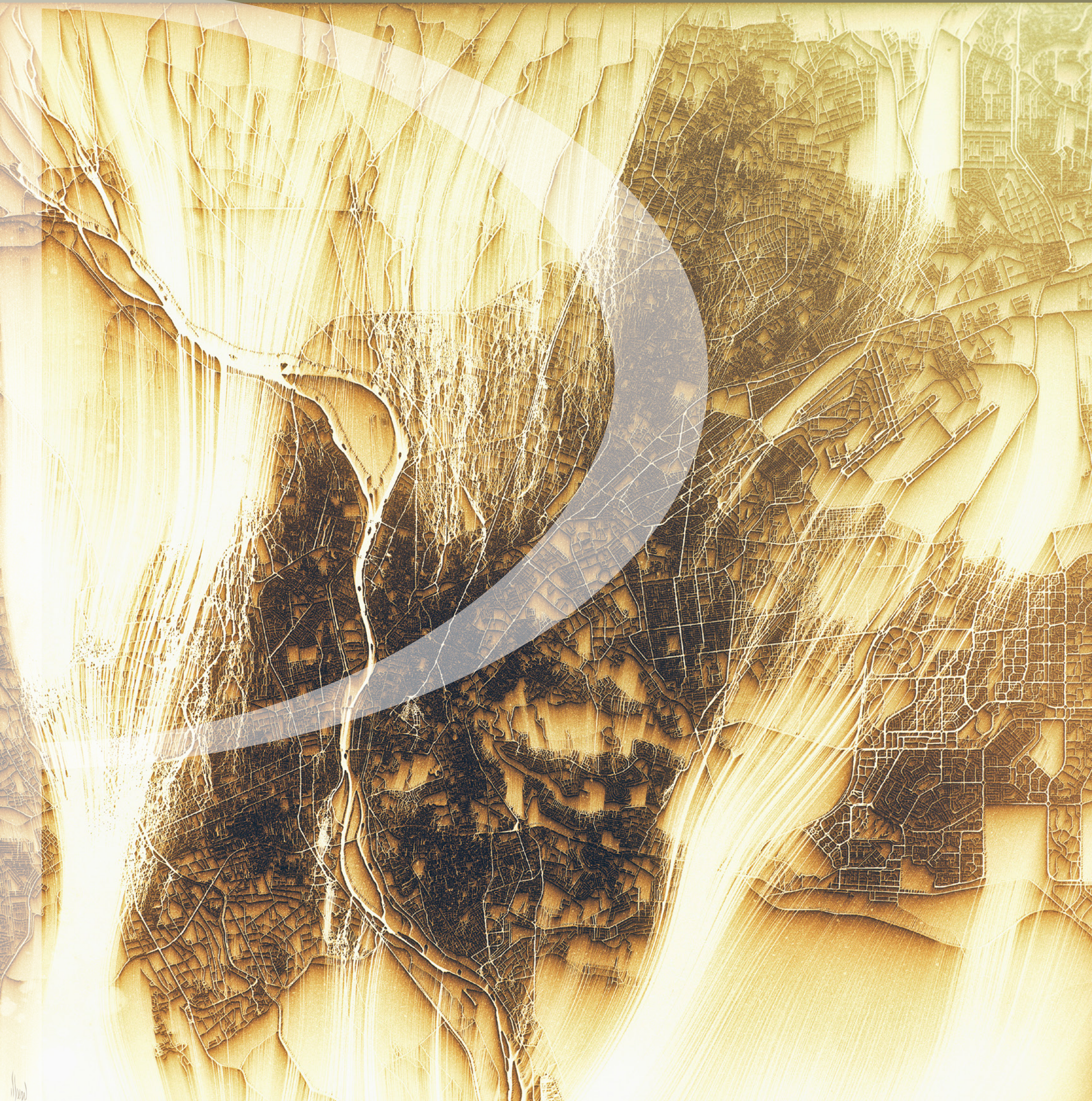
Cartographic Perspectives

The Journal of nacis

Number 81, 2015



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IN THIS ISSUE

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ABOUT THE COVER: *Flowing City Map of Cairo, by Istvan. See* Visual Fields *on page 49 for more details and images of other cities.*

LETTER FROM THE EDITOR

Perhaps you've heard our organization described as "NACIS is nicest," a reflection of the welcoming and inclusive nature of this community of map enthusiasts. I'd like to extend this idea to supporters of *Cartographic Perspectives* with the adage, "it's nice to share," as this attitude permeates our publication process. Examples include the willingness of individuals to step up to serve as reviewers, the open-access nature of our journal, the interchange of opinions and ideas, and the ease with which content is made available within and outside of our publication.

Amy Griffin, the new Co-Editor of our journal, is a stellar example of this spirit. Amy is a well-respected cartographic researcher and instructor, a long-time NACIS participant, and the driving force behind the NACIS Annual Meeting in Minneapolis last October. When I recently took on new responsibilities at my university that caused me concern for keeping *CP* my top priority, I knew I needed to share the editorial responsibilities. Amy was kind enough to join me through the end of 2016, at which time I will step down as scheduled and she will begin a three-year term as Editor.

The timely and accessible sharing of ideas is central to our distinction of being the only fully open-access journal of cartography in the world. Amy and I are committed to recruiting, posting, and publishing accepted materials in an efficient manner, with individual articles published to the website very quickly after they are accepted. In this pursuit, we are happy to share responsibilities with a dedicated a team of Section Editors: Fritz Kessler, Laura McCormick, Terri Robar, Lisa Sutton, Alex Tait, and Andy Woodruff, as well as our talented Assistant Editor, Daniel Huffman, and the entire *CP* Editorial Board.

The peer-reviewed section requires special consideration, and I am very grateful for all of the reviewers, from both my Editorial Board and elsewhere, who have shared their expertise and advice to improve research articles and aid in decisions. To maintain a double-blind review process, where manuscript authors and reviewers remain anonymous, it is not possible to acknowledge those stepping up to take on these tasks for individual issues, but I would like to sincerely thank all those who volunteered during the years 2014 and 2015:

Gennady Andrienko
Naeema Alhosani
Thomas Bassett
Justine Blanford
Manfred Buchroithner
Aileen Buckley
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Jon Cinnamon
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Ian Muehlenhaus
Kristien Ooms
Thomas J. Pingel
Mark Pires
Paulo Raposo
Britta Ricker
Anthony Robinson
Reuben Rose-Redwood
Robert Roth
Terry A. Slocum
Roger Smith
Steve Spindler
Alexander Wolff

Cartographic Perspectives is happy to share its resources to promote interest in and initiatives of other organizations. An outstanding example of such collaboration is *CP 80* (**www.cartographicperspectives.org/index.php/journal/issue/view/cp80**), a Special Issue dedicated to "Education in Cartography." Guest Editor David Fairbairn, Chair of the International Cartographic Association's Commission on Education and Training, highlighted fascinating research and practices in a volume sure to be a touchstone of the ICA's International Year of the Map (**mapyear.org**).

You can share with us too! For example, the new "Books for Review" tab on our web site (**cartographicperspectives.org**) embraces the idea of "share and share alike." Browse the site to see if there is a book that catches your fancy. If you find one, click the "Request this book for review" link. Our Reviews Section Editor will send you a real hold-in-your-hands book! The share-alike component is that we ask you to review the book in a timely manner, so that you can share your opinion with the greater *CP* community.

We also have begun to share information on our most popular articles with our readership. Our home page (**cartographicperspectives.org**) lists the ten most viewed articles since we initiated the web site some three and a half years ago. The large number of views for recently published articles seems to bode well for our open-access journal. This is further supported by statistics from Google Analytics, which indicates a steady increase in readership, resulting in a doubling of viewing sessions over the last three years.

Focusing on our current issue, I am happy to share new articles with you. *CP 81* contains two peer-reviewed articles, the first of which is Nate Wessel and Michael Widener's thought-provoking approach to redesigning urban bicycle maps. In the second article, Joel Radunzel approaches military mapping from a more classical perspective, using David Woodward's framework. Readers with an interest in process and design should find both of these articles well worth reading.

Mark Monmonier is not one to shrug Herculean tasks. Over the last two decades he has worked on completing Volume 6 of the *History of Cartography*, a million-word encyclopedia of *Cartography in the Twentieth Century*. On the heels of its recent publication, Mark here focuses his prodigious abilities to synthesize and communicate on describing six key cartographic themes from the century for the readership of our Cartographic Collections section.

The Visual Fields section includes an article by the digital artist Istvan, who offers insights into his process for rendering a series of "Flowing City Maps." He mixes the elevation of cityscapes with random noise, by using software designed in the video gaming industry to erode terrain. The results reflect his views on the relationship that cities have to their environment, with examples for cities such as Venice, New York, Paris, and Tokyo accompanying his article.

The Practical Cartographer's Corner features an article by Patrick Butler on the use of the Data-Driven Documents (D3) software library to create temporal, animated maps. Finally, the Reviews section includes three new reviews, including one of National Geographic's new *Atlas of the World* (Deluxe 10th Edition).

I am pleased to introduce this latest issue to you, and hope you will consider sharing any articles you find of interest.

Patrick Kennelly
Co-Editor of *Cartographic Perspectives*

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Rethinking the Urban Bike Map for the 21st Century

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"Bike maps," commonly produced by city governments to encourage bicycling, tend to rely heavily on subjective recommendations aimed at an ideal "typical cyclist." Such a typical cyclist is increasingly illusory as people take up cycling for ever more diverse and practical purposes. In order to make bike maps useful for a general audience, we need to rethink some of the basic assumptions these maps have been making. The question should be: what do all cyclists want to know, and how can this information be quantified and depicted such that cyclists can use it to make informed decisions? With this question foremost in mind, we explain the development of a bike map for Cincinnati, Ohio that (almost) completely avoids unquantifiable judgments and, we hope, lights the way for future development of the bike map genre.

KEYWORDS: bicycle; bike map; Cincinnati; cycling; infrastructure; transportation

INTRODUCTION

For more than a hundred years, bike maps have been politely suggesting where recreational cyclists might like to ride their bikes. This simple approach is breaking down as urban Americans increasingly take up cycling for very diverse reasons. The racer, the commuter, the shopper, and the leisure rider, even as stereotypes, let alone as individuals, have totally different abilities, destinations and desires. City departments of transportation (DOTs), which aim to encourage cycling primarily as a replacement for car trips, should acknowledge that many trips will not be motivated by a desire for leisure but by a desire to actually go somewhere. These potential bike trips will have ends too numerous to plan for, and may go to and start from places not usually thought of as "bike-friendly." What is needed is not more simple recommendations for more types of cyclists and more destinations, but more general information that cyclists can put to use for their own contingent purposes. Since such informative (and unpresumptuous) maps seem rare, this paper addresses the gap by presenting a method for more objectively detailing a wide range of street conditions that any sort of bicyclist will likely be concerned with.

BACKGROUND

Bike maps have been around for as long as bicycles have been popular; a brief history of the bicycle and of its maps will help to illuminate the present state of the genre.

In the 1880s, the bicycle was booming for the first time in the United States after the invention of the chain-driven "safety bicycle," the same basic model still used today. This bicycle was born into a world of mud and cobble streets, some even paved with wood (Smith 1972). Riding was often rough, and cyclists, led by bicycle manufacturers, organized to advocate for paved roads in their cities and states. They formed, among other groups, the League of American Wheelmen, which at one point boasted of more than 100,000 members (Smith 1972). These organizations made maps of cities both to actually help cyclists navigate and to pressure politicians to pave the city's streets. They often rated pavements on a scale from "good" to "bad," a well-worn technique for inflaming the egos responsible for such facilities (for a current, non-bicycle example, see the "Infrastructure Report Card" from the American Society of Civil Engineers [2015], with its "failing" bridges and "F" letter grades). The cyclists and their supporters got the

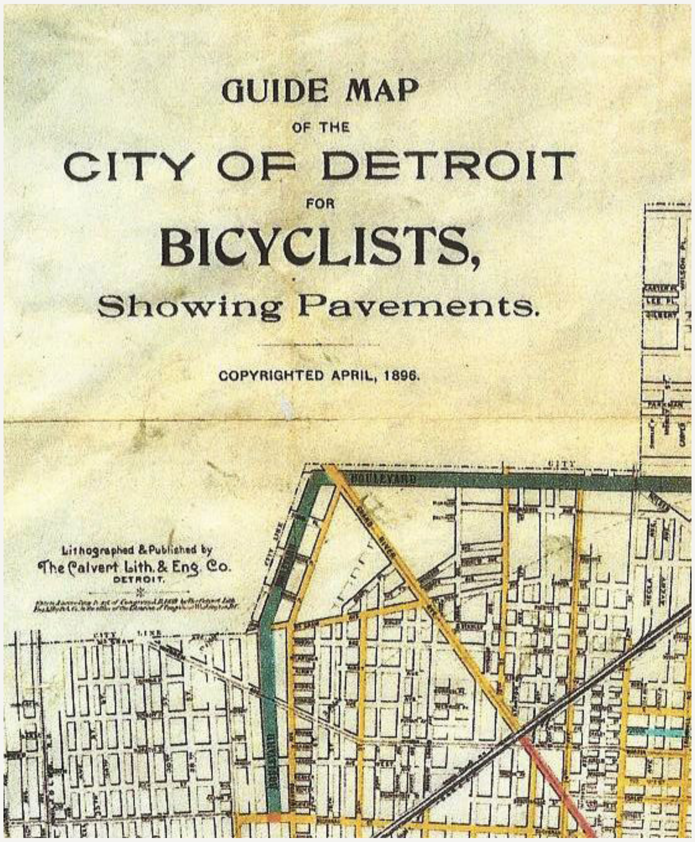

Figure 1. A bicycle map of Detroit from 1896 (Calvert Lith. And Eng. Co. 1896).

paved roads eventually, but these simply enabled the next, motorized, product to come out of the bicycle factories: the car. The bicycle became, for several decades, largely a toy for children, at least in America (Longhurst 2015, ch. 5).

The 1970s saw a second "bike boom" in America (Longhurst 2015). Baby boomers, drawn by a desire for personal fitness, an affection for the environment, and the newly discovered cool of the European bike-racing scene (See for example the 1979 movie *Breaking Away*), bought racing-style road bikes by the thousands. These cyclists entered a world where smooth pavement was almost ubiquitous; the difficulty in riding was in dealing with their car-driving neighbors. The aim of these cyclists was largely recreational, and maps of the period, fewer in number than those of the earlier boom, seemed to mostly suggest more or less circuitous routes allowing people to ride as far as they pleased with relatively little disruption. The young boomers aged though, as we are all bound to do, and many of them eventually gave up riding.

Their children however, finding boredom in their suburbs and dusty bikes in their garages, began moving back to the cities with a new style of cycling. This period has brought enormous change in the way Americans use, perceive and accommodate bicycles (see Longhurst 2015)—a change only partly manifested as yet in contemporary bike maps.

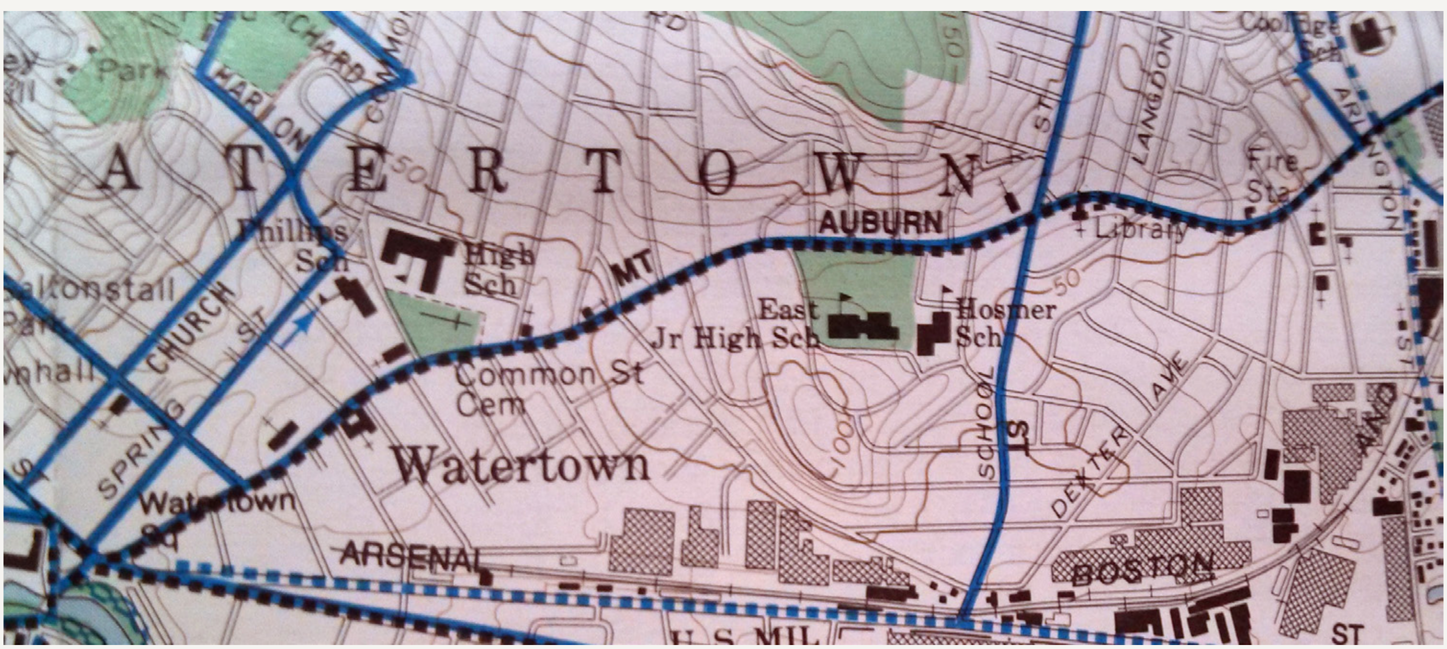

Figure 2. A map from Boston uses dense, fine contour lines to show topography. Blue lines show "bike routes" (BikeMaps Massachussetts 1994).

The collective response of American policy makers to bikes over the last thirty years or so—when not simply ignoring them—has been to *segregate* them from cars and trucks by building specialized lanes and paths (see People for Bikes [2015] and John Forester's work generally). This is to be contrasted with a more European approach where bicyclists are (certainly not always but) more often *integrated* into urban traffic that, on average, consists of smaller vehicles operated with greater temperance. As of 2015, a great many bike lanes and paths have indeed been built in American cities (People for Bikes 2015), but even in the cities that have gone the furthest in this direction, these facilities only exist on a tiny fraction of all streets, and most bicycling almost certainly happens in a roadway shared with cars. The maps of this most recent bike boom have largely been made by city DOTs, and their segregative policy direction has naturally bled into their maps, and into the maps of other groups. Maps of this period emphasize specialized bicycle infrastructure—where it exists—and almost totally ignore most other streets (Figure 3). Such streets, if bike maps tell us anything at all about them, typically have their various interesting qualities reduced to a scale from good to bad. This is the same tactic used before by advocates for better pavement, though it's not clear any more who is to blame for the "bad" streets or what exactly might be demanded of them. This "good/bad" distinction doesn't seem like a conscious political tactic any longer so much as an atavism, especially since it's often the DOTs themselves both making the maps and responsible for the roads.

The construction of segregated facilities is probably the most widely accepted goal among American cyclists

Figure 3. *New York City has enough bicycle infrastructure to populate a map with objective content (City of New York 2012).*

(People for Bikes 2015), but most cities don't yet have the political will to develop extensive lanes, as demonstrated by the fact that they haven't. Instead, such DOTs are often, among other things, making maps as a concession to cyclists, and as a sincere effort to encourage people to ride bikes. If the goal of these DOTs really is to encourage cycling while not immediately developing much segregated infrastructure, then more effective cartography, cartography aimed at helping cyclists to navigate in the world as it currently is, may actually be a great way of doing that. Better bike maps are unlikely to be as politically contentious as re-purposing part of a roadway, and they are certainly less expensive. Despite this potential, relatively little has been done to develop alternative approaches to making useful maps for cyclists in cities.

CURRENT PRACTICES: LANES IN THE VOID

An informal review of several dozen contemporary urban bike maps, mostly from the US, reveals two broad types of map content which we will term *objective* and *subjective* for a lack of better words. Cartographers are perfectly familiar with the fact that ontology is a slippery business and that classifying things is one of the biggest challenges in making a map. There are, however, certain things that are more slippery than others. For example, it is hard to dispute whether or not a street has a bike lane: there is either paint on the street or there isn't. It is hard to argue that a bike path is actually a normal road when the question is decided by the presence of bollards and signs that keep the cars out. These are examples of objective features. On the subjective side though, we see things on maps like "preferred routes," "comfortable streets," and "difficult locations." No amount of definition could make such things incontestable, and they're usually not even well defined on the maps in which they appear. Maps themselves vary greatly in the proportion of objective to subjective content, though most seem to contain at least some subjective content. The variation in this dimension seems, anecdotally, to be well accounted for by the amount of bike-specific infrastructure in a city; cities with less bike infrastructure tend to make relatively subjective

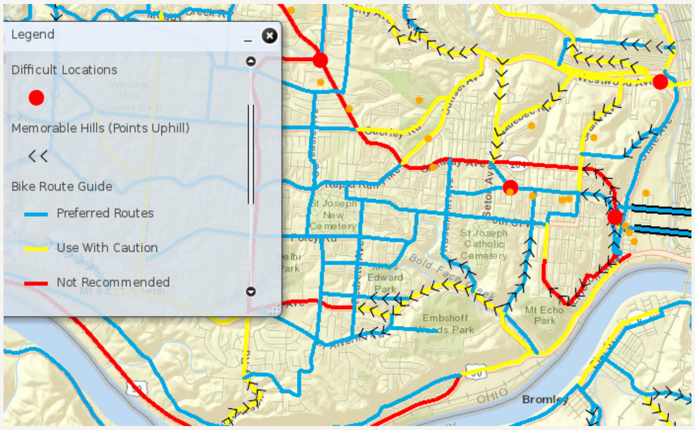

Figure 4. *OKI's map of Cincinnati, if it focused on bike infrastructure alone, would be almost totally bare (OKI 2013).*

maps. Objective content usually does a good enough job of describing itself (see Figure 3 for an example), so we will focus in the rest of this section on cataloging some types of subjective content. We will try to draw examples from a wide a range of cities, though we have limited our review to the United States.

Cincinnati's metropolitan planning organization (MPO) uses a three-tier scale to rate streets, from "preferred routes" to "use with caution" to "not recommended" (Figure 4). Washington DC's 2011 map (District Department of Transportation and goDCgo 2011) uses a scale from "good (or not evaluated)" to "fair" to "poor" and describes this content only as "street/road suitability for bikes." Google Maps, in their widely used bike map rendering, shows "recommended routes." A tremendous amount of searching for an explanation of this short phrase yielded only the following:

> "For many cities we also provide information on streets that have been designated as good for cyclists, so we them [*sic*] into account in our algorithm. These roads are indicated with dashed green lines on our bicycling layer."(Leen 2010)

Los Angeles, in a 2011 map by their DOT, describes many streets on a scale from "comfortable street for biking" to "moderately comfortable" to "uncomfortable" (LADOT 2011). A map by the city of Boston (2013) shows a set of three "suitability rating levels": "beginner," "intermediate," and "advanced." This map is unusual in that it goes on to explain these categories with more than one or two vague words. "Beginner" for example is described as:

> "Suitable for all types of bicyclists including newer cyclists, cyclists with limited on-road experience and/or children. These segments tend to be off-street paths or very low volume/speed roadways."

"Advanced" is described as:

> "Suitable for experienced and traffic confident cyclists. These are often the most direct routes. Traffic volumes and/or speeds can be high. Intersections might be complex."

