside talent.

I encourage all of our members to contribute to *Cartographic Perspectives* (*CP*). This is your journal and it should represent the collective works and interest of the membership. We often work in relative isolation on our projects and research. *CP* provides the opportunity for us to share our work with the NACIS community, and with the world now that *CP* will be archived on-line in the coming year as PDFs going back to volume 1 number 1 published in March of 1989. Then President Juan José Valdés, and Co-Editors David DiBiase and Karl Proehl called it a Bulletin. It has since evolved into a Journal. Prior to the genesis of *CP,* NACIS published 23 issues of newsletters entitled *Map Gap*, and eight issues of *Cartographic Information*. We no longer have these documents, and if any of our members can provide them, perhaps they can be archived on-line as well. The purpose of the on-line archive of past publications is to serve the same role our real-time Annual Meeting does—connecting people and ideas across time and space. It will be an historical outline of the creative legacy of our membership.

We don't know where the future of cartography will take us, or where we will take the future of cartography, but I can predict another lively Annual Meeting in October 2008 in Missoula, Montana. I hope to see you there.

Michael Hermann
NACIS President

The Cover

Title: What the Land Wants

Steven R. Holloway
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toMake Studio & Press
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All matrix done digitally including the transfer of the sketch map to digital form. The area mapped is the East Bay, Berkeley, Aquatic Park, Cesar Chavez Park, Strawberry Creek and Hayward Fault, and Grizzly Peak. Mapped sources include medieval T-in-O, USGS maps, charts, remote sensing imagery, textual history of the aquatic park, field sketches and notes, and the stylized image of park, bell, creek, fault and causeway.

The print combines the notion of the shared or collective maps of the area, parts of which but not the whole, we access in our interactions with the place and the personal map from direct-contact with observations and notes from the specific interaction. The place itself, Cesar Chavez Park, is not isolated but connected to greater wholes through water.

A Publishing History of John Mitchell's Map of North America, 1755-1775

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John Mitchell's *Map of the British and French Dominions in North America* (London, 1755) is a prominent feature of the history of cartography of the British colonies in North America. A close examination of the history of the publication of its seven identified variants (1755-1775) indicates, however, that the map is properly understood in terms of the British, and more specifically London, market for maps and geographical information. There, it contributed to public discussions about the nature of the British empire and the British nation. This study also demonstrates the validity and necessity of applying the established bibliographical scheme of edition, printing, issue, and state to maps.

Keywords: John Mitchell, Thomas Kitchin, William Faden, map trade, colonial cartography, wall map, cartobibliography

INTRODUCTION

Lawrence Martin (1934) called John Mitchell's imposing, eight-sheet *Map of the British and French Dominions in North America* (Figure 1), "the most important map in American history," because British, Spanish, and American negotiators used several versions of the map to conceptualize the boundaries of the new United States of America in Paris in 1782-83. Martin had represented the U.S. government in several international and interstate boundary settlements between 1917 and 1935 (Williams 1956, 359-60), so it is perhaps understandable that he should have emphasized this particular aspect of the map. But even before Martin, scholars were drawn to the map because of its role in the Treaty of Paris and subsequent Anglo-American boundary negotiations. In particular, B. F. Stevens, a U.S. diplomat based in Britain in the 1890s, set out to collect as many variants as he could precisely because of the map's association with diplomatic affairs.[1] After Mitchell, almost every historian who has considered the map has repeated Martin's accolade. In other words, Mitchell's map has consistently been studied solely from the inward-looking perspective of American exceptionalism. This applies to the study of the map's origins in 1750–1755 (see Edney 2008a) and to the history of the seven variants of the map published in London between 1755 and 1775. Each variant is taken to have been prompted by events and surveys that occurred in North America.[2] However, Mitchell's map was prepared and published in London and it was read primarily in London and Britain. My purpose in this paper is therefore to reexamine the publication history of Mitchell's map in terms of the British public and its views of empire, rather than through the lens of colonial concerns.

". . . Mitchell's map has consistently been studied solely from the inward-looking perspective of American exceptionalism."

This argument is grounded in the ongoing reevaluation of the nature and history of maps. Traditionally, map studies have emphasized the production of maps. In this respect, the history of the mapping of Britain's North American colonies has overwhelmingly been told as the history of how the colonies were progressively explored and surveyed, generat-

Initial submission, January 22, 2007; revised submission, August 22, 2007; final acceptance, August 27, 2007

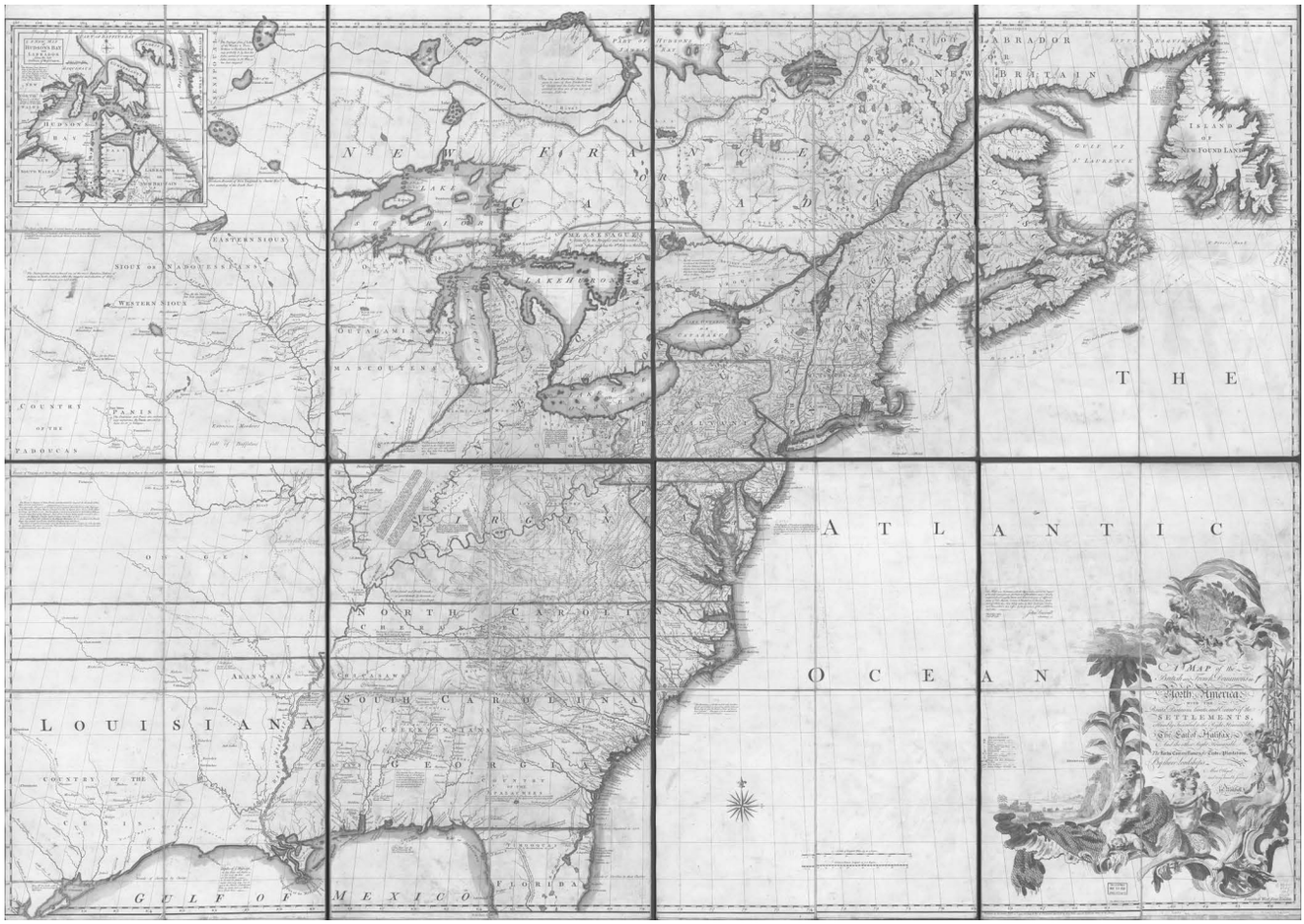

Figure 1. John Mitchell, A Map of the British and French Dominions in North America with the Roads, Distances, Limits and Extent of the Settlements, Humbly Inscribed to the Right Honourable The Earl of Halifax, And the other Right Honourable The Lords Commissioners for Trade and Plantations, *engraved by Thomas Kitchin (London: Andrew Millar, 1755). Variant 1. 136cm x 195cm. Courtesy of the Geography and Map Division, Library of Congress (G3300 1755 M5 Vault). (see page 71 for color version)*

ing new information and so new maps. Critical approaches, exemplified by Harley (2001), Jacob (2006), and Wood and Fels (1992), have however demonstrated that the relationship of the map to the territory has never been as simple as was once presumed. By extension, the burden of explanation in map studies has moved away from the territories depicted and to the contexts in which maps were produced and consumed (see Edney 2007). By examining the geographical and social patterns of the circulation of maps from makers to users, we can say something about the kinds of people who read each kind of map and why they did so. In other words, the study of maps as artifacts—as things made to be physically moved through space, housed, and used—has little immediate connection to the territories being mapped but has everything to do with the people who created and read them (see McKenzie 1999, 43-48).

In remembering that Mitchell's map was a geographical work published in London, we must appreciate that all of its seven variants were intended first and foremost for the British public, and more particularly for that wealthy segment of the public who could afford it. The map was treated just like any other product of the London printing presses. London publishers did ship their books and other printed works to the provinces, but only in a limited manner. The distance from London to the North American colonies meant that London publishers generally shipped few

"By examining the geographical and social patterns of the circulation of maps from makers to users, we can say something about the kinds of people who read each kind of map and why they did so."

copies of any one work to the colonies, although if books did not sell well they did dump the unsold stock onto the colonial markets with the hope of recouping at least some of their expenses (Botein 1983; Raven 2002). Mitchell's map did not suffer such an ignoble fate, and it seems to have been available in the colonies only in very small numbers. Certainly, almost all impressions of the map found in U.S. libraries were acquired only in the nineteenth and twentieth centuries via British dealers from private collections in Britain. We need therefore to look to the London market if we are to understand properly the map's history. Despite its unusual size, careful compilation, and historical significance, Mitchell's map was in this respect no different from the many other maps published in London in the same period, even the small and sketchy maps published within monthly "magazines" (Figure 2).

When we look carefully at the public market for geographical maps and books in eighteenth-century London, we find little sustained interest

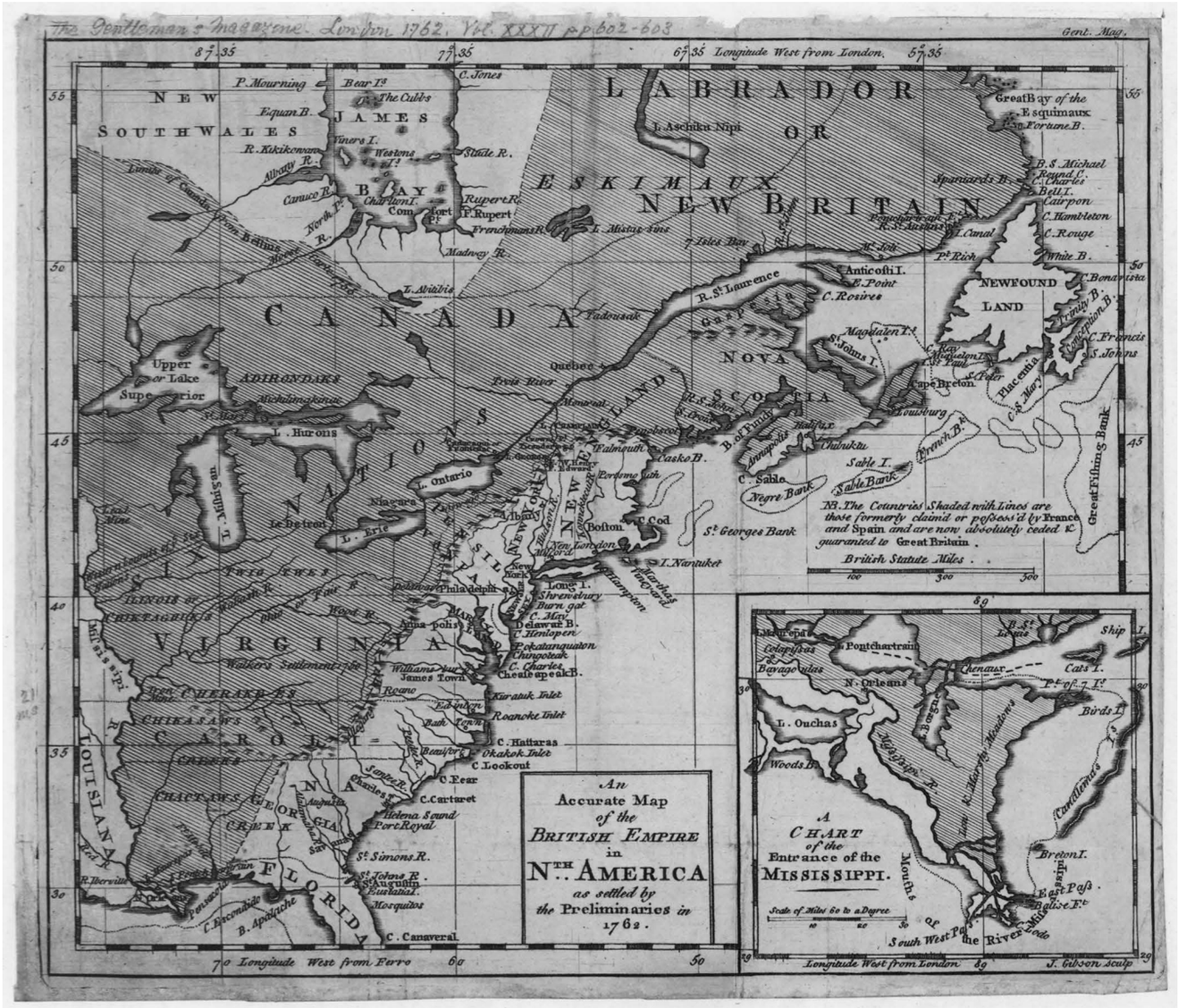

Figure 2. An Accurate Map of the British Empire in Nth. America as Settled by the Preliminaries in 1762, *engraved by John Gibson, in* The Gentleman's Magazine *32 (1762): 602-603. The shaded territory was that to be ceded by France and Spain to Great Britain. 21cm x 26cm. Courtesy of the Geography and Map Division of the Library of Congress (G3300 1762 .G5 Vault / Lowery no. 457). (see page 72 for color version)*

in the colonies. This can be seen in the pattern of maps printed within the monthly periodicals, such as the *Gentleman's Magazine* or the *London Magazine*. These magazines were interested in current affairs, just like the daily and weekly newspapers, but their longer production cycle and greater price permitted their publishers to invest the necessary time and money to include maps in many issues (e.g., Figure 2). The publishers sought to meet the current interests of the reading public, so it is logical to presume that they incurred the extra cost of having maps prepared and printed only when they thought their readers would be interested in them. The appearance of maps in monthly periodicals thus serves as a surrogate for the public's geographical interests. A simple review of the maps in these magazines (as listed by Klein 1989 and Jolly 1990–91) reveals that maps of North America and the West Indies featured in the magazines only during times of colonial conflict or diplomacy: in 1748-49, 1755-64, and 1774-83 (see Carlson 1938; Reitan 1985 and 1986). So, what does the later publication history of Mitchell's map tell us about public interest within the imperial metropol about the North American colonies?

This study of the publication history of Mitchell's map also has the benefit of refining cartobibliographic analyses of the map. The several bibliographic schemes developed between the 1890s and 1920s are explained in the Appendix. They are all misleading, especially in their careless and colloquial use of the term "edition." By distinguishing up to five editions, cartobibliographers have suggested that the map's publication history featured as many distinct publication events, but the evidence adduced here suggests that there were probably only three distinct publication episodes. I therefore take the opportunity to advance a new, although still necessarily preliminary, classification according to the precise bibliographical hierarchy of edition, printing, issue, and state (see Karrow 1985, 4).

"The map's purpose was to educate other administrators and politicians, as well as the general public through its published version, about the threat posed by the French in North America."

John Mitchell Makes His Map

We are fortunate in having a definitive biography of John Mitchell (Berkeley and Berkeley 1974). Born in Virginia in 1711, his family was sufficiently well off to send him to Scotland for his education. He received his M.A. in 1729 from the University of Edinburgh and he then studied medicine there until late 1731. Returning to Virginia, he engaged in a successful career as a physician and pursued an active scholarly interest in botany and zoology. But he fell ill in 1745 and he was forced to quit the colonies. He returned, with his wife, to London. There, his botanical skills brought him to the attention of a circle of aristocratic gardeners. One of these, George Montague Dunk, second earl of Halifax, was in 1748 appointed president of the Board of Trade and Plantations, the government office in London that coordinated communications between the colonial governors and the royal Privy Council. With tensions growing once more with the French over competing territorial claims in North America—and so with rising official and public interest in the colonies—Halifax prevailed upon Mitchell to share his first-hand geographical knowledge of the colonies. Halifax ultimately commissioned Mitchell to make his large map (Edney 2008a; see Figure 1).

The map's purpose was to educate other administrators and politicians, as well as the general public through its published version, about the threat posed by the French in North America. To this end, the Board of Trade's secretary certified the map's status as an official and geographically correct document. What the map presented was the inherent Britishness of the large swathe of territory from the Great Lakes to the Gulf of Mexico and from the Appalachian Mountains to the Mississippi River, to which

the French also laid claim and on which they were building many forts. The map's many annotations and its allegorical title cartouche laid out the legal superiority and historical priority of Britain's claims to this extensive territory, and portrayed the French as interlopers who aggressively and illegally encroached on British lands (see the detailed discussion in Edney 2008a). The map was very much a product of a particular moment in English politics and Anglo-French imperial rivalry.

First Printing (1755)

To publish the map, Halifax and Mitchell contracted with two well-established London tradesmen, the engraver Thomas Kitchin and the book and print seller Andrew Millar. The copyright statement in the map's lower margin, just below the cartouche, bears the date of 13 February 1755, which was probably several weeks before the map was actually made public. Millar did not actually advertise the map until the very end of March. The time delay was perhaps caused by the need to print and color enough copies of all eight sheets to build up a sufficient stock to meet anticipated demand. It was probably during this period of printing the map that small errors in the printing plates were caught and corrected. The first error to be corrected was the misspelling of Millar's name and address in the copyright statement. Someone then realized that the town of Worcester in Massachusetts was wrongly labeled "Leicester," giving two towns by that name; correction of this error produced the map's third distinct variant (see Appendix for details).

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Mitchell's *Map of the British and French Dominions in North America* is a very large map that measures 136 cm (4'5") high by 195 cm (6'5") wide when its eight sheets are assembled. As with other maps of this size and complexity, it was expensive and Millar sought to maximize sales by offering the map in several different formats. It was made available in no less than nine formats. When first advertised in the *Public Advertiser* on 28 March 1755 (repeated 2 and 4 April 1755), it was offered for sale in three formats:

a-b) as eight separate sheets, either colored or uncolored, and suitable for binding as an atlas, priced at one guinea (£1/1); and
c) the first impressions pulled from the plates "on superfine double Elephant Paper," for one and a half guineas (£1/11/6).[3]

That Millar had the printer use "superfine" paper for the first impressions pulled from the printing plates—when the image would have been sharpest and blackest—indicates his intention to sell the map to those high-end print collectors who sought the most perfect examples of the engravers' art. Millar again advertised the map in the *Public Advertiser* one month later, on 29 April 1755, when he specified the availability of the map in another three formats:

d) the eight sheets assembled into two halves, each of four sheets, for £1/5;
e) the same, but bound "so as to represent the whole," for £1/15; and
f) the eight sheets assembled into one map and backed onto canvas for strength, ready for mounting on the wall, for £1/11/6.

After two more weeks—on 14, 15, and 16 May 1755—Millar advertised the assembled map (format f) as now being ready equipped with rollers for

wall display. He also specified new formats:

g-i) all eight sheets assembled, colored, and then dissected and backed onto cloth for folding at three different size (folio, quarto, and octavo) into cases suitable forthe library or the traveling trunk, for £1/11/6.

Finally, all of these different formats were advertised together, starting on 26 August and continuing until 13 September 1755.

This list of the map's formats is actually incomplete. Most of the impressions of the map that I have examined were dissected and backed onto cloth, so they could be readily folded without damaging the paper. Several impressions survive in which the entire map was dissected into thirty-two sections and then mounted onto a single sheet of cloth, which could then be folded up and stored in a folio-sized case (formats g-i). But still more impressions survive in which each of the eight sheets was divided into four, eight, sixteen, or even twenty sections and mounted on cloth; doing so permitted the individual sheets to be folded and stored together in small, but thick, cases. This format was much more manageable because the user could extract individual sheets from the case, perhaps using small leather tabs fixed to the cloth, without having to open out the full map.[4] Maps in each of these dissected formats could be stored in its case just like a small book, which meant that the purchaser did not have to possess special furniture for holding flat sheets or sufficient free wall space to display the whole map. (Special cases could easily be made that looked like books when placed on a shelf.) I know of no surviving impressions of Mitchell's map that were hung on a wall for display (format f): the act of hanging is seriously destructive, with maps fading from long exposure to light and perhaps tearing under their own weight.[5] However, the map was certainly intended to be hung on the wall in a manner akin to a painting or mirror: the ornate cartouche, prepared by delicate etching of the copper printing plate as well as by strong engraving, is of a style commonly found on English wall maps of the eighteenth century. (By comparison, maps for books were positively austere in their aesthetic, as in Figure 2).

"Maps in each of these dissected formats could be stored in its case just like a small book, which meant that the purchaser did not have to possess special furniture for holding flat sheets or sufficient free wall space to display the whole map. (Special cases could easily be made that looked like books when placed on a shelf.)"

Like any other printed map from the period, Mitchell's was printed in black ink on creamy white, hand-laid paper. Any color that appears on the map was applied with watercolors by hand. That the separate sheets were sold with or without color for the same price (formats a-b) suggests that this particular coloring was not sophisticated and probably entailed the addition only of simple outline color of the sort evident in Figure 1. The more expensive versions of the map were perhaps colored more intensely; some impressions have full, bright color covering the entire map, and some of the advertisements refer to the map being "curiously illuminated" rather than being merely "colored." I have been able to examine a number of impressions from this first printing, and it is clear that Mitchell intended a consistent scheme for coloring the maps and he meant this scheme to have political effect. The outline color was applied to emphasize Britain's territorial claims — or rather Halifax and Mitchell's interpretation of them — and full wash applied within the same boundaries of outline color. Virginia and New York, for example, both greatly swollen by the inclusion of supposedly Iroquois lands, were consistently outlined in red and, when filled with a wash, were filled with pink (Edney 2008a, pl.9).[6]

Just how expensive was the map? In its several formats, it ranged from £1/1 to £1/15. Through the comparison of retail indices, these values are roughly equivalent to £87-144 in 1991 (McCusker 1992, app. B) or £125-207 in 2005 (Officer and Williamson 2006). In terms of purchasing power in

the mid-eighteenth century, these prices were truly significant sums. In its cheapest formats, the map cost one guinea, the gold coinage then circulating in Britain. The symbolism was clear: this is a map for the elites, for people who might actually handle gold. In terms of estimates of contemporary wages in southern England, one guinea represented approximately sixteen days' income for a laborer (ca. 16*d* per diem), ten to eleven days' for a skilled craftsman (ca. 24*d* per diem), four days' for a clergyman (ca. £92 per annum), or just over one day's for a lawyer (ca. £231 per annum) (Brown and Hopkins 1955, 205; Williamson 1982, 48; see also Pedley 2005). The more expensive formats of the map would have represented still more labor; those that sold for £1/15, for example, would have required almost three days' income for the average lawyer. Mitchell's map could therefore never have been a casual purchase. It was a luxury item intended for sale to members of London's elites who actively debated English policy for the North American colonies both in the halls of power and in the public sphere of coffee houses and printed discourse.

Second Printing, or Mitchell's "Second Edition" ([1757])

Several of Mitchell's contemporaries in Great Britain praised Mitchell's political image (Berkeley and Berkeley 1974, 201-10). John Huske (1755, 27), for example, wrote in 1755 that

> "it must give every *Briton* great Pleasure to see our Countryman Dr. *Mitchel*, F.R.S. detecting their Mistakes and designed Encroachments, and almost wholly restoring us to our just Rights and Possessions, as far as Paper will admit of it, in his most elaborate and excellent Map of *North-America* just published; which deserves the warmest Thanks and Countenance from every good Subject in his Majesty's Dominions."

"Mitchell's map could therefore never have been a casual purchase. It was a luxury item intended for sale to members of London's elites who actively debated English policy for the North American colonies both in the halls of power and in the public sphere of coffee houses and printed discourse."

The map itself was subsequently copied and reused in much simplified form, for example in the map, also engraved by Thomas Kitchin, included with Huske's book (Figure 3). But once the English and French started fighting in North America during the summer of 1755 and formally declared themselves to be at war in 1756, the moment that had generated Mitchell's map had passed. The map itself was expensive, but it had generated a flood of cheaper derivatives that were widely available in London. Why then was a new printing of Mitchell's map undertaken?

The "second edition" — as Mitchell himself called this new variant in one of the large blocks of text that he had added to the map — has hitherto been explained solely in terms of the improvement of geographical knowledge. Among all the contemporaries who praised Mitchell's map, one leveled a significant criticism: the infamous John Green, gambler, womanizer, sometime jailbird, and critical geographer, who worked in the 1750s for the prominent London map seller Thomas Jefferys (Crone 1949 and 1951; Harley 1966; Worms 2004a). Jefferys published Green's *New Map of Nova Scotia and Cape Britain* in May 1755, together with Green's memoir explaining how he had constructed that map. Green took Mitchell to task for giving Nova Scotia and the adjacent portions of New England an erroneous coastline. After listing Mitchell's errors, and giving a table of differences, Green observed that his own map was indeed better than Mitchell's because he had used not only the recent observations for latitude and longitude made by the marquis de Chabert but also Nathaniel Blackmore's surveyed map of Nova Scotia (see Robinson 1976). In contrast, Mitchell had apparently used only a few spotty observations. Green further complained that Mitchell had provided no memoir or other document that

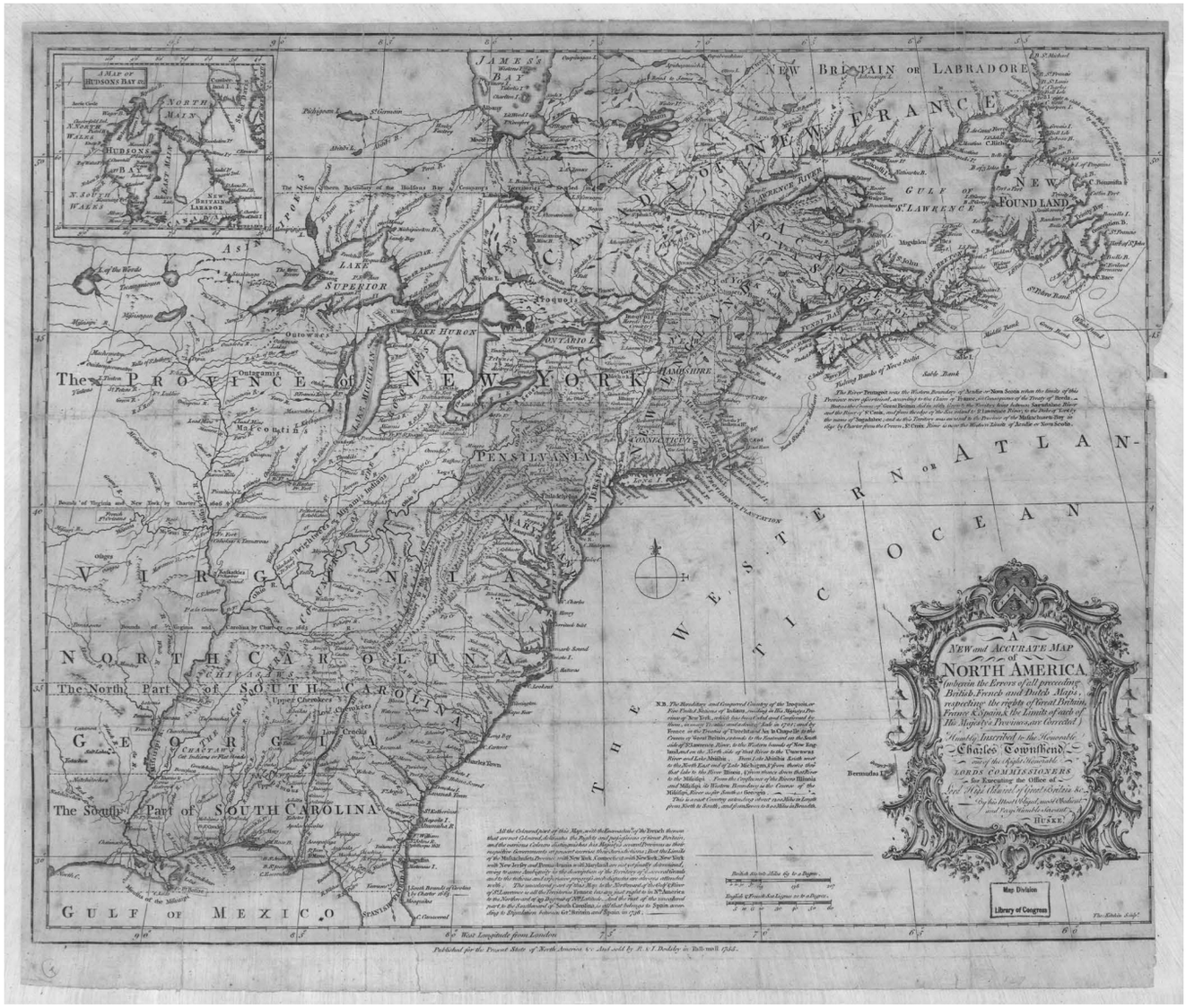

Figure 3. A New and Accurate Map of North America . . . Humbly Inscribed to the Honorable Charles Townshend one of the Right Honorable Lords Commissioners for Executing the Office of Lord High Admiral of Great Britain &c By his Most Obliged, most Obedient and Very Humble Servant Huske, *engraved by Thomas Kitchin, in John Huske,* Present State of North America *(London: R. & I. Dodsley, 1755). 39cm x 49cm. Courtesy of the Geography and Map Division, Library of Congress (G3300 1755 H8 Vault). (see page 73 for color version)*

explained how he had made his map (Green 1755, 8 and 12).

