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ABOUT THE COVER: Kolonya, *by David Garcia, part of an in-progress project about a fictional Pacific aquapelago. You can see more of David's work at* mapmakerdavid.com.

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

LETTER FROM THE PRESIDENT

As it enters its 40th year of existence, I find myself thinking about my past involvement in NACIS. My first meeting was in 1999 in Williamsburg, Virginia—Tom Patterson had invited me to talk about international boundaries—but I didn't start coming regularly until the 2008 meeting in Missoula, Montana, where I was hooked by the relaxed, social format in which cartography was discussed and ideas were shared. I learned a lot about my craft, made friends, and broadened my professional outreach in a convivial and unpretentious environment. And my affection for NACIS has continued to grow along with the organization itself. We're truly a Society that puts an emphasis on interpersonal relationships, and this (among other good reasons) makes me honored to serve as your President.

In this year of pandemic the world—and our Society—has had to make unprecedented decisions and changes in our lives. I'm proud that, despite the challenges, the cartographic community remains engaged. A great example of this is the *How to Do Map Stuff* event, a series of 26 live mapping workshops on April 29th that drew hundreds of viewers thirsty to learn cartographic tips and tricks. I give thanks and congratulations to NACIS member Daniel P. Huffman, who conceived and organized it, and to the presenters who offered the great content, which you can access **here**.

Within NACIS, initiatives new and old are forging ahead. Keep an eye out for the T-shirt store opening on **nacis.org**, where you can buy carto-themed shirts designed by your peers—or design your own. The highly anticipated fifth edition of *Atlas of Design* is due out later this year. Director of Operations Nick Martinelli, Executive Director Tom Patterson, and I are updating our website to make it easier to find things and to add more useful content. Nominations for the Corlis Benefideo Award are open and I encourage you to acknowledge people who exemplify imaginative cartography. And of course, our journal *Cartographic Perspectives* continues to publish top-notch articles, reviews, and other content.

I'd like to thank the people who contributed to the **great meeting** we had in Tacoma, Washington last October. We broke our attendance record with 473 people registered, including 271 at Practical Cartography Day (PCD)—more than half the total! The event organizers had to scramble to accommodate these larger than expected numbers, and we apologize to those attendees who had to stand in the back. So, big kudos to program co-chair Mamata Akella and leaders Elaine Guidero and Ross Thorn for organizing and executing PCD, and to all the presenters who made it such a success. And thanks to those who organize the social events: our Tacoma local coordinators Jim Thatcher and Gordon

Kennedy; Dennis McClendon, the host of Geodweeb Geopardy!; Claire Trainor for the Fun Run/Walk; and the coordinators for the popular Lunch Bunch. To all the volunteers who stepped up to make things run smoothly—session moderators, Map Gallery facilitators, registration desk workers and many others—you help make NACIS the vibrant, relevant and fun organization that it is.

Both at our meeting in Tacoma and in the responses to our post-meeting survey (thanks to all who filled that out!) we heard from our growing and diverse members about their concerns and recommendations, and your Board of Directors is working to address them. In particular, the newly formed Diversity and Inclusion Subcommittee, under the Communications and Outreach Committee headed by Rosemary Wardley, has made progress on several fronts: (1) drafting a Diversity and Inclusion Statement to complement our existing **Code of Conduct**; (2) reserving 20% of our travel grants for minority and underserved applicants; (3) expanding the role of the New Attendee Ambassador to better welcome and integrate first-time attendees. Your Board is also checking out potential future meeting sites in locations outside the United States, and sending notice that conference presentations in languages other than English will be welcome.

On May 29th, the NACIS Board voted to change our 2020 Annual Meeting from an in-person meeting to a virtual event. This decision was made to protect the health of our attendees and in acknowledgement of the difficulties of travel during the COVID-19 pandemic. The Annual Meeting organizers, led by Mamata Akella and Pat Kennelly, are stepping up to the challenges of this new operating environment and are very excited about the possibilities it affords. So, while I'm disappointed I won't be seeing many of you in person this fall, I encourage you to participate in what is sure to be a historic and dynamic Annual Meeting. Consult our website for **Annual Meeting** updates.

By unhappy coincidence, the Board's decision to go to a virtual meeting happened during protests over the tragic and brutal death of George Floyd in Minneapolis, the city in which we were to hold our meeting this year. In lieu of our physical presence there, NACIS has made donations to two organizations dedicated to supporting minority-owned businesses in Minnesota's Twin Cities impacted by both the pandemic and the protests.

Lastly, I want to thank once again all the volunteers who form the heart and soul of NACIS, and especially our Business Manager Susan Peschel, who has poured so much effort into making things run smoothly. And I encourage all of you to consider ways of contributing your time and talent to our Society; check out the website for ways you can do that.

Happy 40th birthday, NACIS!

Sincerely,

Leo Dillon
NACIS President

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PEER-REVIEWED ARTICLE

Exploratory Bivariate and Multivariate Geovisualizations of a Social Vulnerability Index

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In the United States, the Centers for Disease Control and Prevention (CDC) is the national agency that conducts and supports public health research and practice. Among the CDC's many achievements is the development of a social vulnerability index (SVI) to aid planners and emergency responders when identifying vulnerable segments of the population, especially during natural hazard events. The index includes an overall social vulnerability ranking as well as four individual themes: socioeconomic, household composition & disability, ethnicity & language, and housing & transportation. This makes the SVI dataset multivariate, but it is typically viewed via maps that show one theme at a time. This paper explores a suite of cartographic techniques that can represent the SVI beyond the univariate view. Specifically, we recommend three techniques: (1) bivariate mapping to illustrate overall vulnerability and population density, (2) multivariate mapping using cartographic glyphs to disaggregate levels of the four vulnerability themes, and (3) visual analytics using Euler diagrams to depict overlap between the vulnerability themes. The CDC's SVI, and by extension, vulnerability indices in other countries, can be viewed in a variety of cartographic forms that illustrate the location of vulnerable groups of society. Viewing data from various perspectives can facilitate the understanding and analysis of the growing amount and complexity of data.

KEYWORDS: social vulnerability; multivariate mapping; glyphs; Euler diagrams

INTRODUCTION

The motivation for this project was a request from the Sustainability Institute at Florida Agricultural and Mechanical University (FAMU) to locate vulnerable populations within the Florida panhandle. The Sustainability Institute planned to work with pockets of vulnerable populations to strengthen their capacity to anticipate and respond to weather-related hazards. While previous efforts at disaster planning preparedness had been top-down and county-centered, the Institute wanted to identify specific populations of vulnerable residents to select pilot communities for a project to strengthen capacity at the neighborhood scale. At the project's onset, the Institute used social vulnerability index (SVI) data from the Centers for Disease Control and Prevention (CDC) to identify vulnerable populations, but found the volume of data difficult to interpret. They requested custom maps to aid in the visualization of locations of vulnerable residents, leading to the project we describe in this paper.

Social vulnerability can be broadly defined as the risk and potential loss to society as a result of both naturally occurring and human-induced disasters (Cutter 1996). In the United States, the CDC describes social vulnerability as referring to "the resilience of communities when confronted by external stresses on human health" (CDC 2018). When a disaster strikes, socially vulnerable people are more likely to be adversely affected, require more time to recover, and are at a greater risk of injury and death

(Wright et al. 1979; Cutter, Boruff, and Shirley 2003; Peacock et al. 2008). Social vulnerability can be effectively addressed by providing public services in a timely manner to reduce human suffering and to minimize economic losses (Flanagan et al. 2011). Information on social vulnerability can aid in resource planning and social equity decisions and, when used in conjunction with other data, can highlight transportation, housing, recreation, educational, nutritional, medical, and other needs.

The CDC has compiled social vulnerability data using information from the 2012–2016 American Community Survey (ACS). Their SVI is freely available to the public in a digital format, which makes for easy input into a GIS. Typically these data are utilized for univariate mapping, where each vulnerability theme is represented by a single map. However, maps illustrating two or more variables can be employed to convey more complex relationships. The SVI data are multivariate in nature and as such are amenable to the use of more complex geovisualization techniques to illustrate patterns of social vulnerability.

Our objectives in this project were threefold. One, to demonstrate how bivariate maps can combine SVI with population density in order to allow readers to distinguish between urban and rural areas. Two, to employ multivariate maps when illustrating multiple types of vulnerability simultaneously, using graduated glyphs. And three, to show how Euler diagrams can reveal overlaps between the four themes of vulnerability. These three geovisualization methods provide a broader perspective on data interrelationships and can identify pockets of specific vulnerability types.

While mapping more than one variable simultaneously allows the representation of composite trends and relationships, this complexity can come at the cost of visual clutter. To address this, we employ multivariate symbols called *glyphs* to help us fulfill our second objective. Glyphs are commonly used to simultaneously represent several pieces of data for the same location, using one or more visual marks and visual variables. For example, the height of a rectangular symbol might represent one variable, its width another, and its color a third (Ward 2008). One of the better-known types of glyphs is the Chernoff face, where facial features such as nose length or eyebrow orientation indicate data values (Chernoff 1973).

This challenge of making non-spatial multivariate information readable using visual analytics was our third objective. Univariate maps often use analytics such as bar charts to complement the map and further explain spatial data. Much of the data we work with is multivariate, originating from matrices, spreadsheets, sensors, and mathematical computations (Ward 2002). The larger the number of variables, the more difficult it becomes to detect, classify, or measure features and relationships. To work through these difficulties, we explore a more complex visual analytics technique, the Euler diagram, which complements the simple methods for spatial and temporal representation of data that are typically available through GIS.

SOCIAL VULNERABILITY

In 2018, the Federal Emergency Management Agency (FEMA) reported 124 major disasters in the United States, far more than the 16 reported in 1988 (FEMA, n.d.). Some have linked this increase with climate change, as extreme weather events become more frequent and intense (Haines et al. 2006; Wolkin et al. 2015). Research by the National Center for Environmental Health and the CDC has indicated that emergencies stemming from storms would be handled more effectively if accurate information on vulnerable populations were available. Of particular importance is defining which vulnerable groups are at risk, where they live and work, and the fastest ways to communicate with them (CDC 2015).