A 2013 map of Indianapolis gives the categories, once again with no further explanation: "most bikeable," "bikeable," and "least bikeable" (INDYCOG 2013). A map of Cleveland Heights in 2011 gives its readers roads "suitable for bicyclist[s] having basic skills," "intermediate skills," and "experienced bicyclists" (Cleveland Heights Bicycle Coalition 2011). The bike map of Columbus gives streets that are "good," "moderate," and "poor" and provides vague explanations (MORPC 2012). Countless other examples could be given.

Another subjective item common to many bike maps, is the "hill" (Cleveland Heights Bicycle Coalition 2011), the "memorable hill" (OKI 2013), the "steep incline" (City of Springboro 2014), the "climb" (Portland Bureau of Transportation 2011), and from Pittsburgh, the "steep hill" and the "very steep hill" (Bike PGH and Deeplocal 2011). These are all marked by arrows pointing in the uphill direction. No measure defining what qualifies as a hill was given for any of these maps. The closest we get to that comes from Seattle (Seattle Department of Transportation 2012), where the legend tells us that the frequency of the arrows "roughly indicates [the] steepness of [the] grade."

Another somewhat less common feature, included with safety in mind, is the "difficult location" in Cincinnati (OKI 2013), or "difficult intersection" in Los Angeles (LADOT 2011). In both cases, no further explanation is given.

This sampling does not exhaust the genre and it doesn't touch on bike maps in other countries, which also contain a great deal of subjective content if our personal experience is any guide. It should suffice though to demonstrate that subjective content is widespread in bike maps generally. Many other map genres make extensive use of subjective content, but not maps that are meant to aid in navigation. It's difficult to imagine a nautical chart showing water "too shallow for sailing;" instead, it would simply show the actual depth, because different boats have different drafts and sailors know perfectly well what these are. It's hard to imagine a transit map showing "preferred routes" without defining these explicitly: a map only of rail services for example, which would plainly exclude anything not on a steel rail. Imagine a state highway map that took the liberty of advising car-drivers to avoid whole stretches of highway—"interstates to avoid." Such suggestions, I hope, are clearly, perhaps comically, out of place and illustrate that subjective content has little place in a transport map aimed at a general audience. One might contend at this point that a bike map is not aimed at a general audience, but rather at cyclists specifically. But cyclists are not so uniform a group as might be supposed.

DIVERSITY AMONG CYCLISTS

The only thing that really lets us identify cyclists as such is the presence of a bicycle beneath them. Beyond that the similarities quickly break down. Some urban planners have acknowledged at least four main types of cyclists that guide their work (Dill and McNeil 2012):

- **No Way No How** cyclists: these are not active cyclists, but rather people who simply know how to ride a bike and maybe even own one.

- **Interested But Concerned**: These are good-weather riders, who might cruise around their subdivision or ride on a slightly busier street, but only if they can feel quite safe.

- **Enthused and Confident**: These riders may appreciate segregated infrastructure but are also comfortable operating with automotive traffic. This might be an average commuter or fast recreational rider.

- **Strong and Fearless**: Cycling is a part of these people's identity, and usually their primary means of transportation. Typically young, these cyclists ride fast and actively assert and maintain their position on the street among other travelers.

To these categories we should add the distinction between "vehicular cyclists" and those who use the street more passively. Vehicular cyclists take charge of their engagement with cars, claim a whole traffic lane while riding, and use body language to acknowledge and direct car drivers. This stance takes some confidence but is safer than doing otherwise when executed correctly (Forester 1976; 2001). Non-vehicular cyclists, probably the majority in most places, generally observe the often-repeated advice that they should ride defensively as though invisible to drivers. These cyclists hug the curb, or ride in the gutter, and defer to cars in most situations.

Bicyclists further break down into recreational and utility riders. Recreational cyclists ride for fun and use some other mode for general transportation, while utility cyclists use a bicycle for many or all of their daily trips. Racers are a distinct sub-group of recreational riders, riding fast and often huddled together in large aerodynamic packs known as "pacelines."

Obviously, people can and do switch between and among multiple riding styles, not nearly all of which can be enumerated here, both over their lifetimes and from moment to moment. What does seem clear is that with this many ways of riding a bicycle, it can't possibly be easy to make a specific route suggestion of general utility to any cyclist anywhere. Racers on a training ride will often prefer a rural road with few stops that allows a rotating paceline to develop. Timid recreational riders may want only trails and many may be interested to know where they can park a car nearby. Utility cyclists will regularly need to access retail districts for the shopping and errands that direct most of their trips. New cyclists may wish to avoid hills, while the "Strong and Fearless" may seek them out for fun or exercise.

City DOTs in particular should be concerned with utility riders if they wish to supplant some car-trips, though it has been well-demonstrated that when more bicyclists of any sort use a street, the street becomes safer and more comfortable for other cyclists as cycling is socially normalized (Brüde and Larssen 1993). A map with recommendations aimed at any one type of cyclist presupposes that enough people exist in that category to constitute a reasonably large audience. But in cities where cycling is just beginning to (re)grow in popularity, in cities without extensive bicycle infrastructure, this supposition is probably unfounded. In these places, bike maps should attempt to speak to as broad and diverse an audience as possible.

A BICYCLIST'S PERSPECTIVE

Given all these different ways of riding a bike, what is unique to a cyclist's understanding of the world? What must be taken into consideration as any cyclist plans or considers making a trip? It will help to contrast bicyclists with other travelers.

- For lack of a better word, a fearful "friction" is created by cars as they pass cyclists from behind. This friction is experienced as the fear of being struck from behind and takes an emotional toll on most cyclists, though each has their own tolerance and comfort thresholds. It is felt to the degree of the difference between the speeds of cyclists and passing cars. Cyclists often seek to minimize this friction by speeding up themselves or by trying to slow down passing cars. Cars passing from ahead, as on a two way street, don't create friction, at least not to the same degree, because they can be seen and anticipated. The difference between the speed of the cyclist and the speed of the overtaking traffic is of prime concern.

- This same friction is also a function of the distance between cyclists and passing cars. Fast passing becomes much more tolerable when a lane or more of space is allowed between the passing and the passed. When little space is allowed, even a very slow pass may be intolerable.

- Cyclists feel hills much more than cars and more even than pedestrians since they climb them faster and with heavier equipment than the latter. Beyond the obvious physical stress, even very subtle grades can dramatically affect a cyclist's speed, which in turn effects passing friction dramatically. Many high-speed streets can feel very dangerous on the uphill ride and exhilarating on the downhill as a cyclist's speed approaches that of surrounding traffic and friction is reduced or totally eliminated.

- Totally car-free paths of various sorts exist as a distinct type. These may best be subdivided, as in the time before cars, by their paving type: gravel, asphalt, etc.

- Bike lanes define a distinct type of street that can provide a mental break from the active avoidance or management of cars, but which sometimes does little to minimize the friction caused by fast, close passing. Indeed, bike lanes can implicitly condone fast, close passing; a painted line rather than social controls comes to define the extent of a driver's obligation.

- Cyclists are uniquely able to engage in mode-switching: actively alternating between acting as vehicle, pedestrian and transit passenger as suits the needs of the situation. This, for example, makes short one-way streets only a very minor obstacle; a cyclist will almost always mount the sidewalk as a pedestrian rather than circle the block as a car would need to. A cyclist can also take a bus up a steep hill or use a stair as a shortcut.

- Cyclists feel the need to stop and accelerate as not only a time burden, but as a physical stress. This accentuates the relative importance of stop-lights and stop-signs. Excessive stopping and starting can lead to fatigue and diminished speed.

- Cyclists, like runners, are engaged in strenuous physical activity. While seated car-drivers can go hours without eating or drinking, cyclists must usually carry a water bottle and/or stop often for refreshment, particularly on long rides. This need emphasizes the relative importance of drinking fountains, restrooms, and places that allow cyclists to recharge and clean themselves up before arriving at a destination (see Dickinson [2012]).

How can these factors be measured and combined to form a useful map that empowers cyclists to make informed decisions for themselves?

LITERATURE REVIEW

As we've said, not a lot of work has been done on the problem of bike maps, at least as we've defined it, though there is some research worth mentioning here. In 2012, Evan Dickinson developed a bicycle trip planner for cyclists that emphasized experiences, particularly the enjoyable experiences, of riding a bike (Dickinson 2012). Among other things, it highlighted such things as public art, street trees, and human-scaled buildings by way of pictures, comments, and illustrations. The interactive nature of Dickinson's project, and the fact that it only focused on one route at a time let it do a lot that a static map could not, but it also means that most of the graphic techniques that he developed are not really applicable to a static map showing more than one route.

Other researchers, and some departments of transportation, have developed what they call a "Bicycle Level of Service" (see Landis et al. [1997] or FHA [1998]). These are basically regression models that are trained on a sample of cyclists and a sample of streets. The cyclists report how "comfortable" they would feel riding on a street (perhaps after seeing a video of the street), and the model takes some parameters for each sample street and gives coefficients that can be used to systematically rate other streets for which similar data is available. The models have produced very high r^2 values, meaning that they seem able to predict the self-reported comfort of the study participants pretty well. Such ratings could easily be used to develop bike maps, though we have never seen any using this or a similar measure. In any case though, the result would still be a one-dimensional good-to-bad scale with little or no explanation as to how the rating for any given street was arrived at. The bicycle level of service is probably very useful for applications like trip routing and civic administration but it doesn't seem clear that it would be useful for a general purpose bike map.

THE *CINCINNATI BIKE MAP*

In the autumn of 2014, this paper's first author, Nate Wessel, created the *Cincinnati Bike Map* with the help and encouragement of his academic advisor, this paper's second author, Michael Widener, at the University of Cincinnati. The goal of the project was foremost to improve on a history of unsatisfying bike maps in Cincinnati and elsewhere, seeing if the principles spelled out above could inform a legible and informative map useful for a diverse audience of cyclists. The map was also to serve the usual goal of a bike map, which is presumably something like helping people to ride bikes. The map's development and printing was funded by a grant from the Haile US Bank Foundation and by several other local sponsors. This led to a somewhat unusual design situation: because the money was given unconditionally by the Foundation and sponsors before the design was completed, and because no client needed to sign off on the design, we were unusually free to break with norms and expectations associated with printed urban bike maps up to now.

OVERVIEW

The map was designed for print, and measures 24 inches wide by 31 inches tall at a scale of 1:28,000. One full side is the main map showing the central and eastern neighborhoods (Figure 5A). The reverse side is half covered by the map of the western neighborhoods, and half by a series of three insets at a smaller scale (Figure 5B). Two of the insets reproduce the area covered by the main map at 1:84,000 and serve as indices for certain features that we wanted to include prominently, but which didn't necessarily need to stand out on the main map itself. The first such inset (top left of figure 5B) shows elevation, water fountains, and grocery stores. The second inset shows transit lines with frequent service running uphill. The third inset depicts regional bike-only trails at a scale of 1:400,000. Nine thousand copies of the map were printed and distributed free-of-charge throughout the Cincinnati region. For those interested in seeing the map in full, an online version is available at **www.cincymap.org/cbm**.

All vector data for the map came from OpenStreetMap (OSM). Originally the data were somewhat inadequate for our purposes and had to be supplemented with local knowledge and on-the-ground surveys. These additions were contributed back into the OSM database using a data model already well-established by the OSM community. Elevation data came from the US Geological Survey.

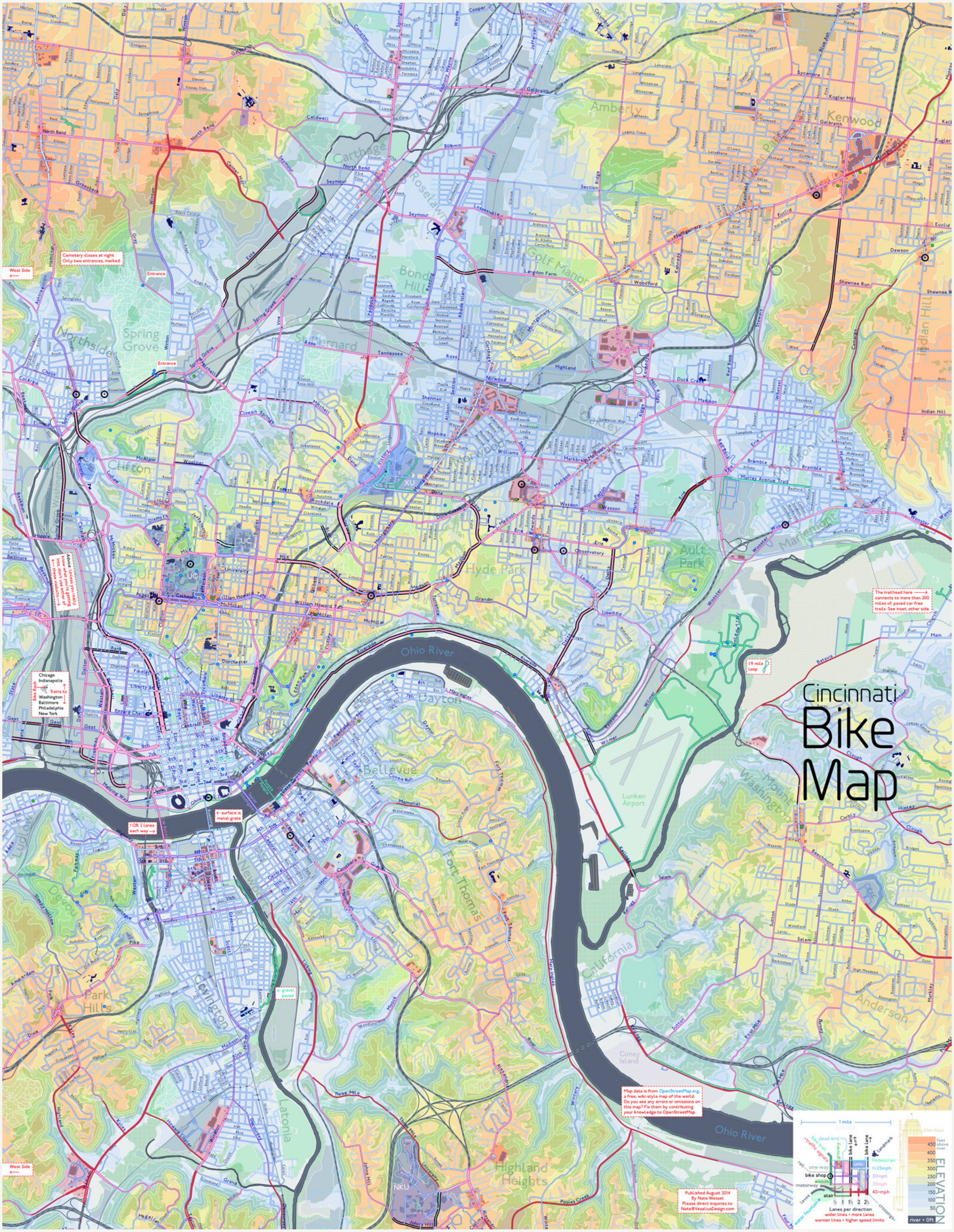

__Figure 5A.__ East/central side of the Cincinnati Bike Map, originally 24" by 31".

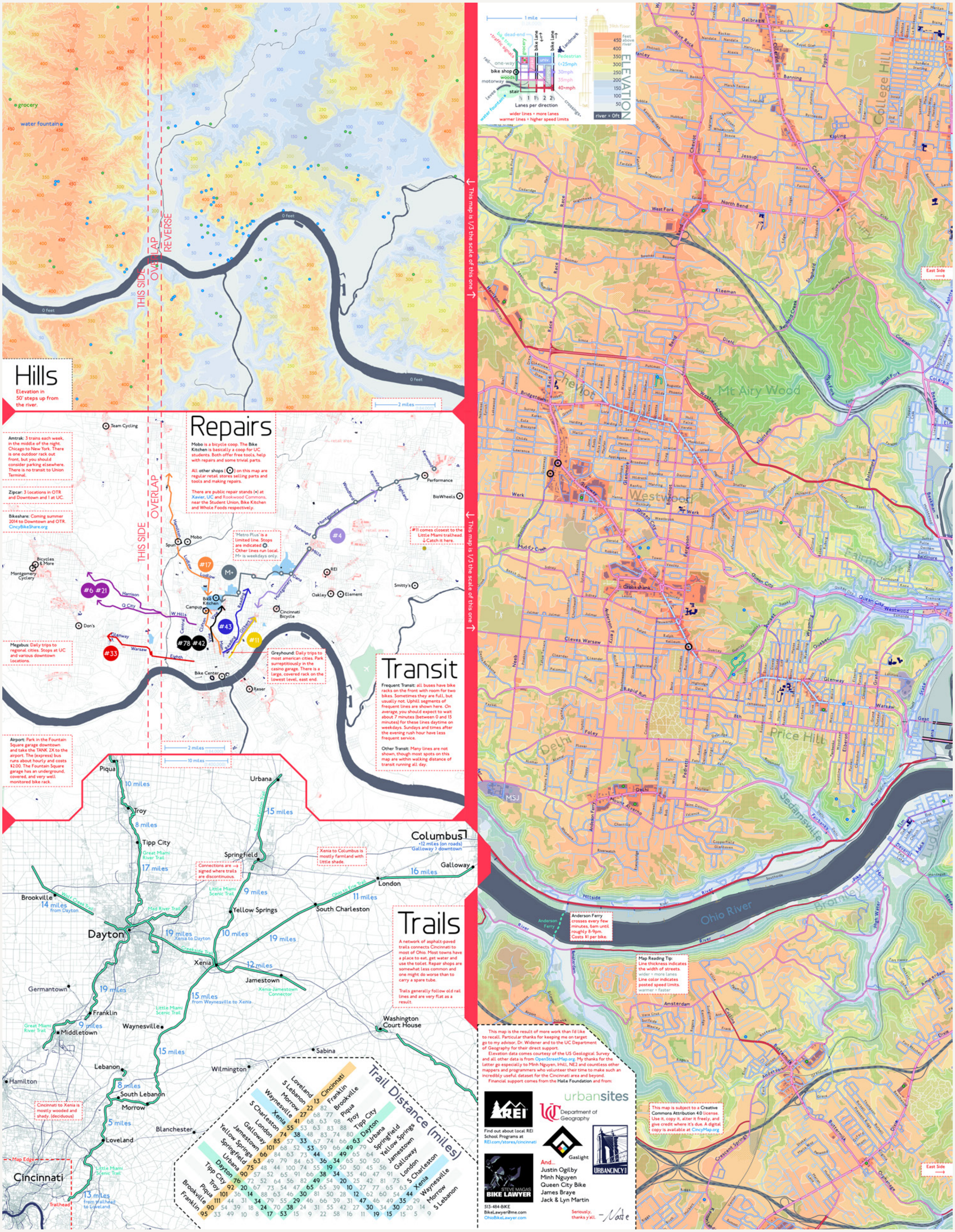

Figure 5B. Reverse side of the map showing west side and insets.

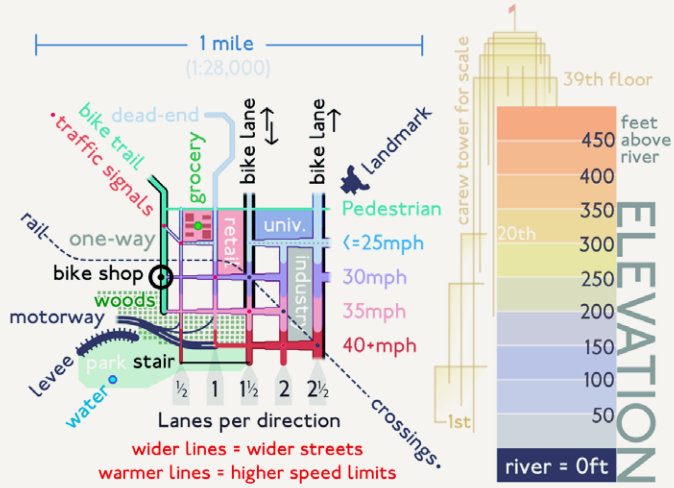

Figure 6. The legend of the Cincinnati Bike Map.

The legend (Figure 6) will help to guide the reader through the sections that follow where we will discuss in detail the various contents of the map.

STREETS AND PATHS

The presentation of streets should tell the cyclist about the nature of potential "friction" as we've termed it: the speed and proximity of cars passing from behind. Since the presence of cars is the initial concern, car-free paths and bike lanes should appear distinct from streets and paths that allow cars. Bike lanes were highlighted with bold black lines parallel to the street (Figure 7). Trails were shown with a vivid green and a high-contrast black border. On streets where some car-traffic is assumed to be present, color and line width were used to indicate the speed and proximity of cars, respectively. Speed, indicated by the color of lines, ranges from blue for the slowest (<=25 miles/hour) to red for the fastest (>=40 miles/hour). We used the official, posted speed limit as the measure of speed; other, perhaps more empirical measures of traffic speed might have served better, but were unavailable. The possible distance between the cyclist and the passing car was indicated by the width of the lines. There are several measures one could use for this as well, but we went with the number of full lanes per direction of travel. A two-lane one-way street therefore is rendered twice as wide as a two-lane two-way street. The presumption implicit in this approach is that the width of the lane itself is unimportant because the cyclist is occupying a full lane. This may not actually be the best assumption in some situations, as we will discuss later.

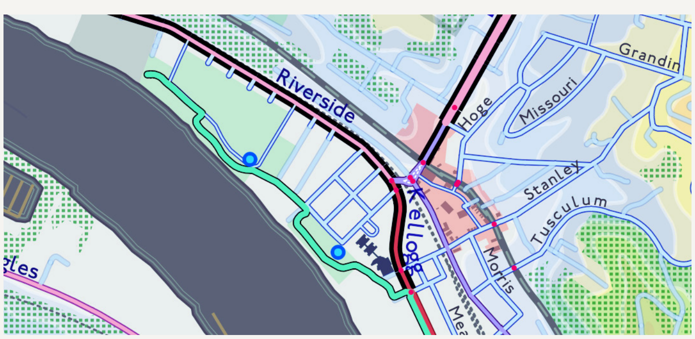

Figure 7. A bike path (green) along the river meets a street with a bike lane (dark border).

The map also shows the possible connections between paths: both where they connect, and where they do not, since this is often different for bikes and for cars. For example, some long suburban streets may connect to each other by a small foot path. Or a whole branch of streets may only connect to a limited access highway at one end; such streets would be dead ends as far as any cyclist is concerned. We wanted to emphasize streets and paths which do let bikes through and deemphasize streets and paths which are effectively dead-ends. Fortunately, since data from OSM are implicitly topological, this was fairly easy to do. We used OSM2pgSQL to create a graph of streets and paths which are traversable by bicycles or pedestrians. Beside all ordinary streets, we included public stairs, pedestrian streets, bicycle-paths, and open-access service roads like alleys and some cemetery paths. We did not include highways and limited access trunk roads. We then used a PHP/SQL implementation of Tarjan's algorithm to decompose the complete graph into a set of distinct biconnected subgraphs. The largest of these subgraphs was what we might call the main street network, and the rest were connected to that by at most one edge. In simpler

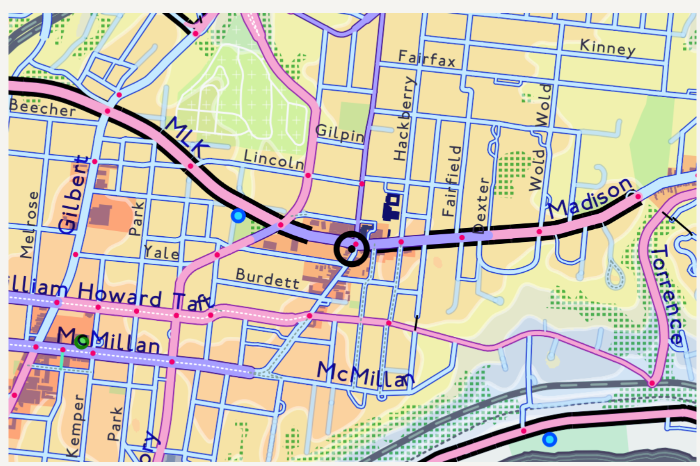

Figure 8. A variety of streets.