Mitchell evidently took this criticism to heart, because in his new variant he corrected his map's outline of Nova Scotia by shifting the positions of two key headlands: Cape Race by twenty minutes of latitude southward, Cape Sable by one degree of longitude eastward. He also added, set in the Atlantic Ocean, two lengthy textual statements to vouch for the quality of his work (transcribed by Edney 1997). The lower text block defined all of Mitchell's original sources: published accounts, direct observations, and most interestingly the logbooks of British men-o'-war to which he had access through the Board of Trade and Plantations. In conjunction with this information, Mitchell now added observations of magnetic variations off the Atlantic coast of North America, labeled with large Roman numerals. Unfortunately, Mitchell's explanations of his sources are rather abbreviated and are by no means as clear as those of other eighteenth-century geographers. The upper text block is more discursive and under-

standable. In it, Mitchell summarized the alterations he had made to the New England and Nova Scotia coastline in reaction to Green's criticism. He apologized for not having used Chabert's work, for the simple reason that he had not known of it, but he had now made the necessary changes. However, Mitchell's access to the Board's documents meant that he had to dismiss Blakemore's survey out of hand: Blackmore had indeed been a lieutenant in HMS *Dragon* off Nova Scotia in 1711 but he did not draw his coastal chart until 1715, and Mitchell found it to be as rough and as inexact as any other work depending on memory. Mitchell also observed that in publishing the map, the map seller Herman Moll had falsely claimed for Blackmore the appointment of "surveyor general," so that Blackmore's map was not at all deserving of the authority given to it by Green. Mitchell also dismissed all of the English maps and charts that had been based on Blackmore's work.

It is difficult to be certain when Mitchell made his additions to create this fourth variant. Neither title nor imprint date were updated. Did Mitchell reconstruct the Nova Scotia coastline and get the map re-engraved before the end of 1755, or did the process take longer? However long the revisions took to be made, it seems likely that the fourth variant was not actually published until 1757. This assessment is based upon a comment in the otherwise anonymous[7] *American Husbandry* (London, 1775), that

> Upon [the] occasion of the last war [i.e., Seven Years' War, 1756-1763] Dr. Mitchel was employed by the ministry [i.e., government] to take an accurate survey of all the back countries of North America, most of them being then but little known except to the French . . . This was the origin of his map of North America, the best general one we have had; at the time it was published, it was accompanied by a bulky pamphlet, written by the Doctor and entitled, *The Contest in America*, in which he enters into a full elucidation of the importance of the back countries . . . (Carmen 1939, 205)

"This was not a war to which the British could apply their usual games of party politics. Indeed, the abiding message was that the war was actually the result of disunity among the British in the colonies: had the colonies been able to overlook their petty differences, they could have united to keep the French from establishing any forts on British territory. What the British needed to do, the pamphlet argued, was to adopt a larger geographical perspective on the colonies, which is precisely what the map provided."

The anonymous *Contest in America* was indeed published in 1757, makes no mention of a map but it does possess the same underlying political ideals as Mitchell's map.

Like the many inscriptions on the map, the pamphlet's purpose was to explain why it was so important for the British to keep the French out of the "back country" between the Appalachians and the Mississippi River, and the valley of the Ohio River in particular. Its author claimed to have had access to a great deal of privileged, governmental information, which he nonetheless omitted to keep simple his argument about why this war required unity among the British. This was not a war, he wrote, to which the British could apply their usual games of party politics. Indeed, his abiding message was that the war was actually the result of disunity among the British in the colonies: had the colonies been able to overlook their petty differences, they could have united to keep the French from establishing any forts on British territory. What the British needed to do, the pamphlet argued, was to adopt a larger geographical perspective on the colonies, which is precisely what the map provided (Mitchell 1757, xli and 17-84). These points strongly suggest that Mitchell did indeed write the pamphlet.

If the anonymous author of *American Husbandry* was correct, then the pamphlet and the map which was associated with it—the second printing of Mitchell's map—were published in order to continue the education of the British public about the nature of the imperial prize in North America.

The distaste shown by Mitchell in the preface to the *Contest in America* for party politics manifested a common rhetoric of public discourse in eighteenth-century Britain; it was part of the manner in which writers could claim to be disinterested, to be above the fray of dirty politics, and to be writing only in the interest of the entire nation. But given the political wrangling that is endemic to any declaration of war, I have to wonder how much both the pamphlet and the "second edition" of the map were once again motivated by the earl of Halifax and his imperial vision.

With the fall of Québec in 1759 and Montreal in 1760, and the end of the North American theater of the Seven Years' War, the British public's interest in the geography of the continent declined. There would certainly have been no further need for Halifax to keep the French threat in North America in the public eye. Halifax himself stepped down as president of the Board of Trade and Plantations in 1761, after which he became Lord Lieutenant of Ireland and a secretary of state, while Mitchell died in 1768. Before his death, Mitchell published a second pamphlet on Britain's empire in North America, but this was more of a commentary on the economic relations between Britain and its colonies (Mitchell 1767). It made no reference to his map, nor does it seem to have been an occasion for a new publication of the map.

During these years, Andrew Millar seems to have kept John Mitchell's map in print, pulling enough impressions from the copper plates to keep up with whatever demand for the map that there might have been, but without making any further alterations to the plates. This is indicated by a much smaller, folio-sized map of North America—*A New and Accurate Map of the British Dominions in America, according to the Treaty of 1763; Divided into the several Provinces and Jurisdictions*—engraved by Kitchin and published by Millar sometime in or after 1763. The imprint for this map included the advertisement, "Where may be had on Eight Imperial Sheets A Map of the British & French Dominions in Nth. America; with the Roads, Directions, Limits, & Extent of the Settlements. Price 1 Guinea in Sheets. 1£ 11s 6d on Canvas & Rollers." Note the price for Mitchell's map had not been reduced.[8]

"The distaste shown by Mitchell in the preface to the Contest in America for party politics manifested a common rhetoric of public discourse in eighteenth-century Britain; it was part of the manner in which writers could claim to be disinterested, to be above the fray of dirty politics, and to be writing only in the interest of the entire nation."

While it is impossible to say how many times, or when, the map was issued during this period of the map's second printing, at least from the evidence of the engraved map alone, it is nonetheless possible to identify to a distinct issue from a particular variation in coloring. A royal proclamation in October 1763 set new bounds for the province of Canada. To the north of the St. Lawrence River, these bounds comprised long straight lines between key geographical features to form a distinctive lozenge-shaped territory; these boundaries are evident in many maps (e.g., Calloway 2006, 115). I have encountered one impression of this variant of Mitchell's map in which this distinctive area is in outline color only, and undefined by engraved lines; the remainder of the map is in full wash color in accordance with other boundaries defined in the same proclamation. The implication is that this map was at least colored, if not printed, after 1763.[9]

Third Printing ([1774-1775])

Andrew Millar also died in 1768. It is uncertain what then happened to the map's eight printing plates, until William Faden eventually acquired them. William Faden senior, a wealthy printer, had bought his then sixteen-year-old son a partnership with Thomas Jefferys in 1767 or 1768. (Jefferys had bankrupted himself in November 1766 with an overly ambitious scheme to make large-scale topographical surveys of several English counties and desperately needed new capital.) On Jefferys's death in 1771, Faden briefly

continued to publish under Jefferys' name. Starting in 1773, he worked under the name of "Jefferys and Faden," before he finally began to trade under his own name in 1775 (Harley 1966, 47; Pedley 2000; Worms 2004b).

Faden published the third printing of Mitchell's map under the imprint of "Jefferys and Faden." We can be sure, therefore, that all three states within the printing appeared between 1773 and 1775. We can in fact be more precise, because Faden (1774, 15) listed Mitchell's map in a catalogue in the following manner:

> The British and French Dominions in North America, with the roads, distances, limits and extent of their settlements, 8 sheets, 1755; *scarce* | *Mitchell*

Unlike most other entries in the catalogue, Faden did not specify a price for the map. Together with his description of the map as "scarce," this silence strongly suggests that he did not at this point own the printing plates, nor had he sold any impressions of the map that might have come his way. Rather, he only knew of the map. Indeed, the map had occasionally appeared after 1768 in the sales catalogues of London book dealers, where they fetched consistently high prices:

"We might conclude that Faden saw some continuing demand for a high-priced, large wall map of North America. Sometime in 1774-1775, therefore, he acquired the plates for Mitchell's map, modified them by abbreviating the existing imprint and adding his own imprint, and then printed three new variants in short order."

"finely coloured," and folded in portable case	£1/1	(Davies 1768, 3)
colored, "half-bound" (format e?)	£0/12	(Payne 1768, 31; Payne 1769a, 33; Payne 1769b, 33)
on large paper, "neatly coloured"	£0/15	(Payne 1768, 31; Payne 1769a, 33; Payne 1769b, 33)[10]
colored, pasted on cloth, and on rollers	£1/5	(Robson 1770, 13)
"finely coloured"	£0/10/6	(Davies 1771, 2)
colored, on cloth, and in a case	£0/12/6	(Todd 1776, 6)
colored	£1/1	(White 1776, 8)
colored, on cloth, and on rollers	£0/18	(Sotheran 1777, 8)

The maps might not in fact have sold quickly: the dealers seem to have offered for sale more copies of Henry Popple and Clement Lempriere's great 1733 map of North and Central America (in twenty sheets; see Babinski 1998 and Edney 2008a) than they did copies of Mitchell's map. We might therefore conclude that Faden saw some continuing demand for a high-priced, large wall map of North America. Sometime in 1774-1775, therefore, he acquired the plates for Mitchell's map, modified them by abbreviating the existing imprint and adding his own imprint, and then printed three new variants in short order.

The occasion for Faden's republishing of the map would seem to have been the passage of the Québec Act, 22 June 1774 (14 Geo. III c. 83). Martin (1934) thought that a copy of the map could well have been used during the parliamentary debate on the bill, a debate which turned repeatedly to the issue of the large size granted to Canada and which even included some detailed redefinition of particular boundaries (Anonymous 1806-20,

17:1357-400 and 1402-07, esp. 1391-92). However, there is no reference to the map in the surviving parliamentary record and we should not be as certain as Brown (1959, 96) that the map was indeed consulted. The act's purpose was to reconfigure the government of Canada. At the conclusion of the Seven Years' War, in 1763, the French recouped only their North American colonies of Cape Breton and other islands in the Gulf of St. Lawrence, and Britain kept France's extensive continental colony of Canada. The royal proclamation in October 1763 established preliminary boundaries between Canada and the Atlantic colonies; those limits were now finalized in 1774.

Faden's alterations to Mitchell's map included several changes in the boundaries of the northern colonies that seem to reflect the Act, with further changes being made in a sixth variant; the two variants manifested different stages in a single process of reworking the boundaries on the map. Perhaps the most important change in the map's details at this time featured the replacement of a straight boundary line running roughly east-west to the north of Lake Ontario—labeled "Limits of Canada and the Iroquois according to De L'Isle and other Geographers" and prominent on the first two editions—with a boundary line passing through Lake Ontario (Figure 4a). Several of the boundary lines delimiting territorial claims by

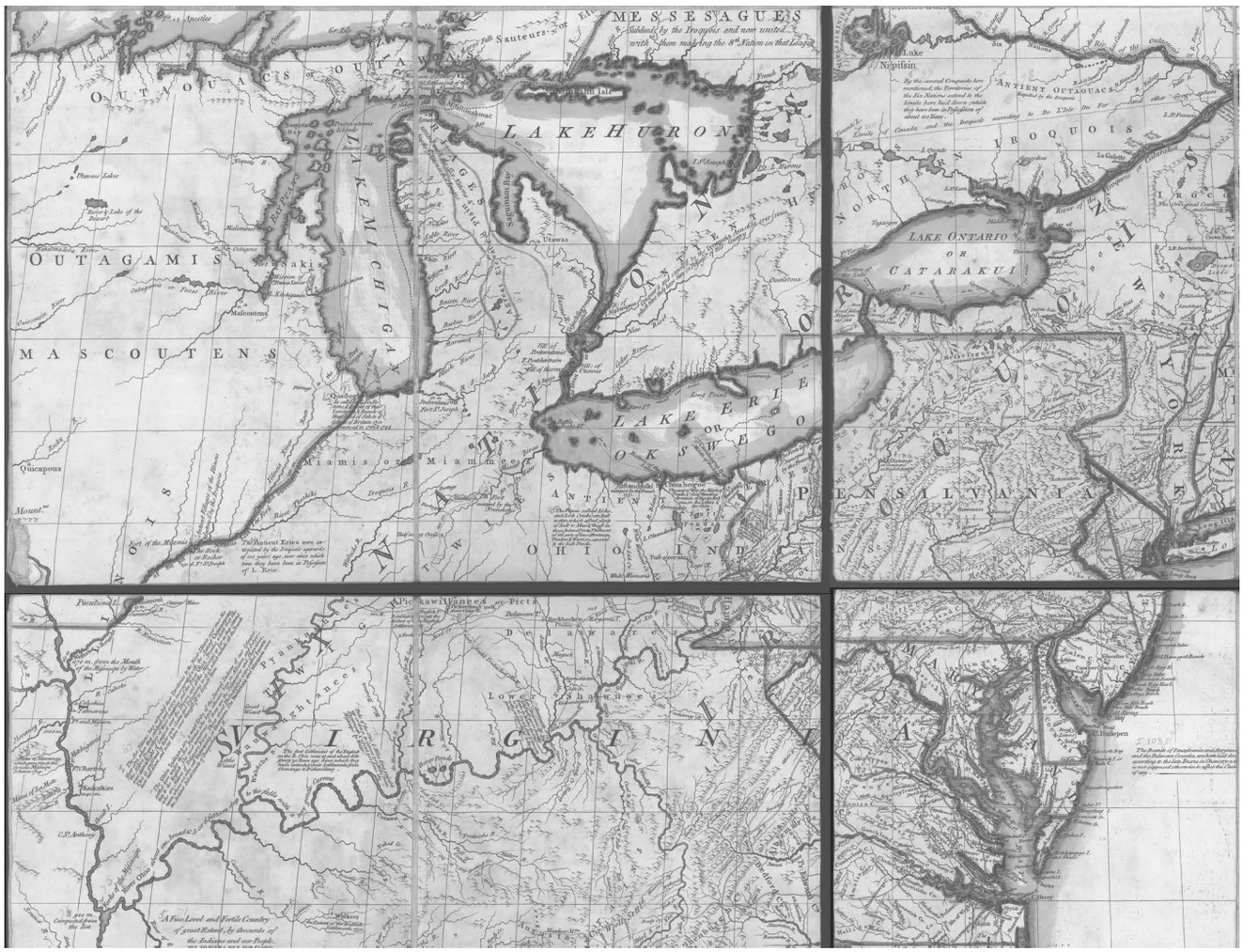

Figure 4a. Detail of the area of Lake Ontario and of political boundaries from first variant. Courtesy of the Geography and Map Division, Library of Congress (G3300 1755 M5 Vault and G3300 1774 .M5 Vault). (see page 74 for color version)

both New York and New Jersey were also deleted. Faden was not, however, completely consistent in his alterations and corrections. The colony of Massachusetts Bay had long claimed all the territory reaching up to the St. Lawrence River, so Mitchell had depicted the New England/Nova Scotia line accordingly, in order to bolster British territorial arguments before the war; although the colony's claim was negated by both the 1763 proclamation and the 1774 act, Faden did not update the map by engraving Canada's newly affirmed boundary running to the south of the St. Lawrence.

The new boundaries established between New England, Nova Scotia, and Canada were, however, properly delineated by the color applied to the map. Faden seems to have imposed a standardized color scheme onto the map, or at least onto those impressions that were sold colored. Referring to an impression of the sixth variant owned by John Jay that was used in the Anglo-American treaty negotiations in Paris in 1782, the early nineteenth-century U.S. statesman Albert Gallatin described this color scheme as follows: "Nova Scotia is designated by a red border, the ground not being colored. New England is colored yellow, New York blue, &c., and Canada green." Gallatin further noted that the green for Canada reached south past the Great Lakes all the way to the confluence of the Ohio and Mississippi rivers (see Figure 4b), depicting Canada in accordance with its

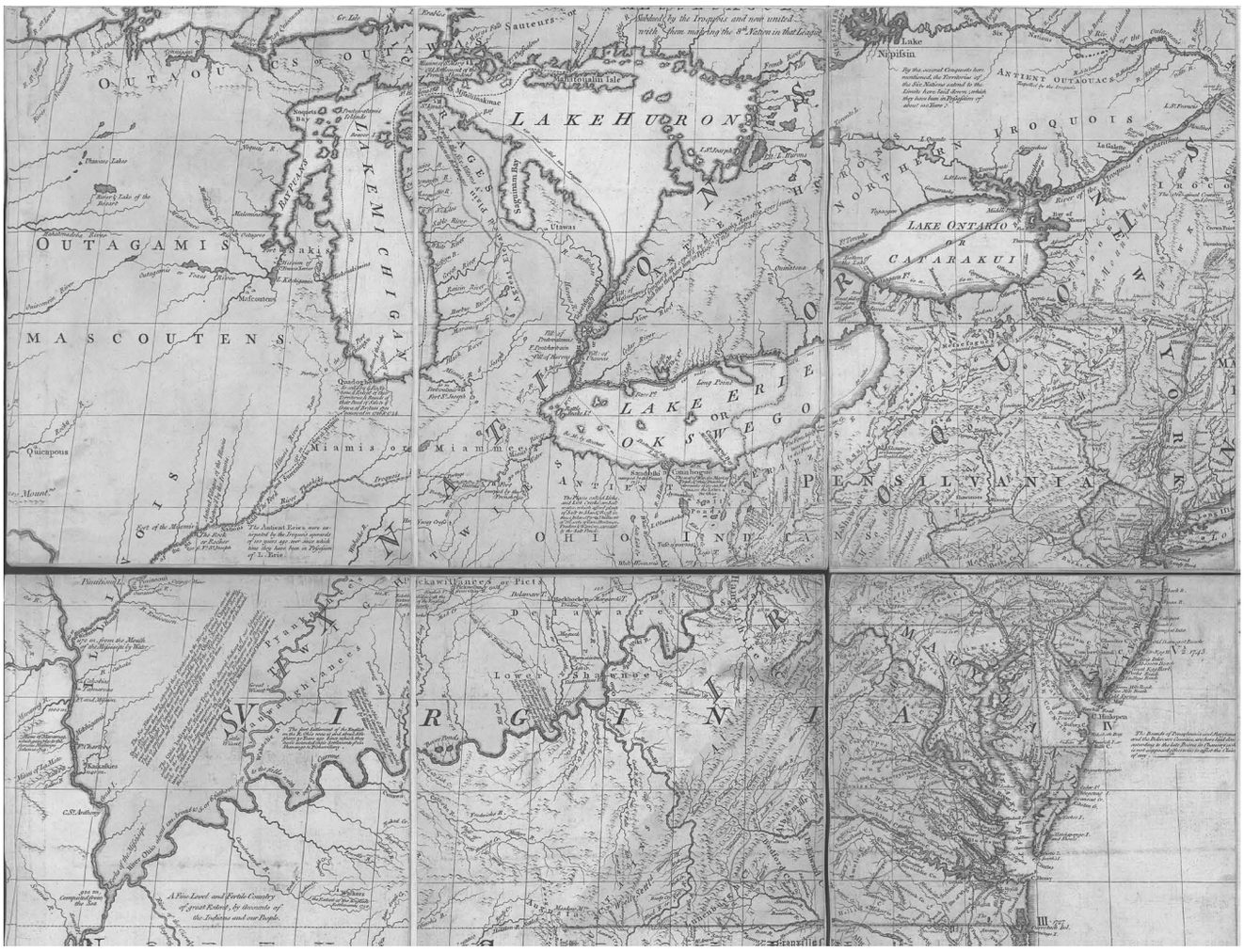

Figure 4b. Detail of the area of Lake Ontario and of political boundaries from sixth variant. Courtesy of the Geography and Map Division, Library of Congress (G3300 1755 M5 Vault and G3300 1774 .M5 Vault). (see page 75 for color version)

boundaries as set by the Québec Act (Gallatin and Webster 1843, 20).[11]

Thereafter Faden brought out a seventh variant, marked solely by an alteration to the map's title. He re-engraved the line in the title reading "British and French Dominions" to read just "British Colonies." The new title was thus, *A Map of the British Colonies in North America*. This change clearly recognized that France no longer had a significant colonial presence in North America and so reflected the culmination of British assertions of imperial power in the continent, especially at a time of increasing civil unrest within the British colonies. It is significant that the seventh variant had no alterations to its geographical detail: the only change is in the title. Moreover, impressions of this variant in original color adhere to the same general color scheme as colored impressions of the fifth and sixth variants (reproduced by Goss 1990, 130; Edney 1997). I should note that I have yet to see sufficient copies of these later variants to be able to say, with any confidence, whether the slight variations in color indicate distinct issues of the map.[12] Indeed, it is evident that Faden made this final alteration in 1775, shortly after producing the fifth and sixth variants: in his 1778 catalog, he identified the map as "A Map of the British Colonies in North America . . . on 8 sheets, 1775, Mitchell" Stephenson (1972, 109-13).

The overall implication is that these three variants of the map represent small alterations made during the course of a single publication event, which can be dated to between later 1774 and earlier 1775, before Faden ceased publishing as "Jefferys and Faden." If so, it makes sense to consider all three variants as being produced to meet the growing interest of the Britain public in North America because of the rising colonial unrest. We can presume that Faden kept the map in print, as the American Revolution developed, but we cannot presume that it was one of his best sellers.

CONCLUSIONS

John Mitchell's map of North America was a large work. It was costly to prepare and print, and it was made for those members of London's elites who were interested in geography and who could afford to spend a guinea or more on it. It seems to have been in print only sporadically, and then only when the London public turned its attention to the affairs of North America. We cannot presume that it was kept in print continuously, although an active second-hand market did make it available should someone want such a map when it was out of print. We certainly must cease to consider it as being solely of colonial interest, or as having its principal meaning in a colonial context. The patterns of its production and consumption strongly indicate that it is more profitably understood within the context of the imperial conceptions held in Britain. It was part of Europe's ironic discourses of imperialism, in which Europeans discussed and created concepts of their imperial territories with little actual regard for those territories or their inhabitants (see Edney 2008b).

"John Mitchell's map of North America was a large work. It was costly to prepare and print, and it was made for those members of London's elites who were interested in geography and who could afford to spend a guinea or more on it. It seems to have been in print only sporadically, and then only when the London public turned its attention to the affairs of North America."

This essay accordingly suggests that some of the concepts underlying traditional approaches to the history of cartography need to be extensively and actively rethought. In particular, we must organize our historical narratives and cartobibliographies around not the regions and places mapped, but rather the contexts within which maps were made and used (Edney 2008c). After all, the goal of the "new history of cartography" championed by the late Brian Harley and David Woodward, among others, is to situate maps within their appropriate contexts of making and usage. In this way, we can be clear about colonial maps of colonies, imperial maps of empires, and their contingent intersections. We can then see how imperial-era maps were selectively appropriated to serve as nationalist and anti-colonial icons. And we can see with precision how maps were

deployed as tools of state authorities, or as instruments of resistance. Most importantly, in this way, maps cease to be understood as reflections of the societies and cultures that produced them, but can be clearly seen as contributing to the constitution of those societies and cultures.

Appendix: Cartobibliographical Information

Cartobibliographical analyses of Mitchell's map have fallen into two groups. First, Benjamin Franklin Stevens (ca. 1897) and then the Library of Congress's Lawrence Martin, working in the later 1920s (Martin 1927, nos. 102-8; Martin and Egli 1929, nos. 92-99; Martin and Egli 1930, nos. 77-81; Martin 1933; Martin 1944), were both motivated by the use made of the map at the Treaty of Paris and subsequent international and interstate boundary negotiations and litigation. Second, Emerson Fite and Archibald Freeman, who discussed the map on the occasion of both its first publication and the use of the final variant by British negotiators in Paris (Fite & Freeman 1926, nos. 47 and 74), and the dealers Henry Stevens and Roland Tree (1951) featured the map in their analyses of the progressive growth of geographical knowledge about North America. Stevens and Tree's work rested on notes first made in the 1880s and their classification scheme had probably been developed well before the 1920s.[13] Unfortunately, these schemes have not agreed on terminology or the precise identification of variants according to the changes made to the printing plates. Martin's work is definitive and has been repeated in subsequent publications of the Library of Congress (Stephenson 1972; Sellers and Van Ee 1981, nos. 37-53). The schemas are related as follows:

	Mitchell	**B.F. Stevens**	**Stevens & Tree**	**Fite & Freeman**	**Martin**
Variant 1	[1st edition]	collation A	1st edition 1st issue	1st edition	1st edition 1st impression
Variant 2			1st edition 2nd issue		1st edition 2nd impression
Variant 3					1st edition 3rd impression
Variant 4	2nd edition	collation B	2nd edition		2nd edition
---			3rd edition[14]		
Variant 5		collation C		2nd edition[15]	3rd edition 1st impression
Variant 6		collation D	4th edition		3rd edition 2nd impression
Variant 7		collation E	5th edition	2nd edition	4th edition

The proliferation of terms that is evident here requires comment. These uses of "edition," "impression," and "issue" do not follow the strict terms developed by bibliographers; rather they rely more colloquially on "edition" as a somehow separate thing; as this essay argues, this is inappropriate. "Impression" is also a problem in that it can mean both a set of printed materials produced in an act of printing (as in bibliographical usage) and the print/map produced by a single pull on a printing press

(as in art historical usage); in a late essay, Tanselle (1982, 9-10) suggested that we restrict "impression" to the second meaning and use "printing" instead for the bibliographical set.