The risk posed by some environmental threats, such as tornadoes, hurricanes, and floods, is a function of their frequency and of societal exposure, determined by an assessment of the number of people and properties located along storm tracks or floodplains. Vulnerability to these threats is also linked with socio-economic indicators, such as the area's proportion of non-English speakers, households earning incomes below the poverty line, and mobile homes, as well as its property values. Indeed, the likelihood of a fatality is 20 times greater for mobile homes than for fixed structures (Brooks and Doswell 2001). While the elderly population of coastal Sarasota County, Florida, faces a considerable threat to property from hurricanes, their overall risk is low because they tend to be affluent retirees, and are therefore less socially vulnerable. In contrast, elderly populations living further inland in Florida may face fewer environmental threats but tend to be more economically vulnerable (Wang and Yarnal 2012).

Understanding where socially vulnerable populations exist, via SVI data, can help with allocating resources more effectively during the four phases of the disaster cycle: preparedness, mitigation, response, and recovery. For example, mitigation planning requires that officials identify socially vulnerable populations in order to provide increased assistance during a disaster. Effective mitigation decreases human and economic losses by providing social services after a disaster (Flanagan et al. 2011). SVI data can be used to help estimate the volume of supplies needed to sustain victims, the number of emergency personnel needed, the areas where emergency shelters are to be located, and the communities that will need continued post-disaster support. It can also be used to plan evacuation strategies, particularly for people with special needs (CDC 2018).

There are many vulnerability indices, each developed for various purposes using different types of data. For example, Cutter, Boruff, and Shirley's (2003) social vulnerability index (SoVI®), which was originally designed at the county level, is used to quantify old-age social vulnerability, as well as environmental hazards (Tarling 2017). In contrast, the CDC developed its SVI as a public tool to identify populations requiring more resources, for improving the effectiveness of disaster preparedness (Flanagan et al. 2011). Both indices are publicly available and can be used with basic GIS tools. We chose to work with the CDC's SVI data, although our methods would work with any index with a limited number of dimensions (in this case fewer or equal to 4).

The CDC's SVI consists of 15 variables, extracted from the 2012–2016 ACS organized into four themes: socioeconomic status (4 variables), household composition & disability (4 variables), ethnicity status & language (2 variables), and housing & transportation (5 variables). Variable descriptions are listed in Table 1. The 15 census variables are grouped into four themes. Each census tract receives a ranking for each of the four themes and an overall ranking

Census Variable	Description (all variables are estimates)
Socioeconomic Status	
Below poverty	Persons below the poverty line
Unemployment	Civilian (age 16+) unemployed
Income	Per capita income
No high school diploma	Persons (age 25+) with no high school diploma
Household Composition & Disability	
Aged 65 or older	Persons aged 65 or older
Aged 17 or younger	Persons aged 17 and younger
Older than Age 5 with disability	Civilian noninstitutionalized population with a disability
Single-parent households	Single-parent households with children under 18
Ethnicity Status & Language	
Minority	All persons except white, non-Hispanic
Speaks English "less than well"	Persons (age 5+) who speak English "less than well" (i.e., "not well" or "not at all")
Housing & Transportation	
Multi-unit structures	Housing in structures with 10 or more units
Mobile homes	Mobile homes
Crowding	At household level (occupied housing units), more people than rooms
No vehicle	Households with no vehicle available
Group quarters	Persons in institutionalized group quarters

Table 1. *The census variables and themes of the CDC SVI.*

from highest to lowest in terms of their applicability for measuring vulnerability.

Socioeconomic status includes income, employment, poverty, and education variables. The poor are less likely to have the income or assets needed to prepare for or recover from a disaster (Morrow 2002). They may potentially lack homeowner's or renter's insurance, thus making property replacement more expensive (Tierney 2006). Unemployed persons may lack health or life insurance (Brodie et al. 2006). Those with higher education are more likely to access and heed information related to disaster preparation and recovery (Tierney 2006).

The **household composition and disability** theme considers the population of those who are at an at-risk age (under 18 or over 65), are single parents, or have a disability. Children often cannot protect themselves in a disaster, and elders living alone or with physical or cognitive challenges are also more vulnerable (Morrow 2002). Single-parent families have more risk, as the caretaker responsibilities cannot be shared between two parents (Flanagan et al. 2011).

The **ethnicity and language** theme considers race, ethnicity, and English-language proficiency. Social and economic marginalization, including real estate discrimination, has left certain populations more vulnerable in all stages of a disaster. Lack of English proficiency can hinder disaster-preparedness communication (Morrow 2002).

The **housing and transportation theme** includes housing structure, crowding, and access to vehicles. Housing is tied to personal wealth, and lower-income persons are more likely to live in poorly constructed homes (Tierney 2006). Mobile homes are not designed to withstand severe weather or flooding, and are frequently located away from interstate highways or public transportation (Flanagan et al. 2011). In more densely populated areas, multi-unit housing poses risks for tenants as emergency exits and stairwells can become overcrowded, and large numbers of people exiting buildings into the streets can complicate safe and orderly evacuation plans (Cutter, Boruff, and Shirley 2003; Tierney 2006). Automobile ownership is lower in urban and less wealthy areas, causing difficulties with evacuation plans (Morrow 1997). Meanwhile, those who do own vehicles can face severe traffic congestion (Flanagan et al. 2011). Persons residing in group quarters (college dormitories, prisons, and nursing homes) face evacuation challenges due to facility understaffing during emergencies and the need for specialized vehicles (Flanagan et al. 2011).

To construct the SVI data, every census tract with non-zero population is ranked, from highest to lowest vulnerability, according to each of the 15 variables. For example, each census tract in a state (or in the United States, if a national assessment is being conducted) is ranked according to its per capita income. For each variable, the tract is then assigned a percentile rank, reflecting the proportion of tracts that its particular score is greater than or equal to. For example, a census tract receiving a percentile ranking of 0.237 (or 23.7%) is more vulnerable than 23.7% of census tracts with regard to that particular census variable.

Next, the percentile ranks for every variable in a theme are summed together for each tract. The tracts are then ranked according to those sums, and given new percentile ranks reflecting their vulnerability according to the theme. Finally, the overall index is calculated by summing the percentile ranks for each of the 15 variables, and then ranking those sums. Each of the five summary datasets (the percentile ranks for the four themes and the overall index) is then classified into quartiles (Flanagan et al. 2011; Flanagan et al. 2018). The CDC's SVI data are provided in three formats: an online viewer on the CDC website, downloadable GIS data at the census tract scale, and premade county maps in PDF format.

There are limitations to this method of calculation. Ranking census tracts according to their vulnerability achieves a sequential order but does not account for the size of gaps in data values. As a result, there is no distinction between large or small data gaps. The four vulnerability themes are calculated from different numbers of census variables, meaning each of those variables has a different level of influence on the outcome. The two variables of the Ethnicity Status & Language theme, for example, each carry more weight than the five of the Housing & Transportation theme. Finally, the quartile classification system cannot adequately distinguish between data values close to the breakpoints. Consequently, data values of .249 and .25 will be placed in two different classes.

MULTIVARIATE REPRESENTATION

One of our objectives was to represent vulnerability data using multivariate methods. To do this, we employed multidimensional glyphs to convey several datasets simultaneously. Typical attributes of glyphs include shape, size, orientation, position, direction, and magnitude, as well as color, texture, and transparency (Ward 2002). Color and size are more dominant than other attributes and can help direct the user's attention (Borgo et al. 2013). Glyph placement within the represented geographic area is important, as glyphs should not overlap (Ward 2002; McNabb and Laramee 2019). Glyphs, as compared to other symbols, allow patterns involving two or three data dimensions to be visualized clearly, as long as they fall within the capabilities of human visual perception. However, glyphs are constrained by the number of data records that can be visualized, as large data sets may require small glyphs in order to fit them all on the page or screen, which will make pattern recognition more difficult (Ward 2008; Fuchs et al. 2017).

VISUAL ANALYTICS AND EULER DIAGRAMS

Most of the data we work with are multivariate, whether they originate from matrices, spreadsheets, sensors, or mathematical computations. The larger the number of variables, the more difficult it becomes to detect, classify, or measure features and relationships. Meeting this challenge of making non-spatial multivariate information more accessible and understandable was our third objective.

Geovisualization relies upon the human perceptual system to guide analysis. Ward's (2002) mantra "I'll know it when I see it" reflects the idea that we often do not know what we are looking for when presented with a large data set (Shneiderman 1996). Geovisualization techniques facilitate exploratory data analysis, including the identification of visual trends, which may lead to explanatory data analysis if trends are confirmed with statistical relationships (Ward 2002). To aid in geovisual exploration, GIS has incorporated visual analytics as a complement to the simple spatial and temporal representation of data. Common visual analytics such as pie and bar charts are often used to provide a quantitative overview of the data to complement the spatial distributions shown on maps. Some other examples of visual analytics include the analysis of tweets (Andrienko et al. 2013), box plots (Willmott, Robeson, and Matsuura 2013), and custom isolines (Collins, Penn, and Carpendale 2009). Many of these analytics work well for univariate data but cannot show relationships between two or more types of data. Visual analytics using bivariate or multivariate data have been used in GIS, such as Sankey charts to visualize the relationships between land use and land cover (Strode et al. 2019) and Euler diagrams (Lemon and Pratt 1997).

The visual analytic concept of *set membership* is of key interest to us in our project. We can group data items into sets based on their specific properties and, since members can belong to more than one set, sets can potentially overlap (Alsallakh et al. 2013). Three relationships between sets are possible: containment (one set falls entirely within another), exclusion (sets have no members in common), and intersection (sets have some members in common). Organizing information into sets lets us ask questions about the relationships between members. For example, by sorting persons into sets representing their club membership, we may ask whether certain clubs are exclusive of each other; by sorting products into sets based on their features, we may ask whether a product feature is always in combination with another product feature (Alsallakh et al. 2013).

The Euler diagram is a traditional, and easily understood, method for visualizing set membership. It is a variation of the Venn diagram. While the Venn diagram maintains its size and shape regardless of data quantity, the Euler diagram is more fluid, adjusting the size and shape of the graphic to match data quantities. Euler diagrams quantify areas of overlap using proportional boundaries, with empty data overlaps removed to give a more intuitive understanding of multiple data relationships. Euler diagrams are the most common representation of set-type data, but are limited in the number of sets they can represent (Alsallakh et al. 2013).