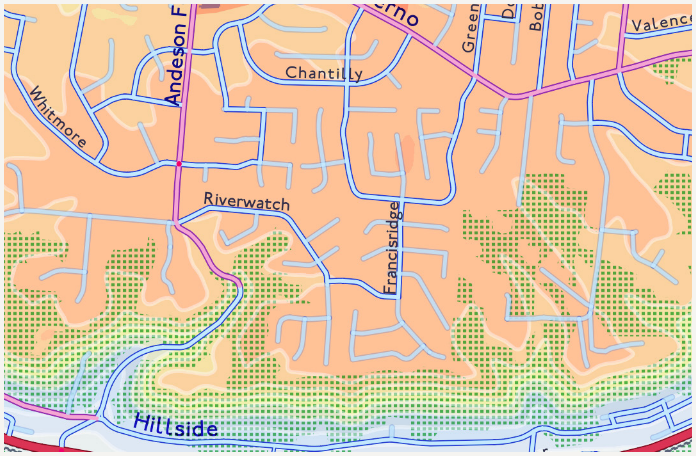

Figure 9. A suburban area showing the relative deemphasis of dead-ending street segments. The internal color of the line (showing speed) remains the same, but the contrasting border on the line is diminished, yielding a low value-contrast between the street and the elevation background.

terms, the algorithm answered the question of where "no exit" signs would be located if the world revolved around cyclists, and allowed us to select the streets that would be behind such signs. Dead-ending public streets thus identified were retained in the map but deemphasized by making the lines' darker border color mostly transparent (Figure 9). Dead-ending minor paths such as service roads and stairs were removed from the map completely.

The visual effect of deemphasizing the dead-ends was tremendous. The resulting emphasis on connecting streets helped to clarify many relationships which could otherwise have been ambiguous at this scale. This was a particularly important consideration in hilly Cincinnati, though a city with a stronger grid would tend to have fewer ambiguous connections and less distinction between the connections possible by car or foot. In our case, roughly 1/3rd of all paths (measured by length) on the map, which otherwise would have been rendered normally, were identified as dead-ends for bicyclists and rendered accordingly. Surprisingly, most readers didn't seem to notice initially that the dead-ends had been de-emphasized, though the visual difference was truly huge. One interpretation might be that this is because such streets play mostly a distracting role in wayfinding anyway, though other interpretations are certainly possible.

HILLS

A digital elevation model was obtained from the USGS, and zeroed to the normal level of the Ohio River, which is the lowest point on the map. Elevations were then divided into 50-foot (15.2 meter) steps up from the level of the river. By dividing the elevation into steps rather than using a smooth gradient or some direct measure of slope, we intended to help readers understand actual elevation changes rather than just assess relative steepness. Even without identifying particular elevations, a reader could easily count the steps between two points on the map and multiply by the 50-foot interval between contours. Thus, five steps would equal a roughly 250 foot elevation change (Figure 10A).

Contour lines were avoided because of the potential for them to get muddled with the lines of streets; instead, we used a solid background with stepped colors. For these we chose some fairly unusual colors for a transport map (Figure 10B). In part, these colors were meant to imply nothing about landuse, but more importantly, they made the map look unusual. Once the color of one major map feature goes against a reader's norms or expectations, they may be more likely question their other assumptions and to look for a legend (Hoarau 2011). Particularly, we were concerned about the way street color (speed limit) and width (number of lanes) might be interpreted by a casual reader, since these are unusual elements for a normal map, but are critically important to understanding this one.

The map also includes a separate inset devoted to elevation (Figure 10B), since it can be difficult to read through the dense street network in places. Only one other map that we reviewed used some actual measure of elevation to depict hills (Figure 2). Instead, most bike maps seemed

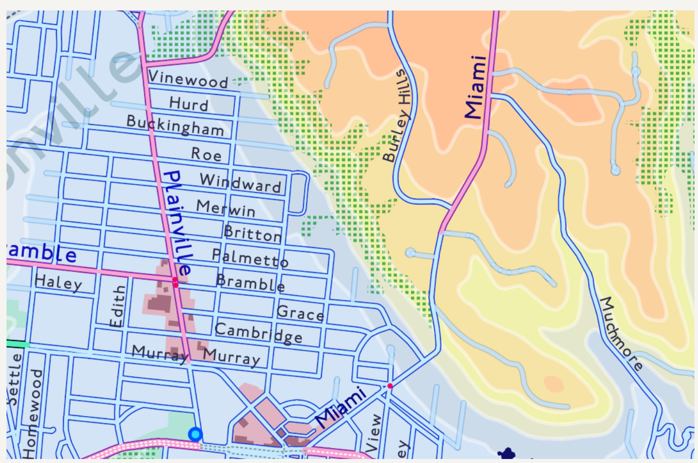

Figure 10A. Cyclists may estimate the length of a climb by counting the number of 50' contour lines they will cross on the way up.

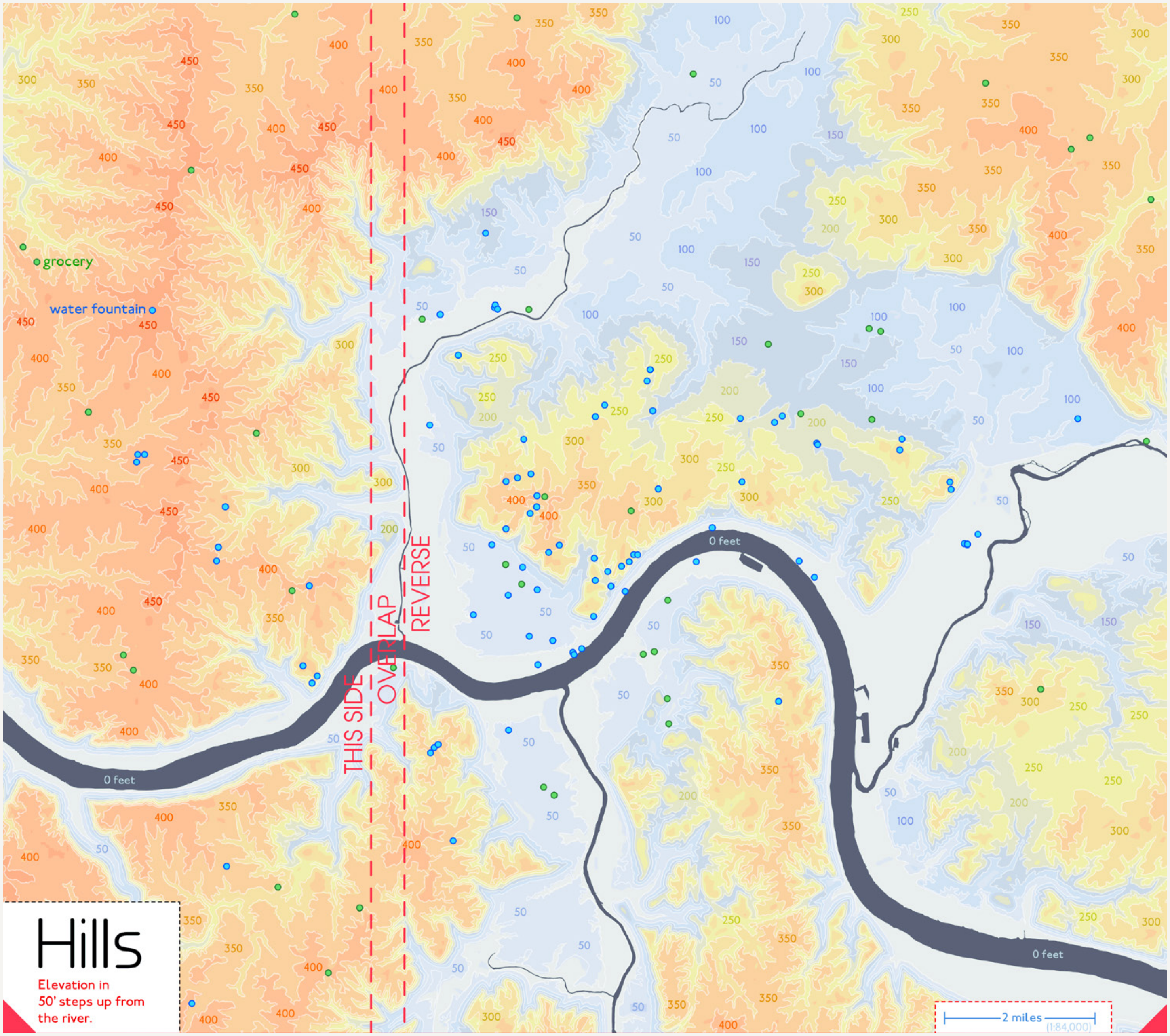

***Figure 10B**. Elevation inset. Certain point features that could get lost among the streets of the main map were also included here as an index because of their minimal interference with the elevation layer.*

to use a subjective measure of steepness and depict it with arrow markers facing uphill and placed over the streets.

INTERSECTIONS

Some subtle information about the intersections of various paths was included. Traffic signals are indicated by a tiny red dot at intersections and railroad crossings by a grey one (Figure 11). Both are intended to be small enough to be noticeable only on a very close reading so as not to confuse readers needlessly.

***Figure 11.** Section showing traffic signals (red dots) and at-grade railroad crossings (grey dots).*

The traffic signals may be read to indicate at least two things: first, the amount of traffic may be inferred to be higher in places where signalization has become necessary. Anecdotally, this is usually true for this map. Second, these are places where the cyclist may need to stop and start again. The railroad crossings are included to draw attention to what may be dangerous intersections between rails and roads. As with highways and trunk roads, rails are rendered below the streets and paths which cyclists can actually travel on. At-grade railroad crossings were indicated with a grey dot *over* the street line which serves to visually continue the rail line over the street. Rails, particularly when they cross a street at an angle or in wet weather, threaten to catch a bicycle's front tire and cause a wreck. To avoid this, cyclists will often slow down and swerve to hit the tracks perpendicularly. They need space to make this maneuver and may simply want to avoid such crossings if possible. The demarcation of crossings also makes clear where crossings are not, since many rail lines also cross above or below the roadway. One problem with this method is that it may confuse people looking for an actual bridge or a tunnel since it doesn't distinguish between the two but renders them both beneath the street.

On maps at a slightly larger scale than this, stop signs might well begin to be symbolized. Residential areas which don't make exclusive use of all-way stops will often have one or a few dominant streets which get priority at intersections. To represent this on a map, the same sort of tiny dot or perhaps a short perpendicular line could subtly disrupt street lines at the location of stops, thereby increasing the visual continuity of lines which do have priority at those intersections. Many such streets are otherwise indistinguishable here, though cyclists may be interested to find them.

LAND USE

Many streets that have a constant speed limit and width can vary through their length in both traffic volume and actual traffic speed. Some indication of land use may let the reader speculate meaningfully about the often desired, though missing, traffic and actual-speed data, as well as other aesthetic qualities they may be interested in (Dickinson 2012, 21). Identified land uses in this map include: retail areas, college campuses, industrial areas and woods.

Retail areas (Figure 12A) generally tend to be busier, often with many turning cars and more traffic than elsewhere. They are often destinations or landmarks in and of themselves, particularly in Cincinnati, which has many distinct neighborhood business districts. To further indicate the nature of retail areas, building footprints within them are included to subtly differentiate pedestrian-oriented retail (small, close buildings) from auto-oriented shopping centers. College campuses (Figure 12B) tend to have more pedestrians than other areas and car drivers might be expected to drive more cautiously. Industrial areas (Figure 12C) often have wider, more generous lanes to allow for turning truck traffic, though some people will be uncomfortable around larger vehicles.

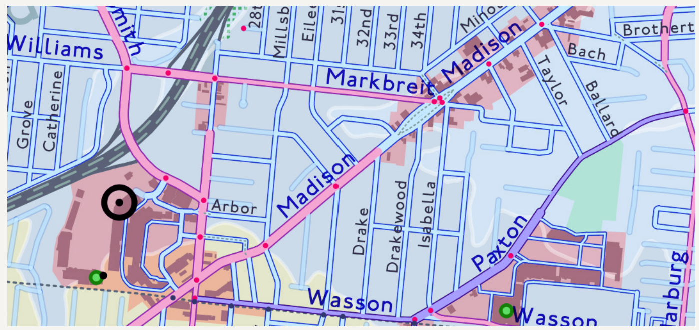

***Figure 12A**. Retail areas (red).*

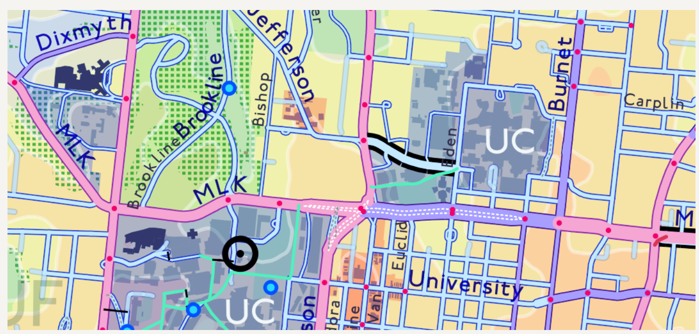

***Figure 12B**. University (blue).*

***Figure 12C**. Industrial (grey) and cemetery (light green).*

Figure 12D. Woodland (green pattern).

It is important to note that these interpretations are not provided as rules or even suggestions, and are certainly not provided on the map itself. These are our own subjective judgments which serve to justify the inclusion of various land uses. The reader should be free to draw their own conclusions based on their preferences and experiences riding in such areas. As elsewhere, we hoped to avoid including our own opinions, our own cynicism or optimism, where it might not be shared by the reader.

Wooded areas (Figure 12D) are included in part because they help to explain what are otherwise large, empty spaces, and in part because trees next to a hilly winding road often constrain a driver's line of sight as they come up behind a climbing cyclist. Only one other map we reviewed, Portland's (Portland Bureau of Transportation 2011; Figure 12E), addressed line-of-sight concerns. It did so with a noisy red border applied to the affected streets. Our own approach may allude to such concerns more naturally and relieve the reader of the need to recall a line symbol with a fairly limited application.

DANGEROUS PLACES

Several maps we reviewed highlighted certain intersections or other places which their creators deemed "dangerous" or "difficult." While such information may be interesting to many people, we think that land use combined with street width and speed limits will probably be just as good an indicator of "difficulty," and will certainly provide the reader with more information in most cases than a binary dangerous/not-dangerous classification. Still, if a cartographer wanted to include such information, they might do well to expound some actual criteria defining a dangerous intersection and then stick to it. Police records could be a good guide: perhaps something like clusters of 3 or more bike-related traffic reports in a one-year period could

Figure 12E. An example of Portland's use of line symbols to show line-of-sight issues, which are almost certainly caused by woods.

indicate such places objectively. However, such a method would also introduce other problems, since bike accidents are notoriously under-reported (de Geus et al. 2012).

TRANSIT

Bikes can be taken on buses in Cincinnati, and cyclists often use public transit to get up some of the larger hills. One of the insets of the map therefore shows transit lines, but only those which both run up hill and which are generally frequent enough not to require reference to a schedule. This inset also serves as an index for the locations of bike shops with the idea that transit will be particularly useful at times when bicycle repairs are needed. The transit inset is one part of the map where we broke with our goal of explicitly defining our classifications. There is no indication of how we defined "uphill" or "frequent," and a visitor from a place like New York City or Colorado may perhaps misinterpret the intended meaning of these words.

OTHER ELEMENTS

Some other elements common to bike maps are important, but do not illustrate a uniquely objective approach. *Amenities* like bike shops, water fountains, and grocery stores are included in this map as well as most other bike maps we reviewed. *Landmarks* of one sort or another are also important, and landmark buildings, subjectively defined, were also included in this map.

DISCUSSION

Nine thousand copies of the map were produced and distributed, and have been in circulation for several months at the time of this writing. The map has generated a great deal of feedback from all sorts of cyclists, including bike shop owners, professional advocates, transportation planners, young people, old people, and many others. This paper's first author has also made extensive personal use of the map in his daily travels and has some first hand experience with its strengths and failings. We have not conducted any formal surveys or user testing, though these would be interesting avenues for further research. The discussion that follows should be considered summary and anecdotal.

To start with the map's failings, we found that many people, despite our attempt to make the map look unusual by its overall color, jumped right into things without referring to the legend. These people tried to guess what the colors of the streets meant from their context, which didn't work very well at all since people aren't used to looking at maps of speed limits. Some of these people interpreted the colors as though they belonged to the standard bike-map good-bad scale. This was particularly frustrating of course, but at least not dangerously misleading since they generally took blue to imply safety and red to mean danger. Others didn't understand how the bike lanes were symbolized. These problems could presumably be fixed by increased familiarity with this map, or with other maps in the same style. It could also be helped by a more prominent legend or better instructions to the reader.

One comment, which we heard from more than a few people once they had understood the legend, was that they didn't trust the speed limit data. That is, not that they didn't trust the accuracy of the map, but that they didn't trust drivers to obey the laws. Some people were quite cynical on this point, and we couldn't help but sympathize with them. They said that they would like to know things like the *actual speed* of traffic or the *actual amount of traffic* on a street. The later measure was not on this map in any sense, but both measures could easily be quantified and rendered if sufficient data were available. It seemed that once some cyclists understood that data like speed limits were available for the entire city, they started assuming that other, more fine-grained data were available too and asking for that as well. This could imply that our drive toward objectivity was going in the right direction, but that at least a few people wanted to go even further in that direction and explore the data at an even finer scale.

One last concern, raised during review, was that such a colorful map may present difficulties for the color-deficient viewer. This is a real, but not fatal, issue for the deuteranopic viewer in particular. We did consider color-deficient users at several points in the design process and reached what we think is an acceptable compromise. A great deal of information is encoded with color in this map, but much is also coded with value, texture, and various line properties like width. We could have reduced the map's use of the color channel, but only at the cost of eliminating some amount of information or by shifting some of it into a different visual channel at the possible cost of legibility for readers with normal vision.

Success in design is usually silent, and it may be enough to say that we haven't received any significant complaints about other features of the map. One silence however is particularly troubling: no one has mentioned the de-emphasis of the dead-ending street segments. This deemphasis introduced a fairly radical change from the basic geometry of most street maps of the city (~30% of all streets were strongly de-emphasized), but no one seems to have noticed their relative absence or cared enough to mention it. This paper's first author found this emphasis on connecting streets to be some of the most useful information on the map when actually planning a route. Is it possible that this technique was simply intuitive and helpful? A formal approach to testing the utility of this particular method would be very interesting, both for bike maps and for other types of transport maps as well since each transport mode would have its own dead-ends.

CONCLUSIONS

The primary strengths of a bike map in the style this paper has proposed, at least as we see them, are as follows.

First, the relatively objective quality of such a map means that readers are free to interpret things as they please without trying to read through the cartographer's eyes. Instead of things like "steep hills," which could be almost anything, our map lets readers see roughly, but in actual numbers, how the elevation changes over any given route they might take. Similarly, instead of "dangerous streets," we present speed limits and lane counts and leave the reader to decide where they are comfortable riding.

Second, a bike map should precisely describe its most important features. While it is certainly possible for our map to be wrong in places, it will generally be wrong in such a way that the error will be easy to fix with little debate. A street either has some number of lanes or some other number and that's not usually a matter of opinion. This should make updates to the map easy, painless and cheap.

Third, our map provides much *more* information than other bike maps. Because each street simultaneously displays a number of different qualities (speed limit, lane count, directionality, presence of bike lanes, surrounding land use, and connectedness), the number of distinct types of streets it can potentially describe is huge—on the order of several hundred. Other bike maps may show as many as eight or ten types of streets, and these are generally limited by the number of colored lines that the eye can distinguish. More information can and should be included in bike maps by making use of multiple visual channels simultaneously.

The main drawback to this overall approach, if our anecdotal evidence can reveal such things, is that people are simply unfamiliar with reading maps like this and therefore prone to making interpretive mistakes. Otherwise, some readers seemed to be telling us that the map didn't go far enough, didn't give them enough information, even though it gave them many times more information than any previous map of the same city.

There is still a place for subjective urban bike maps. Many cities around the world have huge contingents of cyclists and enough of these people will surely ride in some particular way that a map aimed just at them will find an appreciative home. One can easily imagine enjoying a *Triathloner's Guide to Central Park* or a *Fixed-gear Map of Brooklyn* (complete with WiFi access points and coffee shops). But such focused audiences are the exception rather than the rule in 21st century America. If DOTs and advocacy group are serious about wanting to help all cyclists navigate their cities, they should make maps designed with a larger audience in mind.

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Using the Right Tool: David Woodward's Suggested Framework and the Study of Military Cartography

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In 1974 David Woodward suggested a framework for organizing the study of the history of cartography that unified on one hand the process and the output of cartographic production, and on the other hand the four sequential phases of cartographic production, from information gathering through document use. In a survey of scholars who have cited Woodward's model I note that, while this framework has influenced the conceptual development of map history, it has rarely been applied rigorously to specific instances of mapping. I argue that this model is an underutilized tool in cartographic scholarship, and that Woodward's matrix is ideally suited to examining how military units carry out mapping. Because military units, particularly large ones, are in effect self-contained systems that cyclically produce, use, and reproduce their own maps, I contend that scholars can modify Woodward's original model in content, though not in structure, to study military mapping activities. To illustrate this point, I present as a case study the British military's Egyptian Expeditionary Force (EEF) during the Gaza Campaign of late 1917. This force performed a broad range of mapping activity, much of it innovative. A modification of the Woodward framework that brings together the specific elements of the EEF's information gatherers, information processors, and map users into a single cohesive cartographic system illustrates the value and utility of this framework for studying the history of military cartography.

KEYWORDS: military geography; military cartography; history of cartography; David Woodward (1942–2004)

INTRODUCTION

The dictum that any work can be made easier if one first takes the time to select and use the proper tool is as applicable to academic research as to any other activity. One conceptual tool that has remained largely unused in the metaphorical toolbox of academic cartographers is David Woodward's (1974) suggested framework for studying the history of cartography. Recent renewed interest in the history and practice of military cartography, prompted partially by the centenary of World War I, has highlighted an area of study that can benefit substantially from this old but still powerful tool. Woodward's framework is well suited to studying military cartography because it accommodates the cyclical patterns of military mapmaking and generally conforms to the structure of military organizations and operations. Furthermore, the usefulness of Woodward's matrix as a conceptual framework indicates its broader applicability for studying how military organizations view and map their surroundings. As such, this article examines how Woodward's schema can be applied to the academic study of military mapmaking and argues that it is indeed the right tool for approaching this type of cartographic endeavor.

What recommends Woodward's structure over other cartographic models for the study of military mapmaking is how it incorporates actors who contribute to the cartographic process but do not participate directly in mapmaking. This contrasts with other, simpler models for conceptualizing mapmaking such as that put forward by P. C. Muerhcke (1972) and elaborated upon by Arthur Robinson and Barbara Petchenik (1975, 99) and Harold Moellering (1980, 14). Whereas these other models focus heavily on the map and the information that it communicates, Woodward's model explores more fully how this information is gathered, analyzed, and used. These differences give Woodward's framework a distinct advantage in the context of military cartography, in which the information being mapped is often difficult to gather and ambiguous. Furthermore, the resulting map product is usually put to immediate use in ways that prompt renewed mapping activity. Thus, Woodward's emphasis on data gathering and analysis, as well as on map use, leaves his model better suited for studying military cartography. Moreover, one of its best uses is translating military jargon and organizational complexity into terms more accessible to people outside the military community.