In a system advanced by Coolie Verner (1974), it has become common to refer to versions of maps in terms of the "state" of the printing plate and therefore of impressions pulled from that plate. But this terminology is not easily applied to a multi-sheet map such as Mitchell's. We would have to make a matrix of the states of each plate, along the lines of:

	States of each plate, 1 thru 8
variant 1	1 – 1 – 1 – 1 – 1 – 1 – 1 – 1
variant 2	1 – 1 – 1 – 1 – 1 – 1 – 1 – 2
variant 3	1 – 1 – 2 – 1 – 1 – 1 – 1 – 2
variant 4	1 – 1 – 3 – 2 – 1 – 2 – 2 – 3
variant 5	1 – 2 – 4 – 2 – 1 – 2 – 2 – 4
variant 6	1 – 3 – 5 – 2 – 1 – 2 – 3 – 4
variant 7	1 – 3 – 5 – 2 – 1 – 2 – 3 – 5

Note that the values in this matrix are defined by the usual criteria discussed about each variant of the map and are not based upon a detailed search for each and every content change in the interior of the map, so I cannot vouch for the accuracy of this table.

But drawing on Tanselle's (1982) and Cook's (1989) argument that we can, and should, apply the concepts of bibliographers to maps, then it is possible to describe in *preliminary* terms the several variants in terms of the hierarchy of edition—printing—issue—state (see also Karrow 1985, 4; Edney 2008c). All of the map's variants constitute a single edition, because they were all created from a single printing surface, or set of surfaces. It is the French, Dutch, and Italian derivatives of Mitchell's map (detailed by Stephenson 1972) that formed distinct editions. According to the information adduced in the body of this essay, the variants likely formed three printings (the act of taking copies from a printing surface, or set of surfaces)—variants 1-3 in 1755, variant 4 in ca.1757, and variants 5-7 in 1774-1775—defined by several states (marked by alterations to the printing surface[s]). It is probable that there were distinct issues within each printing of the map (acts of publishing printed copies), but the evidence to determine these remains unclear.

1st [i.e., English] Edition

1st Printing (1755)

1st State [variant 1]

[title] A Map of the | British and French Dominions in | North America | with the | Roads, Distances, Limits, and Extent of the | Settlements, | Humbly Inscribed to the Right Honourable | The Earl of Halifax, | And the other Right Honourable | The Lords Commissioners for Trade & Plantations, | By their Lordships | Most Obliged, | and very humble Servant | Jn^{o}. Mitchell.
[inside bottom margin] Tho: Kitchin Sculp. Clerkenwell Green.
[outside bottom margin] Publish'd by the Author Feb^{ry}. 13th. 1755 according to Act of Parliament, and Sold by And: Miller opposite Katherine Street in the Strand.

2nd State [variant 2]

[title: as 1st state]
[inside bottom margin: as 1st state]
[outside bottom margin] Publish'd by the Author Febry. 13th. 1755 according to Act of Parliament, and Sold by And: Millar opposite Katharine Street in the Strand.

3rd State [variant 3]

[title: as 1st state]
[inside bottom margin: as 1st state]
[outside bottom margin: as 2nd state]
One minor change of content: one of the two towns labeled Leicester in Massachusetts Bay is now properly labeled as Worcester.

2nd Printing ([1757])

1st (and only) State [variant 4]

[title: as 1st printing, 1st state]
[inside bottom margin: as 1st printing, 1st state]
[outside bottom margin: as 1st printing, 2nd state]
Significant changes to sheet 7, with the addition of two large text blocks in the middle of the Atlantic Ocean, in the seventh sheet. (The two scale bars in the Atlantic on the first edition were re-engraved — as four bars — above the cartouche on sheet 8.) Observations of magnetic variations are added along the Atlantic coast, labeled with Roman numerals. Finally, Mitchell redrew the northeastern coast because he redefined the positions of two key headlands: Cape Race was shifted in latitude from 46°55′ to 46°35′; Cape Sable was shifted in longitude from 66°35′ to 65°35′. A Maine-related detail: "Sagadahook" was respelled "Sagadahock."

3rd Printing (1774-1775)

1st State [variant 5]

[title: as 1st printing, 1st state]
[inside bottom margin 1] Tho: Kitchen Sculp.
[inside bottom margin 2] Printed for Jefferys and Faden Geographers to the King at the Corner of St. Martins Lane Charing Cross London
[outside bottom margin] Publish'd by the Author Febry 13th 1755 according to Act of Parliament
There are also some changes in the content in the interior around the Great Lakes, with some boundaries being altered and new place-names added.

2nd State [variant 6]

[title: as 1st printing, 1st state]
[inside bottom margin 1: as 3rd printing, 1st state]
[inside bottom margin 2: as 3rd printing, 1st state]
[outside bottom margin: as 3rd printing, 1st state]
Numerous content changes include the deletion from sheet 3 of the straight line labeled as the boundary between Canada and the Iroquois

(running roughly east-west, north of Lake Ontario) and the addition of a straight-line boundary through Lake Ontario.

3rd State [variant 7]

[title] A Map of the | British Colonies in | North America | with the | Roads, Distances, Limits, and Extent of the | Settlements, | Humbly Inscribed to the Right Honourable | The Earl of Halifax, | And the other Right Honourable | The Lords Commissioners for Trade & Plantations, | By their Lordships | Most Obliged, | and very humble Servant | Jn°. Mitchell.
[inside bottom margin 1: as 3rd printing, 1st state]
[inside bottom margin 2: as 3rd printing, 1st state]
[outside bottom margin] as 3rd printing, 1st state]

AUTHOR'S NOTE AND ACKNOWLEDGMENTS

Matthew Edney is Osher Professor in the History of Cartography, University of Southern Maine, and Director, History of Cartography Project, University of Wisconsin–Madison. He is thankful to Joel Kovarsky for useful comments on an early draft. Portions of this essay were originally presented in his "The Mitchell Map: An Irony of Empire," http://www.usm.maine.edu/maps/mitchell, created April 1997; an earlier version of this essay appeared in *Varia História* 32 (June 2007), published by the Department of History, Universidad Federale Minas Gerais, Brazil.

NOTES

1. See Stevens' correspondence preserved in "Collected Copies of Correspondence and Other Memoranda Relating to Col. Lawrence Martin's Studies of the Mitchell Maps, ca.1925-35," National Archives Records Administration, Record Group 76, Records Relating to International Boundaries, Cartographic Series 28. On Stevens' historical interests and manuscript collecting, see Griffin (1946).

2. High-resolution scans of the seven British variants of Mitchell's map are freely available at the Library of Congress's "American Memory Network" «memory.loc.gov/ammem/gmdhtml/gmdhome.html». Browse in the "Creator Index" for "Mitchell, John, 1711-1768." Reference should be made to this resource to consult particular details of the map.

3. One pound sterling (£ or *l*) contained twenty shillings (*s*), each shilling containing 12 pennies (*d*); £1/11/6 therefore indicates one pound, eleven shillings, and six pennies. The guinea was the gold coin then in circulation in Britain, valued at one pound, one shilling (or £1/1).

4. E.g., the sheets of U.S. National Archives, Record Group 76, Cartographic Series 27, Map 3 (Goggin 1968, no. 18), were dissected into twenty sections and mounted separately; small leather tags on the back of the sheets indicate that they were once all folded and placed into a small case, the tags being used to pull out particular sheets from the tight mass.

5. The three copies of the map in George III's collections — British Library K.Top.118.49.a–c — are all assembled, as if for hanging on walls, but they were probably stored as rolls: 'a' shows extensive creasing and damage (now repaired) suggesting that it had once been squashed when kept rolled up; 'b' was actually assembled from sheets that were originally dissected into quarters and well-used in that format before eventually being assembled for the king; 'c' was assembled from sheets that had originally been separately bound into an atlas.

6. Full-colour maps examined are Colonial Williamsburg (variant 3), as reproduced by Pritchard (2002, 169); Library of Congress G3300 1755 .M51 Vault Shelf (variant 2); British Library maps K.Top.118.49.a (variant 3), reproduced by Goss (1990, 130), which was overlain *c.*1774 by some other colour patches; Newberry Library Ayer *133 M66 1755 (variant 3); and Bibliothèque Nationale Française Ge DD 2987 (variant 3). Outline-colour maps examined are British Library maps C.27.f.9 and K.Top.118.49.c (both variant 1); New York Historical Society X3.3.30 (map 9508) (variant 1) and L4.4.18 (map 8616) (variant 3); and Library of Congress G3300 1755 .M5 Vault Shelf (variant 1) and G3300 1755 .M53 Vault (variant 3). There remains the possibility that color was applied by a later hand, as in the impression of variant 1 held by the Hungarian National Library, which was given outline color in a quite inappropriate, vibrant blue-green.

7. Carman (1939, xxxix-lxi) refuted Carrier's (1918) argument that Mitchell had himself written this anonymous work.

8. The particular impression examined — British Library maps CC.5.a.242 — is marked up as an index to the larger Mitchell map.

9. Ayer *133 M66 1755, Newberry Library, Chicago.

10. It should be noted, however, that Payne (1768, 1769a, and 1769b) advertised the same two impressions of Mitchell's map; a third impression listed by Payne (1768, 31) did not reappear in the later catalogues.

11. This map is New York Historical Society M32.2.1a (map 11051). The same coloring is found on an impression of the sixth variant in the U.S. National Archives Record Group 76, Cartographic Series 27, Map 3 (Goggin 1968, no. 18).

12. I have examined the following copies. Variant 5: BL maps CC.5.a.270 (full color, w/ 1763 and 1774 boundaries for Québec); LC G3300 1773 .M5 Vault (outline). Variant 6: New York Historical Society M32.2.1a (map 11051) and LC G3300 1774 .M5 Vault (both full color, with only 1774 boundaries). Variant 7: BL maps C.11.b.17 (outline color); BL maps K.Top.118.49.b (full color, with more color applied later, showing 1765 and 1774 boundaries, but the 1765 could have been added later); LC G3300 1775 .M5 Vault (late color); and Osher Map Library OS-1755-1 (full color, 1774 boundary only, but this might have been applied late).

13. Stevens and Tree's classification had certainly been worked out by 1930, when a catalogue (Henry Stevens, Son & Stiles, ca. 1930, no. 310) listed a putative "third edition" of the map, and probably had been worked out by Henry Stevens's grandfather and father, both prominent antiquarian dealers in their own right. Note also that Stevens and Tree (1951) paid attention only to map titles, imprints, and gross geographical changes and so did not notice variant 3.

14. Stevens and Tree (1951, no. 54) specified the existence of a "third edition" with the imprint "Publish'd by the Author, Feb. 13th, 1755. Printed by Jefferys and Faden, St. Martin's Lane, Charing Cross, London." Yet this imprint lacked the copyright formula ("according to Act of Parliament") found on all other variants of the map. Significantly, Stevens and Tree did not record variant 5; conversely, neither B. F. Stevens nor Lawrence Martin recorded Stevens and Tree's "third edition." That is, I am unconvinced

that such a state ever existed; I suggest instead that it was the result of an incorrect transcription of variant 5. Stevens and Tree's mistake has been recently repeated by McCorkle (2001, no. 755.31), who further confused the "third edition" with variant 4.

15. Fite and Freeman (1926, 182 and 290-91) were rather confused as to the meaning of "second edition" when they variously noted that it was marked by the change in imprint to Jefferys and Faden but also by the retitling of the map.

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The Role of Color Saturation in Maps for Children

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Bright, saturated colors are very common on maps for children, especially maps in grade-school textbooks. This is despite the tendency of professional cartographers to use highly saturated colors sparingly in much of their work. This research seeks to determine if highly saturated colors are necessary for children to understand a map's content and if children prefer highly saturated colors. Two hundred forty two fourth and fifth grade students were tested for both performance and preference on land use and time flow maps. Saturation's effect on performance appeared to be largely negligible, however the students, both male and female, strongly preferred the maps that were highly saturated.

Keywords: color, saturation, children's maps

INTRODUCTION

Do children understand maps in the same way that adults do? It has been postulated that they both perceive the map and interpret the data differently than adults (Bartz 1965; Sorrell 1978; Gerber 1984). These alleged differences have led many publishers and cartographers to create maps for children that are different from those for adults. For example the subdued, de-saturated colors and fine line-work in a National Geographic Atlas (Figure 1) contrast with the bright, saturated colors and bold line-work found in elementary textbooks (Figure 2). This paper investigates the effect that color saturation has on both performance and preference in the reading of maps by children.

This research specifically seeks to answer the question *do maps for children need fully saturated, "bright" colors*? Human subjects research was performed to answer the question. Our goal was to provide empirical guidance to both mapping companies and publishing houses on how to choose colors when producing maps for children. Very little research has been directed at children's understanding of color. What research has been done in this area has occurred in the realm of reference map design for children (Bartz 1965; Sorrell 1978). While reference maps are important to children's understanding of geography, it is (as we will show) thematic maps that are predominantly used in scientific and social studies classes. Currently, color choice for thematic maps in textbooks appears to be based on a mix of artistic decision and a belief of what is "childlike," not on any formal study. Thus, most of the maps found in textbooks for children use highly saturated colors, which may or may not be necessary for children's understanding of maps. Although Sorrell's (1978) "rules" for creating children's maps recommend the use of strongly saturated colors—rules that have reached a wide audience via Borden Dent's introductory textbook (Dent 1999)—these guidelines have not been validated with testing, calling into question the widespread their application.

"Currently, color choice for thematic maps in textbooks appears to be based on a mix of artistic decision and a belief of what is "childlike," not on any formal study."

While the focus of this paper is to report on a map-reading experiment with 242 fourth- and fifth-graders, We will first present (1) a synthesis of

Initial submission, December 11, 2006; revised submission, March 30, 2007; final acceptance, April 1, 2007

relevant color research in order to frame this project and show the gaps within that literature this project was designed to fill, and (2) a survey of the maps found in the textbooks of the five major scholastic publishers to characterize how color (and specifically, saturation) is currently used on maps for children.

Cartographic Studies in Color and Color Perception

The study of color on maps has a long history in cartographic research and is one of the most studied aspects of map design (Robinson 1952; Jenks and Knos 1961; Crawford 1971; Kimerling 1980; Olson 1981; Imhof 1982; MacEachren 1995; Dent 1999; Brewer et al. 2003). Robinson's pioneering work "The Look of Maps" (1952), devoted two chapters to color (out of a seven chapter book) and discussed color through the lens of physics, psychology, and cartography. His discussions of how to choose color for a map are still relevant today, as are his claims that color is governed by "sensation, not arithmetic formulae."(Robinson 1952). One of Robinson's students, Jon Kimerling (1980), investigated perceptual aspects of color that generated useful print rules: He found that due to the small reflectance of yellow, only two to three yellow tints could be discerned reliably on a map, in contrast to as many as six shades of black and four to five shades of both magenta and blue.

Imhof (1982) discussed the psychological theories of color, along with the physiological and chemical theories of color and how they relate to cartography in his book "Cartographic Relief Presentation." Imhof also produced a set of empirical rules that he felt were applicable to map design. In putting forth these rules, Imhof stated that "bright or very strong colors have loud, unbearable effects (Imhof 1982)." He further states that bright colors should not be used on large areas of a map. This advice sits in stark contrast to the use of these colors on children's maps.

"The study of color on maps has a long history in cartographic research and is one of the most studied aspects of map design."

Patton and Slocum analyzed the differences between utilitarian use of color (using color to convey information that would not be transmitted if color were removed) and aesthetic use of color (Patton and Slocum 1985). They found that when using color aesthetically, it did not significantly affect reader's ability to recall spatial patterns. However, they cite Mersey (1984) who said that using color for utilitarian purposes does enhance pattern memory in certain cases. Both of these findings are informative as we are testing both the utilitarian and aesthetic aspects of color. Patton and Slocum also indicated that there were no significant differences in performance between males and females during their study.

Brewer's significant body of work on color (Brewer 1989; Brewer 1992; Brewer 1994; Brewer 1996; Brewer 1997a; Brewer et al. 1997; Brewer 1997b; MacEachren et al. 1998; Brewer 2003; Brewer et al 2003) has touched a wide range of topics, including the use of spectral color schemes, guidance for diverging color schemes, the effects of simultaneous contrast on maps, color selection to aid the color-impaired and a tool to select good colors for mapping. Further, Brewer has looked outside of cartography and brought ideas from other fields into our discipline: The ideas of color psychology research from Sivik, Granger, McManus and others (Granger 1955; McManus et al. 1981; Boynton 1989; Sivik and Hard 1994) have been used by Brewer to identify colors that will not be confused and to identify colors that are most readily named (Brewer 1996; Brewer et al. 1997). In particular, McManus et al (1981) found blue was the most preferred color while yellow the least preferred, and noted that preference does not change during the course of an experiment.

Brewer's body of work provides cartographers with a grounded and

empirically validated physiological basis for the color use. For example, Brewer et al. (1997) point out that we should select colors that can be readily identified, with hue preference as a secondary design concern, while Olson and Brewer (1997) outline how to avoid problem color schemes for color-impaired individuals and found that the maps aesthetics were not affected by the use of these colors.

Brewer has found more recently that a "smooth trajectory through color space perfected logical relationships but had a negative impact on identification of map polygons (Harrower and Brewer 2003; Brewer et al 2003)". She hypothesized that some "jitter" among the movement through color space would better suit the goals of the map (Brewer et al 2003) because it seems to make the colors more legible to the map reader. Brewer found this jitter effect both in the qualitative and sequential schemes she created for ColorBrewer (Brewer et al 2003). This hypothesis will be worth considering as we attempt to ascertain the reasons for performance variance in the discussion section of this paper.

"The area that has been largely absent from cartographic color research has been the use of qualitative colors."

The area that has been largely absent from cartographic color research has been the use of qualitative colors. Much has been made of diverging and sequential color schemes and their use on maps, but far less mention has been made about the proper use of qualitative colors. Our literature review discovered no research focused on qualitative color schemes. Vast number of maps, such as those of climate zones, land-cover, and political areas, depict nominal data distinctions.

Color Research on Children's Maps

While various aspects of children's mapping have been researched for the past 40 years, it is the work of Bartz (1965) and Sorrell (1978) that have had the greatest impact, with others continuing this work more recently.

Bartz addressed the use of color in hypsometric tinting, legend design, and qualitative versus quantitative differences on maps in her seminal work "Map Design for Children" (Bartz 1965). However, Bartz did not address the problem of choosing appropriate colors for use on children's maps. She pointed out that colors that illustrate qualitative change, such as land cover differences, is easily accepted by children, a point that is highly relevant to the research undertaken here. Bartz focused exclusively on reference mapping and basic map reading tasks in her research rather than the thematic maps that so often appear in children's textbooks today. Bartz (1971) points out that while research on color sounds useful, much of it is "virtually worthless in the real choices that must be made as maps are produced." Given the fact that color research was both difficult and expensive at that time, it was reasonable to spend research time on other questions. However we respectfully disagree with this statement, especially given the current ease of color printing, and posit that color has a real, measurable, and understandable impact on the map-reading preferences and performance of children that can now be studied in depth.

". . . children are most interested in thematic maps about interesting subjects (e.g., sports, castles and battles) and reference maps about where they live. They are least interested in maps such as land use or climate, which tend to appear in every fourth- and fifth-grade textbook . . ."

By comparison, Sorrell's work focused on both preferred map types and color associations in children (Sorrell 1978). Sorrell's survey work established two unsurprising findings. First, he found that children are most interested in thematic maps about interesting subjects (e.g., sports, castles and battles) and reference maps about where they live. They are least interested in maps such as land use or climate, which tend to appear in every fourth- and fifth-grade textbook that we surveyed (next section). Secondly, Sorrell surveyed students about the colors they associate with various landforms. The majority of children appear to make associations such as blue for water, yellow for deserts, and green for forests (which

are no doubt, at least in part, culturally proscribed). The lasting messages from Sorrell's work are:

- Children are only aware of the basic spectrum of colors.
- Children appear to reject fully saturated colors – one to two steps below full saturation should be used.
- Children dislike dull and unattractive colors, such as brown.
- Children tend to reject non-colors (e.g., gray).
- The greater the compatibility of the color with the expected, the greater the comprehension. (Sorrell 1978)

Unfortunately, the wording chosen by Sorrell is vague, which makes the suggestions difficult to apply objectively and consistently across maps. In discussing results of our study we will return to some of these suggestions, specifically, the comments about color compatibility and the rejection of fully saturated color.

". . . students as early as second grade should be exposed to quantitative thematic maps as this skill is within their ability level at that age."

More recently the work of Young (1994), Trifonoff (1995), and Michaelidou et al. (2004) has taken up the challenge of critically assessing the creation of children's maps. Young (1994) correctly points out the multitude of problems begetting textbook maps, including "inaccurate and repetitive maps, limited map types, and a scarcity of quantitative data." During the informal textbook survey we conducted below, we witnessed many of these concerns still present ten years after Young's critique.

Trifonoff's (1995) study focused on the use of quantitative data on maps: She argues that students as early as second grade should be exposed to quantitative thematic maps as this skill is within their ability level at that age. These findings are reinforced more recently by Michaelidou et al. (2004) who showed that students in Grade three had the ability to use thematic maps effectively even without prior experience, and stressed that thematic maps need to be used in third through sixth grade studies. Trifonoff (1995) also found during her study that children preferred color on the maps as opposed to grayscale and that they liked bright colors.

Review of Children's Textbooks

The number of publishers working on school textbooks has declined in recent years due to consolidation within the industry, leaving the publishing world with five major players: Scott Foresman, Houghton Mifflin, MacMillan McGraw-Hill, Harcourt and Pearson. These publishers had the majority of textbooks for fourth- and fifth-grade science classes available at the Madison Metropolitan School District's Textbook Library.

". . . the demand for bright colors originates in most cases from the publishers themselves who assume that children will be less interested in subtle color schemes."

Our informal survey of the popular textbooks yielded insights into the guidelines that publishers feel should be followed when producing maps for this age. Ten Social Studies textbooks were surveyed and they contained a total of 186 maps. These maps were broadly categorized as bright (saturated) or non-bright (de-saturated), similar to the characterizations of Figures 1 and 2. While this was obviously a subjective exercise, it nonetheless gave a general sense of current publishing practices. We found that roughly three quarters of the maps had only bright colors, or were dominated by bright colors.

To confirm these findings, we spoke with professional cartographers who routinely make maps for textbook publishers. These cartographers said it is usually assumed less saturated colors on maps are appropriate for a mature reader and bright colors are appropriate for children's maps. They also commented that the demand for bright colors originates in most cases from the publishers themselves who assume that children will be less interested in subtle color schemes.

Methodology

As an assessment of the use of saturation on children's maps, the objectives of this study are to determine if saturated colors aid children's *performance* in map interpretation, and to discover if children *prefer* saturated colors to de-saturated colors.

The two major research hypotheses are: Children will perform significantly better on maps with saturated colors. Children will prefer the more saturated colors and reject the less de-saturated colors. These hypotheses seem reasonable given (1) Brewer's findings that map readers tend to perform best on the color schemes with high contrasts, (2) Sorrell's suggestions that indicate that children will perform better with brighter colors, and (3) the color choices of the major publishing companies.

To test these hypotheses, two sets of data were gathered in a controlled test environment. Responses, correct or incorrect, to substantive questions were observed, and the children ranked the color schemes according to preference. Collection of both of these data sets will be explained in detail below.

The Maps

". . . the objectives of this study are to determine if saturated colors aid children's performance *in map interpretation, and to discover if children* prefer *saturated colors to de-saturated colors."*

Eighteen paper maps were created for use in testing (e.g., Figures 3 and 4). Of these 18, six were land use maps and twelve were time-flow maps. The land cover maps depicted regions of France while the time-flow maps were based on battle maps of the Napoleonic Wars. Land use and time-flow maps were selected because they are the very common in Social Studies textbooks.

France was chosen as the area for the land use maps to reduce the students' familiarity with the base map, but to retain a large geographic footprint similar to what appears in elementary school textbooks. To minimize pre-existing knowledge of the base map further, the geographic area was rotated at various angles for each map. These choices helped eliminate prior knowledge as a performance factor. Fictitious provinces were used and test points were randomly placed on each map to ensure that no memorization occurred during the study. Each test point and province was identified by a letter (A-K). Eleven provinces appear on each land use map. Three test points (A-C) were placed on each map.

The time-flow maps were created using historical battle maps from the Napoleonic Wars as shown in the *Times Atlas of Military History* (Brooks 2000). Two battles from 1806 were selected. The troop movements were traced and simplified. Ancillary data such as rivers and borders were added to the map to simulate common textbook maps. The large-scale nature of these maps required no attempts to reduce familiarity, as the battles are not commonly studied at these grade levels.

Map Color

Both the time-flow map series and the land-use map series featured qualitative, or categorical, color schemes with colors varying primarily by hue rather than by saturation and lightness. The color schemes were designed so that two sets of comparisons would be made. First, differences in performance would be analyzed across color sets, and second, differences in performance would be analyzed for the saturation levels in the color sets.

Six color schemes, broken into two color sets, were represented in total, each appearing on one map in the land use series and two maps in the time-flow series. Figure 5 shows the six color schemes, broken into

color (test) sets A and B. Each color scheme is further identified by the saturation level of the scheme. For the remainder of this paper these color schemes will be abbreviated by the set letter and the saturation level (e.g. AH for set A, high saturation). Color sets A and B were both designed following the same procedure. The initial hue, lightness and saturation values were derived from Cindy Brewer's ColorBrewer resource (www.colorbrewer.com) using her qualitative color schemes Set 1 and Dark 1. These two schemes were chosen because both have been perceptually tested and found to be usable by color- impaired map users.

The Survey

The two sets of maps were tested on children from the target age group of nine to eleven years old. The children's school was chosen based on prior contacts and an attempt to produce a representative sample of students. All of the subjects viewed six of the twelve maps and all of the chosen color schemes.

Subjects

Two hundred forty two fourth and fifth graders from the Mount Horeb (Wisconsin) Area School District participated in this study. Participation of the students required consent from parents or guardians. Both the subject and parents were given the opportunity to opt out of the testing both before and during the testing project.

The testing occurred within the school setting and during the course of the normal school day. An entire class was tested at one time with each subject receiving a different series and order of maps than the neighboring child to reduce the likelihood of copying answers. This followed a typical school test environment. No conversations were allowed with other students; rather, each student worked independently. No compensation was provided to the participants.

"The two sets of maps were tested on children from the target age group of nine to eleven years old."

Training Session

Before beginning the experiment a short training session was conducted. The students were provided with a sample map containing data and questions similar to the actual survey materials. The students were then verbally led through the map, with all of the elements including legend, compass rose, and classification scheme explained. The students answered sample questions together and the answers were discussed to train the students on how to complete the requested tasks. Support was provided during this time by both the researcher and the classroom teacher to ensure that each student was comfortable with both the question type and with reading the maps before beginning the experiment. The large number of participants (n = 242) was expected to create a realistic spread of classroom abilities, and no one subject could overly influence results.

Questions

The questionnaire was created based on observed questions from existing textbooks at fourth- and fifth-grade level. Each subject was asked a series of five questions per map that required "on-the-fly" map interpretation and a written short-answer. The students each had copies of the maps in front of them while they answered the questions. The short answer format

was used to reduce the likelihood of "lucky guesses" that occur in multiple choice testing. Each question required the subject to interpret and extract information about the land cover either at a given point or within a given area, from the map. The subjects were instructed not to guess, but instead to leave the question blank if they did not or could not determine the answer.

The subjects also were asked to express their color-scheme preferences at the end of the survey. Each subject was presented with all six of the color schemes using a legend-like set of colored boxes (Figure 5) and asked to rank the schemes from one to six with one being the most preferred scheme and six being the least preferred scheme. This color preference rank information was collected, in part, to determine if any correlation exists between performance and preference.

Students were also asked four demographic questions: age, grade level, gender and if they used eyeglasses for any reason. They also completed a six-question Ishihara test for color vision deficiency.