In this study, we were interested in using Euler diagrams to model set membership in order to see the relationships between the four vulnerability themes. Do certain vulnerability themes always occur together? Is one theme excluded from the others? Geospatial representation of the four vulnerability themes reveals their spatial locations but cannot reveal the relationships between them.

METHODOLOGY AND RESULTS

We began to explore the CDC SVI data by making basic maps of our study area. Figure 1 shows the CDC's overall SVI ranking for each census tract in Alabama, Georgia, and Florida, while Figure 2 shows each of the four SVI themes separately for the city of Tallahassee, Florida. Univariate maps like these are the typical way that the CDC currently represents the SVI. However, they do not account for population density, which is key to identifying concentrated groups of vulnerable populations. Two areas of equal vulnerability and equal size could have varying population densities; in a disaster, too many or—more importantly—too few emergency responders may be directed to risk areas.

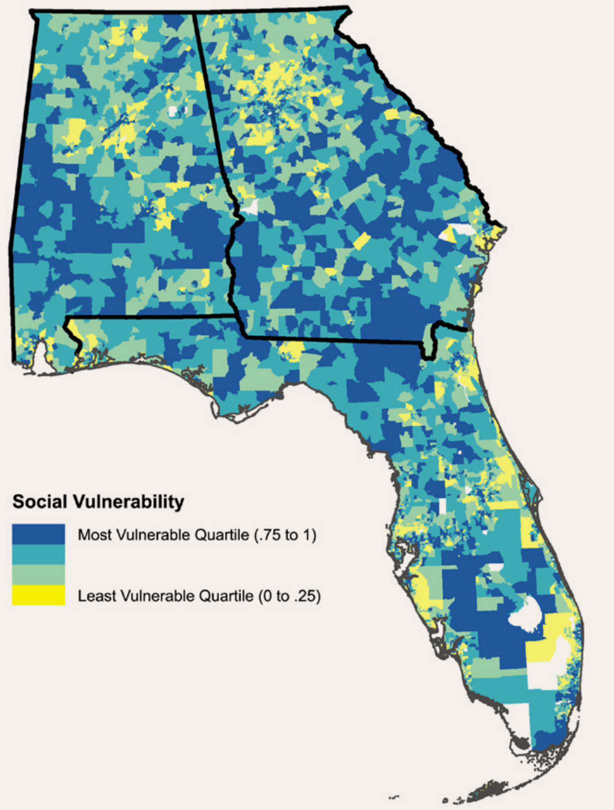

***Figure 1.** Univariate social vulnerability data, by census tract, for Alabama, Georgia, and Florida.*

BIVARIATE METHOD SHOWING SVI AND POPULATION DENSITY

To create maps that conveyed both vulnerability level and population density, we decided to create a grid of 1km vector cells, with each cell containing both density and SVI data (Zhou et al. 2017). We would then be able to vary the color of the cells to indicate the level of vulnerability, and their size to indicate population density; Figure 3 features an example. This grid-based representation would alleviate some of the well-documented problems of choropleth maps, such as inconsistently sized areal units and "data cliffs" where values abruptly change at an area's border (Langford 2013; Mennis 2003; Martin, Lloyd, and Shuttleworth 2011; Jia, Qiu, and Gaughan 2014).

To prepare the data for this representation, we began with a grid system. We chose to use the US National Grid (USNG) because it is a recognized standard (Federal Geographic Data Committee 2001; FEMA, n.d.; US Fire Administration 2015), usable anywhere on Earth (despite its name), scalable at multiples of ten, and a vector system, thereby allowing multiple data values to be associated with each grid cell. The gridded GIS files (US National Grid Information Center, n.d.) include population counts aggregated from cadastral-based dasymetric methods (Strode, Mesev, and Maantay et al. 2018) where possible, and from WorldPop (worldpop.org)

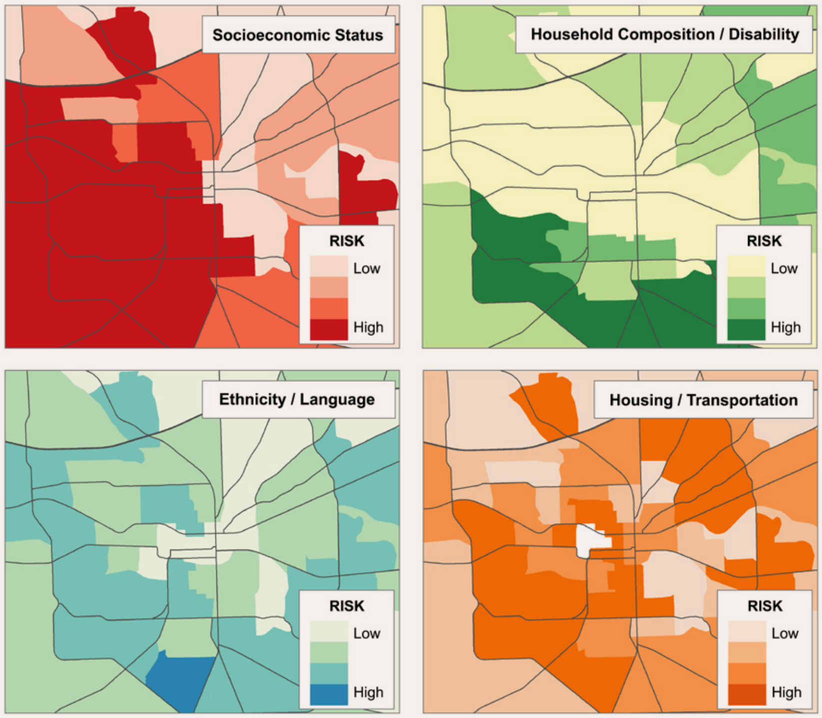

***Figure 2.** Univariate maps representing the risk quartiles of each of the four themes of social vulnerability (see Table 1) for Tallahassee, Florida.*

raster data otherwise. The 1km population grid cells were then overlaid with the census tracts holding SVI data. For cells that intersected more than one census tract, the values were areally interpolated by the amount of land area that falls within each cell. The resulting dataset was a 1km grid, containing values for the overall vulnerability index, for each of the four vulnerability themes, and for the total population. Figure 4 illustrates the results of this process for the Tallahassee area.

The conventional univariate representation in Figure 1 can be contrasted with the bivariate representation in Figure 3. The univariate representation only displays the overall SVI, while the bivariate representation displays the SVI and population density. From a visual perspective, the bivariate map eliminates unpopulated areas and produces clusters of high population density to represent urban areas.

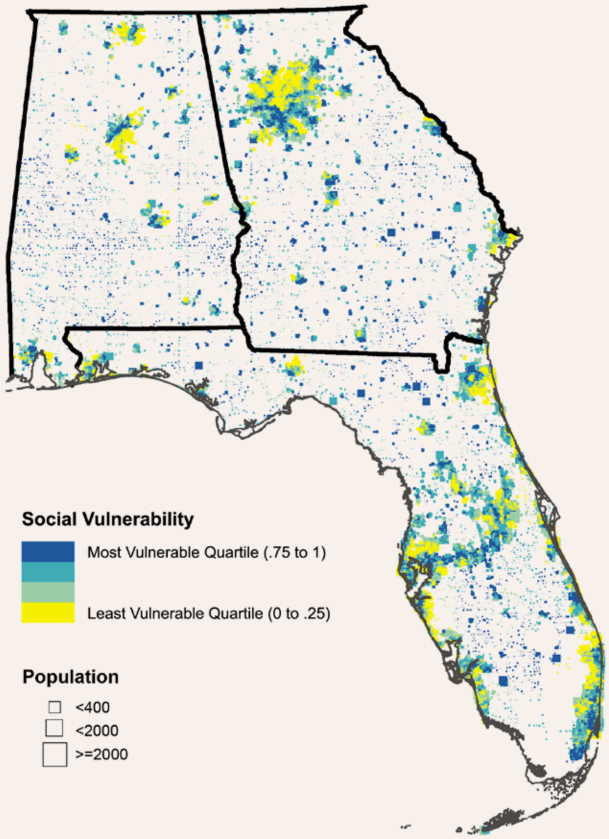

Figure 3. *Bivariate map of Alabama, Georgia, and Florida showing the social vulnerability index and population density. Contrast with Figure 1.*

MULTIVARIATE MAPS OF THE FOUR CDC SVI THEMES USING GLYPHS

While bivariate maps allowed us to visualize both population density and SVI, the SVI index is made of four vulnerability themes, and we wanted to represent each of these simultaneously. To do this, we turned to glyphs. The key characteristic of glyphs is that they encode several dimensions of a single data point using one or more visual marks and visual variables. While the Chernoff face is perhaps the best-known example, Fuchs et al. (2017), in their overview of 64 papers that performed controlled studies on different glyph designs, point out that the possibilities for designing glyphs are endless. We adapted our glyph design from Bleisch and Hollenstein (2018), who used square glyphs to simultaneously represent up to four walkability indices in a regular grid.

Each of the four vulnerability indices is represented by a colored square. In making color choices, we sought four contrasting colors similar to Brewer's (1994) diverging/diverging scheme. We chose highly saturated versions of pink, green, blue, and orange, to enhance their contrast with underlying map colors. Pink and orange squares were placed diagonally to each other, as

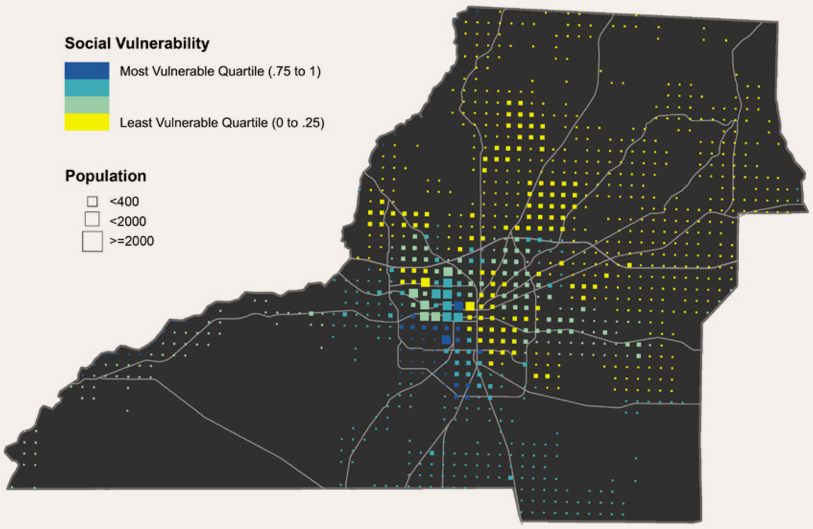

Figure 4. *Bivariate map showing the social vulnerability index (represented by symbol color) and population density (represented by symbol size) for Leon County, Florida. The city of Tallahassee is represented by larger cells, while rural areas have smaller cells and unpopulated areas have no cells.*

were blue and green squares, to increase the contrast with neighboring glyph cells. We then represent vulnerability scores for each of the four themes by resizing the squares (Figure 5). The lowest risk is represented by the smallest glyph and the highest risk by the largest glyph.