Indeed, military cartography appears to be isolated from the broader cartographic and geographic fields, at least in the US academic community. With a few notable exceptions (e.g., Pearson 2002; Schulten 2012; Fedman and Karacas 2012) academic cartographers have engaged only tangentially with the maps produced by military organizations. Rachel Woodward, in her article outlining emerging research in military geography, noted that almost no studies have addressed how military units view and conceptualize terrain (Woodward 2014, 48). Furthermore, Cheryl McGeachan has noted that the centenary of World War I provides an opportunity to study various geographical facets of that conflict, including how militaries view and visualize battlefields (McGeachan 2014, 827). Even so, neither of these scholars advocated David Woodward's framework as a tool to address these gaps in knowledge.

Woodward's (1974) article has been praised for looking beyond map *content* to the actual production process, as well as the *form* of the maps as artifact, and creating a unified system that examines not just how maps are created but also how they are used (Edney 2005, 19). But despite its impact on conceptual thinking, Woodward's suggested framework—concisely laid out in a series of matrices—has exerted little influence on how researchers have structured their projects.

The isolation of academic military cartography and the underutilization of Woodward's framework may be interrelated. Indeed, they provide an exciting opportunity to wade into a largely-unexplored field of cartographic endeavor (Woodward 2014, 47). One reason for the scholarly isolation of military cartography may be the lack of a proper tool for academics to approach what to most must be a very foreign culture in the military community (McGeachan 2014, 826–7). Similarly, Woodward's suggested framework may have remained generally unused because few non-military research topics are well-suited for its application. By contrast, I argue here that Woodward's framework is particularly useful for studying how military organizations produce and use maps.

Military organizations produce maps internally at a prodigious rate and across a broad range of subjects, from complicated assaults using diverse weapon systems to mandated environmental impact statements and even base landscape beautification. These map products are used throughout the entire military decision-making process, from operational planning through after-action reviews, which in turn influence the creation of yet more maps in a continuous cartographic cycle. Furthermore, Woodward's four-row matrix mirrors the influential *observe-orient-decide-act* (OODA) loop suggested by US Air Force colonel John Boyd (Hammond 2004, 1). The OODA loop model has exerted a powerful influence on military thinking in recent decades, and its mark can be seen on how US Army doctrine conceives and communicates the flow of military operations (Mostaghni 2010, 49; US Army 2012, vi). This cyclic activity makes Woodward's framework a powerful tool for studying military cartography and, by extension, how military units and individuals look at landscapes.

To illustrate these arguments, this paper presents an examination of the operational mapmaking conducted by the British Army's Egyptian Expeditionary Force (EEF) during the 3rd Battle of Gaza—fought on the Palestinian Front of World War I—as a case study to demonstrate how Woodward's framework can be applied to the study of military cartography. Specifically, the EEF created a series of "operation" maps throughout the October-December 1917 Gaza battle to track the locations of their own units and those of their Turkish opponents. These maps were notable in that they differed substantially from other "order-of-battle" and "situation" or "position" maps produced by the various belligerents during the war and also because the British 7th Field Survey Company—the cartographic component of the EEF—issued an edition of these maps every day during the entire six-week course of the campaign, with each succeeding map materially influenced by those that preceded it (Collier 2008, 10). These maps were the product of a military intelligence/cartography system that provides an ideal setting for applying Woodward's framework.

DAVID WOODWARD'S SUGGESTED FRAMEWORK AND ITS PLACE IN CARTOGRAPHIC SCHOLARSHIP

In his 1974 article, David Woodward suggested a framework for studying cartography that divided the production, distribution, and use of maps into four consecutive phases (Table 1). These phases are represented by horizontal rows on the table: information gathering, information processing, document distribution, and document use. Each row is then divided into two vertical columns that account for the process of production and the resulting product. The production column is further subdivided to account for the personnel, techniques, and tools active within each row of the table. This model is cyclical, both within and between phases, insofar as the product from each phase—and also each line within the phases—informs both the form and content of the subsequent cartographic activities (Woodward 1974, 109). In many cases—and particularly in military cartography—the entire mapmaking process is cyclic, with each final map product initiating a new mapping cycle.

As Matthew Edney (2005, 23) has noted, Woodward's framework was a key influence in moving the cartographic discipline away from its historical roots—attempts to create a science of mapmaking and the study of map *content*—towards a humanistic approach that allowed a more critical examination of historical maps and the processes and circumstances that created them (Harley 1989a, 3). It accomplished this not by nullifying the study of map *content*, but by integrating this study—defined by the product column of the framework—with the *form* of the maps, which permeates the entire matrix, most prominently in the production columns (Edney 2005, 20). Woodward's matrix also encourages scholars to classify map history studies within one or more cells of the table (Woodward 1974, 114). The penultimate expression of Woodward's humanistic influence on the academic discipline of cartography is the ongoing effort to create the multi-volume encyclopedic *History of Cartography*, which broadly emphasizes the history of the mapping process in the growth of the cartographic field and examines historically each cell of the mapping process (Freundlich 2011, 341).

More specifically, Woodward's framework has been influential in the scholarship of numerous academics, most notably his peer, J. B. Harley (1989b), but also many others, including Arthur Robinson and Barbara Petchenik in their 1975 *Cartographica* article, and Lydia Pulsipher (1987). It was also the subject, initially, of criticism that its structure failed to account for the cultural and historical context in which maps are created and used and that it overemphasized production over product (*form* over *content*), issues that Woodward addressed in his later scholarship (Edney 2005, 20).

That said, perhaps the most potent criticism of Woodward's framework may be that it has been rarely used to frame an in-depth research project. When the framework has been used, it has general served to classify a scholar's contribution within the larger structure of a cartographic system, rather than to provide internal structure for the research project. Even so, a good example of a broad application of Woodward's framework to structure a project is Pulsipher's (1987) examination of 17th-century mapping on the island of Montserrat. However, she acknowledges that, though Woodward's thinking influenced her entire project, she only utilized portions of his framework (Pulsipher 1987, 421). A broad survey of cartographic literature, including review articles by Mark Monmonier (2007), and by Michael Finn and Diana Thunen (2013), failed to locate other scholars who have used Woodward's model to structure their research. So, why the limited application of his framework?

The answer to this question lies partially in the fact that not every map and not every cartographic process lends itself to the full application of this model. Woodward himself noted that "many maps do not progress beyond the manuscript stage, but they are nevertheless subject to distribution…and eventual use by the reader" (Woodward 1974, 113). Of course, many mapping systems have products that never reach their intended recipients. Indeed, in the civilian sphere, a broadly diverse community of users often creates a decentralized system not readily accommodated by the Woodward framework. One could further argue that the contents of the matrix are too specific or rigid to keep pace with the technological advances in mapmaking that have occurred in recent decades. Regardless of the reason, over the past four decades scholars have decided—either deliberately or by default—that Woodward's framework was not an appropriate tool for structuring their research.

	Production			Product
	Personnel	Techniques	Tools	
Information Gathering	Observer	Observation	Physical and Mental Faculties	Image
	Surveyor	Surveying Data Gathering	Surveying Instruments, Questionnaires, etc.	Data
Information Processing	Designer	Design	Design Tools	Specifications
	Editor	Compilation	Compilation Tools	Worksheet
	Draftsman	Drafting	Drafting Tools	Manuscript
	Engraver	Engraving	Engraving Tools	Plate
	Printer	Printing	Presses, etc.	Printed Map
Document Distribution	Publisher	Publishing	Publishing Facilities	Published Map
	Seller	Marketing	Marketing Facilities	Marketed Map
Document User	Librarian	Acquisition Storage Retrieval	Library Facilities	Map
	User	Interpretation	Physical and Mental Faculties	Image

Table 1. *David Woodward's suggested framework for studying the history of cartography (from Woodward [1974]).*

By contrast, the mapping process in military organizations is markedly more centralized, with units gathering and analyzing data, making and distributing maps (paper and digital), and using these maps to plan and conduct operations that generate further data, which must in turn be processed and mapped (Armenis 2010, 207). These comments refer generally to large-scale tactical and operational maps used by individual units as opposed to small-scale strategic maps used for matters of national policy. As an example, the staff of a present-day US infantry battalion (approximately 700–800 soldiers) planning an operation will create and distribute maps dealing with cross-country mobility, expected enemy positions, planned friendly maneuvers, planned artillery fire, medical evacuation schemes, resupply schemes, communication networks, the employment of aerial assets, and any number of other relevant topics (US Army 2010, 2-1 to 2-14). These all inform operations that, one way or another, alter the staff's understanding of the battleground so that a new cycle of mapping and map distribution is required to keep abreast of the changes. Woodward's suggested framework is an excellent tool for studying and analyzing this type of mapmaking. However, making the model relevant requires a modification of Table 1 to better reflect the organizational structure of a military unit.

MODIFYING WOODWARD'S FRAMEWORK TO REFLECT MILITARY ORGANIZATIONS

Whereas the cells in Woodward's table are necessarily generic in content and focused on the traditional civil and commercial spheres of mapping, military mapping requires several adjustments. Accordingly, Table 2 is a modification designed to represent the cartographic system of a generic military formation. This table would be appropriate for examining almost any military unit that makes maps currently or in the past. The following section details the differences between this generic military framework and Woodward's original matrix. Later, the EEF case study will demonstrate this modification's usefulness in historical research.

Beginning in the production column of the information-gathering phase, in the "Personnel" sub-column the generalized "observer" and "surveyor" entries are replaced with their military equivalents: reconnaissance troops, who scout for the enemy ahead of the main force, and technical intelligence-gathering means such as signal intercepts and aerial reconnaissance. Obviously this latter source is very broad and has evolved as technology has advanced, but the mission of scouting forces has actually changed little since antiquity. Since modern militaries (World War I and later) are generally less concerned with mapping terrain than with populating maps with tactically and operationally relevant information, the surveying element of Woodward's table disappears in these cells. The "techniques" column contains the broad methods—both tactical and technical—by which these information-gathering entities operate, just as the "tools" column contains their generic equipment. The products of this phase in Table 2 are the reports sent back by the scouting forces and the information gathered by technical means. These represent fragmentary pieces of data that require analysis to craft them into useful intelligence, a process that occurs in the information-processing phase.

This next row of this modified framework focuses on those individuals who first decide what information is relevant to transmit back to higher headquarters—itself an act of analysis—and the staff officers and commanders who analyze the data received. Military officers use standardized procedures (*doctrine*) to guide them in this analysis, but also have leeway for their own decision-making (US Army 2012, 2-5). The products of this phase include planning priorities issued by commanders to guide the work of the staff officers, as well as summaries that distill the diverse raw data into a useful common picture of the area of operations, perhaps in the form of pre-distribution draft maps. The graphic representation and dissemination of this picture in a final polished map occurs in the document-distribution phase.

Military mapmaking has long been the responsibility of headquarters staff, but prior to World War I, military cartographers had generally focused their efforts on charting physical terrain, whereas during and after this conflict the emphasis shifted to plotting tactical and operational information on pre-existing maps, and distributing these maps to subordinate units through an established chain of command (Collier 1994, 101–3; Collier and Inkpen 2001, 145). In this endeavor, militaries have developed standardized map symbols to streamline cartographic communication and reduce confusion (US Army 2004, vi). These

	Production			Product
	Personnel	**Techniques**	**Tools**	
Information Gathering	Reconnaissance Forces	Patrols Observation	Physical and Mental Faculties Vehicles Optics	Situation Reports
	Technical Intelligence-gathering Means	Signal Intercepts, Image Intelligence, Electronic Intelligence, etc.	Radios, Aircraft, Cameras, Sensors, etc.	Raw Data
Information Processing	Unit Leaders	Physical and Mental Faculties	Report Formats	Operational Priorities
	Communication Specialists and Couriers	Data Transmission	Communication Networks	Compiled Reports
	Staff Officers	Military Decision-Making Process	Military Doctrine Training	Intelligence Summaries Recommendations Common Operating Picture
Document Distribution	Staff Mapmakers	Standard Symbols and Forms	Physical and Digital Mapmaking Tools	Tactical, Operations, and Logistical Maps
	Communication Specialists and Couriers	Intelligence Distribution Operation Orders	Chain of Command	Operations Orders
Document User	Unit Leaders	Military Decision-Making Process	Physical and Mental Faculties	Unit Orders and Operations
	Tactical Military Units	Tactical Operations	Tactical Doctrine and Training	More Intelligence

Table 2. *Woodward's framework modified to reflect the structure of generic military cartographic systems.*

symbols communicate intelligence, analysis, and intentions to subordinates or—in the case of upward flowing information—to superiors.

In the document-use phase, subordinate commanders and units use the maps produced by the headquarters staff to plan and execute operations that move forces into contact with the enemy (or not) and thus alter the battlefield conditions—or at least the perception thereof—in one way or another. This in turn generates reports from these formations back up the chain of command, providing raw data that initiate a new planning and mapping cycle. This phase differs perhaps more than any other from the content of Woodward's matrix. In his framework, the final product is deposited in a library for general access and reference, to be used for some as-yet unspecified future task, perhaps unrelated to the original purpose of the map. Military maps, in contrast to their civilian counterparts, are generally created for an immediate purpose under rapidly changing conditions and are thus more immediately useful. This fact highlights the cyclic nature of military cartographic systems.

Each of the four phases in this military cartographic system builds on the preceding phase, though they may occur concurrently. And as Woodward noted about his original framework, not every step of this military mapping cycle will necessarily occur in every case. Often a map might remain in draft form for use solely by the headquarters staff. Moreover, because of a dearth of reconnaissance information, staff officers might be forced to plot speculative or otherwise questionable information (US Army 2012, 9-10). Even so, the defining characteristic of this system is that it is cyclical, with each map and mapping cycle materially influencing the content of subsequent map products.

Perhaps the ultimate modern expression of this system is the networked digital moving map display fielded by the US military. This technology (a dual system called FBCB2/Blue Force Tracker) equips combat vehicles and command posts with a computer terminal that networks with other vehicles and headquarters equipped with the same system. Linked to a GPS receiver, the terminal automatically transmits the location of the vehicle across a digital radio network and receives and plots the location of all other similarly equipped friendly units. Furthermore, the soldier operating the system can manually plot observed enemy forces or obstacles directly onto the digital map (Armenis 2010, 207). This information is then transmitted to an appropriate headquarters for approval before being broadcast across the entire network, ensuring that every sub-unit possesses a common operational picture of the battlefield situation and allowing commanders to rapidly respond to changing tactical conditions (US Army 2010, 5-5). At times, this mapping cycle can occur in seconds.

Recent technology has drastically shortened the military mapping cycle, but its actual form and concept are not new. One clear application of this cartographic concept is the operation mapping technique practiced by the EEF in Palestine during the 3rd Battle of Gaza in late 1917. This battle is an excellent case study for demonstrating both the cyclical nature of military mapping and the relevance of Woodward's cartographic framework.

THE EEF'S OPERATION MAPS: A CARTOGRAPHIC CASE STUDY

The Egyptian Expeditionary Force's (EEF) cartographic effort during the 3rd Battle of Gaza was a sophisticated process given the relatively primitive technology available at the time. During the six weeks that this battle raged—from late October to mid-December 1917—the EEF's intelligence staff and the 7th Field Survey Company (FSC) produced a series of operation maps showing the positions of friendly units and opposing Turkish forces, with a new edition of the map printed and distributed every day. A complete set of the original editions of this map series are in the British National Archives filed as WO 153/1035/2 and WO 153/1043. The transformation of raw data into a polished operation map is an excellent example of the military cartographic cycle and exemplifies the modification of Woodward's framework seen in Table 2.

This section first illustrates how the modified cartographic model conceptually organizes the production of the operation maps by the EEF (Table 3). It then assesses the value of a rigorous application of Woodward's framework, which demonstrates this model's applicability to military cartography. The section then concludes with some brief comments on the effectiveness of the operation mapping cycle as practiced by the EEF, including the limitations imposed by the available technology and the structure of

	Production			Product
	Personnel	Techniques	Tools	
Information Gathering	Intelligence Officers	Signal Intercepts	Wireless Sets	Intercepted Messages
	Aerial and Ground Patrols	Ground and Aerial Reconnaissance	Aircraft, Cameras, Optics	Aerial Photographs, Patrol Reports
	Interrogators	Prisoner/Deserter Interrogations	Mental Faculties	Prisoner/Deserter Statements
	Agent Networks	Train Watching	Communication Networks	Agent Reports
Information Processing	Communication Specialists	Situation and Intelligence Reports	Report Formats and Communication Networks	Situation Reports
	Intelligence Officers	Multi- and Single-Source Analysis Methods	Mental Faculties, Standardized Forms	Intelligence Summaries
		Compilation, Drafting, Engraving, Printing Tools	Pre-printed Base Maps, Colored Engraving Plates	Draft Operation Maps
Document Distribution	Staff Officers	Daily Intelligence Dissemination	Chain of Command, Subordinate Staffs	Operation Orders
	7th FSC	Compilation, Drafting, Engraving, Printing	Pre-printed Base Maps, Compilation, Drafting, Engraving, Printing Tools	Operation Maps
Document User	EEF Commander, Subordinate Commanders	Military Decision-Making Process	Tactical Doctrine and Training	Operation Decisions, Unit Orders and Movements
	GHQ and Corps Staffs	Enemy Capabilities and Intentions Analysis	Physical and Mental Faculties	More Intelligence

Table 3. *Woodward's framework modified to reflect the specific structure of the Egyptian Expeditionary Force during the 3rd Battle of Gaza, 1917.*

EEF mapping activity. These observations illustrate the broader import of Woodward's table in streamlining map-making in rapidly-changing and time-sensitive contexts.

HISTORICAL CONTEXT

The Palestine Campaign grew out of the British Empire's strategic imperative to safeguard the Suez Canal and the sea lines of communication to India. Several large Turkish raids on this waterway in the early years of World War I convinced the British of the necessity to move the front lines forward across the Sinai Peninsula. However, the forces necessary for pushing the front forward to the Palestine Frontier were also too large to justify their assignment to a purely defensive role once they reached the Ottoman border.

Accordingly, the British government commissioned the EEF's commander, General Archibald Murray, and his eventual successor, General Edmund Allenby, to invade Palestine and capture Jerusalem before Christmas 1917. The British forces under Murray attempted twice—in the 1st and 2nd Battles of Gaza—to breach the Turkish frontier defenses arrayed on a line stretching from the town of Gaza on the Mediterranean coast southeast to the crossroads town of Beersheba. These failures prompted the British Imperial General Staff to replace Murray with Allenby and convinced the EEF of the need to better track the locations of units in the Turkish order of battle, a need that gave rise to the operation mapping technique (Wavell 1936, 94–114; Sheffy 1998, 207–14). The EEF staff used the resulting operation maps to track the location of each British and Turkish regiment in the opposing armies' orders of battle. The maps also helped the EEF commanders make operational decisions about how to respond to Turkish troop movements, much as modern networked dynamic mapping systems help contemporary military officers oversee combat (Armenis 2010, 208).

The 3rd Battle of Gaza occurred in three consecutive operational phases. First, the EEF under Allenby launched a thoroughly pre-planned assault on the Turkish eastern flank at Beersheba that drew the enemy reserves to that end of the line before a second assault struck the weakened Gaza defenses in the west, a sequence that was significantly informed by the information communicated through the operation maps (Figure 1; Meinertzhagen 1917, 46). In the second phase of the battle the Turkish army evacuated their defensive line and retreated northward, pursued by the British, until the front stabilized at a latitude generally running through Jerusalem (Figure 2). The operation maps were least useful during this phase as the chaotic and rapidly changing operational context meant that the twenty-four hour operation-mapping cycle was too slow to

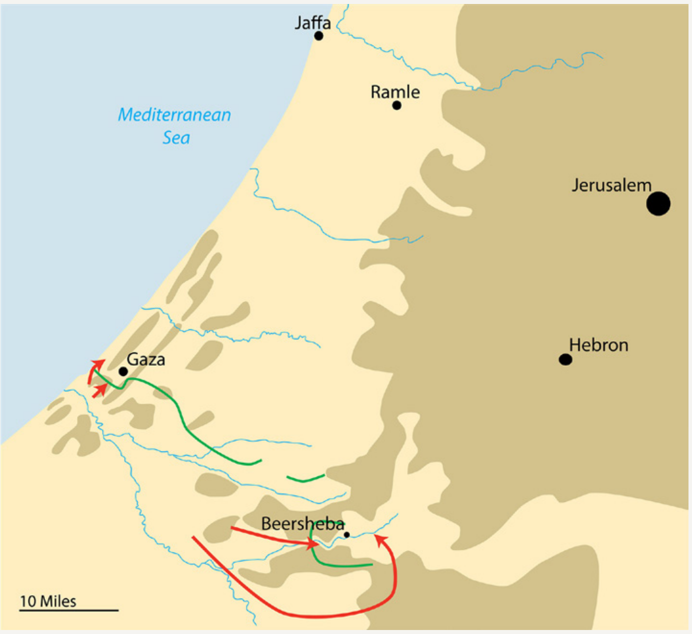

Figure 1. *In the first phase of the 3rd Battle of Gaza, the British forces launched successive attacks (in red) against both flanks of the Turkish line (in green), first at Beersheba, then at Gaza.*

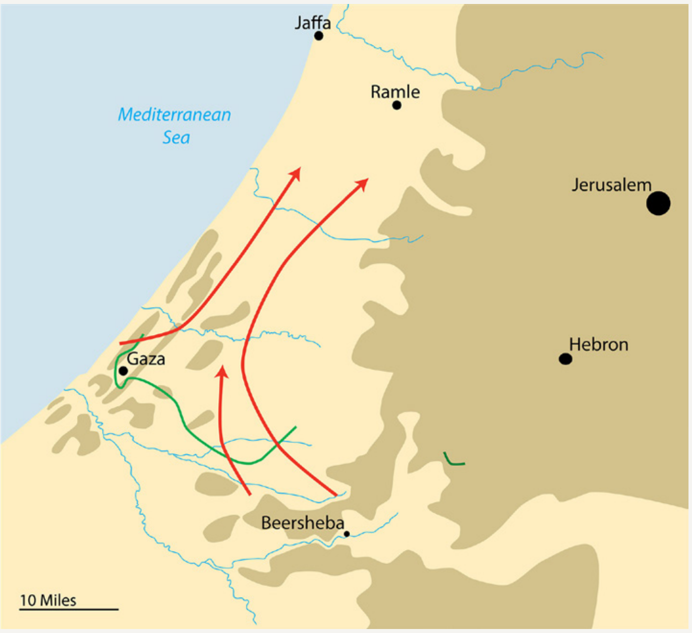

Figure 2. *In the second phase, the British pursued the retreating Turkish army northward until the front stabilized on a new line running generally from Jaffa to Jerusalem.*

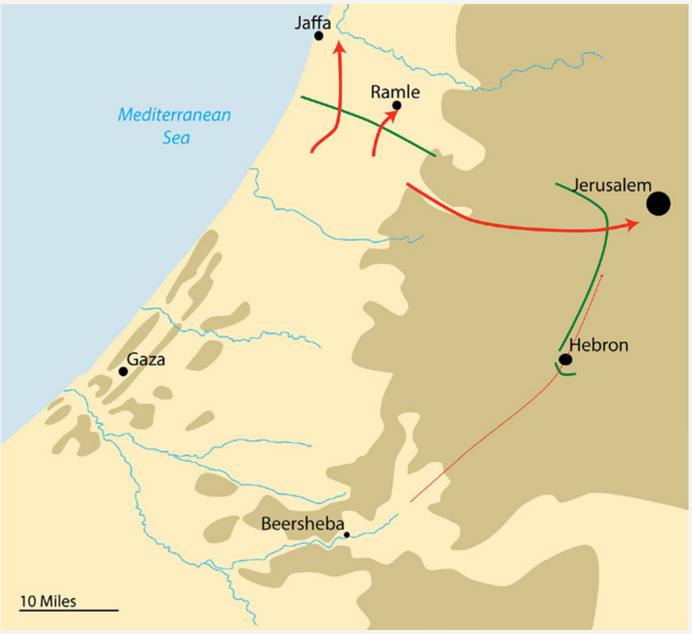

Figure 3. *In the final phase, the British forces conducted a deliberate advance into the Judean Hills, occupying Jerusalem on 9 December.*

allow for timely analysis and distribution of relevant data. In the third phase of the battle the EEF began a slow and deliberate eastward advance into the Judean hills, which resulted in the capture of Jerusalem on 9 December (Figure 3). As the Turkish army was too battered at this point to effectively counter the British advance, the purpose of the operation maps in this phase appears to have changed, with the maps becoming a historical record meant to communicate the EEF's accomplishments to an external audience (Collier 2008, 13).