Results and Analysis

"Each subject was presented with all six of the color schemes using a legend-like set of colored boxes and asked to rank the schemes from one to six with one being the most preferred scheme and six being the least preferred scheme. This color preference rank information was collected, in part, to determine if any correlation exists between performance and preference."

When analyzing the results, the two basic research questions were expanded as follows:

Does saturation affect the student's performance when answering questions? When answering this question, the possible influence of question type, map type, gender and saturation preference of the participant were explored.

Do children overall prefer highly saturated colors when using a map, or are there gender differences in preference?

ANOVA (analysis of variance) tests were generated that addressed the following questions:

- does map color (hue, brightness and saturation) affect performance on each land use question type?
- does the color scheme affect performance on time-flow maps?
- does the saturation affect performance?
- does gender affect performance at varying levels of saturation?
- does color preference affect performance at varying levels of saturation?

For each test, the performance data were aggregated by percentage. This violates the ANOVA requirement that data are free to vary about the mean. Therefore the data were subjected to the arcsine transformation required of percentage data in an ANOVA test to produce a "normal" sample.

One-way and multiple-way analysis of variance tests were used to answer the research questions. Each test addressed the affect of one or more independent variables (hue-brightness, saturation, gender and preference) on performance (percent score by questions or by individual subject?). The null hypothesis in each case was that the independent variables had no affect on performance.

Before performing any of the statistical tests it was important to determine how to handle answers left blank during the study. ANOVA statistics were run both removing blanks from the analysis, as well as counting blank answers as incorrect. In both cases the statistical significance/non-significance remained the same.

Performance on Substantive Questions

Land use Questions

Five questions were asked about each land use map. Two of the five questions asked the dominant land cover type in a given state area (Regional Questions). The other three asked the land cover type visible underneath a randomly placed test point (Test Point Questions). Table 1 shows the aggregated performance breakdown by color scheme for both types of land use questions. Earlier in this study, it was hypothesized that the lowest saturation color schemes would have the lowest performance numbers. At first glance the performance data for the land use maps does not bear this out. It is the highest saturation schemes that produced the fewest correct answers.

To determine if these differences were significant, two one-way ANOVA tests were run. In both tests, color is the independent variable with six groups (AH, AM, AL, BH, BM, BL). Map reading performance was the dependent variable, with each percent made up of an aggregate of the entire test set answers by student. The null hypothesis in each case was that the mean performance of all six groups would be equal ($N_0 = \mu_{AH} = \mu_{AM} = \mu_{AL} = \mu_{BH} = \mu_{BM} = \mu_{BL}$). The null hypothesis failed to be rejected at the 95% confidence interval for both the regional questions and the test point questions. Based on these results it appears that the effects of saturation on performance are negligible, and the differences observed could have occurred by chance.

". . . it was hypothesized that the lowest saturation color schemes would have the lowest performance numbers. At first glance the performance data for the land use maps does not bear this out. It is the highest saturation schemes that produced the fewest correct answers."

Table 1 shows that the questions about points on the map generated lower accuracy than the questions about regions.

For saturation, the null hypothesis expressed that saturation would not affect performance ($N_0 = \mu_H = \mu_M = \mu_L$). For both color schemes we failed to reject the null hypothesis, confirming what the descriptive statistics and the question by question ANOVA showed: saturation does not significantly affect performance. For color, the null hypothesis was the same as for saturation, that hue-brightness did not affect performance ($N_0 = \mu_A = \mu_B$). This null hypothesis was rejected, as the differences in performance were significant between the A and B color schemes. This result indicates that performance differences appeared in the test due to the overall hue-brightness combination more so than because of the saturation level. Table 2 details each of these three test results.

As a result of these ANOVA findings the Tukey's HSD (Honestly Significant difference) post-hoc test was run to determine where the color differences exist. This test indicated that the hue-brightness difference occurs between the A low set and the B high set. However, the overall mean difference between these two sets was small, at about 4.5%, which suggests that performance with color set A low is only slightly better than with set B high.

Time-Flow Questions

In contrast to the land use maps, the time-flow maps used four types of probes:

- which explorer traveled to the farthest point in one direction?
- what single explorer on the map crossed a river?
- determine the explorer that looped his path.
- determine the explorer that traveled through a village or town shown on the map.

Overall, the flow maps resulted in similar percentages for all saturation levels and color sets (Table 3). This is not unexpected considering that each map contains only three classes thereby reducing the number of colors to interpret, by half, of what is viewed on the land use maps.

An ANOVA test was performed to determine if the flow map performance differences were significant. This ANOVA used the subject percentages for each color scheme. The independent variable was again color while the dependant variable was performance. For the third time we failed to reject the null hypothesis. It can be concluded that for time-flow maps, as for land use maps, color and saturation have negligible effect on performance.

Gender

In total 124 girls (53.3% of the total sample) and 118 boys (46.7%) took part in the study. Gender differences were analyzed both for color and saturation performance differences. To accomplish this, a 2x3x2 ANOVA was designed. In this test the hue-brightness sets (Set A & Set B), saturation levels (High, Medium and Low) and gender were the independent variables f, and performance was the dependent variable. The null hypothesis for the main effect of gender was that the means for each gender would be identical ($N_0 = \mu_G = \mu_B$), i.e., there is no interaction between gender and saturation. The null hypothesis for the interaction effect of color and gender is again that no interaction would occur. Finally, the three-way interaction effect of color, saturation and gender again had a null hypothesis that no interaction would occur. All of the interaction effects failed to reject the null hypothesis, but the gender null hypothesis was rejected, indicating that the mean performance of the girls was significantly higher than the mean performance of the boys across all saturation levels.

"It can be concluded that for time-flow maps, as for land use maps, color and saturation have negligible effect on performance."

Color Preference

The initial research hypothesis about map preference was that the least saturated color schemes would be the most disliked schemes. This hypothesis appeared initially to be false. When asked, "what is your preferred color scheme" it was the middle saturation schemes that received the fewest votes, with high saturation being the overwhelming favorite. However, when asked about their *least* preferred color scheme, the low saturation one received the most votes (Table 4).

When the favorite choices were aggregated by color and saturation (Figure 6) it became apparent that the basic colors from scheme AH were the preferred hue-sat-brightness combination for a vast majority (57%) of subjects, receiving more votes than the other 5 color schemes combined. A chi-squared test proved that this difference in preference was statistically significant.

The final set of ANOVA tests analyzed whether saturation preference affected performance. In order to assess this it was important to restrict the analysis to within group interaction only, therefore three separate ANOVA tests were run, one for each level of saturation. For each ANOVA test, the null hypothesis was that the performance means for each saturation level would be equal ($N_0 = \mu_H = \mu_M = \mu_L$). The three tests were run for the saturation preference levels of High, Medium and Low. At each level the null hypothesis failed to be rejected, providing evidence that saturation preference has negligible effect on performance at varying saturation levels.

Would gender have any influence on preference? Initially, we thought that there might be some gender difference in terms of preference. But as

Figure 7 illustrates, there is little difference in preference by gender. The major difference is the preference for color schemes AH (Girls 65%-Boys 52%) and BL (Girls 6%-Boys 16%). The BL color schemes difference in preference by gender is not entirely surprising given the similarity in this color scheme to "camouflage," which may have been chosen due to a perceived match with their perception of land cover or just because these colors are "cool". Overall these differences in preference by gender are not very large and fully saturated colors, in particular those derived from basic colors, are overwhelmingly preferred by children of this age and grade level regardless of gender.

Out of 242 students participating, 13 showed signs of color vision impairment, of which 4 appeared to be severe impairment. Of these thirteen students twelve were male and one was female, or roughly 10% of the males were impaired and less than 1% of females. These numbers reflect the current estimates of color vision impairments in the general population (Olson and Brewer 1997).

". . . fully saturated colors, in particular those derived from basic colors, are overwhelmingly preferred by children of this age and grade level regardless of gender."

Jitter

One color element to be considered in explaining the preference for colors from Set A is jitter. Jitter is the variation in brightness across the Munsell color space. Overall, the jitter values were widely varying from roughly 4.5 in the Set A, High Saturation scheme to just about 1 in the Set B, Low Saturation Scheme. However, it was worth noting that the jitter for every saturation level in the B color set was either roughly equal or less than the smallest jitter scheme in the A color set, the AL scheme. Further, an analysis of Figure 8, which shows a graph of the jitter for each color scheme in Munsell color space, supports the formation of the earlier stated hypothesis that more saturated colors will be easier for the subjects to read.

CONCLUSIONS

Both the descriptive and inferential statistics support the conclusion that children do ***not need*** saturated colors on maps but that they ***prefer*** them. Overall this study provides the following conclusions:

- Highly saturated colors, especially the high saturation scheme from set A, were strongly favored over low saturation colors.
- Students performed better on color set A than color set B.
- Saturation had minimal impact on performance.
- Saturation had a big impact on preference.

While lack of performance difference was surprising, the clear preference for highly saturated colors seems to confirm the practice of using such colors on the majority of children's maps by textbook publishers. Both girls and boys preferred highly saturated colors and disliked the most de-saturated colors. While this appears to be counter to the previously stated opinion of Sorrell (Sorrell 1978) that children reject fully saturated colors in favor of those one to two steps down, in fact, it does not. The saturation level of the high sets were by no means as saturated as possible, and may have more closely resembled the "one to two steps below full saturation" that Sorrell describes.

"While lack of performance difference was surprising, the clear preference for highly saturated colors seems to confirm the practice of using such colors on the majority of children's maps by textbook publishers."

Revisiting Sorrell's suggestions, it is possible to compare the results of this study:

- Children are only aware of (and hence prefer) the basic spectrum of colors – *this appears to be upheld by the preference for the basic colors in color set AH, as well as the previous research by McManus et al. (1981).*
- Children dislike dull and unattractive colors, such as brown – *Low preference for the AL, AM, BL and BM schemes appear to support this state-*

ment .We applied Sorrell's choice of the word "dull" to equate in our study to the color sets at the medium and low saturation level, making no evaluation of the "attractiveness" of each scheme.

This preference for fully saturated colors harkens back to the research about color naming which shows that more basic colors enter the vocabulary earlier and highly saturated colors tend to be more "basic" (McManus et al. 1981; Boynton 1989; Whitfield and Wiltshire 1990; Sivik and Hard 1994). McManus et al. (1981) indicate that high chroma is preferred to low chroma during their study, thus, considering the use of crayon colors on television and in classrooms and clothing further reinforces the preference findings in this study.

"One other question to be raised about our preference findings is whether children are conditioned to prefer saturated, bright colors. It is possible that children prefer these colors because they are more commonly exposed to them on maps."

One other question to be raised about our preference findings is whether children are conditioned to prefer saturated, bright colors. It is possible that children prefer these colors because they are more commonly exposed to them on maps. These are the colors that children have come to expect on maps; therefore they assume that these are the colors that should be on those maps. This experiment was described to the students as being a study of colors used on textbook maps, and that description may have skewed the student's viewpoints to believe that bright colors were the "right" ones. If children were exposed to the less saturated colors more often in their textbooks, these preference findings might change dramatically.

The other significant performance difference was by gender. Across the entire test girls performed better than boys, even though within each group the differences were not statistically significant. This result does not indicate that saturation was the influencing factor, but instead the result is likely caused by well-known differences in development that occur at this age between boys and girls (and that are beyond the scope of this study), which is counter to the research findings of Patton and Slocum on gender.

"For performance reasons, there appears to be no need to present children's maps using fully saturated colors."

For performance reasons, there appears to be no need to present children's maps using fully saturated colors. Saturation's lack of influence on performance should give pause to cartographers and publishers who produce maps for children. While they may prefer the brighter, more saturated colors, it is by no means *necessary* to use such bright colors. In fact, performance proved to be marginally, but statistically non-significantly, better on the reduced saturation schemes. More important than the saturation values of the chosen colors is the overall hue-saturation-brightness combinations chosen and the ease of differentiating between all of the colors on a map. The fact that color set A resulted in better performance than color set B suggests that with set A it is simply easier to discern differences within the map than on color set B (regardless of saturation level). This ease of use may also play into the findings on preference; essentially the easier the map is to use the more it will be liked. Careful choice of hue is vital to ensure the colors are distinguishable and easy to use.

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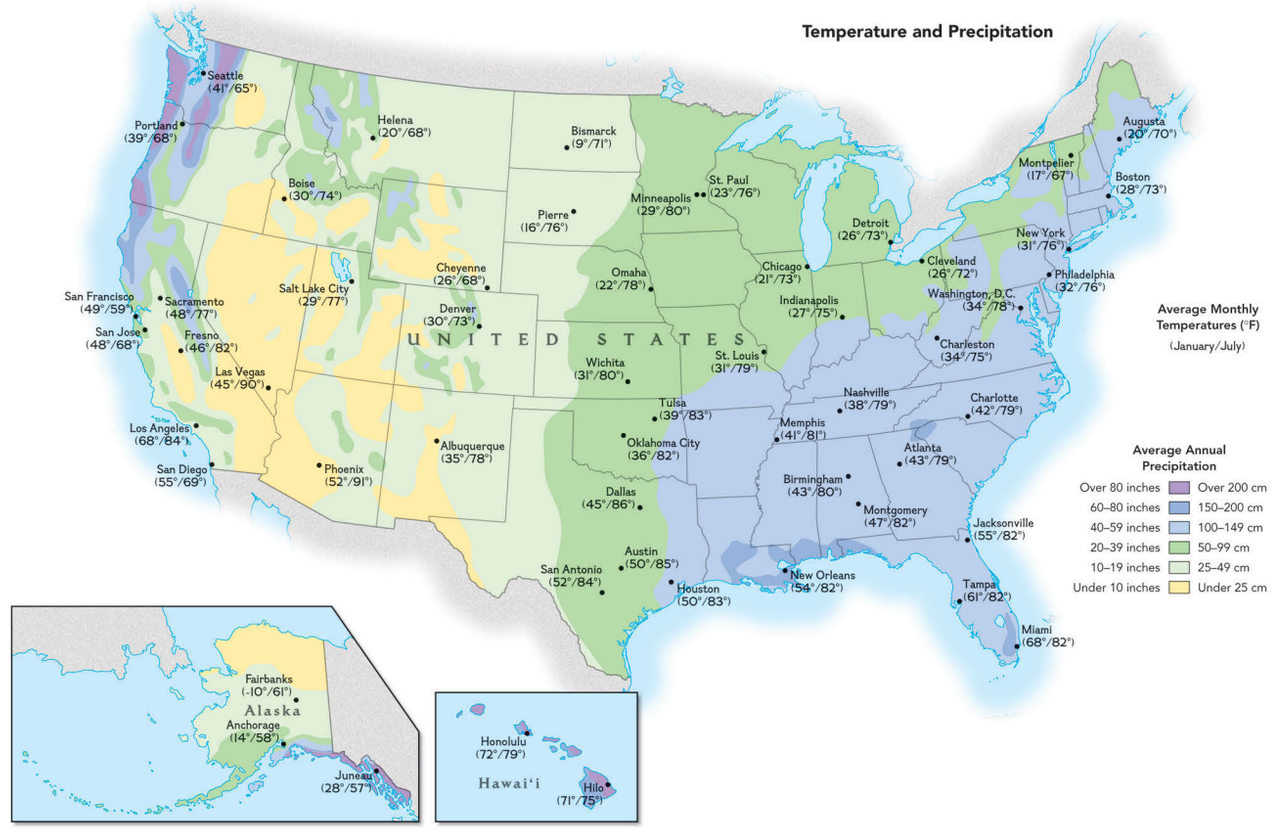


Figure 1. U.S. Temperature and Precipitation Map ©National Geographic (Shown at Reduced Scale).

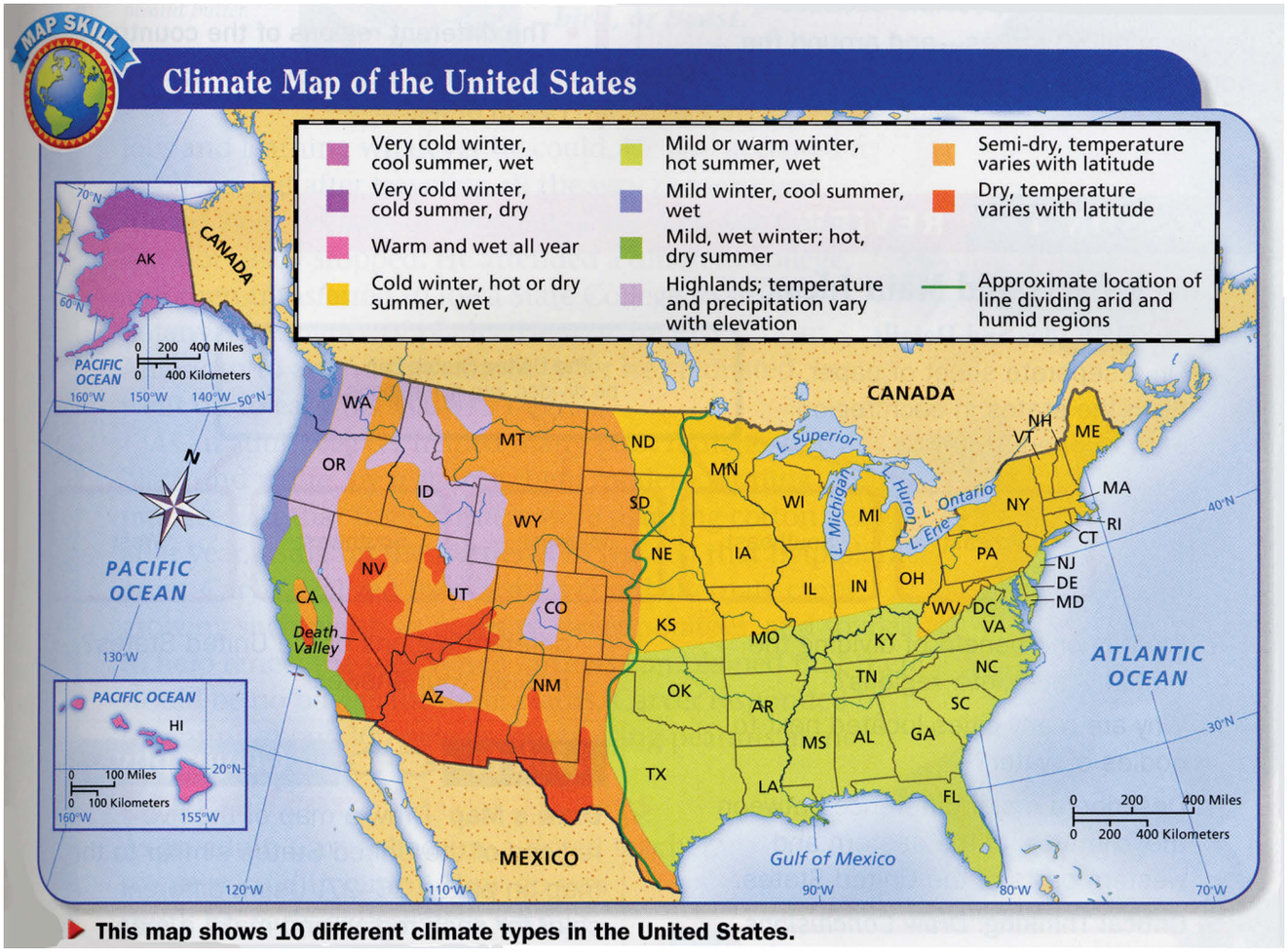


Figure 2. U.S. Climate Map ©Geonova Publishing.

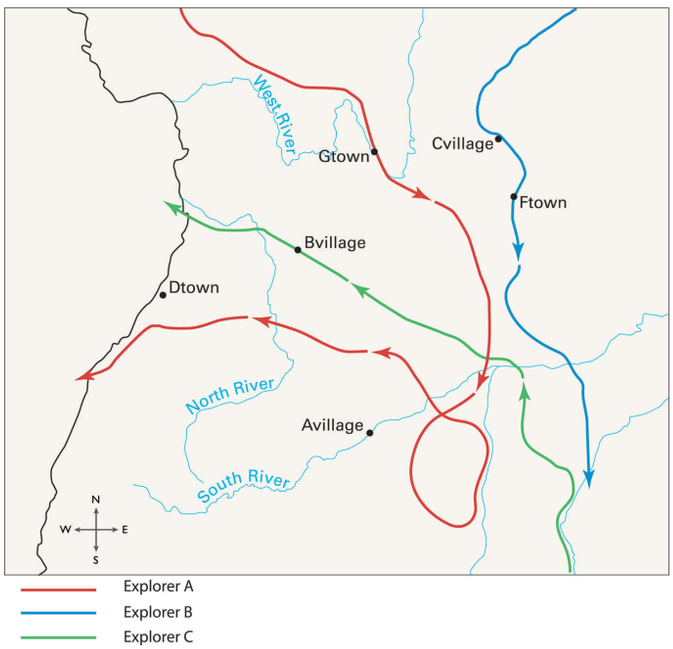


Figure 3. Example of the time-flow map used in this study.

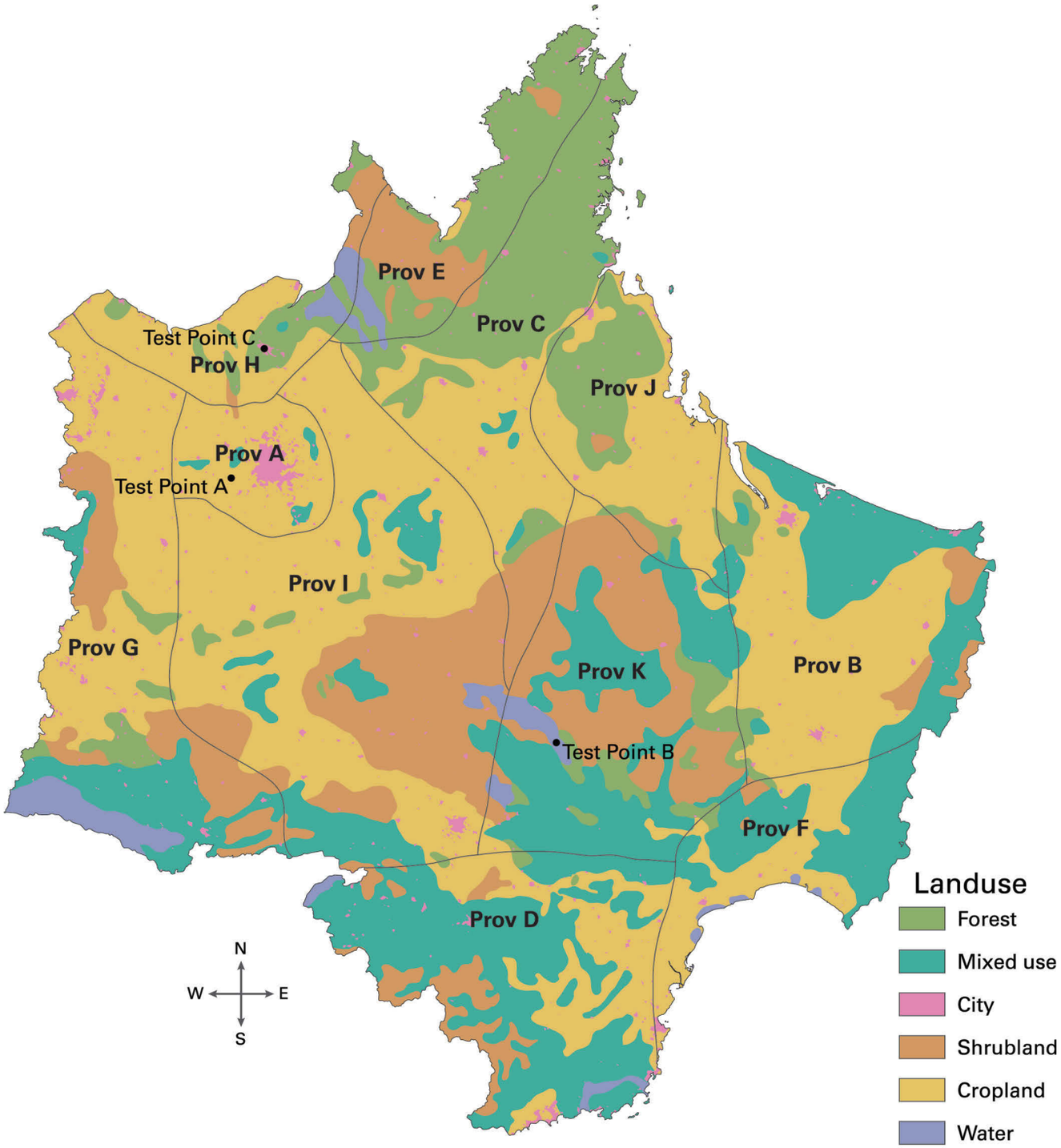


Figure 4. Example of the land use map used in the study.

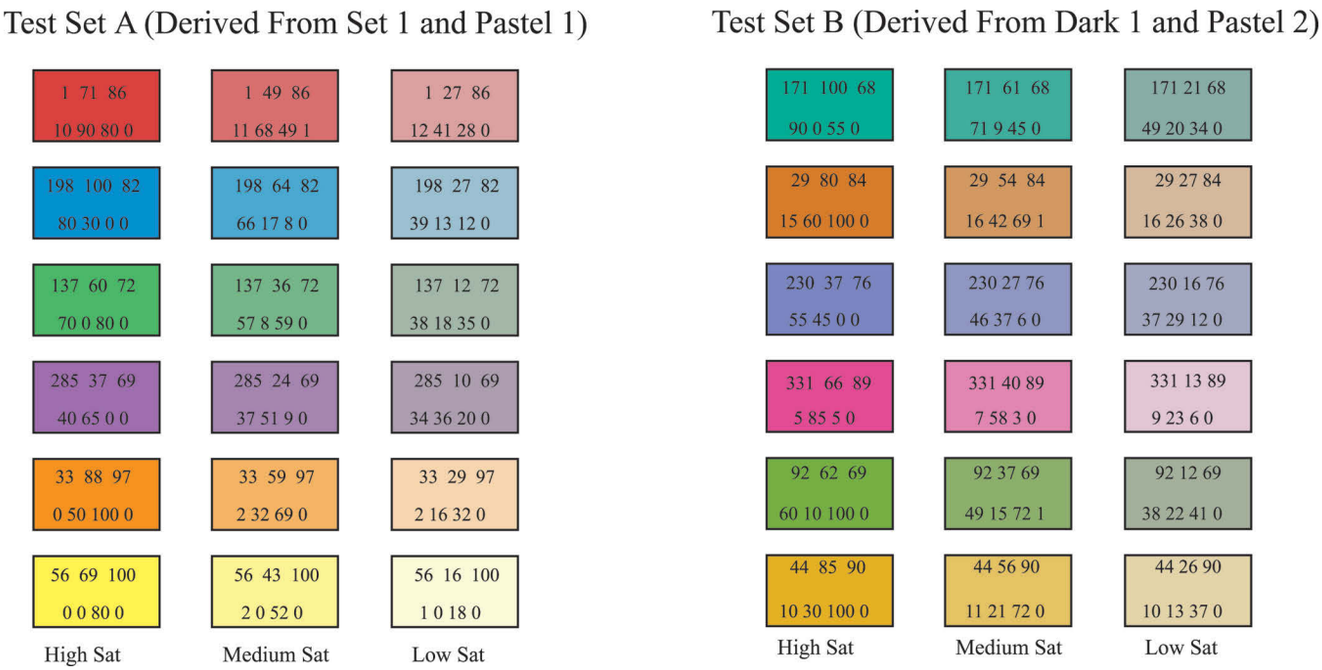


Figure 5. Tested Color Schemes (with HSB and CMYK values listed), derived from www.colorbrewer.org.