To ensure that the glyphs never overlap, and that they display at any scale, we used a 100m grid system within the 1km grid to construct the glyphs, as shown in Figure 5. Glyphs were drawn by adding color to some of the 100m grid cells according to the vulnerability theme and quartile. For example, 1km grid cells with a vulnerability theme ranked in quartile 1 (lowest) would add color to one 100m grid cell (1×1). If the theme was ranked in the second quartile, four cells would be required (2×2). Themes ranked in the third quartile require nine cells (3×3), and the highest quartile uses 16 cells (4×4).

Placement of the glyph colors, and thus themes, needed to be consistent. Starting from the center of the 1km grid cell, socioeconomic data are shown in the upper left, household composition/disability in the upper right, ethnicity & language in the lower left, and housing & transportation in the lower right. Multiple small cells of the same color appear as one unified square symbol. The final glyphs are composed of four contiguous squares with consistent colors and varying square sizes. Figures 6 through 10 illustrate examples of our glyph system. Figure 6 shows an overview of the variety of combinations of vulnerability levels that can be represented. Figure 7 depicts variation across a larger, hypothetical area. Figure 8 illustrates the four vulnerability themes in Leon County, while Figure 9 combines the glyphs with a population density basemap.

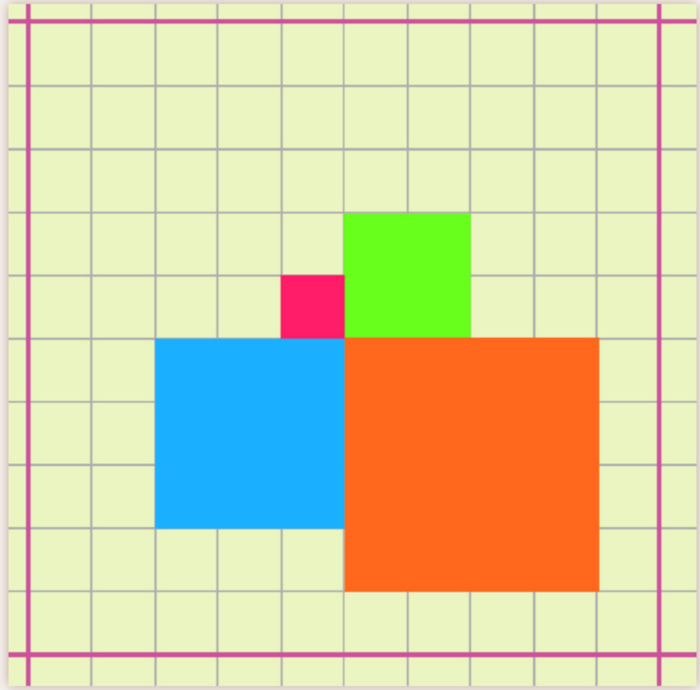

Figure 5. *1km grid (pink outline) over a 100m grid (gray). CDC SVI theme with the lowest vulnerability is represented by thesmallest glyph (pink), and highest vulnerability by largest glyph (orange).*

Unpopulated areas are removed from all maps to reduce clutter. Finally, Figure 10 juxtaposes the four univariate maps of Figure 2 with a multivariate glyph map of the same data.

DATA FILTERING

The CDC publishes SVI maps using a quartile classification, where data are divided into four categories according

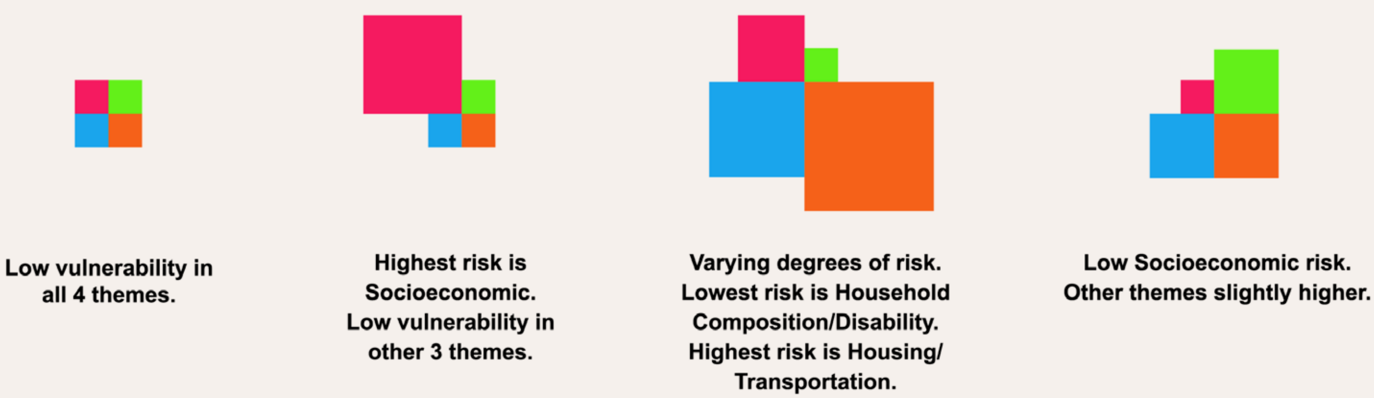

Figure 6. *Glyphs of combinations of vulnerability themes (color) and their degrees of risk (classed square sizes).*

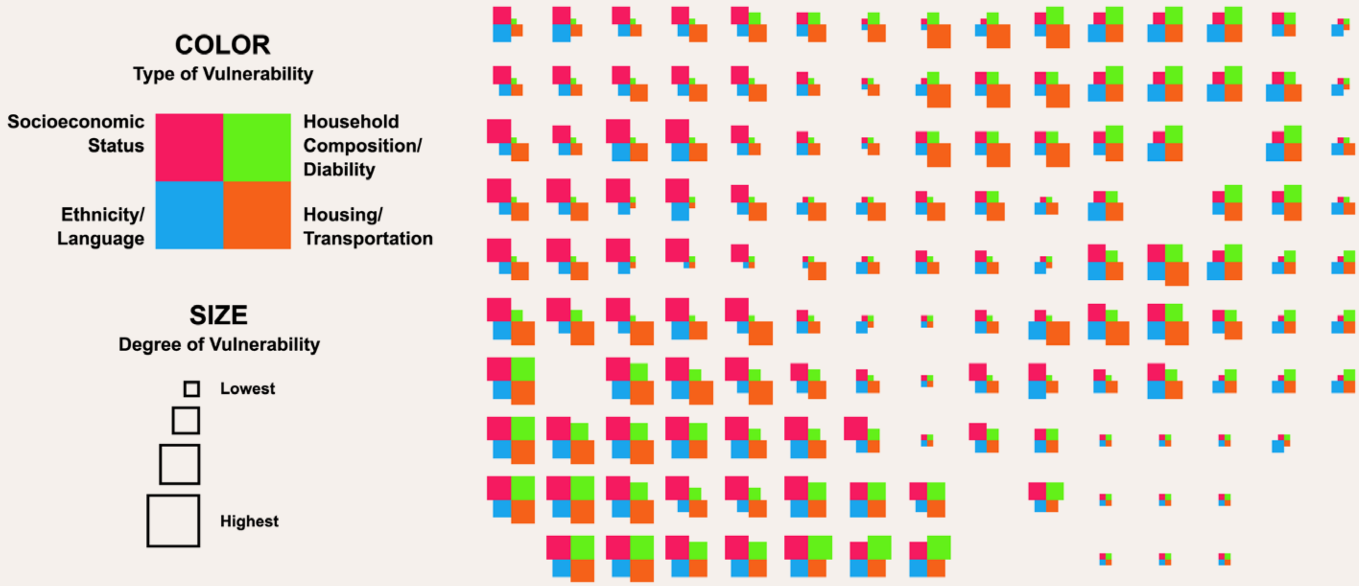

Figure 7. *Multivariate representation of the four themes using glyphs to show type (color) and degree (classed square size) of vulnerability.*