THE EEF CARTOGRAPHIC SYSTEM

The first step in applying the modified framework to the EEF's structure is to define the elements in this force that engaged in the information-gathering phase of the military cartographic system (see Table 3). These included the infantry and cavalry units that conducted ground patrols to ascertain the positions of the opposing Turkish force as well as their aerial counterparts in the Royal Flying Corps (RFC). Furthermore, the EEF employed technical means to gather information about their enemy, including intercepted Turkish wireless messages and reports from agents behind the lines. While each of these sources excelled at providing different types of information, the most profitable source of intelligence appears to have been the statements of Turkish deserters who left their units to seek asylum with the British army, and the broadly similar statements of prisoners captured during combat operations.

The data generated by these patrols, intercepts, and interrogations took the form of reports sent back to the EEF General Headquarters (GHQ) by scouting elements (found in the war diaries of the relevant units in the British National Archives, collection WO 95 for ground units and AIR 1/2210/209/26/2 for RFC patrols), intercepted messages (some preserved in the Gerard Clauson Papers at the British Imperial War Museum, London), and notes gleaned from the interrogation of deserters (WO 157/717 through WO 157/722). As in the more generalized military framework (Table 2), these disparate raw data required further analysis by the EEF's staff to transform them into useful information before they could inform a coherent picture the Palestine front.

In the information-processing phase of the mapping cycle the GHQ staff attempted to compile and analyze the information arriving from these diverse sources to produce operationally useful intelligence for the unit commanders. Staff officers gathered these data into daily intelligence summaries (WO 157/717 through 722) in which they synthesized this information into a coherent whole. These daily summary documents represent a clear link between the information gathered by the EEF reconnaissance forces and the operation maps insofar as specific entries in the intelligence summaries appear regularly as symbols and annotations on the maps.

Another facet of this information-processing effort appears to have been the creation of draft operation maps (Figure 4), which were used to track and analyze the data received at GHQ during the day (Meinertzhagen 1960, 225). These draft maps differed from the final daily editions in that they were unpolished and only showed the positions of the British forces while ignoring their Turkish opponents. These draft maps were intended to inform the central product of the mapping cycle: the daily operation maps printed during the document-distribution phase.

In the third phase of the EEF's cartographic cycle, the GHQ staff intelligence officers submitted the latest copies of their daily draft maps to the draftsmen of the 7th FSC for copying and printing. These draftsmen created colored plates for overprinting the red (British) and green (Turkish) unit symbols onto pre-printed base maps (Maule 1919, 13). This process occurred each evening,

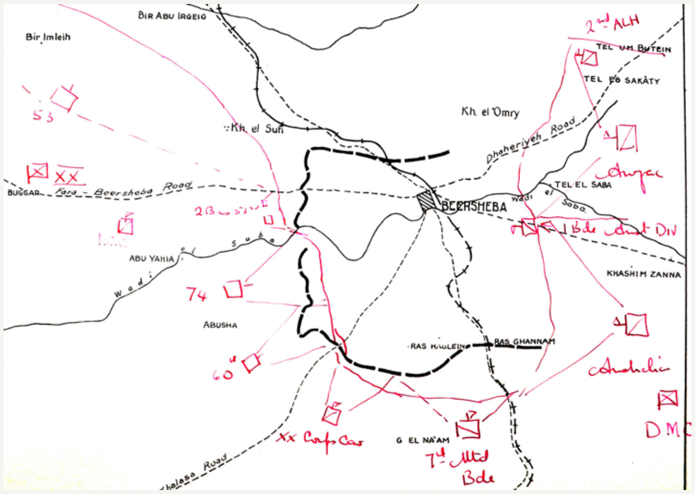

Figure 4. *An excerpt from a draft operation map drawn during the opening day of the Gaza offensive. Note the obviously hand-drawn symbols and that the map only shows British units, omitting Turkish positions. (TNA WO 153/1035/2).*

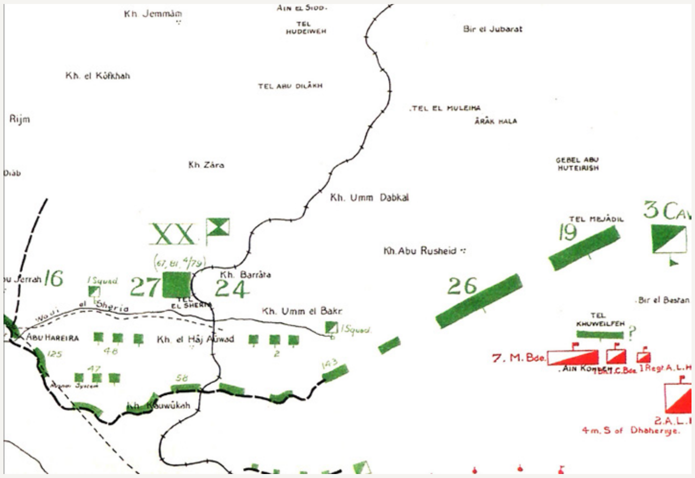

Figure 5. *Facsimile excerpt from the 2 November operation map that shows a strong Turkish reinforcement of their eastern flank to counter the British attack there. Note in particular the 19th and 26th Divisions to the right represented by large rectangles presumably denoting strong formations. The horizontal dimension of this figure is approximately 25 kilometers (TNA WO 153/1035/2).*

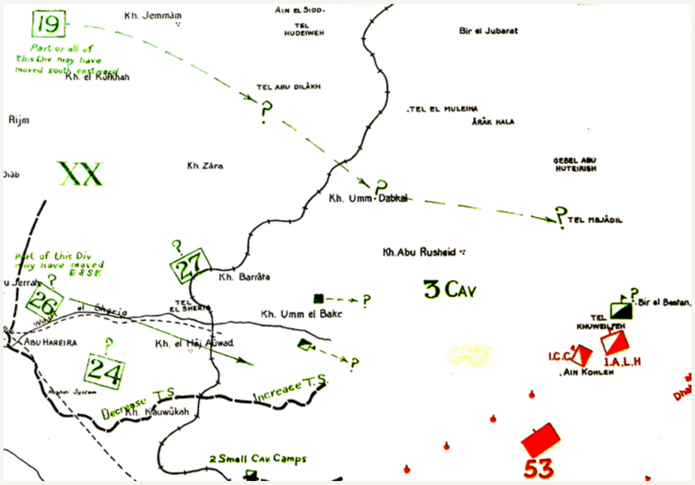

Figure 6. *Facsimile excerpt from the 3 November operation map that shows the same area as Figure 5. Note that the symbols representing Turkish reserve formations have been removed back to their original locations behind the line (left side of the figure) and are now marked by hollow box attenuation symbols. The horizontal dimension of this figure is approximately 25 kilometers (TNA WO 153/1035/2).*

with the draft maps delivered to the 7th FSC at 4pm and the final polished copies available for distribution at 6pm (Meinertzhagen 1960, 225). The maps were then delivered by courier to the EEF's corps and division commanders, with enough copies printed to supply at least one map to each unit, with additional copies retained at EEF GHQ and at the 7th FSC (7th FSC War Diary, entries for 28 October through 9 December). These maps would have accompanied orders sent by GHQ to its subordinate headquarters, which were themselves informed by the freshly produced maps.

In the final phase of this specialized cartographic framework, the EEF GHQ, as well as its subordinate corps and division commanders, used the operation maps to make decisions about forthcoming maneuvers. One clear example of such document use occurred in the early stages of the battle. The 2 November operation map showed strong Turkish reserves moving to the far eastern flank to counter the British advance, a movement that helped prompt the start of the British attack at the western end of the line (Figure 5). However, higher level officers at GHQ, worried that the maps would discourage the British commanders at the eastern end of the line from aggressively pursuing their own attacks, ordered these maps retracted (Meinertzhagen 1917, 46). Accordingly, the 3 November map showed the Turkish reserves back in their original locations, though now represented by hollow box symbols to denote uncertainty about the location of the Turkish units (Figure 6).

This episode illustrates that the operation maps influenced decisions made by the EEF's commanding officers both at the GHQ and the corps level. These decisions guided the movements of British forces and patrols, maneuvering them into positions where they could observe their Turkish opponents (or not, in many cases) and report information back to their higher headquarters, beginning anew the cartographic cycle that would produce the next day's iteration. Moreover, the EEF staff likely considered the operation mapping technique to be successful because they reintroduced it in an improved form during Allenby's final 1918 offensive. Furthermore, James T. Kelly, a US army officer writing in 1933, suggested that the American military was modeling their intelligence maps after the 7th FSC operation maps, demonstrating an even broader influence (Kelly 1933, 42–43).

The process of conceptually organizing the EEF in this way revealed the important roles played by even minor entities within the British army, including units that would not have participated directly in either reconnaissance or mapmaking. For example, one vital element of the EEF cartographic system was the communication troops who, by their efforts in setting up signal networks, largely controlled the amount and type of information that could reach the staff at GHQ. The EEF's intelligence staff could only map information received from those involved in information gathering. The link between the information-gatherers and the staff was often tenuous and restricted, particularly during mobile operations, when the communication infrastructure was usually too slow to keep pace with the advancing formations. The evidence relating to how the maps were actually used in the final phase of the framework shed light onto their intended purpose, another facet of this subject that would have remained unclear under a more narrow examination restricted solely to map content.

This case study demonstrates how a version of Woodward's framework can frame the study of a specific episode of historical military cartography. In the case of the EEF, this framework is useful for understanding the entire cartographic process and drawing conclusions about the mapping cycle's purpose and effectiveness. Indeed, it highlighted the fact that the EEF's twenty-four hour cartographic cycle, suited for graphically organizing a stable front as existed prior to the start of the British offensive, was too slow to cope with the rapidly changing operational conditions of mobile operations such as those in the second phase of the battle. Finally, this conceptual organization highlights the similarity of the EEF's cartographic activity to present-day digital mapping systems.

CONCLUSIONS

APPLICATIONS TO MILITARY CARTOGRAPHY

Woodward's (1974) suggested framework is an excellent tool for examining military mapmaking, as long as certain limitations are recognized. For the framework to be fully appropriate, the military unit studied should be of sufficient size and capability to conduct all phases of the mapping cycle, from information gathering through document use. During World War I this capability was generally held at the army level of organization because these formations were the smallest to possess the drafting and printing equipment necessary for map production. In present-day militaries, the ability to conduct a complete cartographic cycle occurs as low as the battalion level. In each case, lower-level organizations participate in portions of this framework, often making their own simple maps in the process. As an example, junior sergeants in the US Army are trained to draw crude maps in the dirt to rapidly communicate plans to the two or three soldiers they lead, and young officers are expected to produce rough terrain models in the field to brief their platoons and companies on planned operations.

Of course, the maps produced by these systems are imperfect representations of reality, with their own silences, white lies, and inaccuracies that detract from their fidelity as records of the actual course of the battle (Robinson and Petchenik 1977, 101; Monmonier 1991, 1–4; Harley 1989b, 84–85). In the case of the EEF operation maps, the editions printed during the mobile second phase of the Gaza offensive were nearly useless from a tactical perspective because they simply did not communicate much usable information, and what data they did show were largely based on speculation by the intelligence staff. But even in such circumstances, Woodward's framework demonstrates that examining an army as an integrated, cyclical cartographic system can be important in trying to understand what the cartographers didn't know, why they didn't know it, and how they attempted to graphically communicate uncertainty.

If these limitations are recognized, the utility of Woodward's framework in this context becomes obvious. Large military units, at least since World War I, have acted as cartographic systems that rapidly gather, process, and plot spatial information, and then use the resulting maps to plan and execute operations. These operations in turn generate further information that must be mapped and distributed. Whereas only portions of this cartographic cycle may be relevant to most civilian mapping activities, the entirety of the framework comes into play in the military context. While this case study is an example of historical military cartography, this method is just as useful—perhaps more so—for studying contemporary military cartography.

FURTHER APPLICATIONS

The method of considering military units as cartographic systems suggests applications that reach beyond combat operations. Furthermore, such contemporary applications need not be restricted to military organizations. One obvious example of a potential application of Woodward's framework is the response to the Fukushima reactor disaster in Japan, where the spread of radiation-contaminated water needed to be mapped continuously and appropriate action taken to protect potential victims. Another example is the use of mapping in response to an epidemic to ensure efficient distribution of vaccines or the management of a quarantine.

On the other hand, the Woodward framework may be of more limited utility in studying or designing more decentralized crowd-sourced or big-data mapping systems such as OpenStreetMap or Google's influenza mapping algorithms. In these systems many or all elements of the cartographic process may be ill-defined and difficult to incorporate into the framework's structure (Bennett 2010, 8). Even so, some of these cartographic activities seem to be showing a movement towards more centralized control of information processing as well as privileging certain types of information gathering to improve the map products' accuracy and utility (Butler 2013). In these circumstances, Woodward's framework is still a valuable tool for analyzing these systems, at least in part.

To conclude, research into historical and contemporary military cartography provides a context where scholars can make fuller use of Woodward's framework. Indeed, further examinations of the prodigious mapmaking activities of military organizations can enrich academic cartography (Harley and Woodward 1989, 11–13). As Edney noted in his essay about Woodward's impact on academic cartography, "To understand map making and map use as human endeavors requires consideration of all mapping endeavors and not just those which contributed to the present-day concerns of academic cartography" (Edney 2005, 22). Military cartography is one of these endeavors that requires further research, and Woodward's suggested framework is an excellent tool for the job.

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Twentieth-Century Themes for the Progressive Map Collection

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Volume Six of the *History of Cartography*, which focuses on the twentieth century, was released in May 2015 as part of a massive, multi-volume reference work that covers cartography in all its forms across all eras, from prehistory through the end of the last century. At seventeen pounds, it's a big book—two books, actually—consisting of 1,954 large, double-column pages, with 529 encyclopedia entries written by over three hundred contributors and co-contributors, and including 1,153 illustrations, 5,115 bibliographic references, and 61 tables. In addition to serving scholars and interested lay users, it can help librarians organize a map collection to reflect the major revolutions that made the twentieth century arguably the most significant era in map history. Moreover, any one of the six themes that frame Volume Six could provide a coherent focus for an enlightening exhibition.

The first of these themes is the *Diverse Impacts of Mapping on Society*. Whether driven by technology, state formation, imperialism, or other forces, mapping assumed new or greatly enhanced roles in the twentieth century, notably in entertainment, environmental protection, growth management, weather prediction, hazard mitigation, and other arenas with clear social impact. Moreover, the century witnessed not only a relative "democratization" of map use and associated improvements in cartographic literacy, but also an increased awareness of ethical considerations in both the design and the use of maps.

By century's end maps and mapping were subject to unprecedented questioning; what came to be called counter-maps were challenging the authority of official delineations, and participatory mapping was a recurrent theme at academic conferences. Indeed, as mapping practices pervaded all parts of the globe and all levels of society, and as mapping became more important for coping with complexity, for organizing knowledge, and for influencing public opinion, scholars recognized the need (belatedly perhaps) for a critical appraisal of the use, misuse, and effectiveness of maps for exploration, regulation, management, planning, and persuasion.

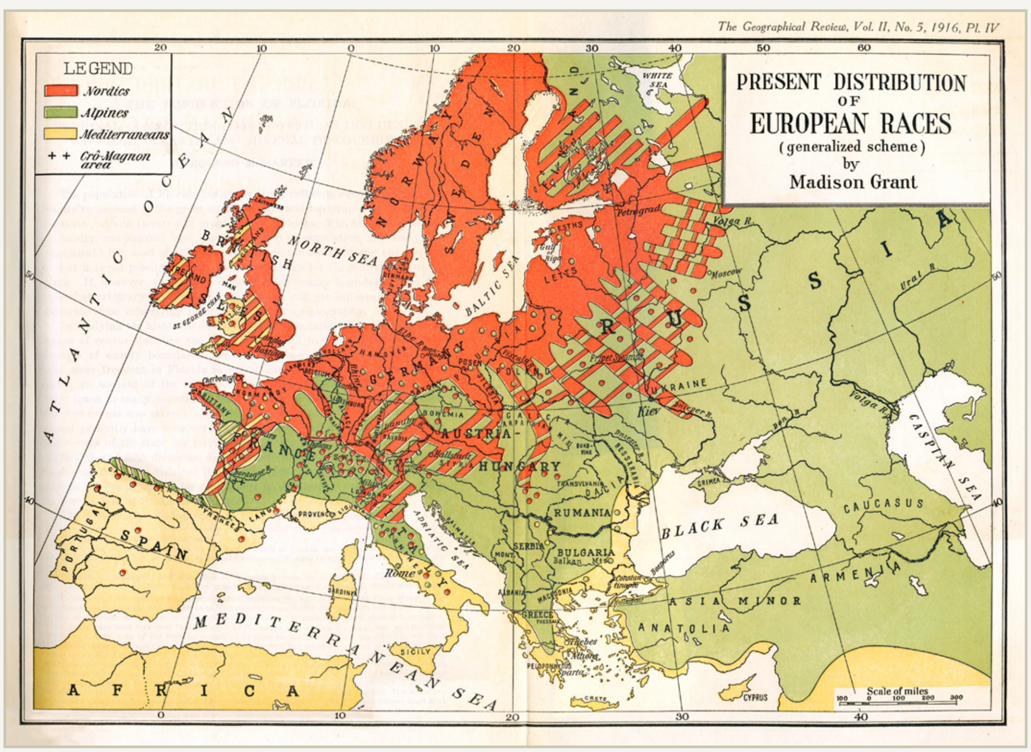

Figure 1. Map promoting scientific racism in the 1916 Geographical Review.

Understanding the importance of maps as tools also demanded a conscientious effort to disentangle significant, demonstrable impacts like those described in Volume 6 from assumptions based largely on theory or conjecture. During the twentieth century simplistic notions of the map as an objective representation of reality gave way to a broader grasp of how the map's respectability as a scientific tool makes it a target of political manipulation, particularly apparent in the geopolitics of Nazi Germany and the Cold War. The century also witnessed a broader and deeper appreciation of the diverse ways in which maps can be read and understood, a trend encouraged by the often-contentious intersection of cartographic scholarship and what's been called social theory. Also apparent was a broader, more nuanced understanding of the role of cartographic visualization in the packaging of ideas, explored under the interchangeable rubrics "propaganda maps" and "persuasive cartography," which mean pretty much the same thing.

The changing boundaries between cartography and other endeavors were also apparent in the growing participation of humanists, literary scholars, and art historians at academic conferences on map use and map history as well as in the adoption of geographic information systems as an analytical tool in archaeology, environmental biology, and public administration, among other fields.

The second key theme is *Overhead Imaging.* Technologies for imaging Earth from aircraft, satellites, balloons, and rockets not only enhanced the efficiency of mapping and surveillance but also had diverse scientific, social, military, and political impacts, exemplified in the early twenty-first century by an increased use of unmanned aerial vehicles as tools of surveillance and weapons of attack.

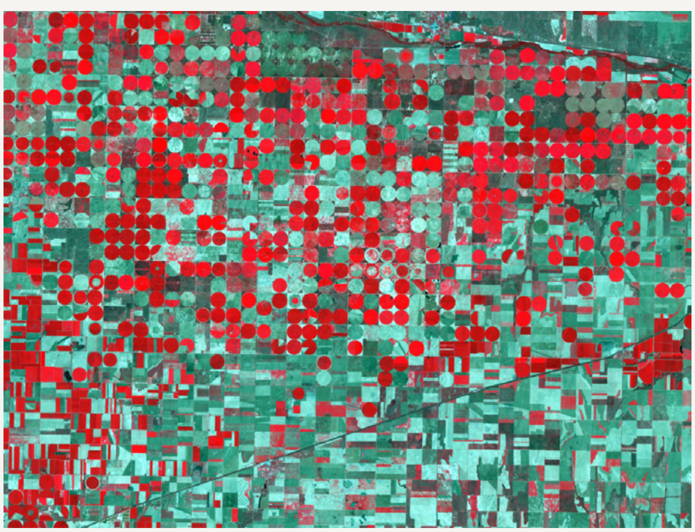

Figure 2. *Excerpt from a color-infrared image captured in 1988 by Landsat 5.*

Improved technologies for capturing image data and extracting cartographic features spearheaded a proliferation of geospatial databases, which in turn fostered a revitalized use of maps in older, more traditional fields of application such as energy exploration, transportation, and urban planning. During the twentieth century, aerial mapping and photogrammetry extended the reach of large- and intermediate-scale topographic mapping so effectively that the term *terrae incognitae* no longer meant the absence of any modern maps but rather a relative dearth of the censuses, detailed land use surveys, and environmental assessments essential to the Western World's managed spaces. In addition, remote imaging of other heavenly bodies helped redefine exploration.

The third key theme of cartography in the twentieth century is the *Electronic Transition*, whereby the dramatic and far-reaching conversion of geographic information to electronic media allowed the creation of interactive and dynamic maps. Although the products of this technology were not necessarily less expensive or more reliable, GIS and the Internet radically altered cartographic institutions and lowered the skill required to be a map author, and satellite positioning and mobile telecommunications

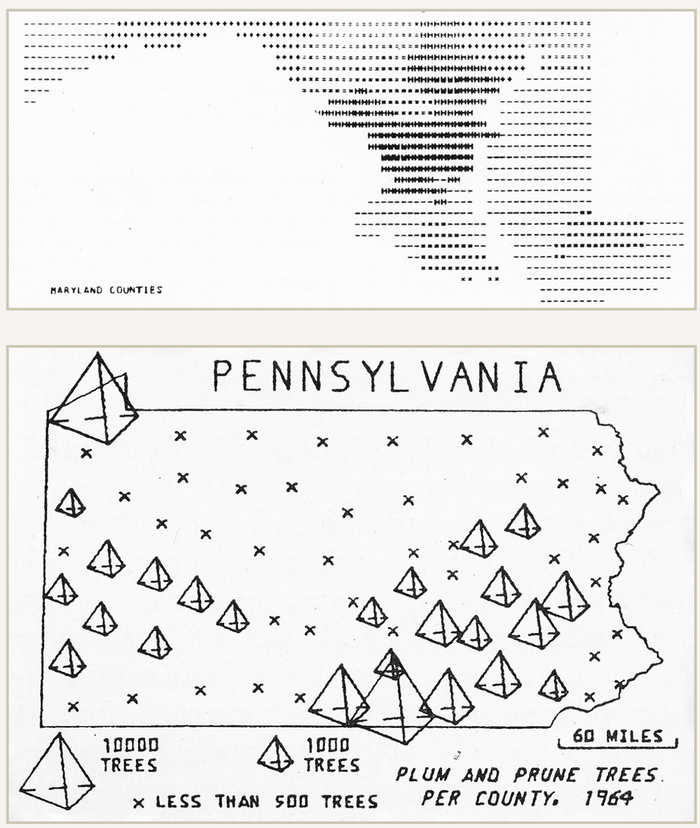

Figure 3. *Line-printer and pen-plotter maps in* The Professional Geographer, *1965 and 1968.*

revolutionized map-based wayfinding. Moreover, web-based technology not only undermined the traditional role of the state in topographic mapping but also made zooming in and out a widely pervasive and intrinsically interactive means of changing map scale—an extension to everyday use of the elegant but static bird's-eye views that had begun to proliferate in the nineteenth century.