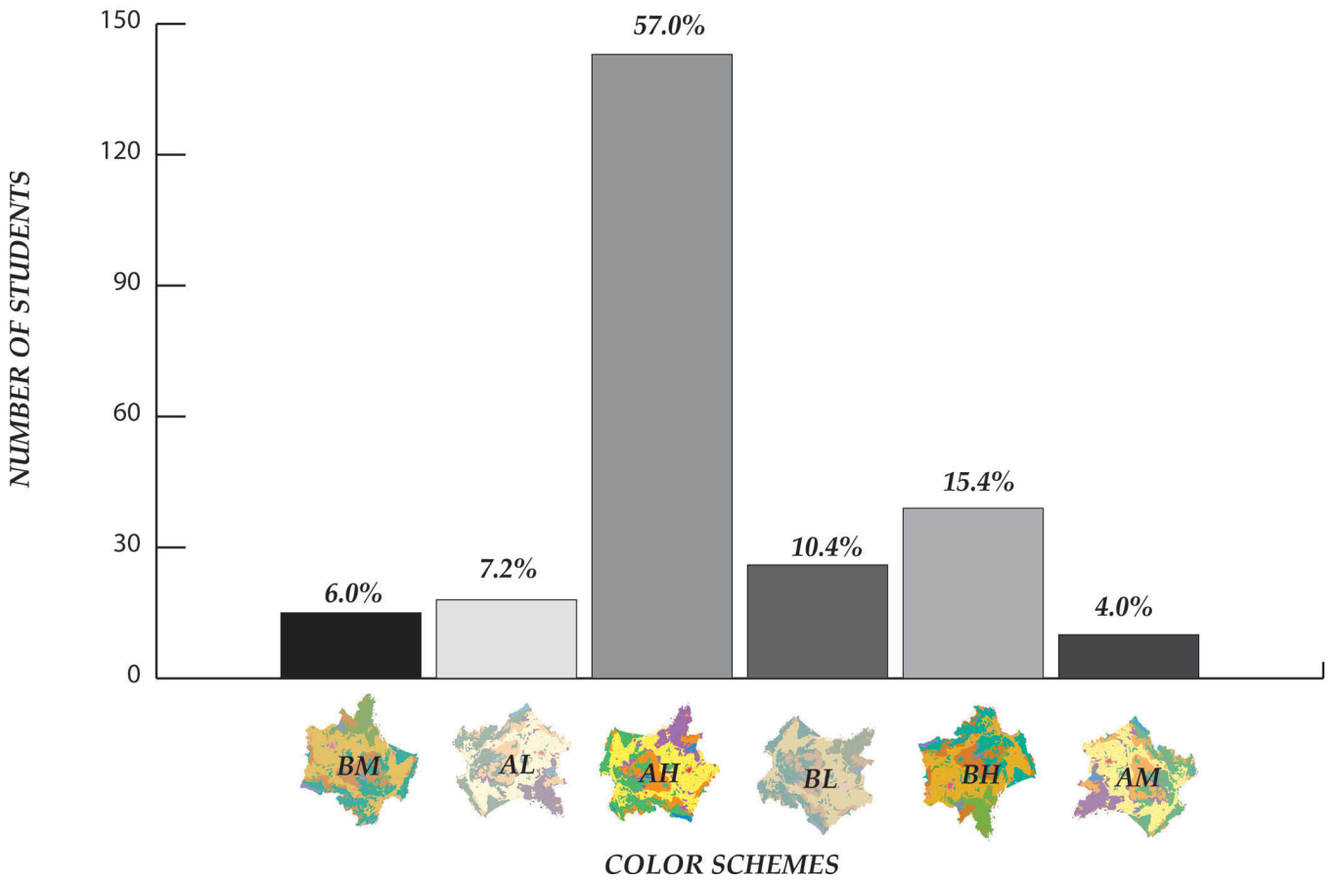


Figure 6. Preference by color scheme.

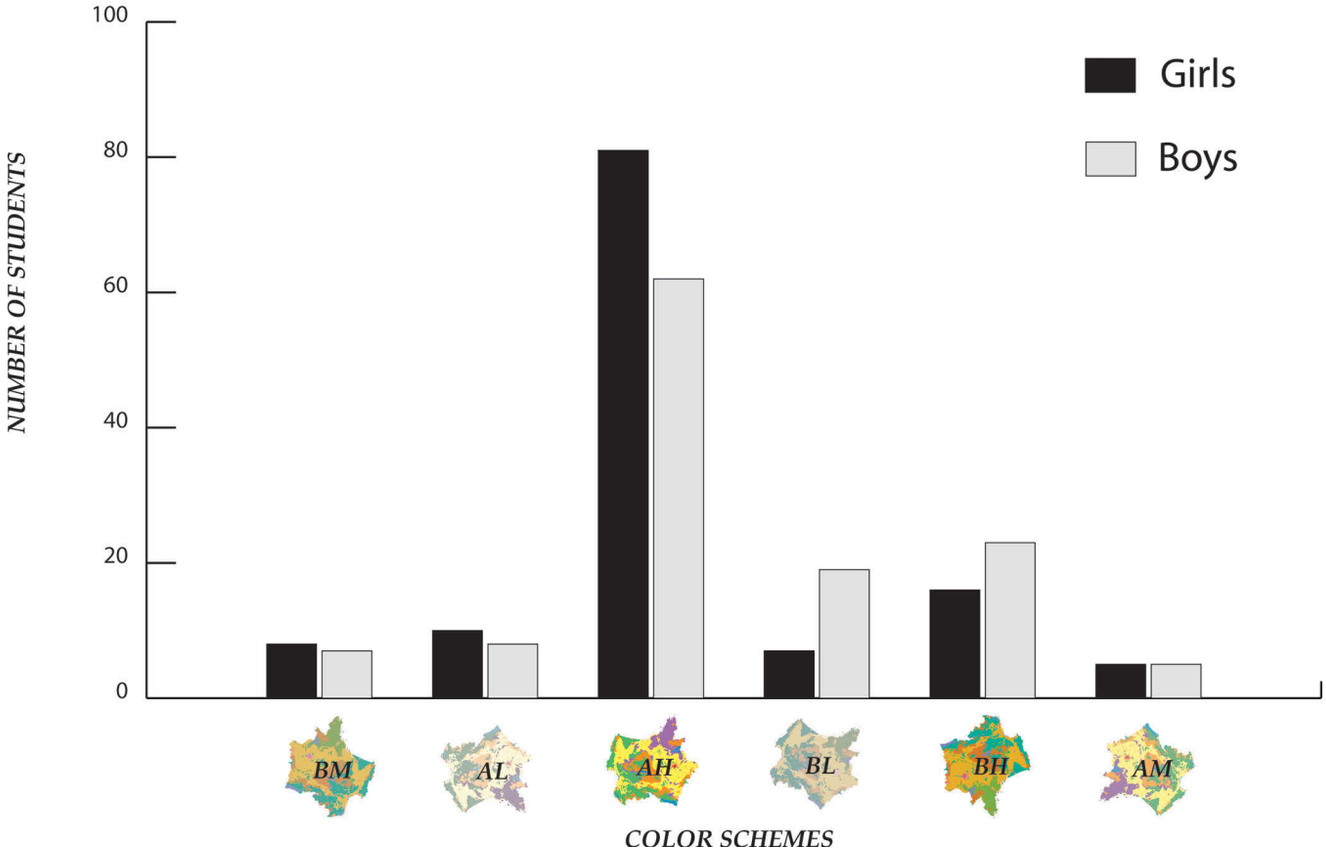


Figure 7. Color scheme preference by gender.

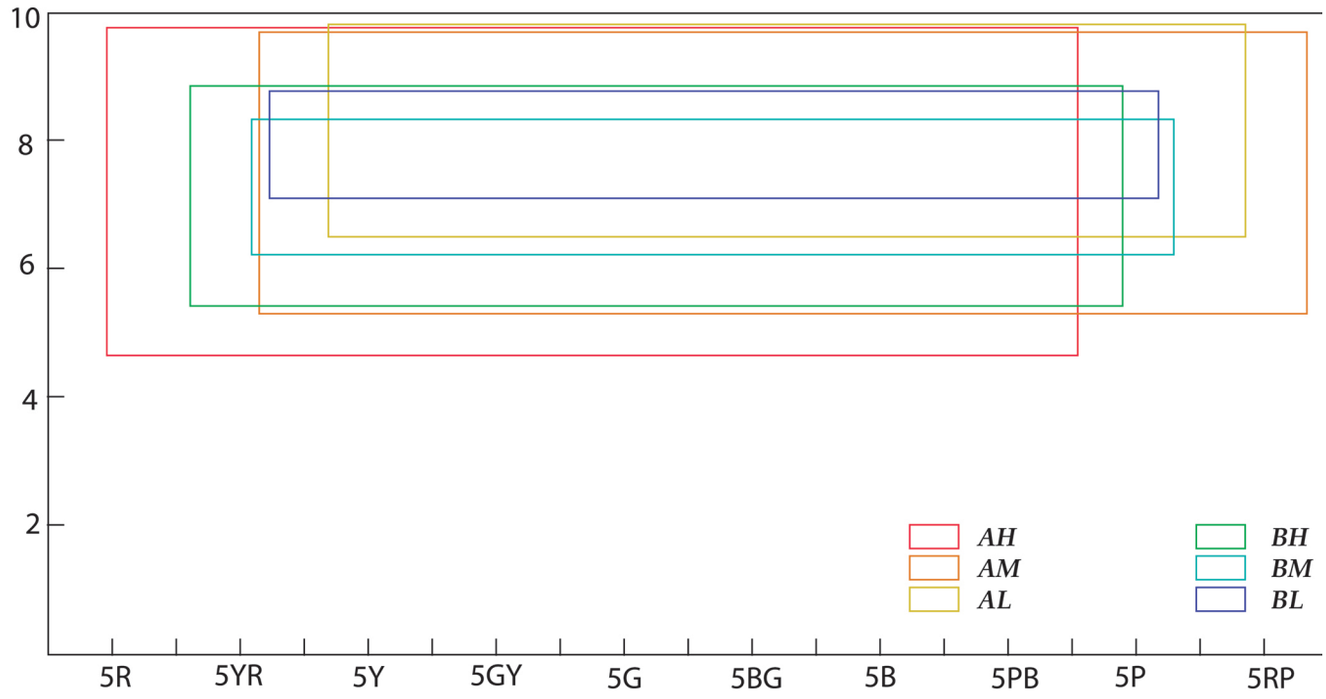


Figure 8. Graph of jitter for the six tested color schemes.

Question Type	 Color Scheme AH	 Color Scheme AM	 Color Scheme AL	 Color Scheme BH	 Color Scheme BM	 Color Scheme BL
Region Question (1,4) mean=88.6%	89.8% (n=322)	89.3% (n=318)	92.7% (n=328)	86.2% (n=318)	90.2% (n=328)	83.2% (n=322)
Point Question (2,3,5) mean = 76.35%	76.4% (n=483)	80.1% (n=477)	82.3% (n=497)	71.3% (n=477)	75.0% (n=492)	73.0% (n=483)
Total Performance	82.5%	84.7%	87.5%	78.8%	82.6%	78.1%

Table 1. Land use Performance (%Correct) by Color Scheme.

Source	Sum of Squares	df	Mean Squares	F ratio	Sig.
Saturation	910.82	2	455.41	0.9	0.39
Color	5157.92	1	5157.92	10.7	0.0011*
Sat*Color	1584.35	2	792.18	1.6	0.20
Error	470492.84	972	484.05		

*p<0.05

Table 2. Saturation, Hue, and Brightness versus Performance ANOVA.

Question Type	Flow Map	***AH*** Color Scheme AH	***AM*** Color Scheme AM	***AL*** Color Scheme AL	***BH*** Color Scheme BH	***BM*** Color Scheme BM	***BL*** Color Scheme BL	Means
Direction Question	1	69.8% (n=43)	82.5% (n=40)	79.5% (n=44)	88.4% (n=40)	85.3% (n=44)	50.0% (n=43)	75.9%
	2	89.5% (n=37)	88.4% (n=43)	88.2% (n=34)	82.5% (n=43)	75.0% (n=34)	90.7% (n=37)	85.7%
River Question	1	83.7% (n=43)	92.5% (n=40)	88.6% (n=44)	97.7% (n=40)	91.2% (n=44)	73.7% (n=43)	87.9%
	2	89.5% (n=37)	79.1% (n=43)	82.4% (n=34)	80.0% (n=43)	86.4% (n=34)	88.4% (n=37)	84.3%
Loop Question	1	48.8% (n=43)	85.0% (n=40)	79.5% (n=44)	88.4% (n=40)	85.3% (n=44)	50.0% (n=43)	72.8%
	2	81.6% (n=37)	58.1% (n=43)	52.9% (n=34)	65.0% (n=43)	50.0% (n=34)	88.4% (n=37)	66.0%
City Question	1	57.0% (n=86)	88.8% (n=80)	79.5% (n=88)	93.0% (n=80)	88.2% (n=88)	57.9% (n=86)	77.4%
	2	82.9% (n=74)	62.8% (n=86)	54.4% (n=78)	73.8% (n=86)	64.8% (n=78)	89.5% (n=74)	71.4%
Total Mean Performance		73.35%	79.65%	75.63%	84.18%	78.64%	77.99%	

Table 3. Time Flow Map Performance (%Correct) by Color Scheme and Question Type.

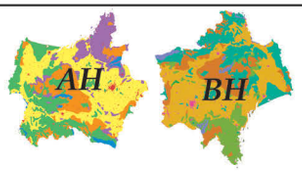
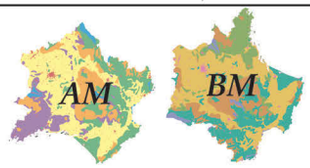
	 High Saturation	 Medium Saturation	 Low Saturation
Most Preferred	182	25	44
Least Preferred	37	51	164

Table 4. High and Low Preference by Saturation Level.

Reviews

Historical Atlas of Oklahoma
Written by Charles Robert Goins and Danney Goble
Cartography by Charles Robert Goins and James H. Anderson
Published in 2006 by University of Oklahoma Press, Norman, Oklahoma
286 pages, with illustrations, tables and graphs throughout
$39.95 hardcover
ISBN 0-8061-3482-8

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

The *Historical Atlas of Oklahoma* is comprised of 119 individual essays that explore various aspects of the state's rich history. Each essay is visually complemented by maps, charts and graphs. This book was originally published in 1956, but has been updated and re-released to coincide with the 100th anniversary of Oklahoma statehood on November 16, 2007.

Charles Robert Goins is Professor Emeritus of Regional and City Planning and Architecture at the University of Oklahoma. Danney Goble is Professor of Letters at the University of Oklahoma. These co-authors, along with seventeen other contributors, provide the essays that document Oklahoma history. James H. Anderson, Manager of Cartography for the Oklahoma Geological Survey at the University of Oklahoma, collaborated with Charles Robert Goins to provide the book's extensive cartographic elements.

The State of Oklahoma was created from the twin territories of Oklahoma Territory and Indian Territory. The original Oklahoma Territory forms the western part of the current state, including the familiar Panhandle, while the original Indian Territory makes up the eastern portion of the current state. A small area between the two territories was once an Osage reservation. The state's name is derived from Okla-Homma, which is Choctaw for "red people."

Oklahoma is the 20th largest state in the United States, with a total area of 69,898 square miles. Census 2000 recorded a state population of 3,450,654.

The *Historical Atlas of Oklahoma* is presented in six parts. Part I, *Native Oklahoma*, provides maps and essays about the land itself. The local terrain is clearly mapped, and varies in type from the Granite Mountains region to the High Plains to the Cimarron River Valley.

Topography in Oklahoma tends to slope downward from the west side of the state toward the east. The state's highest elevation ison Black Mesa (4,973 feet), which is located within the Panhandle. The lowest elevation in Oklahoma is 287 feet, diagonally across from Black Mesa near the southeast corner of the state.

Just as the land slopes from west to east, so does precipitation increase from west to east across Oklahoma, with the Panhandle area being the driest. Oklahoma has the dubious honor of being located within "tornado alley," averaging anywhere from 17 to 145 tornadoes per year. Many of the tornado forecasting and warning systems that are relied upon today throughout the United States were developed in Oklahoma in response to a very deadly tornado there in 1947. Atlas maps show Oklahoma's overall location within the greater area of "tornado alley," and document the specific locations of some of the state's worst storms.

The Red and Arkansas Rivers flow in part through Oklahoma. Looking at the accompanying maps, it is easy to visualize how these rivers assisted early settlers with the transport of people and supplies. The Red River forms the southern border of Oklahoma.

The opening of Oklahoma land to settlement in the 1880s ultimately set the stage for the Dustbowl of the 1930s. Farming meant breaking up tough prairie sod comprised of thickly matted grass roots and soil – sod so thick, it could be stacked like bricks to build sod huts for early residents. But breaking up the prairie sod opened the delicate soils underneath to wind and water erosion. Each subsequent year of plowing by eager farmers further exacerbated this condition. In drought years, dust storms occurred. The prairie winds simply blew the loose soil at will, just as northern winds blow snow into deep drifts. In 1934 and 1935, dust from Oklahoma and surrounding states actually traveled eastward as far as the Atlantic Ocean to blanket eastern cities in dust. The dust was so dense on the horizon that it actually blackened the sky as if it were evening. Startled New Yorkers and other eastern residents had to turn their lights on during the day and hold handkerchiefs over their mouths to filter the air, just as Oklahomans had done for decades. The vast extent of the dust storms finally made soil conservation an important concern.

Oklahoma is the fifth largest producer of crude oil in the United States, and the third largest producer of natural gas. Maps show large natural gas fields in the Panhandle, with smaller oil fields scattered throughout the central portion of the state. Other mapped

resources include coal, limestone and salt.

Part II, *Humans on the Landscape*, begins 40,000 years ago and continues chronologically to the present. Maps show evidence of early settlements in Oklahoma, including important archaeological sites. Spanish explorers such as Coronado were searching for fabled cities rich in gold and turquoise during the 16th and 17th centuries, but such cities were never found. French explorers came in the 18th century to establish trade with native tribes. Many of the mountain ranges, rivers and towns in Oklahoma still bear the names left by early Spanish and French explorers.

In 1803, Oklahoma was included in the Louisiana Purchase and became part of the United States. Various expeditions explored the region in and around Oklahoma between 1806 and 1821. Trading routes were established, and military posts were built to provide protection and ensure safe passage. Political boundaries began to be delineated. The familiar Panhandle was designated as "No Man's Land" until 1890, when it officially became part of Oklahoma Territory. The development of the present day borders of Oklahoma is further documented with an intriguing map, as latitude, longitude and local politics delicately converge to create a new state.

Part III, *Oklahoma as Native America*, explores the state's important tribal heritage. Cherokees, Creeks, Chickasaws, Choctaws and Seminoles were among the major Indian tribes relocated to the Oklahoma region in the 19th century. They had been pushed steadily westward across the Mississippi River as the American settlement expanded in the east. The Cherokee territory in particular was an extended source of conflict. A large portion of what is now Tennessee and Kentucky, along with smaller portions of the Carolinas, Georgia and Alabama, was considered Cherokee land until the Cherokees were removed by force in 1838. The "Trails of Tears" map poignantly marks their difficult treks westward toward self-governed territory in Oklahoma. The Cherokees occupied much of northern Oklahoma as well as a portion of Arkansas and Kansas for the next fifty years. Congress ultimately purchased it all back by 1893 to allow for expansion of non-Indian settlement in Oklahoma. Similar fates befell the Choctaws, Creeks, Chickasaws, and Seminoles during that period.

Many Indians in Oklahoma kept African American slaves during the early 19th century, as did many whites in the southern portion of the United States during that same period. But in Indian society, the slaves were permitted to establish their own homes and communities as long as they continued to perform the duties required by their masters. Numerous slave communities were formed, and some still exist today as predominantly black communities. Scores of Indians sided with the Confederates during the Civil War and fought with them in vain to retain their shared institution of slavery. The end of the Civil War brought freedom to the slaves of Indians as well as Confederate whites in Oklahoma.

In Part IV, *Where the Frontier Ends*, a clear vision of the Old West emerges, with Oklahoma taking center stage. The buffalo herds that once extended from the East Coast [*sic*] to the Rocky Mountains provided food and clothing for local Indian tribes. But completion of the transcontinental railroad in 1862 brought buffalo hunters to Oklahoma and other areas where buffalo were plentiful, and made it possible to transport meat and hides to ready markets. The great herds were decimated by the end of the 19th century.

Military forts were built and served as refuge during the many Indian Wars between 1847 and 1878 in Oklahoma's Indian Territory. Roads were also created to connect the forts and allow movement of people and goods. The military was expected to provide protection to new settlers in the area, but many Indian raids continued to occur throughout the frontier in nearby Kansas and Texas. In response to these raids, and to increasing government pressure to exact revenge, George Armstrong Custer led the Massacre on the Washita in 1868. An entire Indian village was destroyed near the present day town of Cheyenne, Oklahoma.

From the end of the Civil War until the mid-1880s, millions of Texas cattle crossed through Oklahoma territory on their way to Kansas, where they would be shipped by railroad to northern and eastern markets. Of all the cattle trails shown on the accompanying map, the Chisholm Trail was perhaps the best known. It was relatively safe from Indian Territory, where monetary payment was often required in return for safely crossing the land. The Chisholm Trail also provided ample grazing and water along the way.

As railroad lines extended into Oklahoma beginning in 1870, cattle, coal and agricultural products began to be shipped by rail. Treaties had to be negotiated with Indian tribes to allow construction of the railroads through Oklahoma's Indian Territory.

The first Oklahoma Land Run took place as a result of the Homestead Act. On April 22, 1889, a small expanse of land in the center of the state was formally opened to settlers, and included the area that today comprises Guthrie and Oklahoma City. About 50,000 homesteaders gathered all along the border of the unsettled territory, waiting for the chance to stake their claims to 160 acres each. Bugles and cannons sounded to initiate the land run, and prospective settlers raced in on horseback or by covered wagon to look for the boundary markers left by government surveyors. Once a marker was located, the prospective settler needed to take down the information from the marker and proceed in haste to the nearest federal land office

to ensure a claim for that location. The Homestead Act required each settler to live on the land for at least six months out of each year for a five-year period before ownership of the land was provided free and clear. Each settler also had the option of paying $1.25 per acre for the land after living on it for twelve months in order to obtain ownership more quickly.

Part V, *Brand New State…Gonna Treat You Great*, examines the political and social elements surrounding the statehood of Oklahoma. County lines were drawn with quantity in mind, since more counties meant more government jobs, contracts and services. Due to the extreme poverty among farmers, Socialism was a major political presence between 1907 and 1920.

As in other southern states, segregation was enforced by state law during the early part of Oklahoma's statehood. The 1920s saw the rise and fall of the Ku Klux Klan in the state, and a violent race riot occurred in Tulsa in 1921. The main thoroughfare in the local black community was destroyed in just over a day, and countless people of both races were injured or killed.

Although the production of corn and oats declined in Oklahoma over the last century, the production of sorghum and rye has increased significantly. Cattle ranching is one of the state's leading businesses.

In Part VI, *You're Doing Fine, Oklahoma*, maps provide a tour of Oklahoma's geographical regions, while political boundaries, highway systems, colleges and universities, museums and historic sites, and state parks and recreation areas are also explored.

Unfortunately, no new chronicle of Oklahoma would be complete without some reference to the 1995 bombing of the Alfred P. Murrah Building in Oklahoma City. A Bomb Damage Assessment Map shows the tremendous power of the explosion, which not only destroyed the Murrah Building, but also caused damage ranging from collapsed structures to broken windows for a radius of over half a mile. Photos show the devastation as well as the evocative memorial that rose in its place.

Oklahoma has a proud history of athletic, literary, theatrical, artistic and musical accomplishments. These are amply illustrated with photographs and maps. The final two essays describe specific men and women as "partners on the land" of Oklahoma. Brief biographies, photographs and maps of birthplaces illustrate their accomplishments. An extensive bibliography and index complete the atlas.

In the preface of the *Historical Atlas of Oklahoma*, the authors make some intriguing statements regarding why the original version of this book, which was published in 1956, was not noted as a first edition. "There must have been some who unthinkingly presumed that geography and history are, after all, two aspects of human affairs that are utterly impervious to change," they theorize. "The physical planet is not going to change. History lies entirely in the past, and that past is not going to change either." It is easy to believe that physical changes like global warming, and historical changes ranging from population growth and related development to local and international terrorism could not possibly have been foreseen in the 1950s. From the vantage point of 2007, however, it is just as easy to believe that future editions of this atlas will necessarily be inevitable as the world and its societies continue to evolve.

Prior to reading this book, my knowledge of Oklahoma was based more on films like Edna Ferber's *Cimarron,* John Steinbeck's *Grapes of Wrath* and Rodgers and Hammerstein's *Oklahoma!* than on anything I ever learned in geography or history classes. The *Historical Atlas of Oklahoma* provided an enjoyable way to increase my understanding of Oklahoma's unique role in American history. The simultaneous presentation of essays and accompanying cartographic elements ensured that I never lost my sense of place within the state as historical events unfolded. The maps were easy to read and understand, and the division and progression of the essays, though overlapping at times, was largely chronological throughout the course of the book. I did not have the impression that the *Historical Atlas of Oklahoma* was simply the retelling of an older edition with some new information tacked on at the end to bring it up to date. The sense of continuity and overall flow of the book was seamless.

The enthusiasm of the co-authors and other contributors for all things Oklahoma is apparent in the text, yet it does not preclude the unbiased presentation of the unflattering aspects of the state's history, such as slavery and racism, in tandem with the noble ones. The *Historical Atlas of Oklahoma* is a very comprehensive volume for a broad range of academic studies, including cartography. I would highly recommend it for anyone with an interest in American history, American geography, the Old West, or Oklahoma in particular. To quote from the title song to Rodgers and Hammerstein's great musical, which has since become Oklahoma's state song: Oklahoma, and the historical atlas named for it, is "OK."

Historical Atlas of U.S. Presidential Elections 1788-2004

Written by J. Clark Archer, Stephen J. Lavin, Kenneth C. Martin and Fred M. Shelley
Published in 2006 by CQ Press, Washington, D.C
164 pages, 55 maps, 3 tables and 3 figures, $150 (US). Hardbound,
ISBN-13 978-1-56802-955-9, ISBN-10 1-56802-955-1

Reviewed by Edith Scarletto, Kent State University

J. Clark Archer is the author of several books and articles concerning the mapping and geography of elections, including the seminal *Section and Party: A Political Geography of American Presidential Elections, from Andrew Jackson to Ronald Reagan*, and *American Electoral Mosaics.* The former work was the first to use factor analysis to look at the voting patterns and critical geographies of elections. Archer is a Professor of Geography from University of Nebraska, and the winner of several Journal of Geography Awards. Stephen J. Lavin, also a Professor of Geography at the University of Nebraska, was a partner in the *Atlas of American Politics, 1960-2000* and created maps for the *Atlas of the Lewis and Clark Expedition*. Kenneth C. Martis, Professor of Geography at West Virginia University, is the author of *The Historical Atlas of the United States Congressional Districts* and has authored several additional electoral and congressional district atlases. Fred M. Shelley is Professor and Chair of the Department of Geography at the University of Oklahoma and has co-authored *Political Geography of the United States, American Election Mosaics* with Archer. All four geographers also recently published *Atlas of American Politics, 1960-2000* (2002).

The *Atlas* is a great resource for undergraduates or casual history buffs who want to browse through the map section and to see the detail of presidential election outcomes. It is very accessible in the map keys and descriptions, and is even inviting to students of history in its analysis of each election. The real resource, though, is the Introduction, which may only be fully appreciated by geographers and overlooked by others who skip to the maps and ignore the text.

The Introduction begins with a review of the Electoral College, the presidential election process, and party nomenclature. It goes on to discuss the candidate selection process, geographic voting patterns and election theory, as well as touching on the patterns of voter participation. Further discussion includes a review of the history of mapping presidential elections, accompanying theory, and previous atlases on the subject, including Turner's *Atlas of the Historical Geography of the United States*. There is an extensive review of the methodology of the mapping processes for the *Atlas*, data gathering, and analysis techniques, as well as software and color choices for the maps themselves. The map section is brightly marked with blue edge margin so the reader can turn directly to this, the most interesting section of the book.