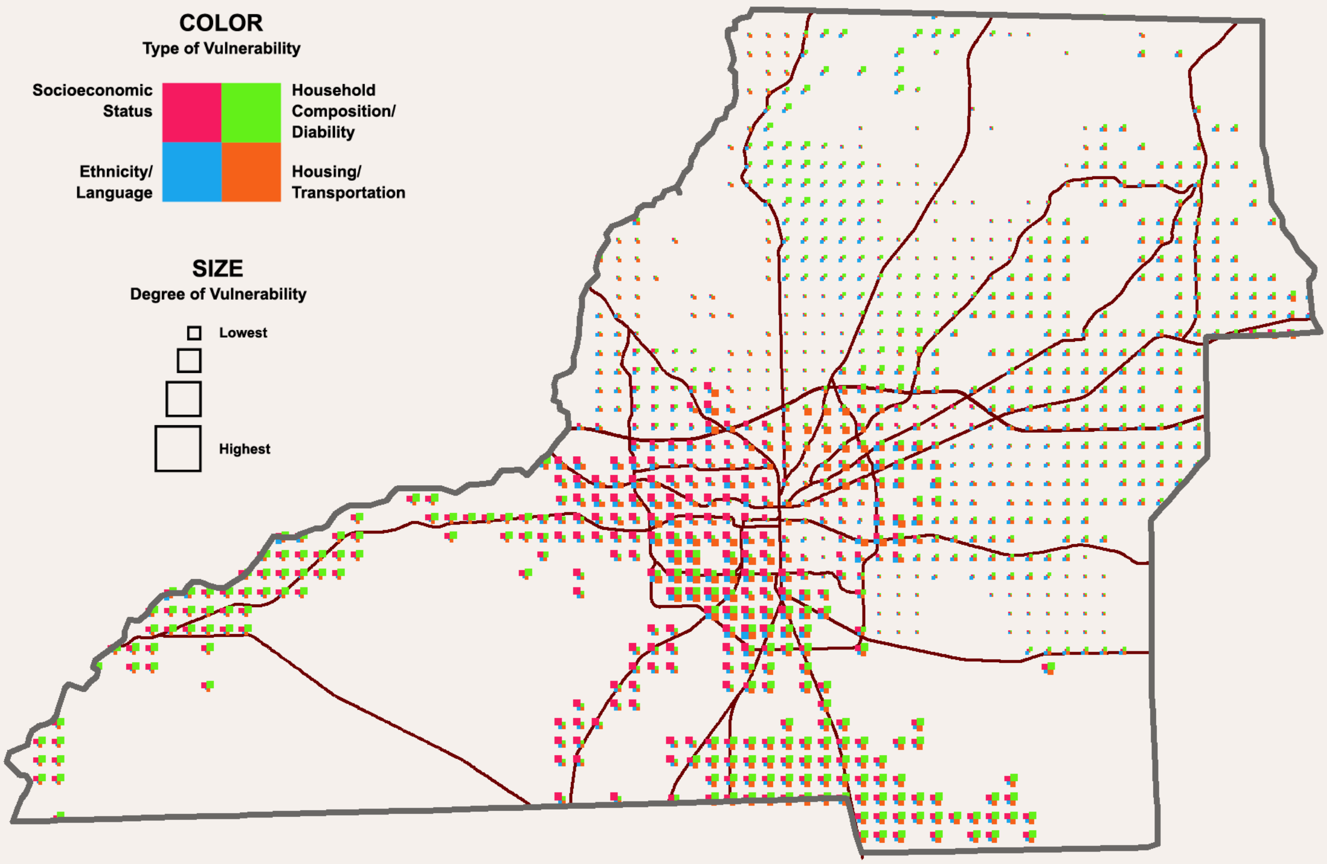

Figure 8. *Multivariate map of social vulnerability for Leon County, Florida.*

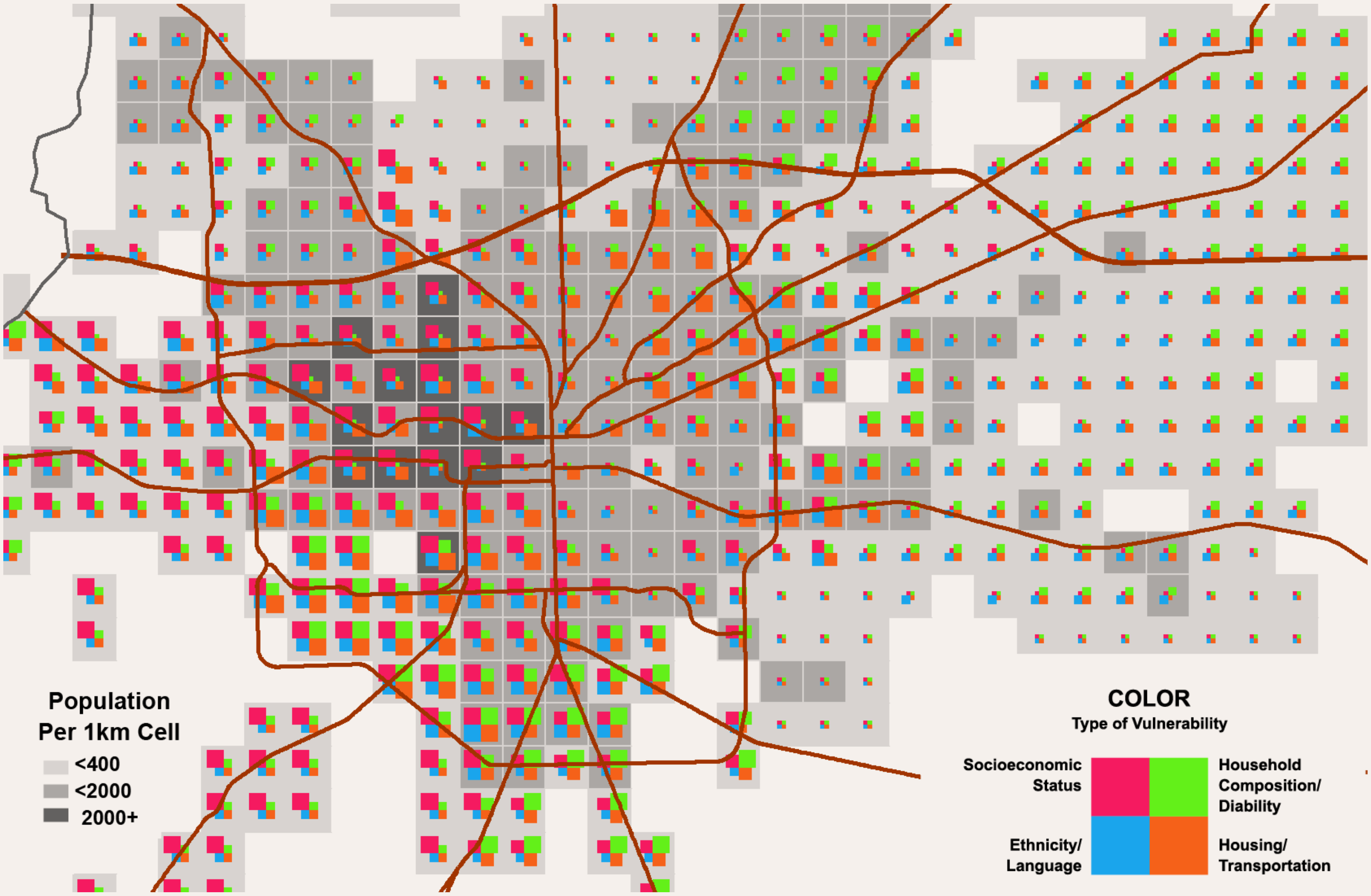

Figure 9. SVI data with population density of Tallahassee area.

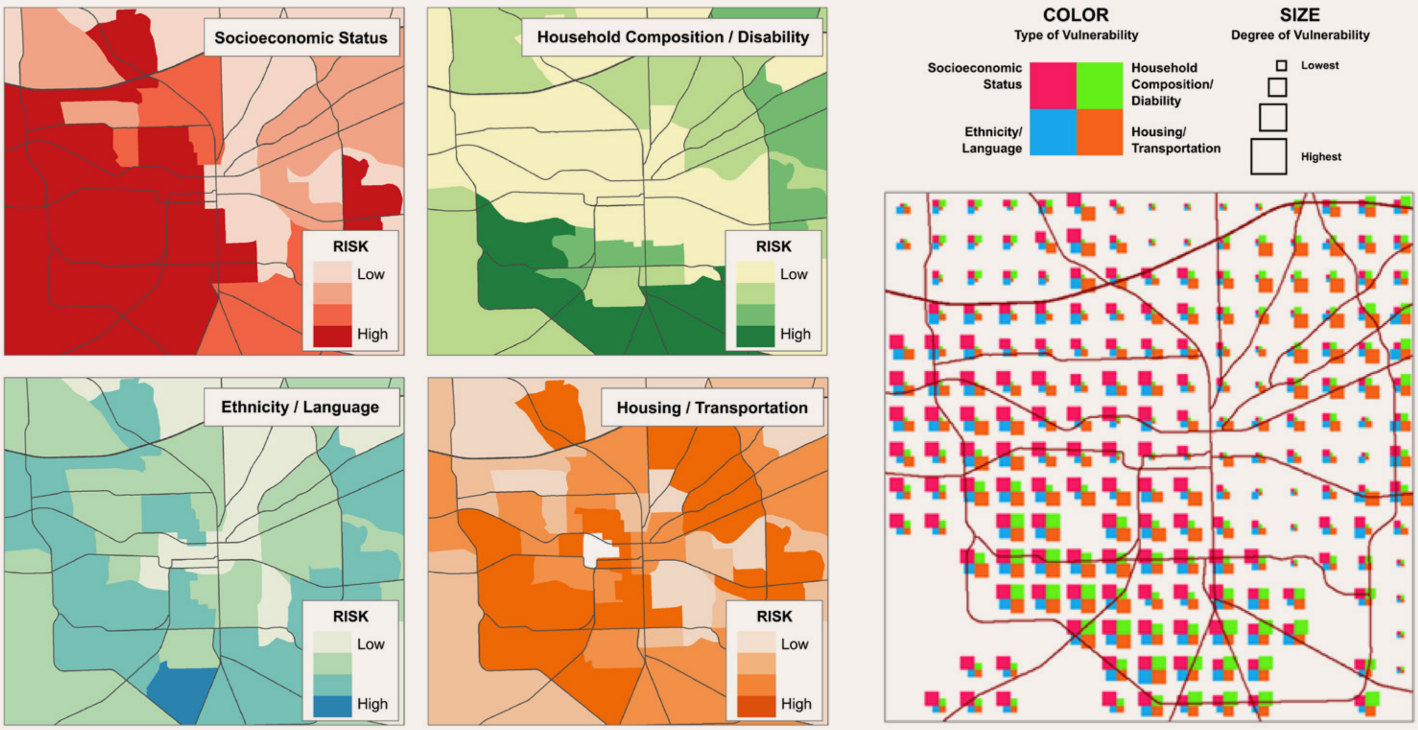

Figure 10. Left: Univariate maps of the four vulnerability themes. Right: Multivariate map of the same area using glyphs to depict the same data.

to the vulnerability score. While our maps above also use the quartile classification, we decided, additionally, to examine the value of filtering our data. By removing some data from the map, we could highlight areas with the highest vulnerabilities. Such a map would be useful to, for example, emergency planners, who may wish to view a map in which data below a threshold (e.g., 95th percentile) are removed, thereby focusing their attention on areas of interest. The maps in Figure 11 show 1km grid cells filtered by percentile: at least one of the cell's four vulnerability indices must meet the percentile threshold to remain on the map. The maps illustrate areas of high vulnerability, ranging from the 95th vulnerability percentile (top 5%) to the 70th percentile (top 30%).