Connections with earlier periods of map history are also apparent in the increased role of government in collecting, mapping, and using scientific data; the heightened concern for data quality; the rise and decline of truly mass production in the twentieth century; and the conflation of geographical, thematic, and topographic mapping whereby users could toggle between different layers or "coverages" while interactively manipulating map scale. Astute implementation of digital technologies, though never straightforward and far from complete by century's end, had moved cartography further beyond description and delineation and closer to the more ambitious goals of seeing and knowing.

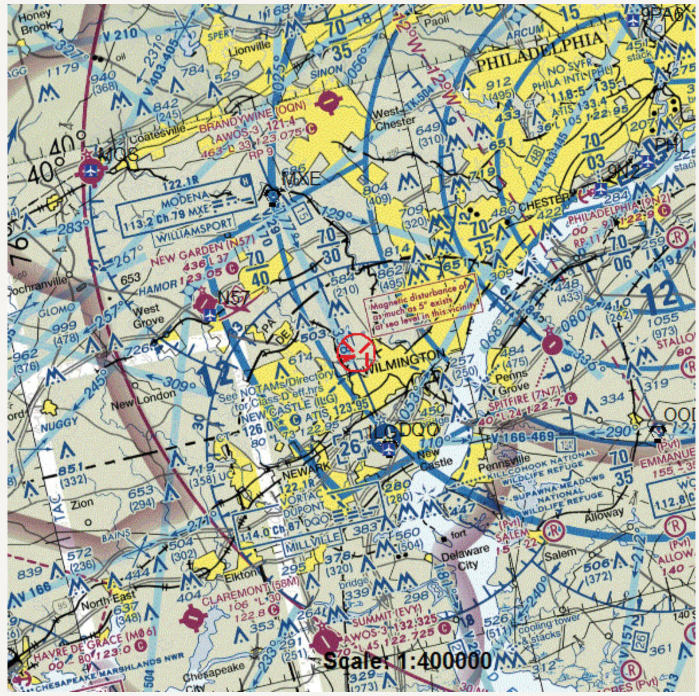

Figure 4. *Online map of a "temporary flight restriction," identified by a red circle, over Vice President Biden's home, ca. 2009.*

The fourth key theme is *Maps and Warfare*, noteworthy because the longstanding relationship between cartography and warfare became evermore prominent in the twentieth century. Along with the greater efficacy of precisely targeted cruise missiles and the trickle-down of military technology into civilian applications, this development brought impulsive aggression, the diversion of funds from beneficial public investment, and a reduced reliance on diplomacy. Accompanying this technology-inspired reconfiguration of military mapping were new notions of territory that a nation-state might claim as well as new prohibitive cartographies to protect these claims.

Chief among these prohibitive genres is aeronautical charting, which arose during the twentieth century to produce, reproduce, and regulate navigable airspace and later became a defensive strategy through the declaration of no-fly zones, actively enforced in some cases but largely rhetorical in others. Radar, a new mapping tool adept at tracking aircraft, became a strategy for enforcing other kinds of no-fly zones, including airspace restrictions above coastal waters and dynamic temporary flight restrictions (TFRs) that could emerge or expand suddenly in accord with the movements of top officials.

The growth of prohibitive cartography during the twentieth century is also apparent in increased maritime restrictions, including the widening of most territorial seas from three to twelve nautical miles and the delineation of Exclusive Economic Zones (EEZs), which gave coastal nations new authority over fishing and subsurface mining within two hundred nautical miles of their shoreline. The advent of offshore drilling and submarine warfare led to a broader, more intensive mapping of the sea floor as well as the discovery of a multitude of seamounts (submarine volcanoes), which triggered a round of aggressive naming reminiscent of the seventeenth century. Mapping had an inevitable if not indispensable role in dividing the seas and shrinking international waters.

New mapping technologies strengthened the bond between national defense and cartography and underscored the unintended consequences of technological innovation. Cold War fears of nuclear weapons and intercontinental ballistic missiles inspired the development of artificial satellites useful not only for monitoring weapons development and launch sites but also for mapping terrain and monitoring weather systems.

More exact representations of the planet's shape and gravity anomalies, originally intended to guide intercontinental ballistic missiles toward precisely pinpointed targets, provided a more accurate geodetic framework for geographic information of all types, civilian as well as military. In addition, the prospect of low-altitude unmanned bombers guided by the automated comparison of altimeter readings with onboard electronic terrain maps led to digital elevation models, which by century's end were supporting civilian applications as diverse as geographical mapping, landscape architecture, and commercial forestry. Moreover, the global network of seismographs sensitive to underground explosions—essential for ensuring compliance with nuclear test-ban treaties—proved useful in studying continental drift and modeling seismic risk.

And finally, the global positioning system, or GPS, intended as a more reliable way to route cruise missiles, became a commonplace tool for navigation, field measurement, land survey, and location tracking.

A fifth key theme is the *Paradox of Globalized Practices and Customized Content.* While the globalization of mapping technology and cartographic practice diminished international differences among cartographic products, fuller customization of map design and content fostered a broader range of cartographic applications, an unprecedented diversity of map types, significant changes in the form and appearance of maps, and the increased prominence of maps in the mass media. The globalization imperative was already apparent in commercial and institutional arenas at the end of the nineteenth century.

Perhaps the quintessential example of these is the "International Map of the World," proposed in 1891 by Albrecht Penck, at the Fifth International Geographical Conference in Bern. The movement toward global standardization intensified after World War II, and new cartographic genres emerged when distinct consumer communities adopted standardized aesthetics that ran from the highly formal designs of marine charts and orienteering

Figure 5. *Excerpt from Boston sheet (1912) of the "International Map of the World."*

maps to the aggressively informal look of advertising maps and political cartoons.

Prominent examples of international standardization include soils maps and the "World Aeronautical Chart," which outlived the comparatively purposeless "International Map of the World." The coexistence of global standardization and increased customization is epitomized by infectiously innovative designs instantly recognizable to map collectors and cartophiles worldwide.

Distinctively functional examples include the "London Underground Map" and Erwin Raisz's physiographic diagrams. Preeminently ideological examples include the Earth-from-space perspective of Richard Edes Harrison, whose dramatic illustration of the proximity of the United States and the Soviet Union fostered the notion of "Air-Age Globalism," and the "Peters Map of the World," which triggered a media scrum between Third World advocates and professional cartographers.

Digital technologies intensified these trends, but globalization often superseded customization. Although illustration and map projection software encouraged map authors to customize their designs for specific audiences, GIS software and web-based mapping typically constrained graphic style while simultaneously supporting flexibility in content and geographic scope. Maps produced using ArcInfo and other products of the Environmental Systems Research Institute (now known as Esri) had a distinctive look epitomized by line symbols in the key that resembled an italic letter *N*. No less distinctive was MapQuest.com, which introduced millions of do-it-yourself online mapmakers to the interactive, zoom-in / zoom-out graphic scale.

The growing ascendancy of digital technologies hastened the standardization of the data structures and the adoption of exchange formats required for efficient communication among data providers, software developers, and mapmakers. Stylistic homogeneity increased when new organizations emerged to promote data sharing both internationally and within governments. By century's end online mapping applications with a rich toolbox of standardized symbols and layers promised unprecedented customization in content and relevance.

My sixth key theme is *Maps as Tools of Public Administration*. Although maps were used in urban governance during the nineteenth century, they assumed greater importance during the twentieth century in local and national public administration, regional planning, and the representation of national identity. Key roles at the municipal level include land-use planning and code enforcement;

Figure 6. *Excerpt from New York City "Use District Map" (1916). Solid, dashed, and blank street symbols represent business, "unrestricted," and residential uses, respectively.*

emergency response; the delineation and publication of election district boundaries; the delivery of regionalized municipal services; the assessment, taxation, and sale of real property; the design, management, and promotion of public transit networks; the analysis and control of crime; the management of networked infrastructure for electronic communication, energy distribution, water supply, and sewage; and the delineation of historic districts established to preserve a city's architectural heritage. Effective municipal administration came to depend heavily on reliable large-scale maps. At regional and national levels, mapping activities evolved during the twentieth century to include map-intensive systems for monitoring weather and water quality, for predicting environmental disasters, and for planning and orchestrating evacuations.

The twentieth century themes presented here run counter to the practice of most map collections, where acquisition strategies range from the systematic ingestion of topographic series maps through a government document depository program to the more eclectic accumulation of older, rarer maps purchased from dealers or donated by wealthy supporters seeking a tax advantage. Without a concerted effort, neither strategy is likely to yield a representative sampling of media maps and facility maps related to the city or the region, a representative sampling fundamental to a twenty-first century map collection. Of course, scanning and electronic media can fill many gaps, particularly with the assistance of a map society or knowledgeable and energetic volunteers, who need not be local. And networked catalogs can be avoid needless duplication as well as give distant users access to a rich diversity of materials, assuming support is available to refresh the electronic storage as needed, to avoid the ravages of disk rot.

Interactive and dynamic maps pose the greatest challenge for progressive map collections, particularly if the chosen strategy requires the concurrent preservation of working software and hardware, easily undermined by ephemeral operating systems. A more reliable and less costly approach to conserving dynamic cartographic artifacts might be to record interactive map use sessions with a variety of users and to maintain these recordings with whatever technology proves effective in conserving the cultural heritage of film, television, and artistic performances in general. This strategy has the added advantage of focusing on map use rather than graphic or physical objects. A still broader approach, designed to focus on impact, not mere objects, might employ documentary films to acknowledge the growing awareness among scholars of the map's value as an instrument of persuasion, empowerment, and resistance.

MAP CITATIONS

Figure 1. *Present Distribution of European Races*, plate iv accompanying Grant, M. 1916. "The Passing of the Great Race." *Geographical Review* 2: 354–60. doi: **10.2307/207903**.

Figure 2. NASA. 1988. Excerpt from color-infrared image, bands 4-3-2, captured in 1988 by Landsat 5. **http://www.nasa.gov/images/content/668535main_Garden_city_KS-1988.jpg**.

Figure 3 (top). Line-printer map from Monmonier, M. 1965. "The Production of Shaded Maps on the Digital Computer." *The Professional Geographer* 17(5): 13–14. doi: **10.1111/j.0033-0124.1965.013_r.x**.

Figure 3 (bottom). Pen-plotter map from Monmonier, M. 1968. "Computer Mapping with the Digital Increment Plotter." *The Professional Geographer* 20(6): 408–9. doi: **10.1111/j.0033-0124.1968.00408.x**.

Figure 4. Map of temporary flight restriction over Vice President Biden's home, Greenville/Wilmington, DE, first issued 27 January 2009, by the Federal Aviation Administration. **http://tfr.faa.gov/save_pages/detail_9_3124.html**.

Figure 5. US Geological Survey. 1912. Excerpt from "International Map of the World on the scale 1:1,000,000," Boston sheet. **http://ark.digitalcommonwealth.org/ark:/50959/x633f991m**.

Figure 6. City of New York, Board of Estimate and Appropriation. 1916?. Excerpt from "Use District Map Section No. 12." **http://digitalcollections.nypl.org/items/510d47e4-7681-a3d9-e040-e00a18064a99.**

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Mapping Temporal Datasets with D3

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INTRODUCTION

Many JavaScript libraries and APIs intended for mapping require long lines of code to perform even the simplest forms of animation. The Data-Driven Documents (D3) software library, however, offers a very simple option for quickly presenting a series of maps. D3's library contains various features that allow for geographic data to be bound to SVG objects in a webpage and presented chronologically. Animations can often be created with one short line of code.

ANIMATING WITH D3

D3 was developed primarily by Mike Bostock at Stanford University in 2011 with the intention of "bringing data to life." It offers a set of JavaScript functions for data visualization, which can be accessed by loading the *d3.js* library into an HTML document. These functions allow for the visualization of data sets by binding them to SVG objects and displaying them in a web browser. SVG is an XML-based format that allows for vector graphics to be grouped, styled, and transformed. After the data are tied to these objects, they may be animated using D3's *transition* method.

The *transition* method is a special type of selector. Selectors allow objects in a webpage to be selected and then manipulated. Objects may be selected based upon their properties, such as tags, classes, attributes, or unique identifiers. Once a selection is made, operators may then be applied. These operators may manipulate an object's attributes, styles, or text content. They may also join data to the selected objects. By itself, an ordinary selector applies the subsequent operations instantaneously. By using the *transition* method, instead, the changes will occur gradually over time as opposed to immediately. When multiple transitions are

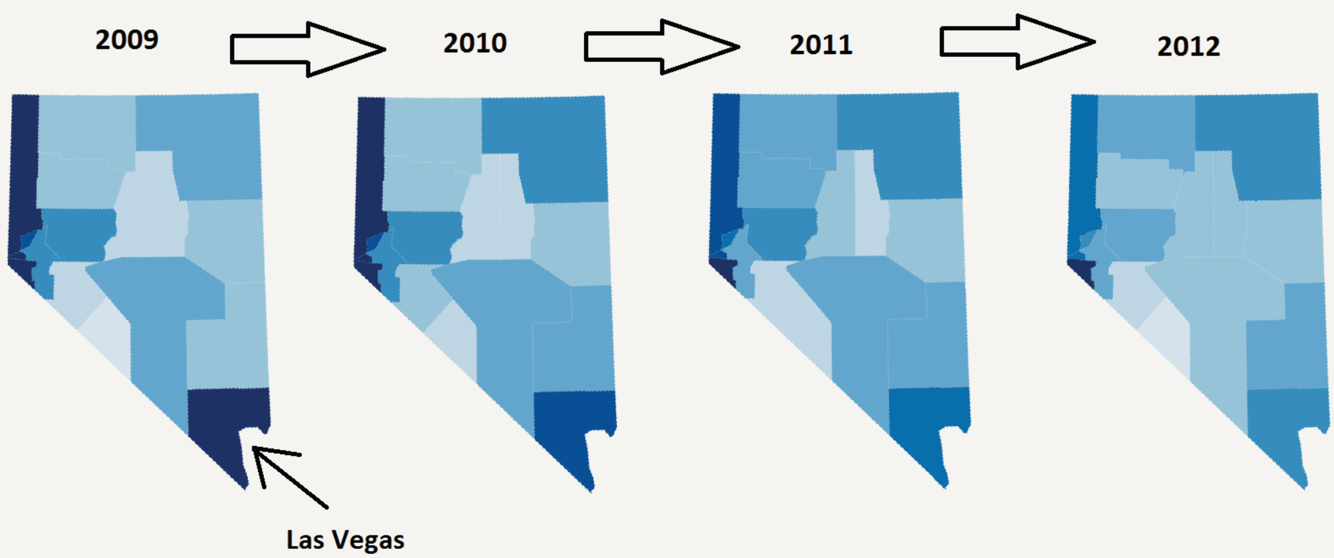


Figure 1. *Nevada median home values from 2009 to 2012.*

applied, the *delay* method may then be used to add separation between each transition. The *delay* constructor specifies, in milliseconds, how long the transition should wait to begin. By pairing each transition with a delay, the transformation may be specifically timed to string multiple maps together into a smooth animation (see Figure 1).

D3's user-friendly, minimalist approach allows for the easy borrowing of code. There are hundreds of examples of D3 maps on websites such as GitHub, and any example from the Web may be manipulated for use with another dataset with very little effort. Existing code examples demonstrate how to use D3 to take raw datasets and bind them to graphic elements for display in a browser (Figure 2). To add even more functionality, parts of various existing scripts can be combined.

D3 is very efficient, often requiring less code than other software libraries to accomplish the same task. The selection methods, for example, allow for elements of a webpage to be selected and manipulated either individually or all at once using a single line of code, whereas other libraries often require a *for* loop just to select an element and change one attribute. In addition to these efficiencies, D3 also offers options such as shape generators, scale constructors, and a variety of map projections.

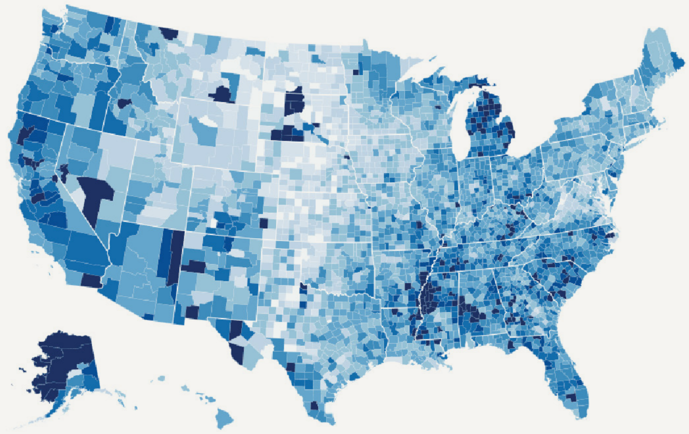


Figure 2. *Mike Bostock's choropleth map of US unemployment rates for 2008 demonstrates the binding of data to graphic elements using D3.*

DATA SOURCES

Data may be loaded into a webpage via D3 in multiple formats. D3 can accept GeoJSON and TopoJSON data, which store the coordinates of geographic features, and are variants on the JSON (JavaScript Object Notation) format, which uses simple text to pass attribute data in pairs. JSON files offer a simple way to organize and store data into variables and load them quickly in the background of a webpage. GeoJSON and TopoJSON can also include non-geographic attributes for each feature. Attribute data may also be stored separate from geographic data, in a comma-separated values (CSV) or tab-separated values (TSV) file. In Example 1, used to create Figure 2, a JSON file is loaded in which contains the outlines of US counties.

The United States Census Bureau's American FactFinder is a great resource for finding datasets with a temporal component, with thousands of different categories of statistical data at various levels of spatial resolution. Once downloaded, some manipulation is necessary for the data to be properly read by the specific code in Example 1: it is important to rename the FIPS code field to "id" and the statistic field title to "rate." The data can be saved as a tab-separated file using the extension ".tsv."

MAPPING AND ANIMATION

Once the data files are in the correct format, they may be bound to an SVG element and visualized using D3. SVG uses the *path* variable to bind it to the county geometry defined in the JSON file and draw the counties in a webpage. D3 then uses what it calls a *dictionary* to relate the unemployment values in the TSV file to their respective counties. After data classification using the *quantize* function, D3 uses inline CSS, a computer language used for manipulating the presentation of a webpage, to color each class (see Example 1). CSS offers many advantages to web design because it separates the content of a webpage from its styling.

The animation process begins by drawing the first map. After this is completed, the map may be redrawn multiple times and staggered with the delay function. This can be

```
//Creating choropleth map of U.S. unemployment rates

                                                        //Define fill colors for 9 possible classes
.q0-9 { fill:rgb(247,251,255); } .q1-9 { fill:rgb(222,235,247); } .q2-9 { fill:rgb(198,219,239); }
.q3-9 { fill:rgb(158,202,225); } .q4-9 { fill:rgb(107,174,214); } .q5-9 { fill:rgb(66,146,198); }
.q6-9 { fill:rgb(33,113,181); } .q7-9 { fill:rgb(8,81,156); } .q8-9 { fill:rgb(8,48,107); }
</style>
<body>
<script src="http://d3js.org/d3.v3.min.js"></script>    //Load D3 libraries
<script src="http://d3js.org/queue.v1.min.js"></script>
<script src="http://d3js.org/topojson.v1.min.js"></script>      //Imports external JavaScript file of
                                                                //reusable functions
<script>
  var width = 960, height = 600;                                        //Set size of map in pixels

  var rateById = d3.map();              //Create dictionary to relate counties in JSON to respective values in TSV

  var quantize = d3.scale.quantize()                    //Determine 9 possible classes
    .domain([0, .15])                                   //Set domain with maximum and minimum values of dataset
    .range(d3.range(9).map(function(i) { return "q" + i + "-9"; }));

  var projection = d3.geo.albersUsa()           //Set projection to Alber's Equal Area Conic
    .scale(1280)                                //Preserves area proportionally between two parallels
    .translate([width / 2, height / 2]);        //Ideal for large areas running east-west, such as U.S.

  var path = d3.geo.path()                      //Create path generator, for JSON geometries to be drawn
    .projection(projection);

  var svg = d3.select("body").append("svg")                     //Select body of DOM, append to SVG element
    .attr("width", width)
    .attr("height", height);

  queue()                                               //Load files, wait for ready function
    .defer(d3.json, "/mbostock/raw/4090846/us.json")
    .defer(d3.tsv, "unemployment.tsv", function(d) { rateById.set(d.id, +d.rate); })
    .await(ready);                                      //Populate dictionary with id and rate fields from TSV

  function ready(error, us) {                           //Call JSON file, bind to SVG
    svg.append("g")
    .attr("class", "counties")
    .selectAll("path")
    .data(topojson.feature(us, us.objects.counties).features)                   //Convert JSON to GeoJSON
    .enter().append("path")                                                     //Bind county data to path
    .attr("class", function(d) { return quantize(rateById.get(d.id)); })        //Determine each county's class
    .attr("d", path);                                                           //Draw counties

    svg.append("path")
    .datum(topojson.mesh(us, us.objects.states, function(a, b) { return a !== b; }))
    .attr("class", "states")                    //Mesh state boundaries to prevent duplicate paths for borders
    .attr("d", path); }                         //Draw states

  d3.select(self.frameElement).style("height", height + "px");
</script>
```

Example 1. *Code for Mike Bostock's U.S. unemployment map.*

done by creating an update function that includes some of the same code from Example 1, but with a different year's dataset (see Example 2). The *transition* method creates a pause between the drawings of the two maps. The standard transition time is 250 milliseconds. By using the *delay* method after each transition, that time can be lengthened, adjusting the speed of the animation.

The addition of the *transition* and *delay* components to each update create the animation. The data update function may be repeated for the number of time periods present in the time series. It is important to include the minimum and maximum values that would be appropriate for the entire series of datasets in the original *quantize* function, so that each set is classified in the same way. The delay time must also be incremented in equal intervals to form a consistent animation.

The animated map still needs to be paired with a dynamic title. To do this, the *span* HTML element can be used (see Example 3). *Span*, short for spanning, is similar to the *div* element, as both are used for organizing and styling particular pieces of a webpage. The *div*, or division, element is typically for larger areas of a webpage, and may be made up of many different spans. The *span* element is for smaller areas of text. Both allow for specific parts of an HTML page to be grouped together and easily referred to later in the document. By adding a span to the *h2* element,

```
//Creating update function

function updateData() {

  queue()
  .defer(d3.json, "us.js")
  .defer(d3.tsv, "unemployment2.tsv", function(d) { rateById.set(d.id, +d.rate); })
  .await(ready);                    //Update script with new dataset

function ready(error, us) {

  svg.append("g")
  .attr("class", "counties")
  .selectAll("path")
  .data(topojson.feature(us, us.objects.counties).features)
  .enter().append("path")
    .transition()                          //Create a brief pause between redrawing of map
    .delay(750)                            //Extend pause to 3/4 of a second, increase by
                                           //equal intervals each update

  .attr("class", function(d) { return quantize(rateById.get(d.id)); })
  .attr("d", path);

  svg.append("path")
  .datum(topojson.mesh(us, us.objects.states, function(a, b) { return a !== b; }))

  .attr("class", "states")
  .attr("d", path);

  updateData();                     //Add to each ready function preceding an update function

}
```

Example 2. *By creating an update function that includes a transition and delay constructor, the map may be continually redrawn using a new dataset.*

```
<h2>
    <span> </span> //Add to beginning of body
</h2>

d3.select("h2 span").text("U.S. Unemployment Rates 2010"); //Add to end of ready function
```

Example 3. *By adding a span to the h2 element, the space may be selected in each update function and a dynamic title may be inserted.*

which indicates header text, a new title may be inserted each time the update function is called. In order to create the same animated effect displayed by the map itself, the transition and delay parameters must be added to each title as well. By using the same delay timings from each update function, the titles stagger at the same intervals as their respective maps.