In this hard cover text, each election outcome is both described in several pages of text and illustrated in the election maps themselves. A two page entry is used for each election year, highlighting geographic voting trends as well as the strengths and weaknesses of the candidates in question. Research notes regarding where data was recovered for each report are given. Special attention is paid to the geography of voting patterns and changes in voting / election laws for each new presidential election. The authors discuss any data irregularities for the election year and how those data were addressed within the project. Subsequent pages note the national candidates and figures for the popular vote percentage as well as Electoral College Vote Percentage. Each entry concludes with a citation for additional reading.

Two map pages are presented for each election result. On the left page, the percentage of popular support for each candidate is displayed in three graduated color shaded maps. The maps are presented using consistent color coding throughout the map section: red for Republican affiliation, blue for Democratic, and green for Independent. On the right page is illustrated the wining popular vote by party and majority, as well as pie charts illustrating the difference between popular and electoral vote percentages. The authors map each election result making clear distinctions for states with appointed electors and areas with either no reporting or no voting rights. For years when a state was not included in the election, (there are, for instance several states which during the Civil War or during reconstruction did not participate) an explanation is given and noted on the map. These markings are employed consistently throughout the atlas. The Atlas concludes with an extensive bibliography for each election discussion and an index containing each candidate discussed as well as applicable scandals, voting populations, historical events and definitions used within the text.

Archer, Lavin, Martis, and Shelley give a comprehensive look at the results of each presidential election from 1788 through the recent 2004 election. They aim to produce "the first reference book to map election outcomes for all the counties in every presidential election, through 2004" (ix). They do so in a very clear and readable way, even for the reader who merely flips through the map sections.

The Introduction gives a brief scholarly overview of election cartography with detailed discussion of electoral politics and voting patterns. Using plain language to explain detailed spatial analysis and election theory, they step even a non-geographer through

the stages of election mapping and cartographic techniques. Later, in the section *Construction of the Presidential Election Maps*, they provide a very nice and detailed discussion of sources consulted, data manipulations conducted, and techniques used so that each stage of the process can be critiqued.

In discussing the history and lines of historical demarcation in the eras of political parties, they present interesting analysis of third party eras and the difference between traditional thinking on dating the eras. "Most literature suggests that the Third Party System begins in 1960. Because the presidential election of 1856 displays a geographical pattern unlike previous elections, one could argue that the Second Party System had sufficiently broken down and that a new party system had begun in the mid-1850's" (p.9). Because of the nature of the data collected, and the painstaking way that it was analyzed using current spatial theory, Archer *et al*. can discuss geographic patterns in a more meaningful way than with historical literature alone, or without the benefit of the entire data set. While the maps themselves are the centerpiece of this atlas, the text could serve the geography student well as an explanation of applied mapping and the use of GIS. The research for this volume, and the level of detail used to distinguish and define variables from sources as varied as Census figures, local newspaper reports, and private data collections provides the most comprehensive comparable data set for presidential election results.

The maps themselves are very colorful and easily distinguished using clear keys and distinctive shading. Often other atlases use color coding that can be so difficult to distinguish that it renders any analysis moot. This is definitely not the case here. My only criticism is that some of the maps could have been reproduced larger so that finding and determining counties might be easier, although this would take away from the ability to see the all of the maps for a single election spread out before you at once (if they appeared on separate pages). Additionally, a chart at the beginning of the map section showing how each state selects electors may answer some of the questions raised by the display of popular vs. Electoral College results.

The fortunes of third party national candidates are represented as well, with number of electoral votes and party affiliation. Care is taken to be as inclusive and detailed as possible while leaving the display of the maps uncluttered and easy to read. Shading the percentages of popular vote, they invite the reader to casually flip through the map section between election years and scan for patterns in popular votes as well as checking for electoral vote patterns using the color scheme.

In comparison to the *Routledge Historical Atlas of Presidential Elections* (Mieczkowski, 2001), I again go back to the geographical analysis of this atlas. It is the point of the authors of this book, a task I assert that they accomplish quite effectively, to study the geography of the data and to come to conclusions based on it. The *Routeledge* is a much more historical reading, using the maps to illustrate a point, rather than to bring you towards it. Another contrast between the two are the maps themselves. Mieczkowski maps only the electoral vote, leaving off the support of the states based on political party affiliation, as well as the all important popular vote.

In conclusion, as an atlas this volume may seem a hefty price for historical voting patterns. However, using the text as a reference for further electoral analysis and as a source for interpreting spatial patterns, it would be well worth the cost. Additionally, its inclusion of each presidential election that was contested does tend it toward a definitive reference for an academic or large public library for historical research. It is unique in its approach to the subject matter and in its treatment of data. All in all, a great product.

Works Cited

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disORIENTATION
Counter-Cartographies Collective
University of North Carolina-Chapel Hill, 2006

Reviewed by Denis Wood, Independent Scholar

I love this map!
I love almost everything about it. The cover fold – the map is available rolled but most will encounter it folded – carries the title "dis" (and this is lower case running vertically) "ORIENTATION" (all caps and horizontal). Below, the phrase, "your guide to UNC-Chapel Hill," with a credit to "Counter-Cartographies Collective, 2006." The map on the cover? An azimuthal equidistant projection centered on Chapel Hill's antipode in the Indian Ocean.

I mean, right off the bat: this is not your ordinary map. In fact, it's an anti-ordinary map. Instead of orienting you, it wants to disorient you. Instead of decorating its cover fold with cute images of Chapel Hill, it displays the world that *isn't* Chapel Hill. Its author is … "*Counter*-Cartographies."

So no surprise that when you make the first unfolding you're confronted with a Mercator projection of "The World Through Course Titles" based on UNC's 2005 Undergraduate Bulletin. The next unfolding adds Mollweide projections of "International students

enrolled at UNC-CH in 2005" and "UNC-CH students studying abroad in 2005." The third unfolding adds "Graduate research at UNC-CH, 1990-2005," based on places included in the titles of UNC dissertations. It also reveals two blue boxes of text, the first headlined, "… a factory" and the second "… producing your world." This explains the maps of the world on this map of Chapel Hill: *Chapel Hill produces your world*. Talk about actor-network theory! The final unfolding unveils two more headlines, "UNC is …" and "… a functioning body," this last over another blue box of text. Run together, as your eye now does, these headlines say, "UNC is a factory, a functioning body, producing your world." *Holy gamoly!*

This last unfolding reveals a lot more too. It now becomes plain that there's a map of the Triangle underlying everything else, schematically rendered with major roads in red and railroad tracks in grey. The Triangle is what locals call the region comprised of Raleigh, Durham, and Chapel Hill; that is to say, of NCSU, Duke, and UNC-CH, as well as twenty-five other educational knowledge factories (denoted by silver boxes crammed with vital statistics); the "educational" to distinguish them from the *corporate* knowledge factories broken out in a separate map of Research Triangle Park, where purple circles are graduated according to number of researchers employed, the largest of which is GlaxoSmithKline with its 4,000 researchers. The emphasis here on labor and profits gives meaning to the idea that the region's a knowledge *factory*, while the red roads and grey railroad tracks suggestive of arteries and veins, and the silver boxes of clusters of neurons, underline the idea of its being a body.

The body that UNC is "has bodily functions," reads the text in one of blue boxes, that include "sleeping, walking, driving, and consuming." Correspondingly there are maps of "Where UNC Sleeps" and maps of "Pedestrian Spaces," "Automotive Spaces," and "Dangerous Places for Pedestrians," as well as an air photo of "The Most Dangerous Intersection in North Carolina for Pedestrians." Erupting like an igneous dike into this cool map of pale blues, greens, and grays is a full-color geologic map of the area.

From this description you could imagine that this amounts to noise amid chaos, but everything's all so beautifully organized that the map reads like an elegant essay. Laid out by five graduate students in geography with minimal design training, Tim Stallmann (actually at the time an undergraduate), Craig Dalton, Sebastian Cobbarubias, Maribel Casas-Cortes, and Liz Mason-Deese, with only minor input from a graduate student in UNC's Studio Art program, Lauren Rosenthal, the map's brilliantly effective design makes the point better than pages of argument that design is essentially driven by the motivation to *make meaning*, not to look good. It also makes the point that maps packed with meaning *can* look great, even sexy.

The flip side, in black and grey on white, gives us a number of text blocks floating this time on a hydrologic diagram of the Haw River watershed. Charts of gender, labor, and diversity at UNC; a map of local economies; a timeline "People's History of UNC-Chapel Hill"; texts about precarity, health, and alternative media; a directory of local progressive organizations; and a list of "A Few of Your Constitutional Rights" ("If Stopped by Police …"), round out the Counter-Cartographies Collective's disorientation for incoming students. Compared to the usual orientation materials *disORIENTATION* is a "sleeper's awake" call to acknowledge the university as a site of production, one in league with other sites of production, and one that exploits labor of all kinds ("ask about your student debt as an Undergrad, your health coverage as an adjunct professor, your overtime as a cafeteria worker," the map encourages); and to acknowledge the local as reciprocally constituent of the global.

It also begs the question why so many orientation materials are not only so uninformative, but dull. *disORIENTATION* not only bristles with intelligence, it's exciting to look at. Its large size (it's two by three feet) and cutting-edge layout make it a great poster, but one that reveals more and more of itself the closer you get to it. It literally takes hours to read, and repays that time handily. Yet it was produced by a handful of geography students, a working group of the Culture of Economies Project supported by UNC's University Program of Cultural Studies. We should be seeing maps like this on every side, but instead this one is becoming iconic. As I write this, *disORIENTATION* is on exhibition in Just space(s) in Los Angeles (at Los Angeles Contemporary Exhibitions, September 26-November 18, 2007); and in Pedagogical Factory: Exploring Strategies for an Educated City in Chicago (Hyde Park Art Center, July 22-Sept. 23, 2007), where Counter-Cartographies members will also be presenting their map in a workshop on "How We Make a Disorientation Guide to Our University."

Although these days terrific new maps are erupting from the least likely sources, apparently we still need models to lead the way. I can't think of a better group to do this than UNC's 3-Cs. You can visit their map, both sides, navigable and zoomable, at www.countercartographies.org.

Cartographic Collections

Expansion of the Osher Map Library and Smith Center for Cartographic Education at the University of Southern Maine

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The Osher Map Library and Smith Center for Cartographic Education (OML) is one of the newest rare map collections established in the United States. Housed on the Portland campus of the University of Southern Maine (USM) since 1994, the collection consists of rare maps, atlases, globes, geographies, and explorer's accounts ranging from 1475 to 1900. The scope and variety of OML's collections is readily seen from the library's website, www.usm.maine.edu/maps, which provides digital versions of past exhibitions.

During their first twelve years, the OML staff has developed a broad range of services for several distinct constituencies. Their success has brought the OML to the verge of a dramatic, physical expansion that is planned for 2008.

Academic Support

OML is first and foremost a part of a comprehensive metropolitan public university, and its staff seeks to address the instructional needs of its faculty and students through direct curriculum support. Professor Matthew Edney, who joined USM as OML's Faculty Scholar in 1995, has successfully promoted the use of OML's maps as primary source materials in his own courses and in special classes for courses in several departments including history, geography, philosophy and political science. Graphic arts students from the Maine College of Art visit annually to study examples of early printmaking technologies.

Conference Organization

OML has broadened its academic reach by organizing and hosting scholarly conferences. Beginning with its own inaugural conference in October 1994, *Reading the World: Historical and Contemporary Perspectives on Maps*, OML has hosted conferences for the Society for the History of Discoveries in1996 and the North East Map Organization in 2000. OML co-hosted the International Conference on the History of Cartography with the Harvard Map Collection in 2003, which is the best attended map history conference to that date, and was awarded first place by the Association for Collegiate Conference and Events Directors International.

General Public Support

Situated in Portland, Maine's largest city, OML also provides a variety of services to area residents. OML's guest lectures and exhibitions are free and open to the public. For the cost of shipping, traveling facsimile map exhibitions are offered on extended loan to libraries, schools and historical societies throughout Maine. OML's exhibition catalogs and other publications are sold at modest cost recovery rates to the widest possible readership. The library staff routinely conducts guided group tours and prepares special events tailored to reflect the interests of organizations such as antiquarian booksellers, professional calligraphers, and alumni associations.

K-12 Support

OML has also received recognition for its innovative educational outreach to elementary and high school students. The lesson plans OML created to accompany the *Neptune's Realm* exhibition on nautical charts were selected as one of the best educational resources by StudySphere, a web site that evaluates and recommends educational resources for students, teachers, and parents. Through its teaching kits, in-service workshops, and school group tours, OML attempts to share its resources in a variety of formats for the K-12 community throughout Maine and northern New England.

Expansion

A dozen years after opening its doors, OML has outgrown its space on the first floor of the Glickman Family Library. This is in large part due to the generosity of several map collectors, whose gifts have joined those donated in the late 1980s by the Smith and Osher families. These donors include Peter Enggass (historic maps of Iberia), Doug Yorke Jr. (U.S. road maps from the early twentieth-century), and Tony Naden (cartographic ephemera and road atlases).

USM has incorporated OML's expansion into its plans for a *University Commons*. This ambitious building project links the University's Glickman Family Library, situated at the periphery of campus, to the campus center through a complex of new buildings and landscaped walkways. Three commercial properties — a defunct car dealership, a PVC pipe company, and an electrical supply company — separated the library from the rest of the campus. Once these properties were purchased, the University was able to implement the plan conceived by Boston-based architectural and urban design firm of Koetter Kim & Associates (KKA). The Glickman Family Library is itself the former National Biscuit Company factory; it was one of the earliest industrial structures USM renovated for academic use, opening in 1993. These acquisitions enable USM to expand by transforming a blighted industrial zone into an inviting new gateway to the campus.

With the demolition of the former automobile dealership, the first phase of the new University Commons — the Wishcamper Center, which will house the Muskie School of Public Policy and the Osher Lifelong Learning Institute — began construction in Spring 2007. The OML expansion started in Summer 2007 with the demolition of the electrical supply company. Completion of the entire complex is projected for Fall 2008. The University Commons project was made possible by a successful private fund-raising campaign, including a Kresge Challenge Grant, and dedicated sources of public funding. The building site can be tracked with USM's web cam, at www.usm.maine.edu/abromson/webcams.html.

Figure 1A. This composite of a 1776 coast chart by DesBarres graphically reveals the shape and growth of the urban core of the Portland peninsula over the past two hundred years. Rosemary Mosher, USM graduate and co-founder of Orbiss, LLC, created these composite maps of Portland and the USM campus by combining historical maps with aerial photographs and CITIPIX Ortho-rectified Digital Images (ODI). The illustrations depicting Portland's growth and development originally appeared in The Changing Peninsula: Two Centuries of Portland Maps and City Views, *an exhibition guest curated by Earle G. Shettleworth, Jr., Director of the Maine Historic Preservation Commission. The exhibition can be viewed at the library's website: http://www.usm.maine.edu/maps.*

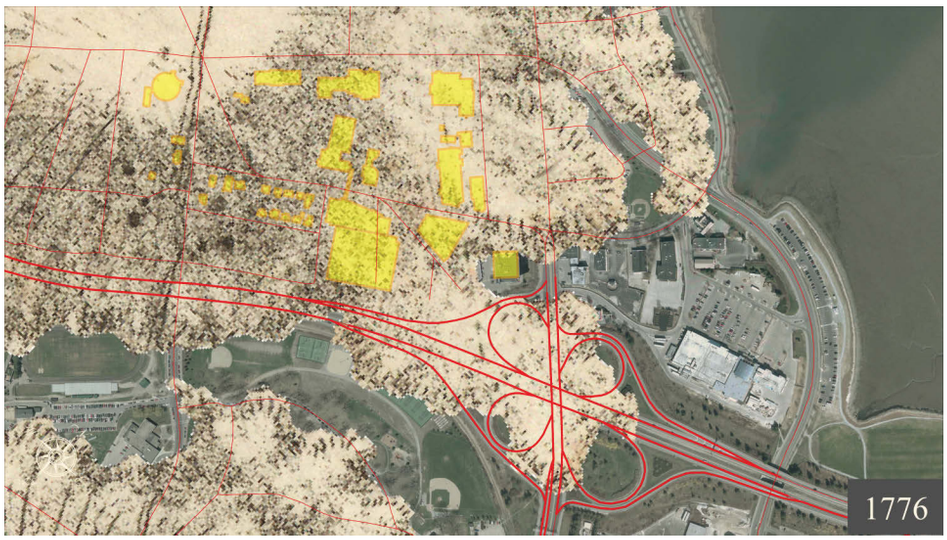
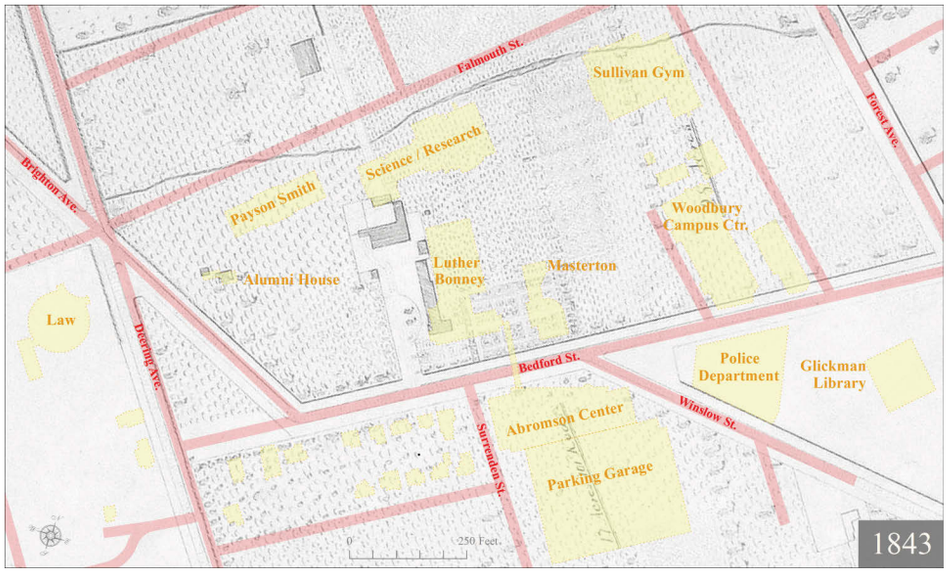
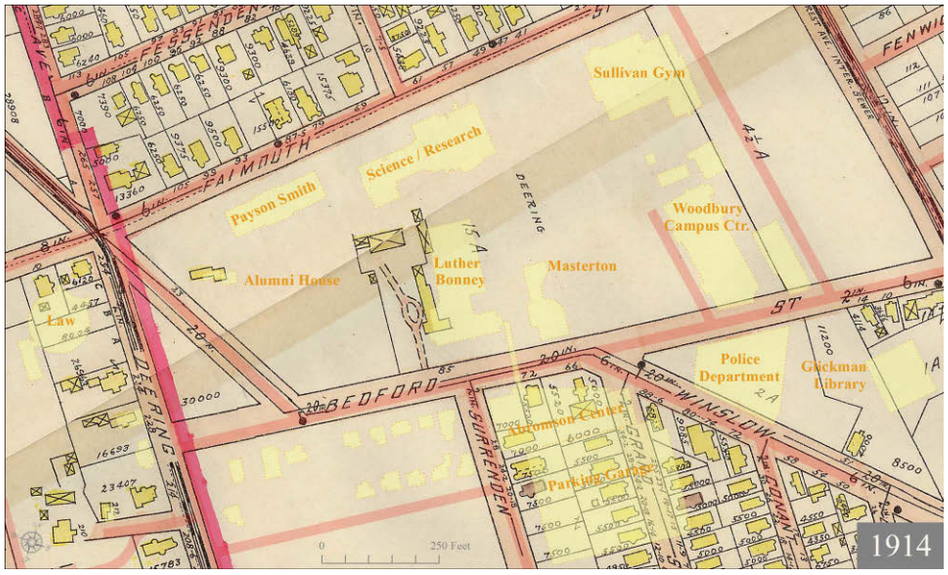


Figure 1B. To support its commercial and industrial growth, the city of Portland expanded its borders by infilling along its shoreline. As can be seen in this detail of Back Cove, the University Commons will be built on a former tidal estuary. Marine clay in the soil test borings has confirmed the sites' wetland origin. The cube shape of the Glickman Family Library roof demarcates the campus boundary at the crossroads of Forest Avenue and Interstate 295.





Figures 2A and 2B. This series traces the development of the USM Portland campus from a farmstead shown in this 1843 manuscript, as the site was transformed into Portland Junior College some one hundred years later. The Deering farm, the only original structure remaining on this site, now houses USM's Alumni Association. Other University owned properties are shown in yellow and present day streets indicated in red. Winslow Street, an important early land route to the Portland peninsula, was converted to a dead spur after the construction of the Interstate 295 on-ramp. Composite provided by Rosemary Mosher.

Like other urban universities in the northeast, USM is balancing the demand for morre classroom, lab, and office space with built in constraints inherent to its location in an old, established city neighborhood. Its' choices are limited.

Figure 2C and 2D. As shown in this detail, the campus is bordered on one side by tree lined streets and stately nineteenth century homes, long since subdivided into studio apartments for USM students. Two major transit routes intersect directly outside the Library: Interstate 295, a major commuter highway, and Forest Avenue, a heavily traveled six lane thoroughfare. Oakhurst Dairy, the University's closest neighbor in the commercial zone along Forest Avenue, completes the campus boundary with its processing plant, which occupies a full city block. Provided by Rosemary Mosher.

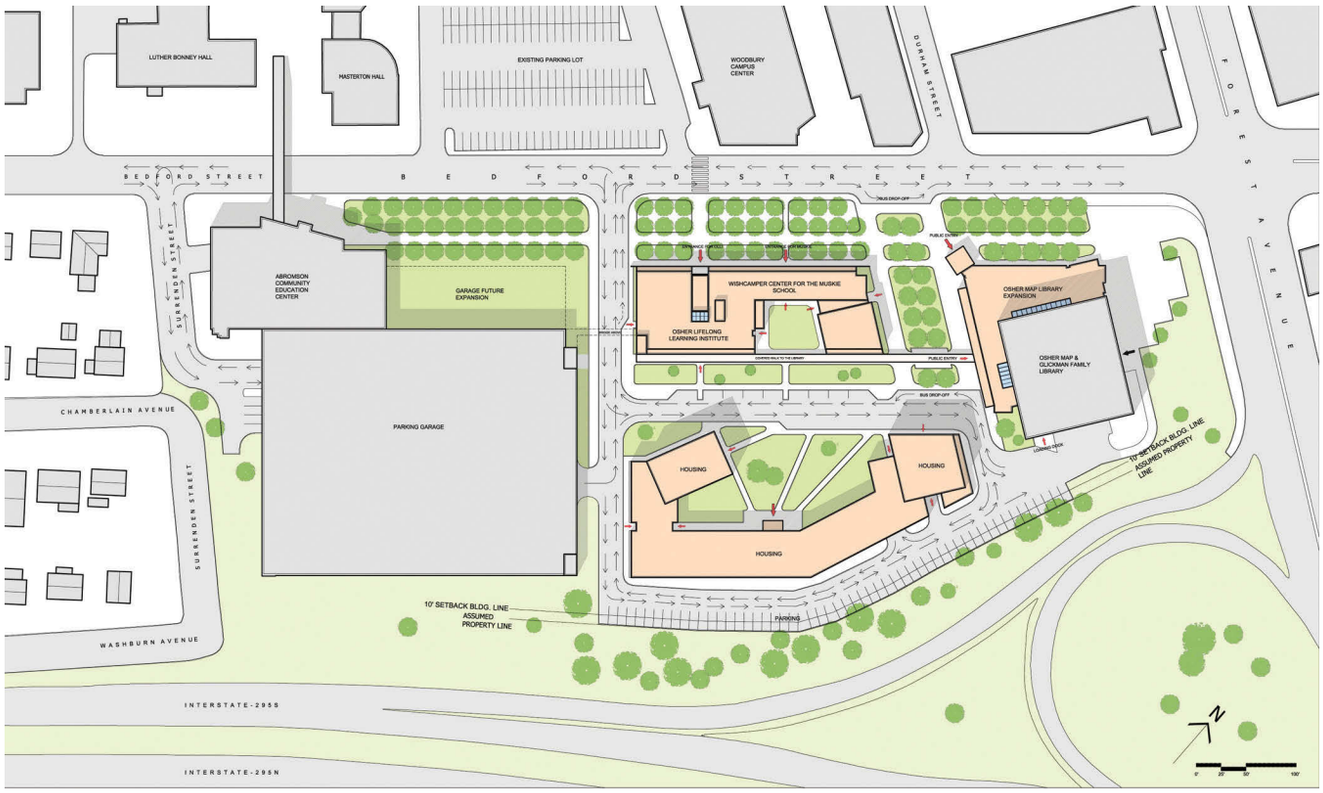
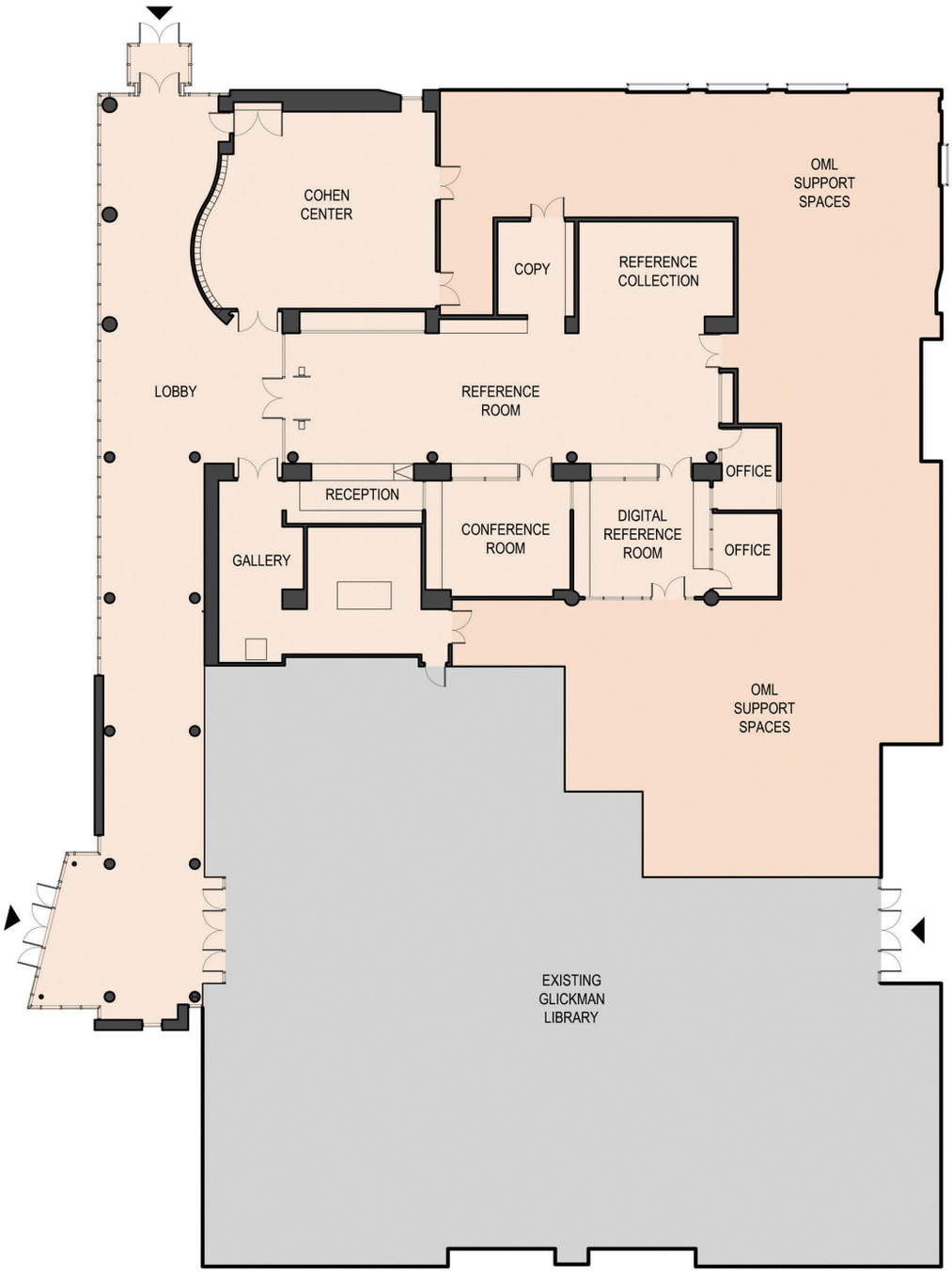


Figure 3A. As shown, the University Commons project consists of three programmatic components contained in two separate buildings, the Wishcamper Center and the Osher Map Library: (1) the consolidation under one roof of all the operations of the Muskie School of Public Service currently housed in various rented offices throughout the city; (2) a multi-purpose facility for the Osher Lifelong Learning Institute, a consortium of senior colleges, which will also serve as its national headquarters; (3) the expansion of the Osher Map Library's footprint on the corner of Bedford Street and Forest Avenue to support its growing collections. The master plan for University Commons was designed by Koetter Kim & Associates, an award-winning architectural and urban planning firm which specializes in campus planning. The Boston based firm is currently in the news for designing a new expansion to the port city of Aktau in Kazakhstan, located next to the Caspian Sea. Their website can be found at www.koetterkim.com.