VISUAL ANALYTICS USING EULER DIAGRAMS

As we have only four CDC SVI vulnerability themes, we can use Euler diagrams to represent them. Figure 12 demonstrates how, in the highest areas of vulnerability in Leon County, populations overlap across multiple themes. We can see that the highest number of persons are vulnerable due to socioeconomic factors, and that this population partially overlaps with those vulnerable due to housing & transportation. At the 85th percentile, vulnerability due to household composition & disability becomes apparent, but has no overlap with the socioeconomic or housing & transportation themes until the 80th percentile. The 85th percentile diagram reveals a second group of vulnerable people separate from the previous groups. The fourth theme, ethnicity & language, is not evident until the 75th percentile and overlaps with the other three themes. Ethnicity & language does not occur in isolation from other themes. Figures 13 through 15 show the pairing of the maps and Euler diagrams to fully convey information on higher vulnerabilities.

INSIGHTS ENABLED USING MULTIVARIATE VISUALIZATION

These methods were developed and adapted using feedback from the Florida Agricultural and Mechanical University's Sustainability Institute and planners at the

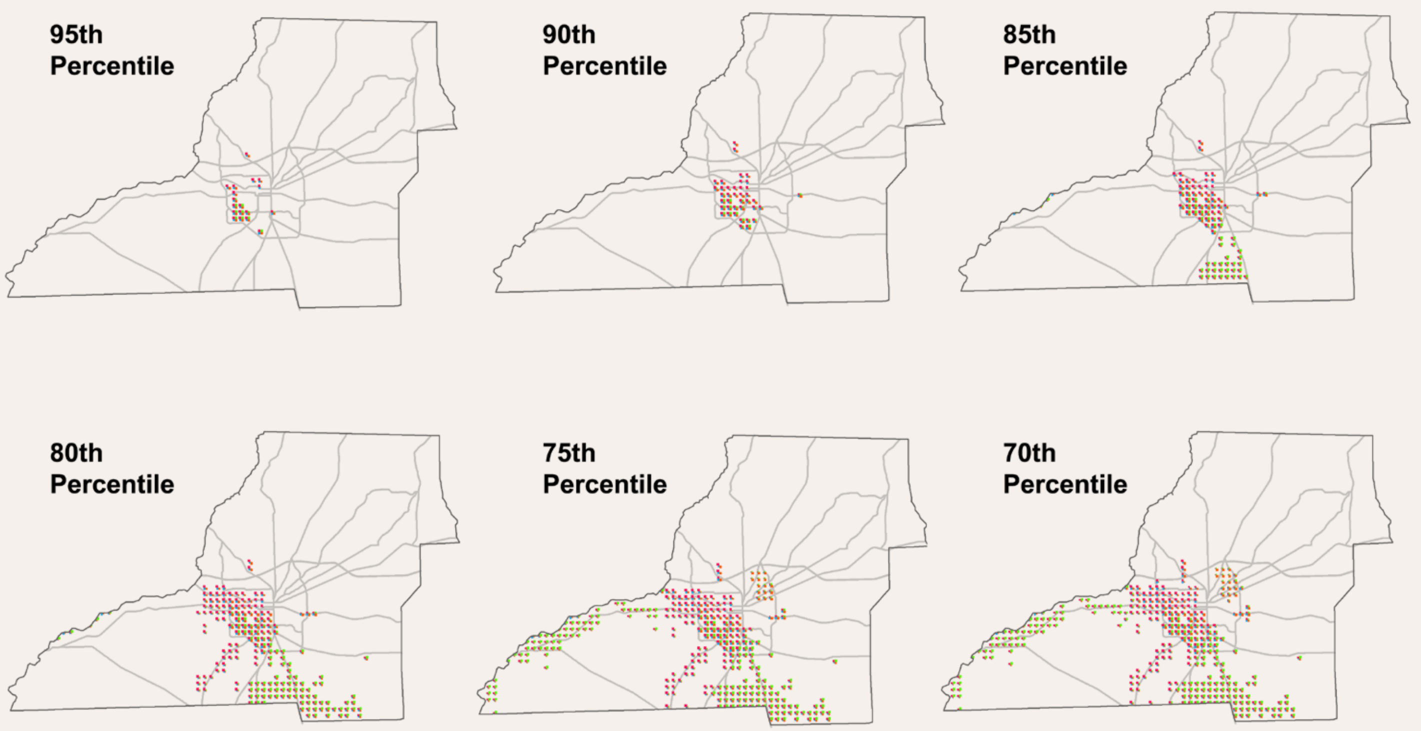

Figure 11. *Leon County data filtered by percentile. At least one vulnerability index must be above the threshold indicated next to the map. Figures 13, 14, and 15 show larger images.*

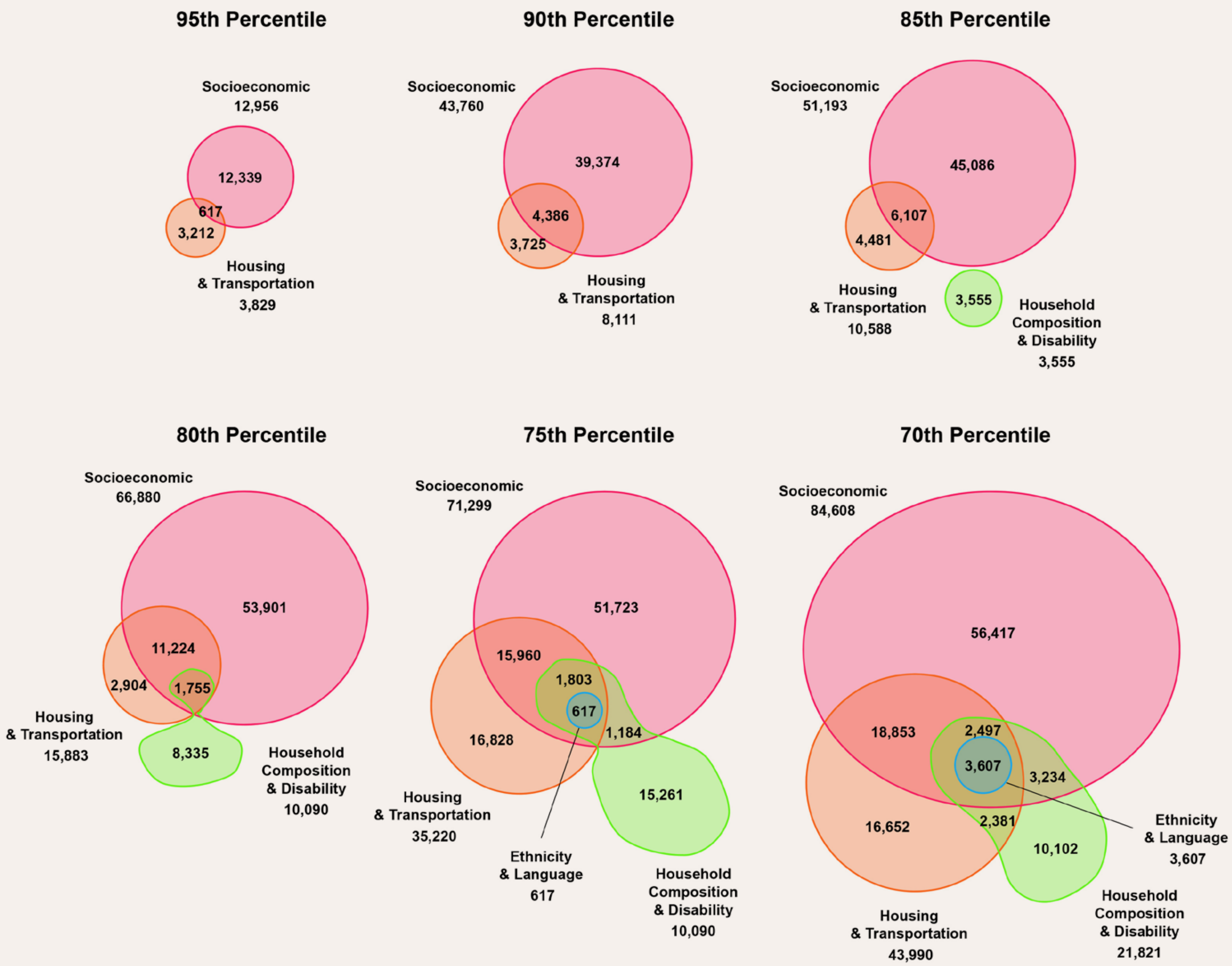

Figure 12. *Euler diagrams of population counts within CDC social vulnerability themes at varying degrees of vulnerability for Leon County.*

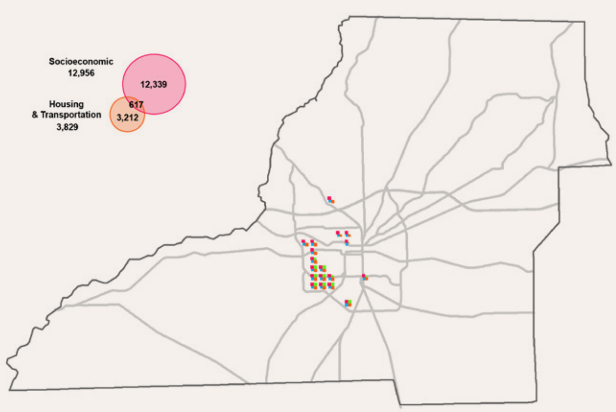

Figure 13. *Euler diagram and filtered glyphs of areas with at least one social vulnerability theme ranking in the 95th percentile.*