CONCLUSION

D3 NOT ONLY transforms raw datasets into static graphics, but also graphics with movement and interactivity. By using D3's animation capabilities, a sense of change over time may be conveyed. Applying a custom dataset to one of the many D3 map examples on the web is easy; an update function can then be assembled to reload the existing script with new data. The *transition* method is used to redraw the map after the update, and the *delay* operator adds timing to the animation to generate a smooth progression of graphics. The library is simple enough to use so that anyone with a basic understanding of HTML and JavaScript can easily turn almost any time series dataset into an animated map.

A sample animated map, based upon this article, can be viewed at **http://pjbutler.podserver.info/test.html**.

SUGGESTED RESOURCES

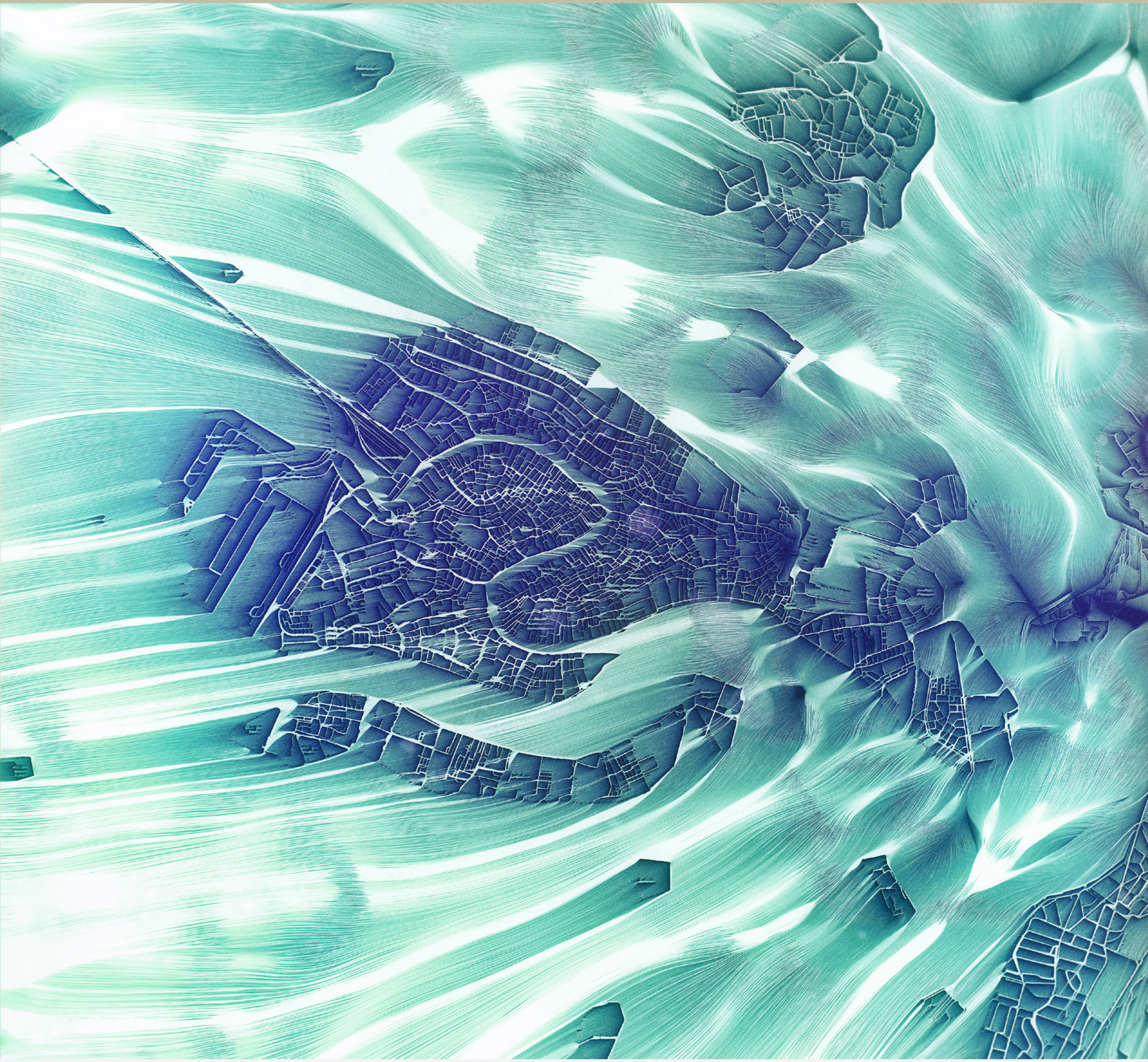
Bostock, Mike. 2012. "Choropleth." *Bl.ocks.org*. **http://bl.ocks.org/mbostock/4060606**.

Maps on D3 — Tutorial. 2013. *Social Innovation Simulation*. **http://socialinnovationsimulation.com/2013/07/11/tutorial-making-maps-on-d3**.

DOI: 10.14714/CP81.1316

Flowing City Maps

Istvan
Chaotic Atmospheres
istvan@chaoticatmospheres.com



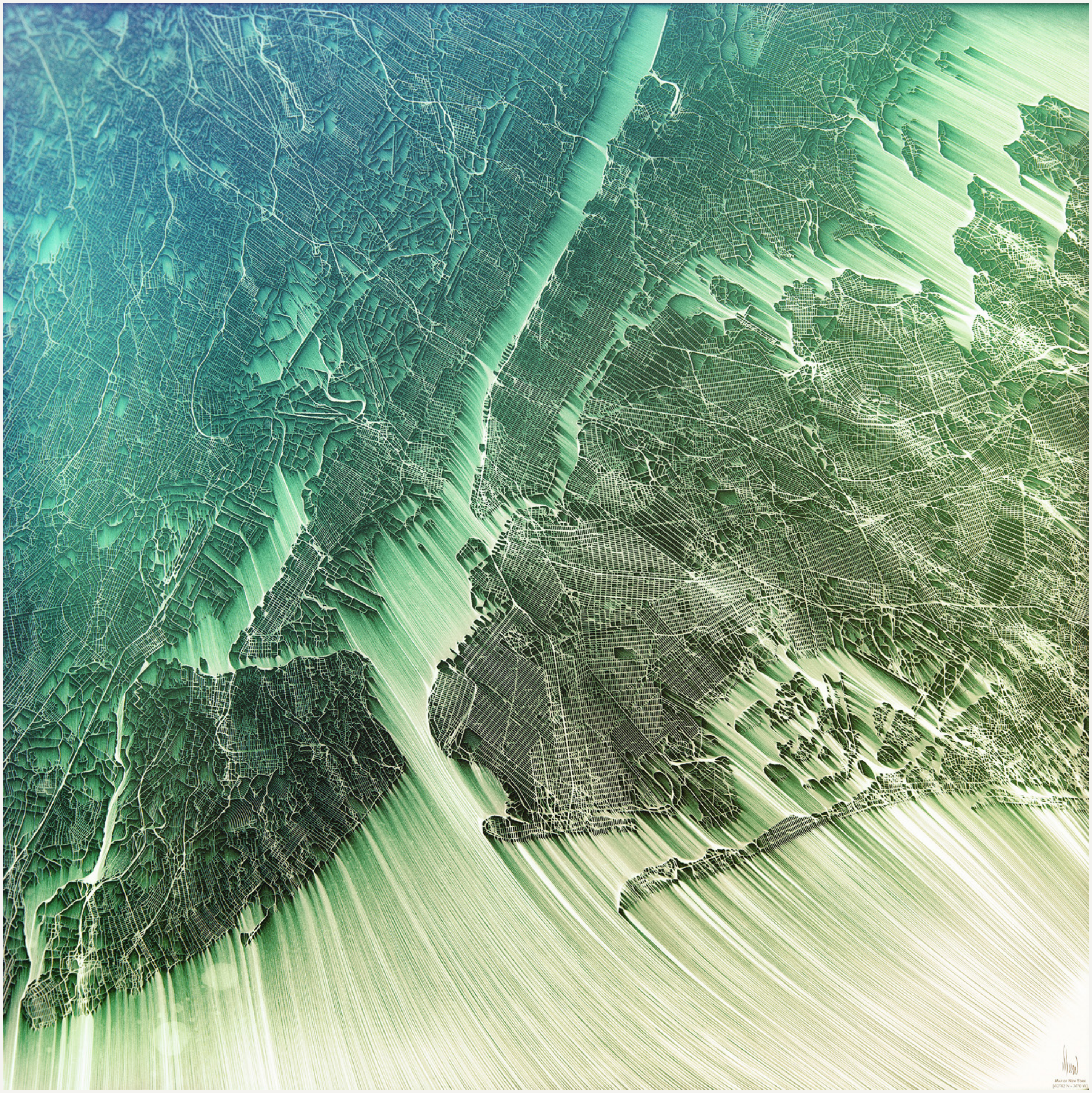
Venice

This series was made for an exhibition about cities, their environments, and the relation between them.

Human cities have spread all over the planet. They have colonized the wilds, stand proudly in the middle of deserts, cling to the cliffs, and spill over swamps to cover them; they extend and flow back, struggling to survive.

Although they seem immobile, they live and move like trees and mountains. Their time is not that of one person, it is that of the human species. They are witness to what we are, but also what we have been.

Cities resonate both the choices imposed on us as an animal species (proximity to water, climate, etc.) and the choices we have made as humans (their architecture, monuments, town planning, etc.). The accumulation of these

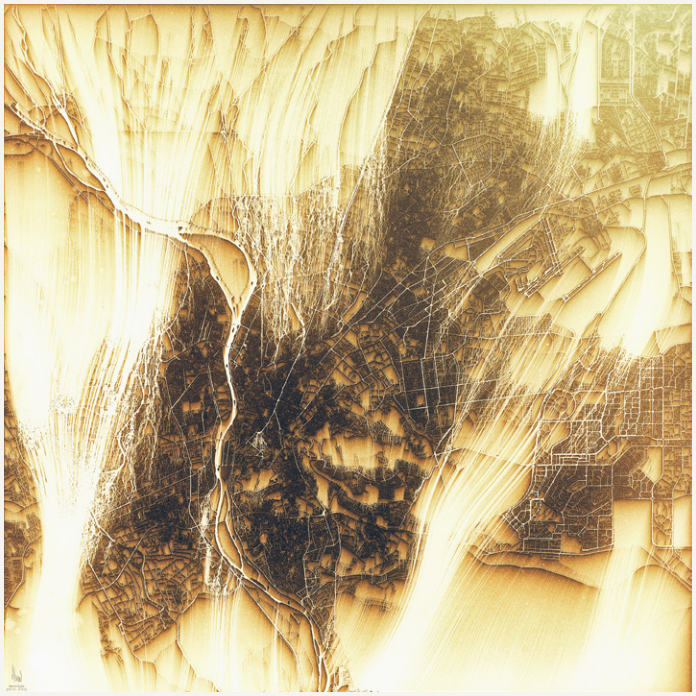


New York

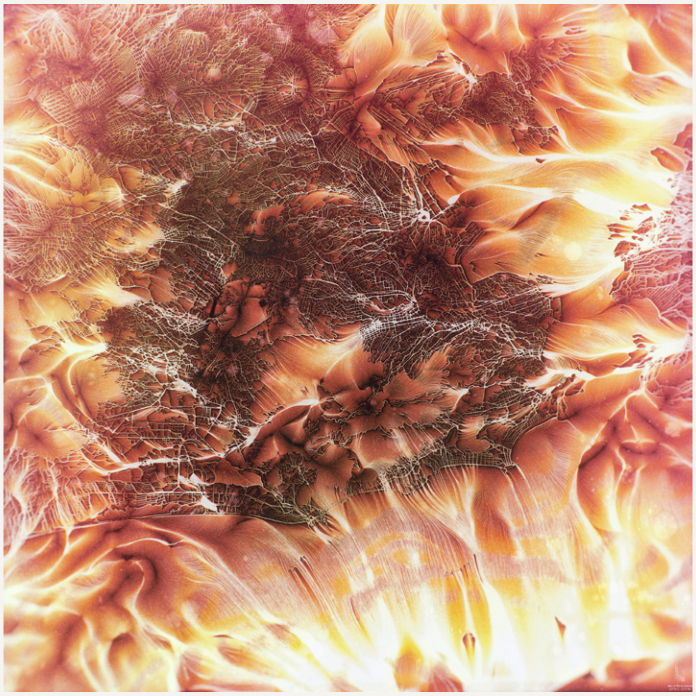
choices is felt every day by the inhabitants of a city. In turn, they grow up infused with this identity, just as ants absorbing the pheromones of an anthill.

The popularization of pictures of our Earth from space gives a new opportunity to understand the identity of cities as a whole. From far enough away, they reveal their history as their deep symbiosis with their environment. The concentric lines of Paris, like those of a tree trunk, reflect different periods of growth of the city; the streets of New York have structures similar to plant cells; Rio de Janeiro's buildings nestle along mountains like a river bed; however, although very different from each other, all human cities are recognizable as such in the relation they have with their environment. They therefore reflect both our cultural differences as human beings and our common identity as an animal species.

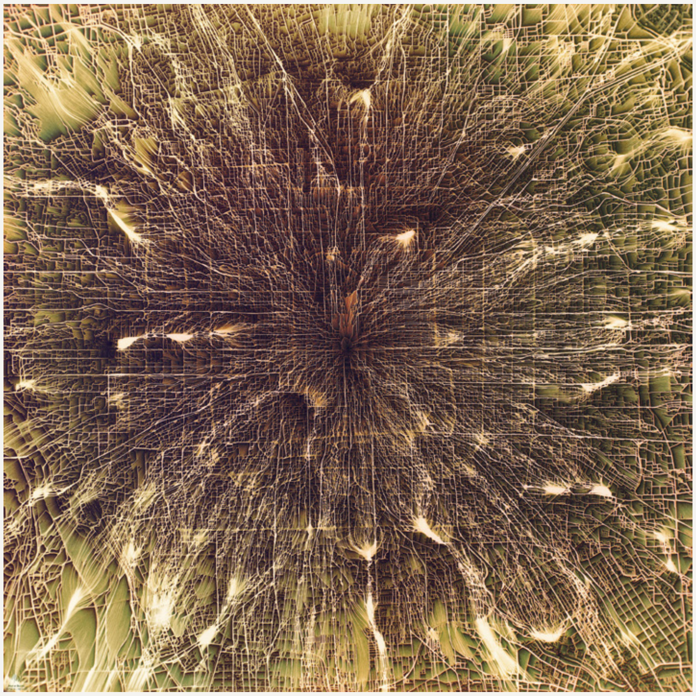
I wanted to represent this relation as a kind of invisible fluid that overflows from the city to its surrounding area.



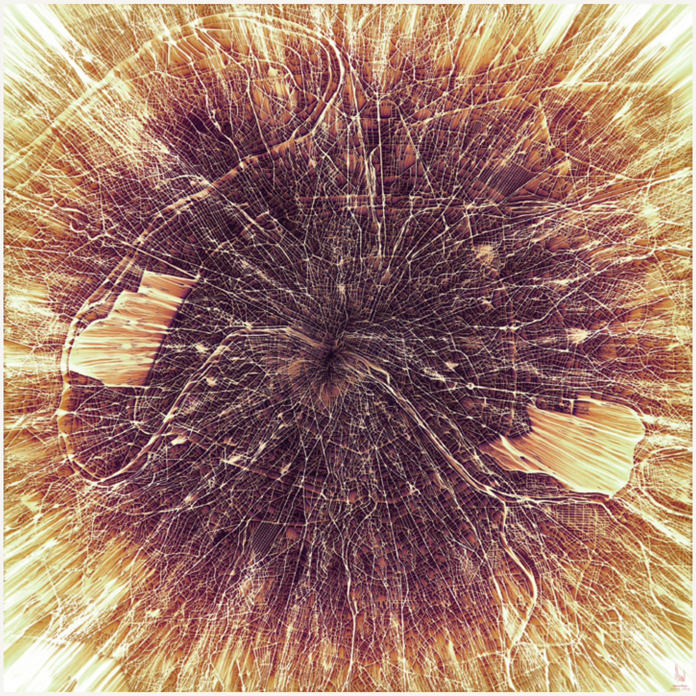
Cairo



Rio de Janeiro



Beijing



Paris

For that, I've retrieved city maps and used processing software that specializes in generating eroded 3D terrains for video games. This software can export pictures called "flow maps," usually made for texturing purposes inside a game editor because they follow precisely the elevation of the terrain.

But I didn't want this flow to follow the actual topology of the city and its surroundings. So I "mixed" the city map with a random noise that simulated an elevation map that the software interpreted like the true elevation map of the city. This way, I was able to change the original flow map to better meet my own vision of the relation each city has with its environment. I used these pictures as a basis for my final illustration and I added colors and effects in order to give to each city a unique identity.

I'm a digital artist who uses math and procedural functions to create series of pictures based on the repetition of a process.

I began my artistic education in the Fine Arts School of Geneva when I was seventeen. Then I moved to Paris to attend a school of fashion design. This gave me the opportunity to meet a lot of creative people. After my studies, I shared the next five years between Paris and Geneva, working as a freelance graphic designer for the friends that I'd met when I was student.

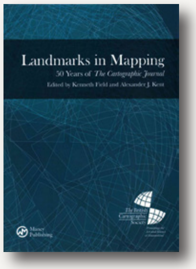
After these formative years, I decided that it was time to go back to what first brought me to Fine Arts: my will to "design pictures with computers." At this time, digital art was only a passion, but one in which I had already put a lot of work and personal feelings. So I started to work on my passion as if I was working for clients: thinking in terms of projects, following them until the end, not losing sight of the final message… Over the years, I developed my early experimentations until they evolved into true subjects of pictures.

The result of these experimentations is what you can find now on my portfolio: chaoticatmospheres.com.

Tokyo

Visual Fields focuses on the appreciation of cartographic aesthetics and design, featuring examples of inspirational, beautiful, and intriguing work. Suggestions of works that will help enhance the appreciation and understanding of the cartographic arts are welcomed, and should be directed to the section editor, Laura McCormick: laura@terracarta.com.

LANDMARKS IN MAPPING: 50 YEARS OF *THE CARTOGRAPHIC JOURNAL*



Edited by Kenneth Field and Alexander J. Kent.

Maney Publishing, 2014.

416 pages, maps, diagrams. $125.00, hardcover.

ISBN: 978-1-909662-38-4

Review by: Judith A. Tyner, California State University, Long Beach

In 1975, John Wolter referred to the "emerging discipline of cartography" that began after WWII (Wolter 1975). At that time, cartography was beginning to be viewed not as a mere tool for geographers, but a branch of knowledge in its own right. Whereas, in earlier days, the only cartography-related articles to be found in journals (or acceptable for thesis or dissertation subjects) concerned map projections or historical subjects, cartographers were beginning to analyze how maps work, and cartography textbooks discussed not just *how to*, but *why*. Arthur Robinson wrote the first dissertation on a cartographic subject, *Foundations of Cartographic Methodology*, which was published in 1952 as *The Look of Maps*.

Wolter also noted the post-war proliferation of organizations and journals devoted to cartography. The American Congress on Surveying and Mapping was founded in 1941 with a journal, *Surveying and Mapping*; the British Cartographic Society began in 1964 and launched *Cartography*, now *The Cartographic Journal*; The *Canadian Cartographer*, now *Cartographica*, was also founded in 1964. Articles in these journals dealt with automation, how maps communicate, symbolization, perception, and the like. Now, more than 50 years later, cartographers are looking back at the early days of the discipline; several books have been published that examine classic and groundbreaking articles in the field, including *The Map Reader*, which covers the field in general, *Classics in Cartography*, which looks at landmark articles in *Cartographica*, and this work, *Landmarks in Mapping*, celebrating the 50th anniversary of *The Cartographic Journal*.

Landmarks consists of a brief introduction that describes the history of the British Cartographic Society and its journal, plus the rationale for article selection. It is followed by sixteen articles regarded as landmarks in the field. The chosen articles are presented in chronological order, from the earliest from 1965 to the most recent at the time of writing, 2012. "Reflections" on the articles written by members of the Editorial Board follow each selection. The reflections do not all follow exactly the same structure, although each is about 2–3 pages, has a discussion of the article and explains why the reviewer considers it important. Each has a list of references. These reflections are interesting, in part, in that they reveal not just the trends of the field, but the current thinking in the cartographic community and what scholars and practitioners now consider relevant.

For the editors of this type of book, the biggest difficulty lies in which articles should be considered classic. The editors of *Landmarks in Mapping* state that their intention "is to bring a flavour of the quality and breadth of the Journal into one volume that spans its history" (4). Various models for inclusion of papers were tried based on different rationales, such as the number of citations, the number of downloads, and personal experience. A further attempt was to choose from winners of the Henry Johns Award of the BCS (first awarded in 1975), or papers that, while not necessarily considered landmarks in their time, were deemed critical to the development of the field or those that were deemed worthy by the members of the Editorial Board. The final selection was based largely on the opinions of the reviewers, who are all members of the Editorial Board: "…papers only made the final cut if, in light of the above criteria, the reviewer made a solid justification for its inclusion" (4).

Of course, each reader of the book will have their own idea of the appropriateness of the sixteen selections, but the articles range from Waldo Tobler's 1965 article "Automation in the Preparation of Thematic Mapping" to Damien Demaj and Kenneth Field's 2012 "Reasserting Design Relevance in Cartography." I will not comment on my preferences for inclusion or omission, save to note that there is a skewing toward papers published in the 21st century. For the 35 year period from 1965 to 2000, there are 8 papers, and 4 of those are from 1990; the 12 year period from 2001 to 2012 also has 8 papers, 3 from 2008 alone. Were there only 4 landmark articles in the 25 years from 1965 to 1990? I wonder if 35 years from now the 8 papers from 2003 to 2012 will still be considered landmark works.

Of course, with sixteen reviewers there will be variations, but I might note that, in some cases, the reviewers do not put themselves in the context of the time the article was written, and do not discuss its contemporary significance. Nor do we learn why it was considered important and worthy of publication in the *Journal* or why the three award-winning papers were given the Henry Johns Award.

The Cartographic Journal is credited as the first general-distribution journal of cartography to appear in English. This should be clarified. The American Congress on Surveying and Mapping was founded in 1941 and the Cartography Division was formed in 1950. As noted above, ACSM published *Surveying and Mapping*, which dealt with cartographic subjects as well as surveying; *The American Cartographer*, which was "purely" cartographic, was split off in 1975 and it is probably this date that the editors consider.

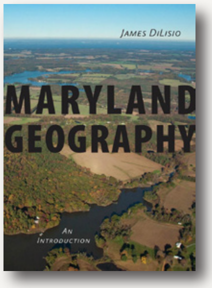
Two things I would have liked to see, but which probably were omitted due to editorial and publishing constraints, were brief biographies of the article authors and reviewers, and an index. For those new to the field, it would be helpful to know who the article authors were and their overall contributions to the field. As it is, the reader is not even told what the author's affiliation was. In some cases this is dealt with in the "Reflections," such as Kenneth Field's comments on Waldo Tobler's "Automation in the Preparation of Thematic Maps." The reviewers are simply listed by name and University or professional affiliation. Again, those who have been in the field for some time will probably know of these Editorial Board members, but for those new to the field or graduate students who may be using the book in a seminar, the information would be helpful. Likewise, an index would also have been useful. This is admittedly a large task, but would aid a reader who is looking for a particular topic or subtopic.

These small complaints aside, I definitely recommend this book. It is a valuable addition to the history of cartography in the past 50 years, giving, as the editors desired, the "flavor" of the period, and also serves as a starting point for researchers in cartography. It will be a much used resource for those in seminars of mapping sciences.

REFERENCE

Wolter, John. 1975. "The Emerging Discipline of Cartography." PhD diss., University of Minnesota.