Figure 3B. Koettter Kim & Associates model of University Commons.

Figure 3C. Artist's rendering of the Osher Map Library expansion.



UNIVERSITY COMMONS
Portland Campus
UNIVERSITY OF SOUTHERN MAINE

OSHER MAP LIBRARY
FLOOR PLAN

KOETTER KIM & ASSOCIATES INC.
ARCHITECTURE URBAN DESIGN
344 Boylston Street, Boston, MA 02116
T 617 536 8560 F 617 536 1217 W koetterkim.com
0' 5' 10' 20'

Figure 4A. The Osher Map Library expansion, adjoining the Glickman Family Library along Bedford Street, will roughly quadruple the size of the map library from 4,525 to 19,000 sq. feet. A two-story vault will house its growing collections. The seating capacity in the reference area is doubled. Permanent globe displays at each end of the reference room will showcase OML's rare globe collection. Rapid changes in access technologies are addressed in a digital reference room and a digital reproduction center. For improved group tour access, the renovated gallery will have a separate entrance. The Cohen Education Center will provide instructional space for K-12 outreach. This multi-purpose space can also be converted into a lecture room with seating capacity for seventy-six.

Mapping: Methods & Tips

Color Design for the Color Vision Impaired

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Eight percent of men are affected by color vision impairment – they have difficulties distinguishing between colors and thus confuse certain colors that the majority of people see readily. Designers of maps and information graphics cannot disregard the needs of this relatively large group of media consumers. This article discusses the most common forms of color vision impairment, and introduces Color Oracle, a new software tool that assists the designer in verifying color schemes. Color Oracle filters maps and graphics in real-time and efficiently integrates with existing digital workflows. The paper also discusses color combinations and alternative visual variables for map symbology that those with color vision impairments can distinguish unambiguously. The presented techniques help the cartographer produce maps that are easy to read for those with color vision impairments and can still look good for those with normal color vision.

Introduction

One in twelve men sees color differently than the rest of the population. Afflicted by a condition often inappropriately described as colorblindness, these men confuse certain colors that the majority of people are able to distinguish.[1] Their perception of hue, saturation and brightness varies. Color vision impairment is typically inherited due to a sex-linked recessive gene carried on the X chromosome and predominantly affects men. Eight percent of the male population may not appear as a large number, but when publishing in a mass market (e.g. for a major newspaper) the number of affected readers may reach tens of thousands. Maps with smaller circulation have fewer affected readers, but they may be critical members of the audience.

Designers, and especially cartographers, should ensure that their work is clear to the color impaired as well as to the viewer with full color vision. Such barrier-free, "universal" design is especially important when readers have very limited time to read maps and information graphics, as, for example, for the reading of evacuation plans in emergency situations. Universal design can even be required by law: In the United States, Section 508 of the Rehabilitation Act amendments to the Americans with Disabilities Act (ADA) requires disabled people receive equal or comparative access to information. Cartographers may also consider barrier-free design as part of their professional ethics, since color vision impairment is probably the most widespread physiologic impairment hampering map reading.

It is thus important for cartographers and designers of information graphics to know how the color vision impaired perceive color and what color combinations are confused. The first part of this article addresses this question by describing the most common forms of color vision impairment, and how they affect color perception. We then introduce Color Oracle, a new application for the digital simulation of color vision impairment. This software assists designers in verifying that color combinations are universally legible by filtering graphics on computer monitors in real-time. The final section provides practical tips for the selection of colors, and demonstrates how map legibility can be improved by the use of alternative visual variables and direct annotation.

Common types of color vision impairment

A wide range of color vision anomalies exist – some genetic and some the outcome of degenerative diseases, poisoning or physical injury. The commonly called "red-green blindness" is by far the most frequent form. It affects about 8% of all males, mainly causing difficulty when distinguishing colors emanating from the red-green portion of the visible spectrum.

Color vision is linked to the cones that respond to light entering the eye. People with full color vision perceive color with three types of cones, which are called L, M and S-cones. Each type registers light from a different portion of the spectrum. People who confuse red and green are affected by a complete lack or a dysfunction of the L and M-cones. A complete lack is called protanopia or deuteranopia. These forms of color impairment are relatively rare and can be

thought of as "pure" form of color deficiency. Dysfunctions of lesser degree are much more common. They are usually caused by a slight shift in sensitivity of one cone type towards another color hue in the light spectrum (protanomaly and deuteranomaly).

Table 1 lists the percentages of affected males by the four forms of red-green deficiency, and illustrates the perceived color spectra. The degree of impairment varies from one person to another between almost full color vision and "pure" protanopia and deuteranopia. Indeed, the measurable variation among individuals with "normal" vision is so large that the boundary between normal and color impaired vision is arbitrary. The spectra for protanomaly and deuteranomaly displayed in Table 1 (stared) are therefore very speculative and only provide a rough guess of how affected people could perceive color.

	Cones	Affected men	Estimated perceived color spectrum
Protanopia	L-cones absent	1%	
Protanomaly	L-cones abnormal	1%	*
Deuteranopia	M-cones absent	1%	
Deuteranomaly	M-cones abnormal	5%	*
Full color vision	-	92%	

Table 1. The four forms of red-green confusion. The protanopia and deuteranopia spectra are very similar, the protanomaly and deuteranomaly spectra are rough estimations (numbers are rounded, after Birch, 1993).

Women are much less likely to be affected by red-green confusing vision than men with only 0.4% women impaired (Birch, 1993). Other rare forms of color vision impairment exist, which affect less than approximately 0.3% of all men and women. Tritanopia is a very rare lack of S-cones. The similarly rare monochromatic vision—true color blindness as the general public thinks of it—impedes any discrimination based on color (see Birch 1993 for more information about the different forms of color vision impairment).

The consequence of color vision impairment is that afflicted people are slower and considerably less successful in search tasks, when color is the primary attribute of the target object, or if color is used to organize visual displays (Cole, 2004). Seeking to address this problem, section 508 of the U.S. Rehabilitation Act states:

> "Color coding shall not be used as the only means of conveying information, indicating an action, prompting a response, or distinguishing a visual element." 1194.25(g).

While map reading by the color impaired has not been studied extensively, it was found that readers with impaired color vision make errors naming the boundary lines on multi-colored terrain maps (Kuyk et al., 1987). Another study confirmed that only a small percentage of color-impaired readers could name the colors of a weather radar display without error (Mertens and Milburn, 1996). A low level of illumination further impedes successful reading of color-coded information. Investigations have shown that under reduced illumination, subjects with impaired color vision make considerable more errors when identifying color (for more details see Cole, 2004).

A variety of assistive computer software can help the color impaired to more easily read color-coded information on screen. Examples include programs such as eyePilot (http://colorhelper.com/) or Visolve (http://www.ryobi-sol.co.jp/visolve/en/). These programs do not allow color impaired individuals to see the full range of colors. Instead, they increase the contrast between confusing colors. While this assistive technology can be extremely useful to the color-impaired, it must be considered as a last resort. For printed "hard copy" graphics, these digital tools are not convenient. Instead, maps and information graphics should be designed for universal legibility.

Specialized software helps the designer select universally legible color combinations, for example ColorBrewer, a popular online tool that suggests color schemes (Harrower and Brewer, 2003; www.colorbrewer.org). Color Oracle and other simulators of color-impaired vision are complementary tools that help verifying the legibility of a design.

Color Oracle

Color Oracle software allows the designer to see colors on screen as people with color vision impairments see them. It is permanently accessible via the Mac OS X menu bar or the Windows system tray. Color Oracle works by filtering whatever appears on the computer monitor, therefore its benefits are universally available to all applications. The Color Oracle user triggers a simulation by selecting the type of color impairment in a drop down menu (Figure 1). Color Oracle then takes a snapshot image of the pixel values currently shown on the monitor, and filters the pixels accordingly. The filtered image is displayed afterward in a borderless full-screen window floating above all other windows—the user sees the monitor colors switching to color impaired vision, without noticing the additional window. The window disappears when the user presses any key or clicks any mouse button. The designer can toggle between normal color vision and three varieties of simulated impaired vision to identify problematic color combinations. This approach

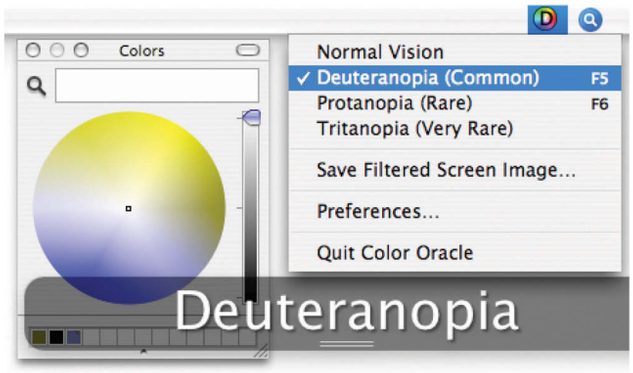

Figure 1. Screenshot of Color Oracle on Mac OS X simulating deuteranopia on a color picker wheel.

does not interfere with the user's usual workflow and works with any graphics or mapping software.

Color Oracle simulates deuteranopia, protanopia, and tritanopia, which are the "pure" forms of color vision impairment. As explained in the previous section, these extreme forms, which are characterized by the complete functional absence of one type of cones, are not as common as the milder forms with partial or shifted sensitivity. These milder, intermediate forms are more difficult to simulate, since the dysfunctions vary to a high degree from person to person. It can however be assumed that if a color scheme is legible for someone with extreme color vision impairment, it will also be easily legible for those with a minor affliction.

To simulate how a color will appear to a color impaired viewer, Color Oracle uses an algorithm based on confusion lines.[2] Simulations by Color Oracle are accurate, except for very saturated colors, which might slightly deviate from the values that are seen by persons with "pure" forms of color vision impairment. The software was developed by the authors of this article and is freely available from http://colororacle.cartography.ch.

Color as seen by the color vision impaired

The blue-yellow color table in Figure 2 contains an estimation of all colors that a red-green confusing viewer can unambiguously distinguish compared with a normal vision viewer. Other colors can only be distinguished with difficulty or not at all, especially those along the vertical red-green ramp in Figure 2. The figure shows the b-plane of the CIE Lab color space, which is similar to the colors discernable by a red-green impaired reader. The Lab b-plane can be visualized in the color picker of Adobe Photoshop by selecting the "a" button to the right of Figure 2 and entering 0 in the associated field. The number of colors that red-green confusing readers can unambiguously distinguish is rather small.

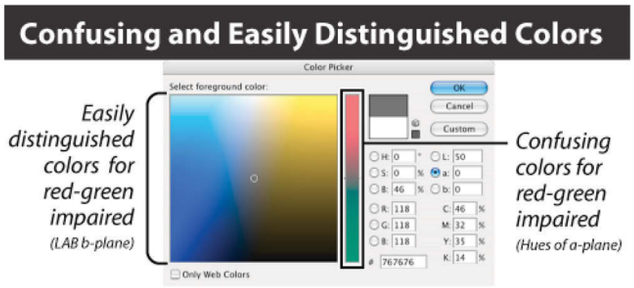

Figure 2. The Lab color mode in Photoshop can be used to explore red-green confusing vision.

Besides the well-known red-green combination, they also confuse other color pairs, as illustrated by Figure 3. Swatches grouped at the left show colors that readers with normal color vision can easily distinguish. The right side shows how red-green impaired readers confuse these colors. Dark green, brown, orange and dark red in the first row appear as almost indistinguishable olive-green tones to the red-green impaired. The second row contains less saturated blue, turquoise and purple, which are all seen as undistinguishable pale violet-blue. The saturated purple and various blue tones of the third row manifest as almost identical bluish tones. Cartographers should be wary of pairing these colors, especially for diverging quantitative color schemes.

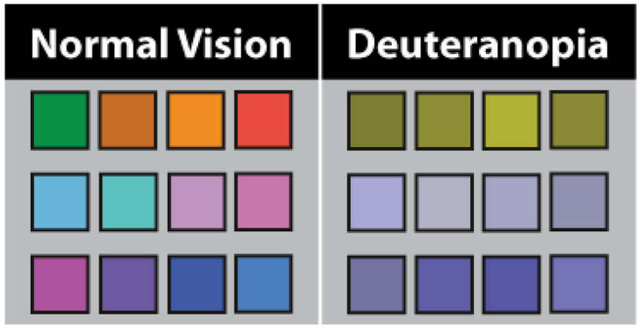

Figure 3. Colors as they appear to readers with normal vision and deuteranopia.

For example, the map in Figure 4 visualizes the approval and rejection of a ballot with a diverging red-green scheme (top left). Shades of red and green appear as undistinguishable shades of olive-green to a reader with deuteranopia (top right). Because the brightness varies between classes, the intensity of the voters' opinion can be understood, but not the type of opinion (approval or rejection). The alternative purple-green color scheme is also legible by the red-green impaired reader (bottom row). The ColorBrewer online tool can help choose other, universally accessible color schemes.

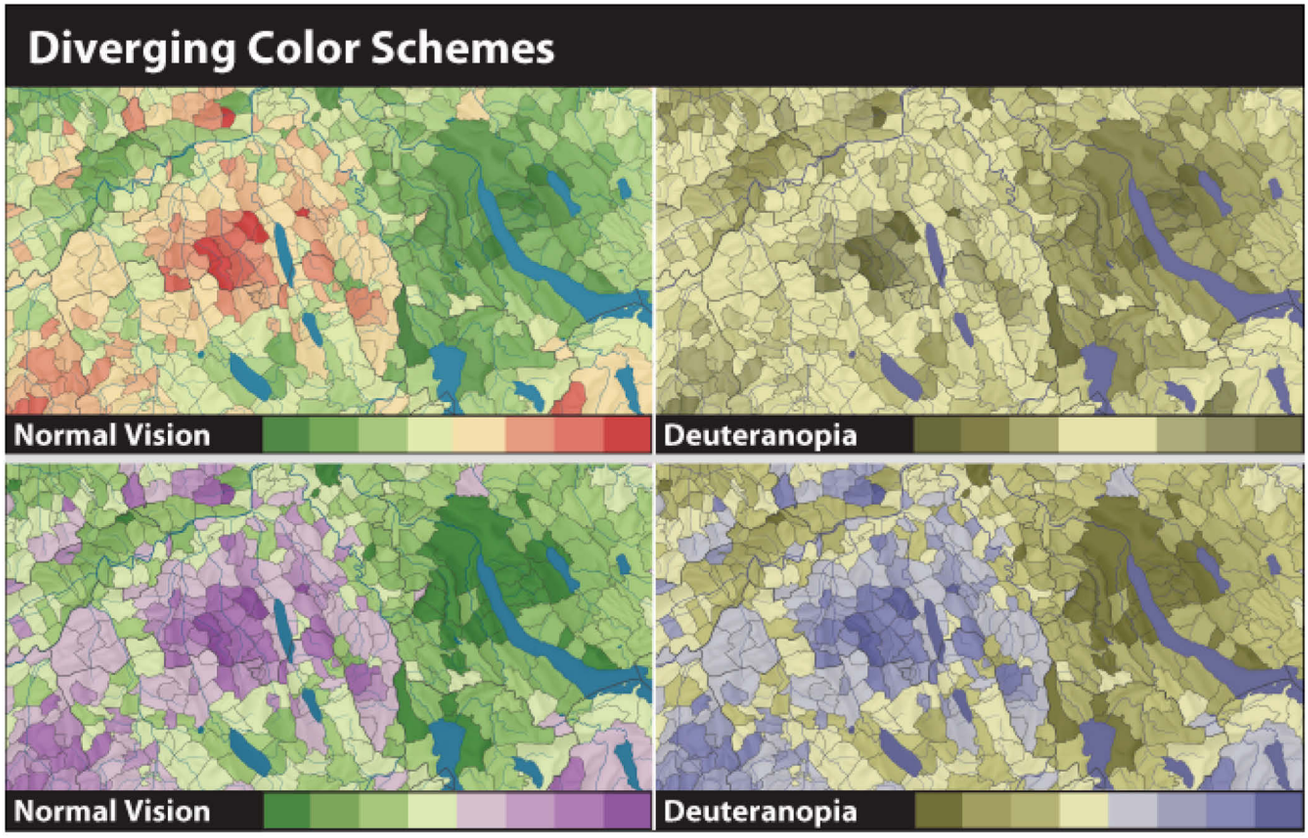

Figure 4. Color schemes on a choroplethic map of voting results. Readers with deuteranopia cannot interpret the red-green scheme of the top row. The purple-green scheme in the bottom row is legible by everyone. The diverging color ramps are depicted below the maps. (©Atlas of Switzerland 2, 2004).

Designing maps to accommodate the color vision impaired

Greater clarity can be brought to maps by (1) choosing unambiguous color combinations, (2) using alternative visual variables, and (3) directly annotating features. These techniques will improve maps for those with full color vision and will establish a level of distinction for those with color-impaired vision. In this section, we concentrate on red-green confusion, since it is by far the most frequent form of color vision impairment.

Maps are made under optimal illumination, but they are often read in poorly illuminated rooms, hallways, or subway stations, making it hard to tell colors apart. A strong figure-ground contrast with a clear difference in brightness and saturation, as well as a reduced number of classes in color ramps help everyone to more easily read a map under normal and poorly lighted conditions.oint classes

Dot maps often use hue as the only differentiating variable between different classes of points. This hue coding can be difficult to interpret for color-impaired readers. Figure 5 illustrates how point symbols can be redesigned to increase legibility. Varying the saturation increases contrast and differentiates the dots only slightly for red-green impaired readers ("poor" column). While shifting hue from green to blue improves legibility ("better" column), the best solution is achieved with distinguishing geometric shapes in combination with varying hue and saturation. The last column shows that color could even be discarded and the map would still be legible with differing geometric shapes. Well-designed symbols are easy for the reader to decode without consulting a legend.

Distinguishing line classes

To minimize confusion, color-coded lines on maps can be redesigned in a manner similar to color-coded dots (Figure 6). Changes to line width must be applied with care, however, since different stroke widths imply varying quantities ("poor" column). Directly annotating the lines with labels is a better solution that clarifies ambiguous colors and reduces the need to reference a legend. Figure 7 shows an example of a diagrammatic transportation map that uses labels for metro lines and stations. Readers can follow the line to its label at the route terminus to discern routes directly on the map, without relying on a color-coded legend.

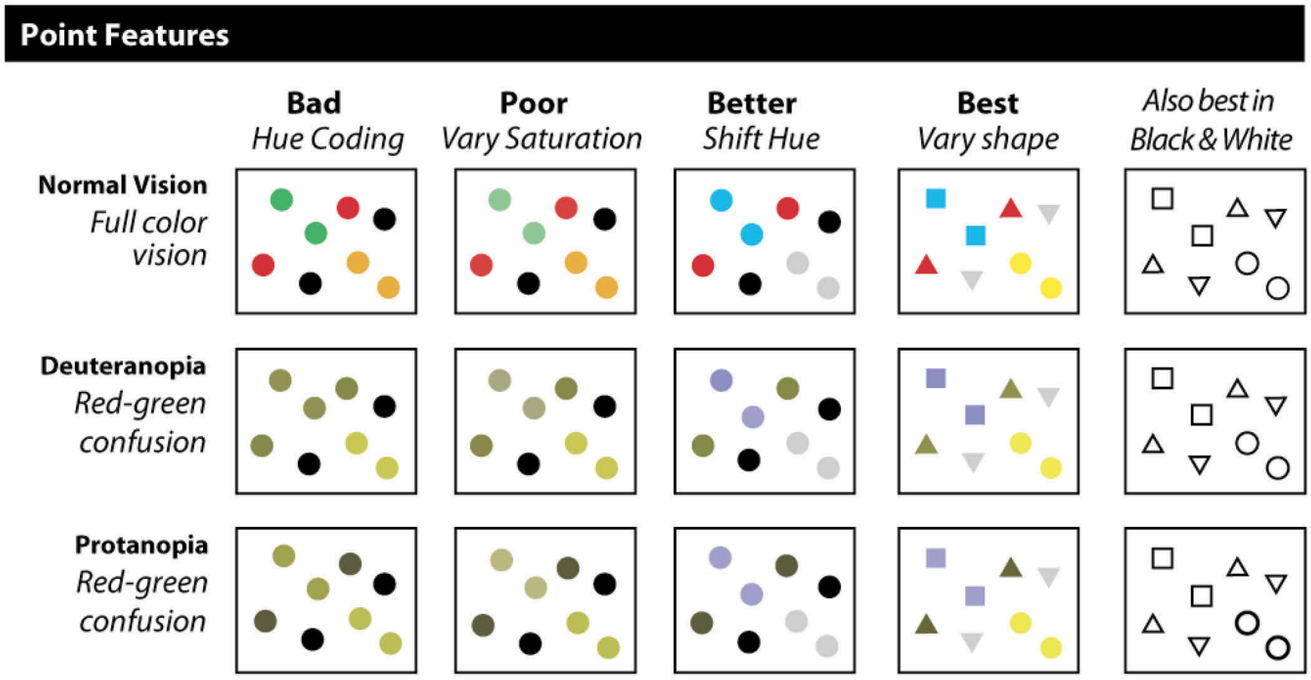

Figure 5. Point classes typical of a dot map distinguished by saturation, hue and shape.

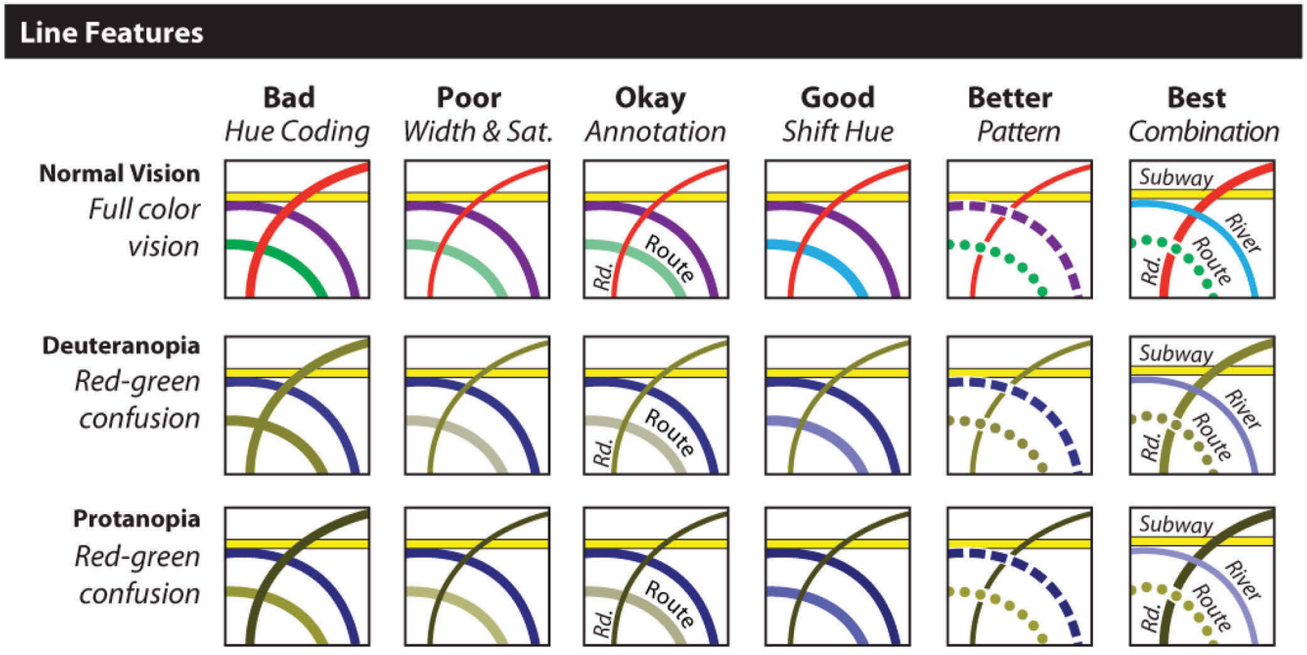

Figure 6. Line classes distinguished by width and saturation, annotation, hue and line pattern.

Altering color hue is another way to improve legibility ("better" column in Figure 6). A combination of modified hue and saturation with varying line patterns and annotations is our preferred solution, because it is legible to everyone ("best" column). While line patterns (dash, dot, etc.) can imply unwanted qualitative or quantitative meaning or create undesirable visual noise, for complex maps with more than a handful of line classes, texture can become essential.

Distinguishing area classes

Qualitative mapping can combine problem color hues as long as they are differentiated by saturation and

Figure 7. Annotation of metro lines and stations in the transportation diagram of Madrid.

value (dark red, bright green). The use of overlay hatching can sometimes avoid the use of problematic color combinations in choropleth maps.

For continuous tone raster data where colors merge into one another, scientists often apply spectral rainbow color ramps, which typically include red, orange, yellow, green, blue and purple. Brewer (1997) found that many readers prefer such spectral color schemes, and that they are also easy to read and interpret. This finding challenges the opinion of many cartographers, who advise against the use of spectral schemes for ordered data. To accommodate red-green impaired readers, Brewer makes the following suggestions: (1) Vary lightness on the red-orange-yellow end of the rainbow. (2) Omit yellow-green to avoid confusion with orange. (3) For bipolar data, omit green and use a scheme with red, orange, yellow, light blue and dark blue; and align the yellow-blue transition with the pivot point of the diverging data range.

The precipitation map in the first row of Figure 8, for example, shows low quantities of rainfall in red, and intermediate values in green. Hence, low and intermediate values appear identical for readers with deuteranopia. The map in the second row uses an alternative spectral ramp that omits yellow-green, uses a darker red, and places the transition between yellow and blue at the mean of all values. To bring further clarity to the map, selected high and low values could be labeled when the map is printed. For a digital map, the user could query values by hovering the mouse over map locations.