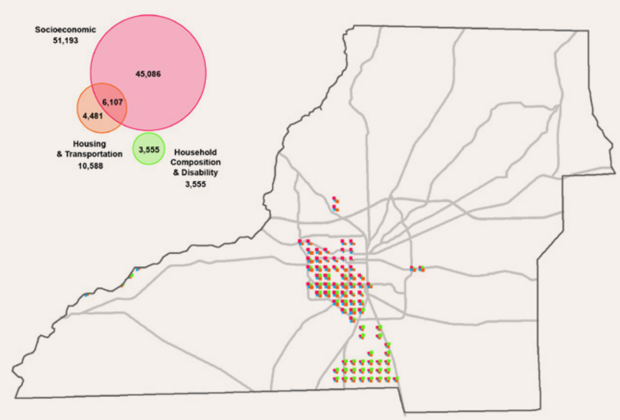

Figure 14. *Euler diagram and filtered glyphs of areas with at least one social vulnerability theme ranking in the 85th percentile.*

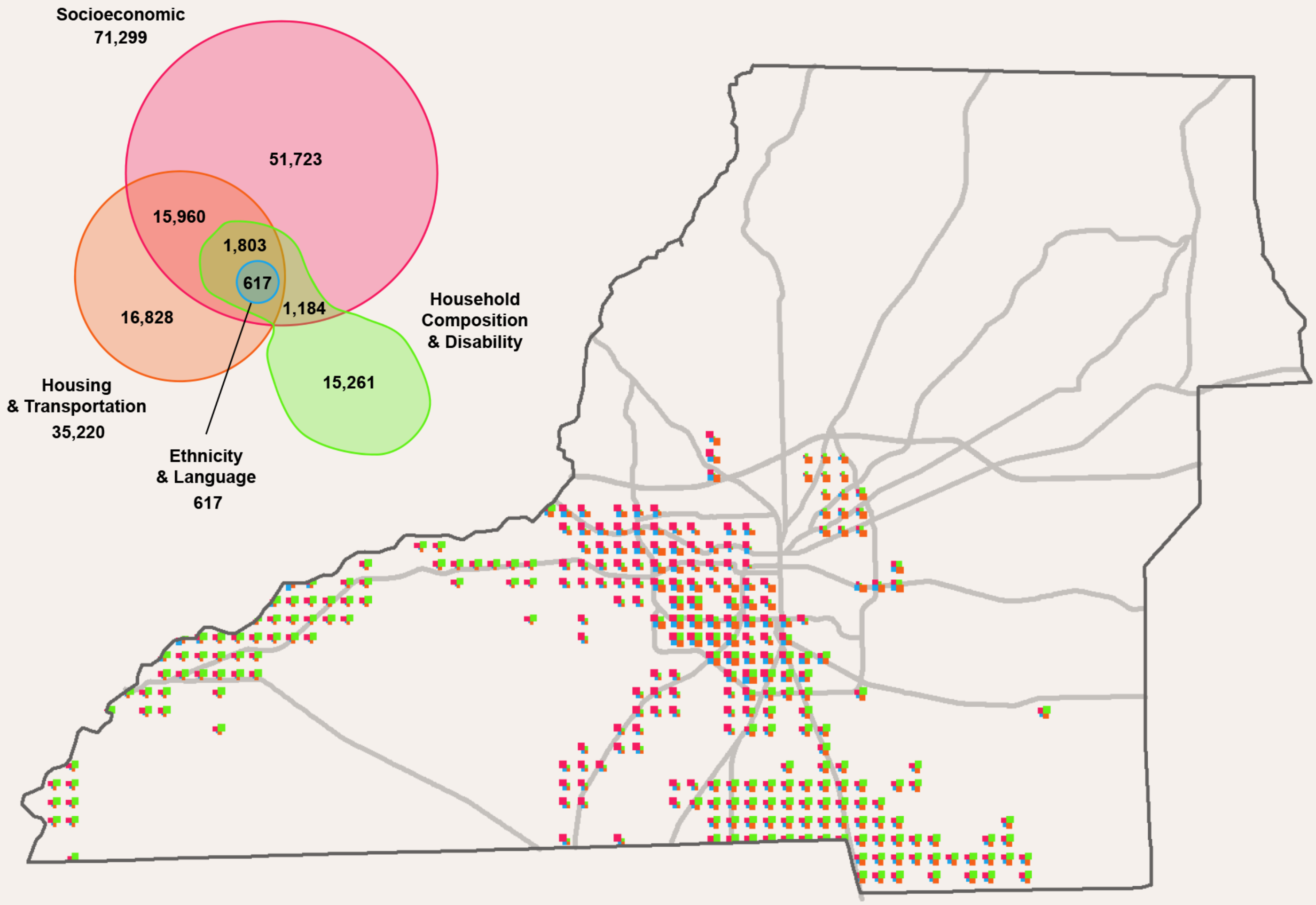

Figure 15. Euler diagram and filtered glyphs of areas with at least one social vulnerability theme ranking in the 75th percentile.

City of Tallahassee. After this project's completion, we solicited additional feedback from experts in other fields as well as final feedback from the original planning group.

Visual Design

> "This multivariate mapping technique for the visual display of social vulnerability index indicators is a brilliant display of design techniques to simplify a very complex issue. By combining color and size as indicators of type of vulnerability and degree of risk (respectively), it is possible to look at just one map and easily interpret the SVI for a particular area. The combination of these design elements makes the overall map easier to interpret than looking at the four univariate vulnerability indicator maps. The multivariate mapping technique is a wonderful example of how design techniques can simplify and aid data visualization." (*Professor of Visual Communication)*

Planning

The SVI data can be used in all phases of disaster management, including mitigation and planning. The following statements are from planners at the City of Tallahassee:

> "The [multivariate] map draws my attention to the west side of the city. In particular, the southwest part of the city appears to have multiple layers of vulnerability confirming what we know about the socio-economic demographics of that area. As practitioners, it alerts me about the complexity of building resilience for vulnerable people and clues me in to the customized approach necessary, from neighborhood to neighborhood." (*City Planner 1;* see Figure 16)

> "I can see where we need to locate our next resource center. This [multivariate] map makes the location stand out." (*City Planner 2)*

Emergency Management

Puerto Rico has experienced several disasters in recent years: Hurricane Maria in 2017 and earthquakes in 2019, presenting challenges for the recovery process. The following comments relate to Figures 17, 18, and 19, which show both univariate and multivariate views of vulnerability indices for Puerto Rico.

> "As an emergency responder, I use SVI data almost daily in a univariate form. If I had been supporting the recent earthquakes in Puerto Rico, I would be alerted to the poverty in the southwest. The high housing & transportation vulnerabilities indicate pre-existing resource limitations. High percentages of household composition & disability would cause me to question if there is a high elder population. Those factors would lead me to believe that those municipalities are going to have very few resources to recover quickly from this latest disaster. The univariate maps show single vulnerabilities, but assessment of multiple vulnerabilities requires much flipping between maps, taking time and mental capacity. In my opinion, a multivariate SVI map would be a valuable complement to the univariates." (*Disaster Recovery Specialist working for a government agency)*

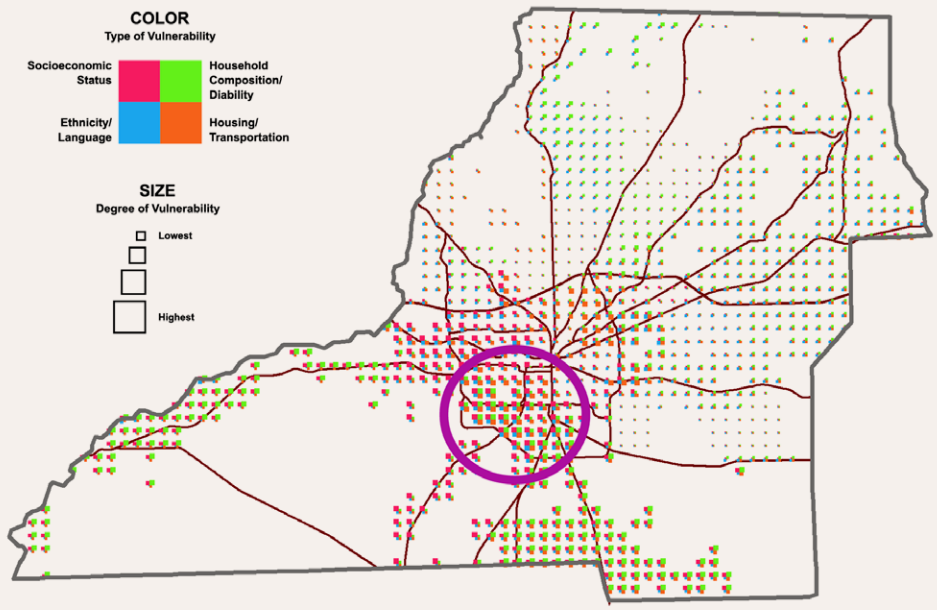

Figure 16. *Vulnerability data for Leon County, Florida. The purple circle identifies the most vulnerable areas.*

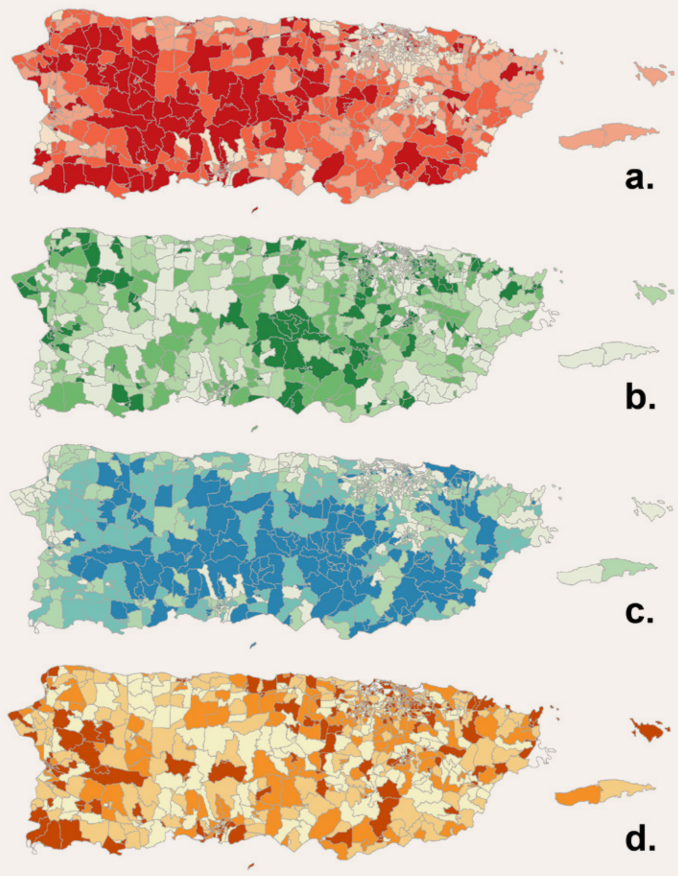

Figure 17. *Univariate maps showing the four themes of 2016 social vulnerability for Puerto Rico. Darker colors represent higher vulnerability. a. Socioeconomic Status; b. Household Composition & Disability; c. Ethnicity & Language; d. Housing & Transportation.*