MARYLAND GEOGRAPHY: AN INTRODUCTION



By James DiLisio.

Johns Hopkins University Press, 2014.

320 pages, 43 line drawings. $35.00, softcover.

ISBN: 978-1-4214-1482-9

Review by: James Saku, Frostburg State University

Professor James DiLisio is an accomplished academician and administrator at Towson University. During his 35-year teaching career, he has taught several geography courses, including Geography of Maryland. He published his first book on the state of Maryland in the 1980s. That book undoubtedly served the needs of students and professors of Maryland geography for several years. However, with socio-economic changes in the state over the past three decades, DiLisio recognized the need for updating and publishing a new textbook. This new book, *Maryland Geography: An Introduction*, is comprehensive and covers a variety of topics including physical, economic, political, and social geography. Overall, it offers an excellent understanding of the regional geographic landscape of Maryland.

The book is organized into three parts. The first part is entitled "Shaping the Landscape" and is comprised of four chapters. Chapter One focuses primarily on the history of Maryland. DiLisio presents a very detailed account of Maryland starting with the pre-European American Indian era, followed by the period of European colonization and agrarian development, the early urban industrial period, and the mid-industrial period. Like many other areas in the United States, Maryland was originally settled by Native Americans who maintained a nomadic lifestyle. After contact with Europeans, the economic lifestyle of Native Americans changed from nomadic to semi-nomadic and ultimately sedentary. Regionally, European colonization and settlement started in southern Maryland and proceeded progressively towards the central and western regions of the state. The second chapter examines the location and physical geographic regions of the state. Using the concept of absolute location, the author notes that Maryland is a very small state, characterized by an irregular shape. On the other hand, within the concept of relative location, Maryland exhibits substantial regional geographic diversity. DiLisio examines the relative location of Maryland within the contexts of Appalachia, the Northeast Megalopolis, and the Manufacturing Belt of the United States.

Chapter Three examines the physical geographic characteristics of the state. Those characteristics include climate, soils, geology, vegetation, and water resources. The author observes that different areas of the state are characterized by different climates: while Western Maryland is cold and experiences high annual average snowfall in the winter, the central and eastern areas are comparatively mild with less snowfall. The main factors affecting the climate of the state include its topography, water bodies, and urban built environment. The next chapter deals with the Chesapeake Bay, focusing on the environmental issues confronting it. Population growth, industrialization, and agriculture are factors that have contributed to the pollution and environmental destruction of the Bay.

Part Two of the book is titled "Old Economy, New Economy" and consists of four chapters. The opening chapter deals with agricultural activities in Maryland. From historic and regional perspectives, DiLisio provides an elaborate account of crop cultivation and livestock ranching in the state. Historically, farming in Maryland has changed over the years from an emphasis on tobacco cultivation in Southern Maryland, to food crops and animal husbandry. The decline in tobacco production is attributed to health concerns, state buyout of tobacco farms, urbanization, and competition from other states. Regionally, the Eastern Shore of Maryland dominates in the production of fresh fruits and vegetables, while the north central areas are known for raising farm animals and grain cultivation. There is limited farming in Western Maryland because of topography, climate, and lack of good agricultural soils. However, this area is involved in fruit cultivation and animal husbandry.

Chapter Six focuses on commercial fishing in Maryland, including crabbing, which the author identifies as the principal type of fishing in Maryland. While crabbing accounted for about 73.3% of the total catch in 2013, menhaden was a distant second with 11.8%. Though the second-leading resource of the Chesapeake Bay, oyster fishing has declined extensively over the past three decades. There was an 88% decline in oyster harvest between 1980 and 1990. DiLisio identifies numerous problems confronting commercial fishing, including decline in fish stocks, variable harvests, and competition from other states and abroad.

Chapter Seven examines mining from historical and contemporary perspectives. While iron ore, copper, and chromite were once mined in Maryland, presently coal and building materials are extracted in the state. While mining of building materials occurs in the Coastal Plain, Piedmont and Blue Ridge, Valley and Ridge, and Allegheny Plateau regions of Maryland, coal mining is limited to the two western counties of Allegany and Garrett. DiLisio notes a decline in coal mining in the state over the years.

As an important economic sector in Maryland, manufacturing activity is presented in next chapter., There have been tremendous changes since the mid-20th century because of technological advancement. Presently, the manufacturing sector in Maryland focuses on the production of defense electronics, fiber optics, and biological products. Despite a decline in employment within the manufacturing sector in Maryland, it still accounts for about 6 percent of the state's employment.

Part Three of the book is titled "Human Footprints on the Maryland Landscape." Chapter Nine focuses on the population geography of Maryland. The author notes that, between 2000 and 2011, Maryland's population grew at about 9.7%. Most of this growth is attributed to migration of minority populations into the state, bringing an increase in Maryland's racial diversity.

As an important economic sector of the state, the chapter on transportation focuses on the Port of Baltimore, air, road, and rail transportation, and communication. The author demonstrates how the evolution of transportation in Maryland is closely related to human settlement. Even though Maryland is a small state, it is characterized by a very integrated transportation network that serves the people of the state, businesses and institutions.

The last two chapters deal with political and urban geography of Maryland. Politically, Maryland is comprised of twenty-three counties and Baltimore City. Regionally, four counties are located in Western Maryland, eight in central Maryland, three in southern Maryland and nine in Eastern Shore. DiLisio notes that counties represent an important component of Maryland's political landscape because they are responsible for providing basic services such as education, fire, public works, and safety. Within the framework of political affiliation, Maryland is dominated by registered Democrats. However, there are noticeable regional differences in political affiliation and voting. While the people of the Eastern Shore and Western Maryland are mostly conservative and therefore vote Republican, the urban corridor comprises of a mix of Democratic and Republican registered voters. Residents of Baltimore City, Montgomery County, and Prince George's County are mostly registered Democrats. On the other hand, Frederick, the Baltimore suburbs, and Southern Maryland have a high Republican presence.

Chapter 12 focuses on urban geography. Overall, Maryland consists of few large metropolitan centers and many small towns. Baltimore is the largest metropolitan center with more than 600,000 people. DiLisio identifies three distinct urban patterns in Maryland: a dominant Baltimore-Washington DC corridor, smaller cities serving as regional centers, and several small towns and villages located in the rural areas. Furthermore, Maryland is home to two historically planned cities: Columbia and Greenbelt. While Greenbelt was originally planned and funded by the federal government for low-income families, Columbia was planned with private investment for middle income families.

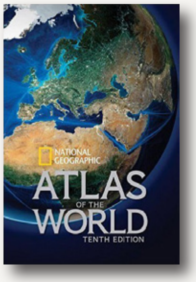
Maryland Geography: An Introduction is an outstanding and useful regional geography textbook for instructors and students. The book covers important physical, human, and economic issues confronting the state. It is written in a very simple language and without disciplinary jargon. As such, the book is easy to read and understand, and very enjoyable. DiLisio has structured the book well by including topics that appeal to a wide audience and multiple disciplines. Starting with an impressive historical analysis of the state, the book contains interdisciplinary topics and includes very useful illustrations from a variety of sources. Publishing it in softcover makes it relatively cheap for students to buy.

Notwithstanding these positive aspects of the book, there are a few issues. As it is a textbook, the author should have outlined the objectives and provided an overview of each chapter. This would allow students to identify the key issues covered in each chapter and relate to them. Secondly, while publishing the figures in black and white makes the book more affordable for students, the drawback is the difficulty of analyzing some of the figures. For example, it is fairly difficult to identify the various soil associations in Figure 3.4 and rocks and sediments in Figure 3.5.

Furthermore, a chapter on tourism could enhance the overall content of the book. Tourism is an important emerging economic sector in Maryland. It accounts for about $15 billion annual revenue and employs about 206,500 people. Regionally, there are different tourist and recreational facilities in Maryland. Western Maryland offers tourists an attractive physical geographic landscape, seasonal outdoor activities, historic sites, and state parks. Recreational activities in Southern Maryland include boating, fishing, historic sightseeing, and camping. For the Eastern Shore, wildlife spotting in the wetlands, the Chesapeake Bay, and Ocean City offer excellent recreational activities for tourists.

Additionally, there are numerous governmental and non-governmental websites that deal with Maryland which offer further reading and research opportunity. Pointing to these sites would provide additional sources for students seeking more information. Finally, there are instructional videos on Maryland that can be used to enhance teaching. Providing a list of these videos could be helpful. Overall, the book is an excellent regional overview of the Geography of Maryland. It is strongly recommended to anybody interested in knowing more about the state.

THE NATIONAL GEOGRAPHIC ATLAS OF THE WORLD (DELUXE 10TH EDITION)



The National Geographic Society, 2015.

448 pages, 145 plates, 300+ maps, 250+ graphs and charts, 75 color photographs. $195.00, hardcover.

ISBN: 978-1-4262-1355-7

Review by: Christine Newton Bush

The National Geographic Atlas of the World (Deluxe 10th Edition) is a large format (12.125" × 18.25") tome that includes a colorful hard shell slipcase with full color graphics and a collectible double-sided insert (41.5" × 29.75") featuring a map of "today's physical world" on one side and "the first world map published as a supplement to National Geographic magazine in 1922" on the other. The product as a whole weighs 10.6 pounds.

This atlas is organized similarly to its predecessor (9th edition, 2010), with four sections: World Themes (Plates 5–25); Maps (Plates 26–142) organized by continent, with additional sections for "The Poles," "Oceans," "Space," and "Nations"; a short Appendix (Plates 143–145) for "Geographic Comparisons," "Time Zones," and "Foreign Terms, Abbreviations, and Metric Conversion Tables"; and an extensive Index (pages 1–148). Each plate is a two-page spread.

The inside front and back covers feature a "Key To Atlas Maps" with related symbology that provides a way to quickly identify the plate you need. These are indicated by the outlines of overlapping map extents with page numbers indicated in the corner of each area (see Figure 1).

As with previous editions, much of the current research in this atlas is presented in the initial section of twenty World Themes. Each World Theme plate features a world map in a Winkel tripel projection displaying geospatial data corresponding to its theme. Each of these World Themes is introduced by several paragraphs of contextual prose followed by sub-sections that break the theme into specific areas of analysis. Colorful, modern infographics are liberally used to present findings or to provide keys to inset maps (see Figure 2). Fourteen of these themes focus on humans and our activities, which sets a strong anthropocentric tone for the *Atlas*.

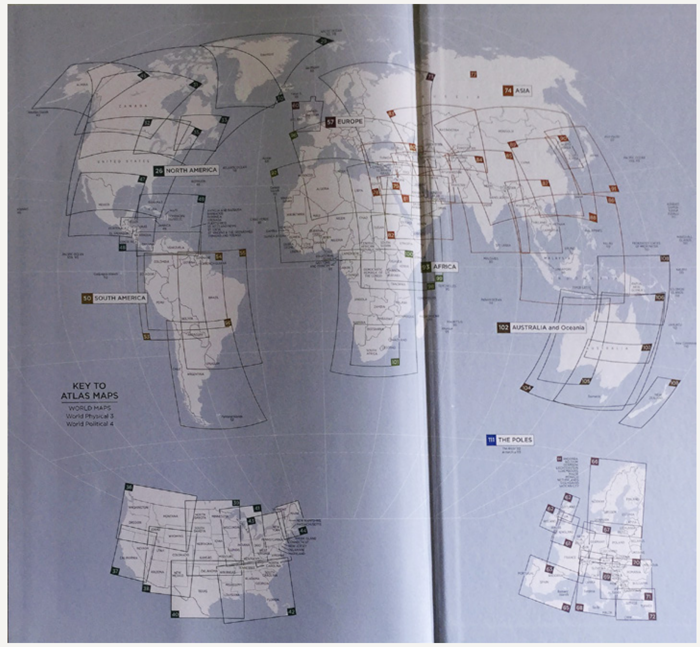


Figure 1. *Inside back cover showing the "Key to the Atlas Maps," which reveals the shape and extent of the maps found within—a map of the* Atlas *itself. Photo by C. Bush 2015, Creative Commons Attribution-ShareAlike 4.0 International License.*

The cartographic centerpiece of the *Atlas* is, of course, the collection of eighty-eight physical and political maps. They are cross-referenced in a place-name index which includes more than 15,000 entries, with separate lists for undersea, Moon, and Mars features. From the perspective of cartographic design, the maps of this atlas are outstanding and remind us that certain projections present different regions of the globe to best effect. For purposes of selecting a projection, this atlas is an authoritative reference.[1]

Following the Index of place names and a section for "Flags and Facts," the "Acknowledgments" deserve special attention by cartographers. Here you will find the data and online sources for key plates, including each of the World Themes. This information provides a wealth of contacts and resources for use in your own cartography, research, or teaching.[2]

As one might expect from a long-standing, influential institution such as the National Geographic Society, the

1. Absent a centralized listing of projections used in the *Atlas*, I have created one for ease of reference on my blog: **ngs.missingmaps.net**.

2. For a digital listing of these and other resources, see **ngs.missingmaps.net**.

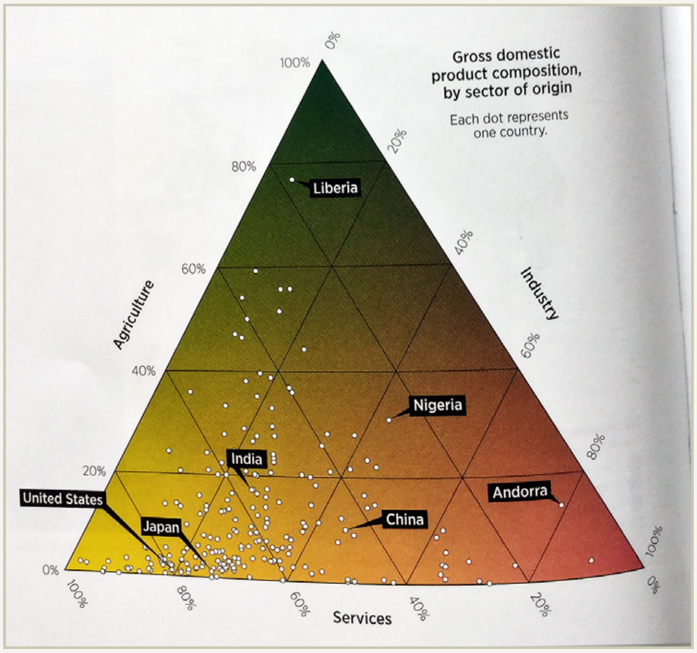


Figure 2. Detail of Plate 24—"Economy: Straining Financial Links" showing Gross Domestic Product composition by sector of origin. The Atlas *makes use of triangular scatter plots on several plates in the World Themes section. This one is less confusing than others and is based on data from* The World Factbook *by the CIA and from the Population Reference Bureau. Photo by C. Bush 2015, Creative Commons Attribution-ShareAlike 4.0 International License.*

objectives for this landmark volume are grand. National Geographic Fellow Paul Salopek, making the epic journey entailed by the Society's Out of Eden Walk project, penned the book's Foreword while following the trail blazed by our ancient ancestors. Salopek describes the *Atlas* as "a profound traveler's conversation" that "locates us not just in space, but also in our time. And like the best of map collections, its plates don't simply just display the shape of the world as it stands, but as it could be—with all its promise and peril." On Plate 2—"How to Use this Atlas"—the editors describe their work as "a useful reference tool," and that "this Atlas is also a guide for dreaming. Its lines, colors, and patterns evoke images of exotic places, of visits made, and trips anticipated."

A comprehensive analysis of a major reference work such as this is beyond the scope of this review[3], so I will focus my explorations on new or revised cartographic plates in the in hopes that a sampling may serve to represent the whole.

3. For an extended version of this review, see wp.me/pkZiT-6V.

WORLD THEMES

When comparing the "World Themes" research section of the 10th edition to its corresponding predecessor (the "Thematic World" research section of the 9th edition) one finds the editors have simply shuffled the deck a bit. Three of the plates were given new names, but focus on the same area of research: "Population Trends" morphed into "Human Influences"; "Impact of Cities" was changed to "City Dominance"; and "Communication" was updated to "Interconnectivity." Much of the content in these sections has been revised (or replaced) but there are no entirely new areas of research presented.

Plate 9—"Climate: Shifting Winds and Weather."

Sea ice in the Arctic is shrinking faster than models predicted, the result of a climatic feedback loop powered by the increase in absorbed solar radiation resulting from the loss of ice. Sea levels are rising, however, not only as a result of melting polar sea ice, but also from melting polar and glacial sheet ice releasing fresh water that was being stored on land into oceans. In the era of satellite measurement of sea-level change, we have witnessed an increase in sea level from just over 150mm in the mid 1990s to ~225mm in 2013.

Plate 11—"Biodiversity: Life, Protected and Otherwise."

Acknowledging that "scientists believe that Earth in the midst of its sixth extinction crisis, with thousands of species vanishing each year," this plate commences with a chart showing the growth of seven different types of "nationally designated protected areas." During the period from 1950 to 2010, the most dramatic growth is found in National Parks and Protected Areas with sustainable use. Cumulatively, all these different types of protections are adding up. Their combined area has more than doubled from roughly 6 million square kilometers in 1950 to over 15 million in 2010.

Plates 15, 16—"City Dominance: Cities Rule the World" and "City Characteristics: A Diverse Urban Landscape."

In 2008 humanity for the first time became "majority urban," with more of us living in cities than not. Plate 15 looks more closely at this milestone and explains that while the largest population centers, the "megacities" with 10 million or more residents, "seem to define our age" they are not representative of city life for most urban dwellers:

"Only a quarter of the urban population lives in cities with more than five million residents, and rapid growth is mostly found in cities of fewer than 500,000. More than half of all city dwellers—a quarter of humanity—call these smaller cities home."

Plate 16 states: "a fresh future is taking shape, with urban areas around the world becoming not just the dominant form of habitat for humankind, but also the engine rooms of human development as a whole." Given this historic shift in human habitation and multiple World Theme plates in this and the previous edition being presented on the significant role of cities, one wonders why this edition of the *Atlas* does not include any maps of megacities and major metropolitan areas.

NEW MAPS

Updated cartography in this edition includes new plates of Ireland, Scotland, England, Wales, and Australia as well as new maps covering the Mariana Trench, Africa, and the Mediterranean Basin.

Plate 61—"England and Wales (Cymru)."

This plate is new to this edition, but is quite similar to Plate 60—"British Isles" (presented at a scale of 1:1,932,000) while this new plate is displayed at a scale of 1:1,136,000. Both plates use a polyconic projection.

Plate 62—"Ireland (Éire)" on left side of plate, "Scotland" on right side of plate.

This plate is new to this edition and each of these maps is presented at a scale of 1:1,136,00 in a polyconic projection. It presents Scotland in its entirety including the Orkney Islands and Fair Isle to the north, and the Inner and Outer Hebrides to the west. The map also includes an inset of the Shetland Islands (Zetland) in the upper left.

Plate 96—"Mediterranean Region."

This new plate fills a gap found in the 9th edition and is grouped with the African maps. It presents the Mediterranean Sea, the Black Sea, Turkey, the Levant, and most of northern Africa in their entirety at a scale of 1:8,000,000 in an azimuthal equidistant projection. It also includes much of the Red Sea and portions of Saudi Arabia and Iraq to the east. This is a useful reference with regard to increasingly desperate migration attempts from northern Africa toward Europe.

Plate 98—"Northeastern Africa."

This plate has been updated to show the new country of South Sudan at a scale of 1:8,525,000. One can also see most of South Sudan at a larger scale on the next page, Plate 99—"Horn of Africa," where all but the westernmost part of the country is displayed at a scale of 1:5,750,000. Both plates use a transverse Mercator projection.

Plate 101—"South Africa."

This is new plate that shows South Africa, Lesotho, and Swaziland in their entirety with much of Namibia (including all of the Namib Desert) and Botswana to the north as well as portions of Zimbabwe and Mozambique. This plate is displayed at a scale larger than many other maps in the *Atlas*, 1:3,500,000 using a transverse Mercator projection. At this scale all of the region's primary towns and cities are well spaced and easily located.

Plate 103—"Physical Map of Australia."

This plate has been updated for presentation at a scale of 1:8,575,000 in an azimuthal equidistant projection with the improvement of showing Tasmania in situ rather than as an inset map. The 9th edition of the *Atlas* presented this plate at a scale 1:7,375,000.

Plate 104—"Australia."

This political map of Australia has no changes in scale from its counterpart in the 9th edition of the *Atlas*, but also now presents Tasmania in situ. It still features inset maps for Christmas Island and the Cocos (Keeling) Islands, but they now appear in the upper left of the plate instead of lower left with a corresponding change in placement for the plate's legend. This places the insets in more accurate relative positions to the northwest of the Australian continent, but leaves room for improvement in a future edition when perhaps the Atlas will also show them in correct relative position to one another. Christmas Island is west of the Cocos (Keeling) Islands, but the inset maps (as in the

9th edition) present Christmas Island on the left and the Cocos (Keeling) Islands on the right, reversed from their actual disposition to one another.

Plates 105–107—"West Australia," "Northeastern Australia," and "Southeastern Australia."

These plates are new to this edition and presented at a scale of 1:5,100,000 in an azimuthal equidistant projection.

"West Australia" displays all of Western Australia and portions of Northern Territory and South Australia. More details of various nature reserves, the western coast, and Melville Island are revealed.

"Northeastern Australia" presents Northern Territory and Queensland in their entirety and portions of Western Australia, South Australia and New South Wales. Also indicated are major coral formations of the troubled Great Barrier Reef Marine Park, and other major coral formations to the east and northeast of the park.

"Southeastern Australia" presents South Australia, New South Wales, Victoria, and Tasmania in their entirety as well as portions of Western Australia, Northern Territory and Queensland.

Plate 115—"Pacific Ocean Floor."

This plate's cartography has not changed dramatically, but its sidebar text has been updated from previous editions to include acknowledgment of James Cameron's historic solo descent into the 11-kilometer deep eastern depression of the Mariana Trench. On March 23, 2013, Cameron piloted the DEEPSEA CHALLENGER to a depth of 10,908 meters, just 4 meters shy of the 1960 descent by the U.S. Navy's Picard and Walsh. The latest measurements of the "Challenger Deep" indicate a depth of 10,920 meters, which places Cameron's descent to less than 100 feet from the seabed of Earth's deepest, darkest location.

CONCLUSION

The National Geographic Atlas of the World (Deluxe 10th Edition) remains a good value and meets very high expectations, but not without leaving room for improvement. Future printed editions should be printed on paper large enough to display an entire map at the desired scale, thereby eliminating page gutters. An example of this disruption can be found on Plate 62 which is actually a divided plate featuring "Ireland (Éire)" on left side of plate, and "Scotland" on right side of plate, but with the same plate number on both maps. A casual researcher (the likely market for this atlas) could easily misread this plate as a single map if they failed to notice the lines of latitude not running congruently across the gutter. The Index—if not the entire *Atlas*—could be made available as a fully searchable digital product. Covering every part of the world could be done more equitably, with less emphasis placed on the United States. Future editions should break through the self-imposed geographic scope and present maps of megacities and major metropolitan areas. The *Atlas* could also be improved by increased coverage of the whole biosphere by including more plates that focus on flora and fauna.

As I researched this atlas one of the main things I came to appreciate is that its long-term role is largely historical, not geographical. It is meaningful, for example, to look at the 1922 Map of the World (included as an insert with the deluxe edition of this *Atlas*) to find a large region in the Arctic labeled "Unexplored Region." This historical function also reveals one of the greatest weaknesses of the *Atlas*: it fails to effectively explain or illustrate within the context of individual editions what has changed since the previous one.

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Robinson, A. H., J. L. Morrison, P. C. Muehrcke, A. J. Kimerling, and S. C. Guptill. 1995. *Elements of Cartography, 6th Edition.* New York: John Wiley & Sons.

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

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

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

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