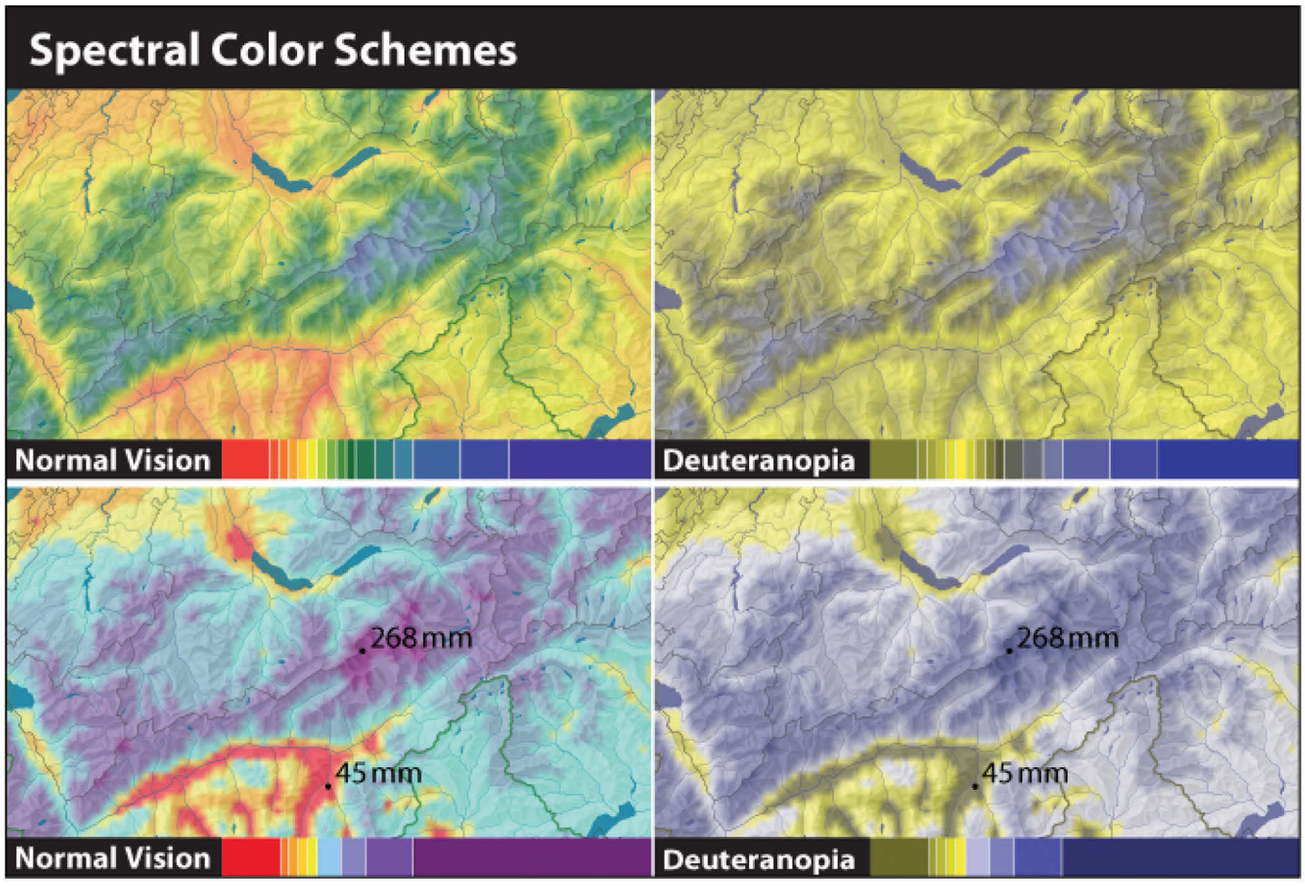

Figure 8. Spectral color schemes for precipitation maps with rainbow colors (top row) and with an improved spectral scheme (bottom row). Color ramps are depicted below the maps. (Mean monthly precipitation in January, ©Atlas of Switzerland 2, 2004).

Conclusion

Color impaired vision affects a significant portion of the population and therefore must be taken into account by the cartographer. Color Oracle provides a convenient method to verify that colors on a map are legible to everyone. Indeed, we have discovered many problematic color combinations in our daily mapmaking work thanks to the help of Color Oracle. Adjusting color schemes is not always simple and forces the cartographer to reassess well-established conventions—for example, red-green color schemes for voting maps or rainbow color ramps for precipitation maps.

When adjusting a color scheme, the cartographer has to find a balance: On one side, the 8 percent of men who are color impaired have the right of equal access to information. On the other side, the 96 percent of the population with normal vision has the right for pleasant maps that are easy to read. It is the cartographer's responsibility to adjust colors where judged appropriate.

To avoid problematic color combinations, the cartographer should use colors with strong contrast and supplemental visual variables, such as shape, size, and pattern variations to allow all readers to discern and directly interpret a symbol without consulting a legend. Additional techniques include simplification of the map design and annotating the map directly where the reader might be confused.

Interactive digital maps can further support color impaired readers by providing tooltips or labels that are displayed on-demand. Digital environments should additionally allow the user to customize color schemes to suite their needs, and provide methods to query individual values.

Color Oracle provides a convenient tool for seeing maps the same way that color impaired readers do. It is now an integral part of our workflow and we hope you also find it valuable for designing maps that are universally accessible to all.

Notes

1. Anomalous color vision is commonly called "color-blindness". This term, however, is not appropriate because it erroneously suggests that affected subjects cannot see colors. This article generally uses "color vision impairment", as suggested by Olson and Brewer (1997).

2. For more information about the algorithm, see Brettel et al. (1997) and Vienot et al. (1999). Meyer and Greenberg (1988) propose a related method. Fulton (2005) suggests that the confusion lines, which are the base for this algorithm, should be improved, especially for saturated colors.

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Visual Fields

The Process of Map Design: Equal Cartographic Voice

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The title, Thoreau-Wabanaki Trail, implies equal billing. But early in this project it became clear that Wabanaki content, cartographically, was not equal; in fact, it simply was not there. The map would be dominated by Thoreau's writings with Wabanaki content only implied through the routes taken by Thoreau and his Native guides.

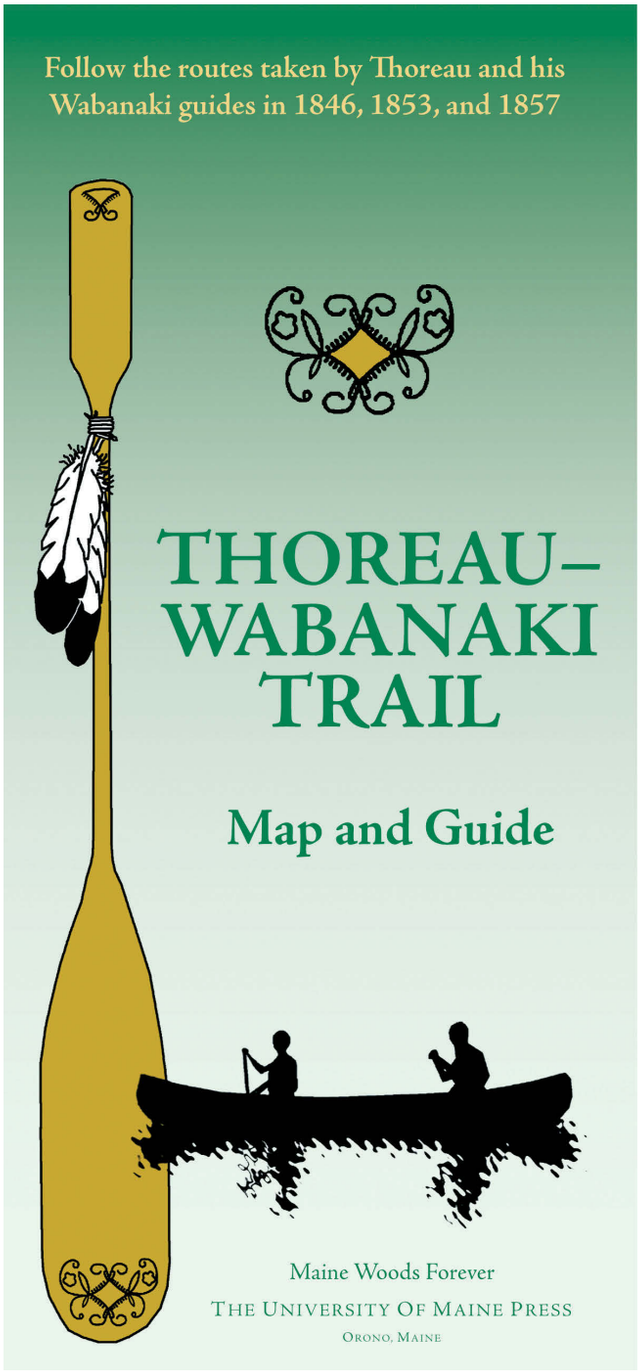
James Francis, a historian and Penobscot native, worked closely with me to find quotes from Thoreau's 1864 book, *In the Maine Woods*, about Indians that were respectful and correct. Not necessarily politically correct, but simply correct—many of Thoreau's observations were wrong because he misinterpreted the scene or was hindered by his own prejudice.

We chose to work with Native placenames to balance the cartography and reinforce the depth of Native knowledge and understanding of place. Thoreau comments that what appears on his Anglo-american maps as an unnamed landscape is, in fact, richly named by his Native guides. We identified appropriate Penobscot placenames in three forms: Native spelling and alphabet, literal meaning, and English translation. This way a more complete story is revealed; the reader can see the Anglo interpretation of the name and understand the descriptive aspects of the name. A second legend was added to give the reader the tools to accurately pronounce the Penobscot language and balance the Thoreau legend.

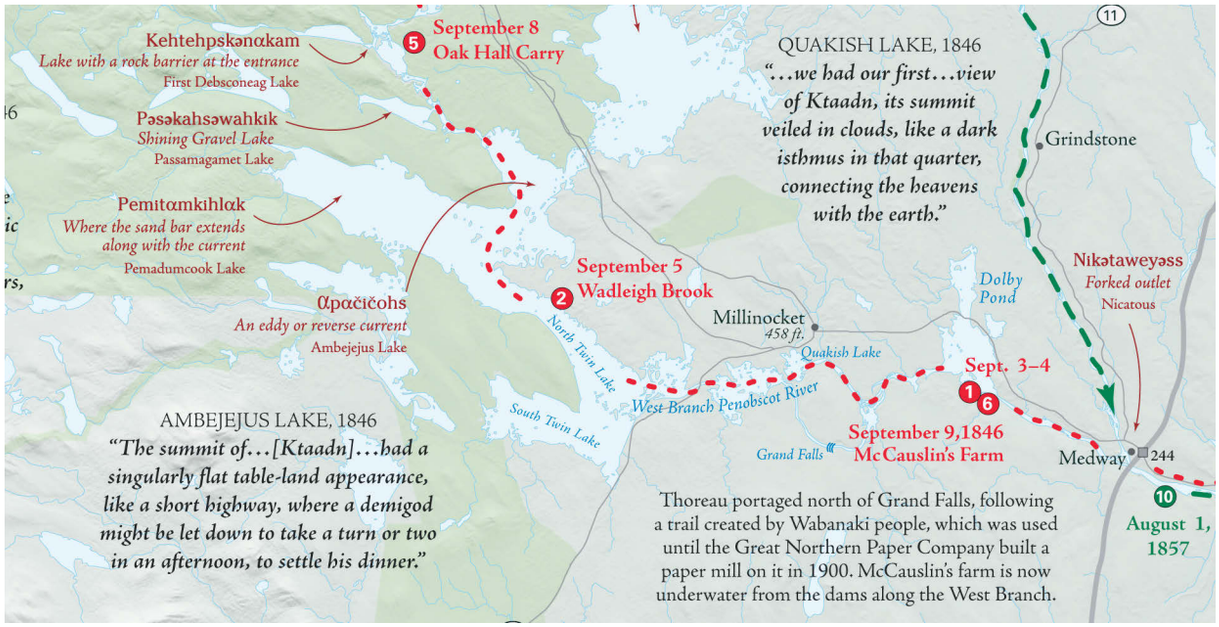
Cartographically, the native placenames evolved to a separate visual layer with a unique hue. Arrows were drawn to point to the specific feature, as Native names are often particular to a specific place. In most cases this is the only treatment of that place; meaning it is not redundantly labeled with blue hydro text.

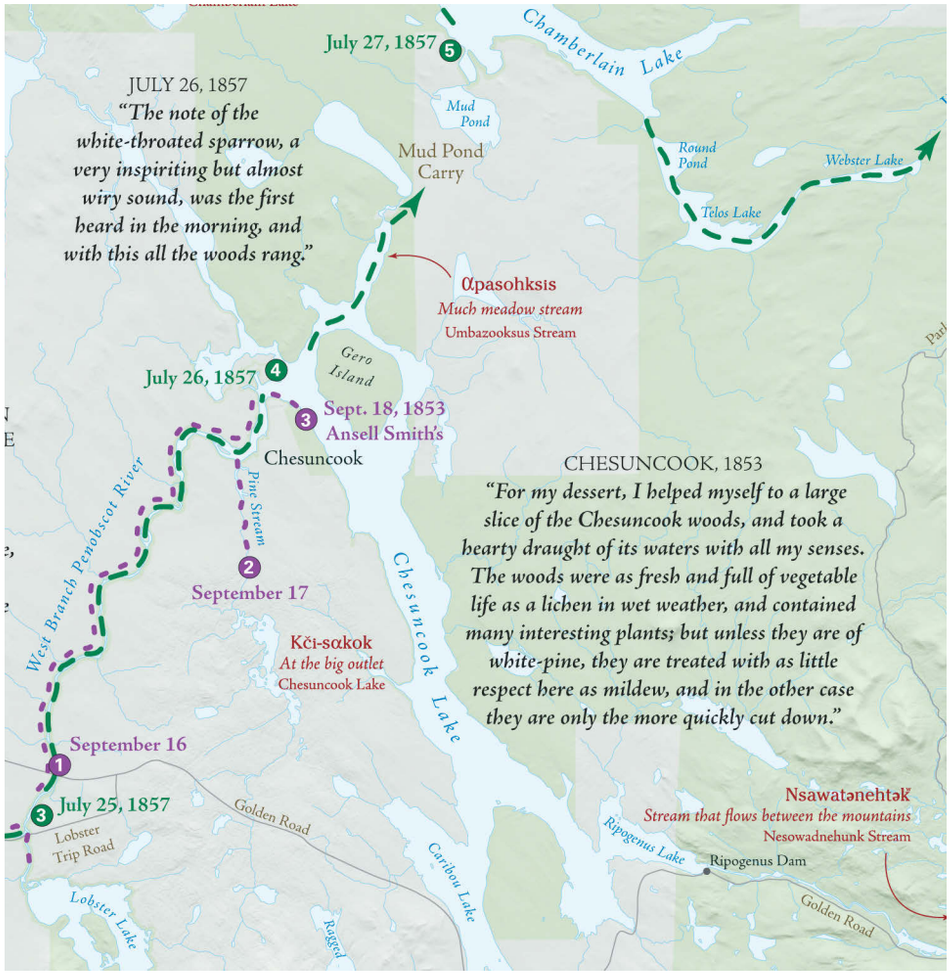
By combining Wabanaki orthography and a tri-label approach, the Native placenames become an equal cartographic component, just as Native guides were an equal component of Thoreau's travels.

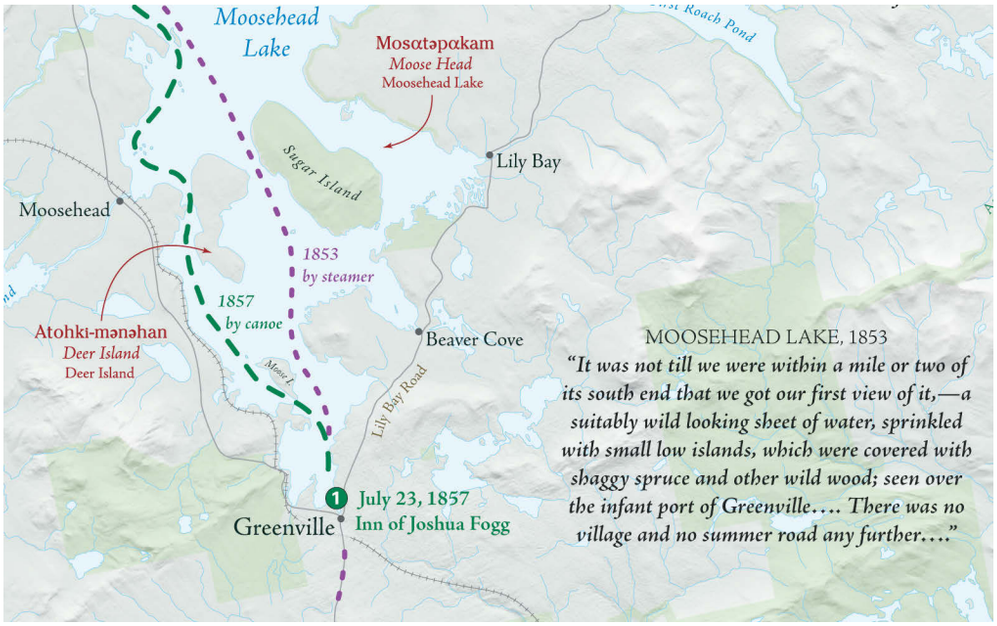
The map was funded by Maine Woods Forever and published by the University of Maine Press. Printed on HopSyn by J.S. McCarthy Printers, Augusta, Maine.



ISBN 978-089101-115-3. Michael Hermann designed this map as an independent cartographer.


Kehtehpskənɑkam
Lake with a rock barrier at the entrance
First Debsconeag Lake
Pəsəkahsəwahkik
Shining Gravel Lake
Passamagamet Lake
Pemitɑmkihlɑk
Where the sand bar extends along with the current
Pemadumcook Lake
ɑpɑčičohs
An eddy or reverse current
Ambejejus Lake
5 September 8
Oak Hall Carry
2 September 5
Wadleigh Brook
AMBEJEJUS LAKE, 1846
"The summit of…[Ktaadn]…had a singularly flat table-land appearance, like a short highway, where a demigod might be let down to take a turn or two in an afternoon, to settle his dinner."
QUAKISH LAKE, 1846
"…we had our first…view of Ktaadn, its summit veiled in clouds, like a dark isthmus in that quarter, connecting the heavens with the earth."
11
Grindstone
Dolby Pond
Nikətaweyəss
Forked outlet
Nicatous
Millinocket
458 ft.
North Twin Lake
Quakish Lake
Sept. 3–4
1 6
West Branch Penobscot River
South Twin Lake
Grand Falls
September 9,1846
McCauslin's Farm
Medway
244
10 August 1, 1857
Thoreau portaged north of Grand Falls, following a trail created by Wabanaki people, which was used until the Great Northern Paper Company built a paper mill on it in 1900. McCauslin's farm is now underwater from the dams along the West Branch.


July 27, 1857 5
Chamberlain Lake
JULY 26, 1857
"The note of the white-throated sparrow, a very inspiriting but almost wiry sound, was the first heard in the morning, and with this all the woods rang."
Mud Pond
Mud Pond Carry
Round Pond
Webster Lake
Telos Lake
ɑpasohksis
Much meadow stream
Umbazooksus Stream
July 26, 1857 4
Gero Island
3 Sept. 18, 1853
Ansell Smith's
Chesuncook
Pine Stream
West Branch Penobscot River
2 September 17
Kči-sɑkok
At the big outlet
Chesuncook Lake
Chesuncook Lake
CHESUNCOOK, 1853
"For my dessert, I helped myself to a large slice of the Chesuncook woods, and took a hearty draught of its waters with all my senses. The woods were as fresh and full of vegetable life as a lichen in wet weather, and contained many interesting plants; but unless they are of white-pine, they are treated with as little respect here as mildew, and in the other case they are only the more quickly cut down."
1 September 16
3 July 25, 1857
Lobster Trip Road
Golden Road
Lobster Lake
Caribou Lake
Ripogenus Lake
Ripogenus Dam
Nsawatənehtəǩ
Stream that flows between the mountains
Nesowadnehunk Stream
Golden Road



Color Figures

A Publishing History of John Mitchell's Map of North America

Matthew H. Edney

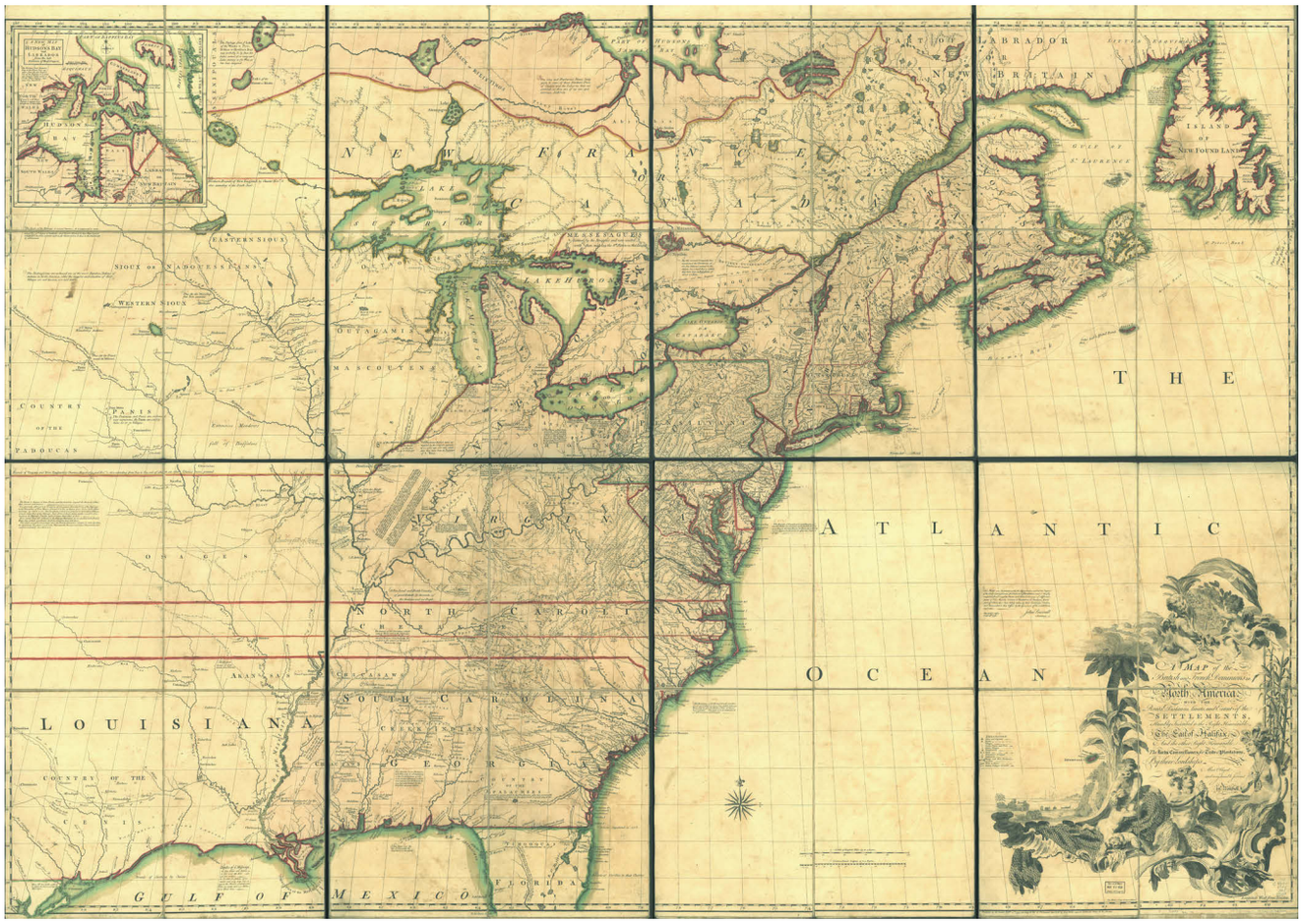


Figure 1. John Mitchell, A Map of the British and French Dominions in North America with the Roads, Distances, Limits and Extent of the Settlements, Humbly Inscribed to the Right Honourable The Earl of Halifax, And the other Right Honourable The Lords Commissioners for Trade and Plantations, *engraved by Thomas Kitchin (London: Andrew Millar, 1755). Variant 1. 136cm x 195cm. Courtesy of the Geography and Map Division, Library of Congress (G3300 1755 M5 Vault).*

Figure 2. An Accurate Map of the British Empire in Nth. America as Settled by the Preliminaries in 1762, *engraved by John Gibson, in* The Gentleman's Magazine *32 (1762): 602-603. The shaded territory was that to be ceded by France and Spain to Great Britain. 21cm x 26cm. Courtesy of the Geography and Map Division of the Library of Congress (G3300 1762 .G5 Vault / Lowery no. 457).*

Figure 3. A New and Accurate Map of North America . . . Humbly Inscribed to the Honorable Charles Townshend one of the Right Honorable Lords Commissioners for Executing the Office of Lord High Admiral of Great Britain &c By his Most Obliged, most Obedient and Very Humble Servant Huske, *engraved by Thomas Kitchin, in John Huske,* Present State of North America *(London: R. & I. Dodsley, 1755). 39cm x 49cm. Courtesy of the Geography and Map Division, Library of Congress (G3300 1755 H8 Vault).*

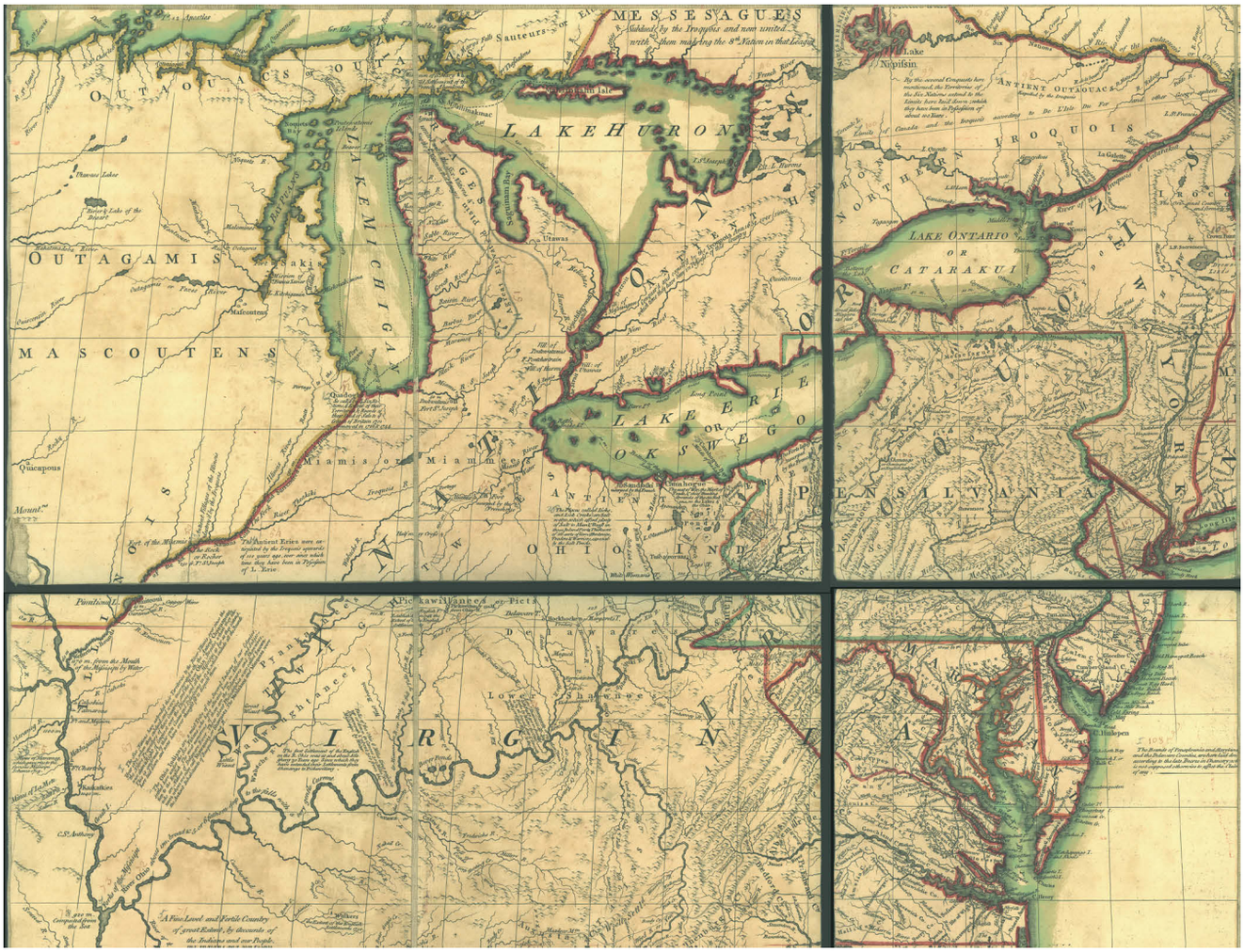


Figure 4a. Detail of the area of Lake Ontario and of political boundaries from first variant. Courtesy of the Geography and Map Division, Library of Congress (G3300 1755 M5 Vault and G3300 1774 .M5 Vault).

Figure 4b. Detail of the area of Lake Ontario and of political boundaries from sixth variant. Courtesy of the Geography and Map Division, Library of Congress (G3300 1755 M5 Vault and G3300 1774 .M5 Vault).