DISCUSSION

Social statistics, including the CDC's SVI, are typically mapped using univariate graphic representations, without population counts, and with no supporting charts or graphs to aid in the understanding of social trends, including areas of social risk and vulnerability. They do not convey the *number* of people who are predisposed to higher risks from social and environmental hazards through pre-existing vulnerabilities. On the other hand, bivariate and multivariate geovisualizations facilitate the

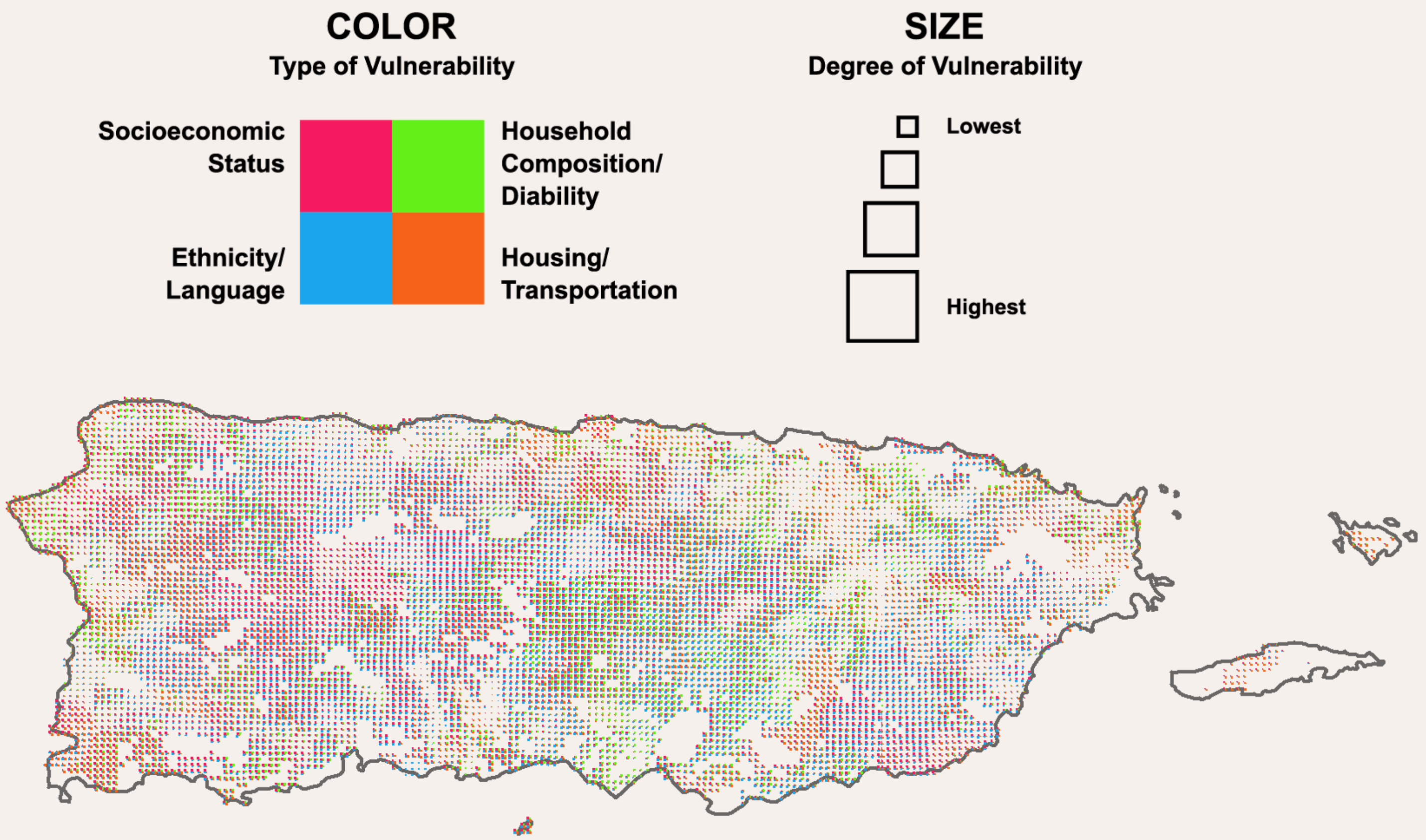

Figure 18. *Multivariate 2016 social vulnerability map of Puerto Rico.*

comparison of more than one social variable, and enable the correlation of overall vulnerability with population density. Using the designs we have demonstrated above, maps featuring as many as four variables (the CDC's SVI vulnerability themes) can be produced, showing their quartile rankings. The glyphs illustrate the magnitude of the four vulnerability themes within a single point symbol, while Euler diagrams convey relationships across multiple themes and their associated population counts. Further, data filtering can be applied to focus on areas or themes of interest and to remove potentially distracting data (i.e., highlighting areas of higher vulnerability and removing areas of low vulnerability). These maps and visual analytics can be combined as needed to convey a fuller picture of an area's social vulnerabilities in future planning projects.

For policy makers, planners, public health researchers, and public officials who use maps to develop and implement hazard response or resilience-building strategies, the bi- and multivariate techniques offer several advantages over univariate mapping. First, by distributing population to grid cells and removing those cells in unpopulated areas, the inaccurate impression that population characteristics are spread evenly over a census tract is replaced by a

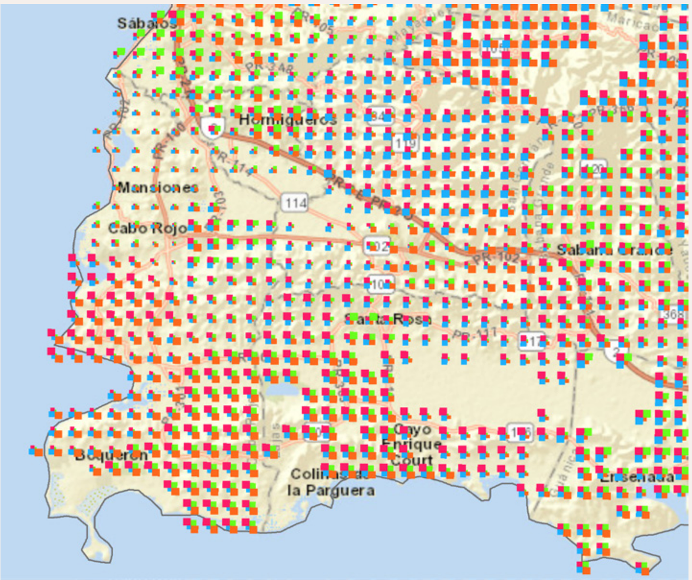

Figure 19. *Multivariate map of 2016 Puerto Rico, southwest corner, at close zoom.*

more nuanced and accurate representation. Combined with use of glyphs that simultaneously assess various vulnerability themes, the resulting maps convey a wealth of information in one representation. Euler diagrams provide at-a-glance population estimates, while the ability to filter vulnerability to various percentiles allows for well-informed planning to meet the needs of the most vulnerable people. For example, officials seeking to create "resilience hubs" in new or existing civic structures could readily see where resources are most needed. Local officials, even those who believe they have deep familiarity with the locality's population, may see patterns and pockets of vulnerability they were unaware of. By communicating information precisely and succinctly these maps will be critical for emergency response teams, which can be composed of personnel unfamiliar with the areas they are assisting. The methods described and illustrated here together form a promising platform for use in better understanding and responding to the geographically uneven characteristics of social vulnerability.

LIMITATIONS

While our method can be considered an innovative demonstration of multivariate mapping, it is not without limitations. Data collected at the census tract level can mask patterns within the tract; it is possible that isolated or rural populations may be overlooked and these may sometimes contain crucial minority enclaves. When census tracts are resampled to a 1km grid system, the finer scale can falsely imply that the data are collected or analyzed at this higher-resolution scale. The quartile classification system classifies data at a class border without providing any indication that data may be very close to another class. Finally, the data size of the 100-meter vector grids can be challenging, but this can be resolved by removing any unshaded grids or converting to a raster layer.

FUTURE WORK

This method can be easily adapted in a number of different ways. The data can be included in an online interactive environment that could benefit those needing information quickly, such as emergency management and response teams. The Euler diagrams and maps could be hyperlinked, so that clicking on a segment of the Euler diagram could highlight the relevant glyphs, and vice versa. The data itself could be modified for specific purposes, with CDC SVI data being replaced by other relevant indices. For example, groups focused on elderly populations could remove SVI data not pertinent to the elderly and replace them with more relevant measures from external sources, such as whether food or medical resources are available within the community. Users could be given the ability to filter data on the fly, reducing map clutter and showing only targeted areas of interest. Rather than showing the glyphs, cells could be filled with bar charts or other creative designs to convey data meaning.

CONCLUSIONS

Risk managers require an integrated understanding of vulnerability data, which are multidimensional. Yet visualization of this particular type of data has not yet been thoroughly discussed in the cartographic literature. In this paper, we have demonstrated a useful method of presenting social vulnerability data via quadrant glyphs on a map, to better represent multiple variables along with population size and geographical location. The bivariate and multivariate mapping strategies, as well as the visual analytics shown here, offer an improvement over traditional univariate mapping. A member of an emergency response team told us that she used SVI data daily when her team was deployed to unfamiliar areas. She stated that "This method would clearly be easier than looking through four separate maps."

With this method, the viewer can target a specific area and immediately see the extent to which vulnerability types vary. The resulting maps are more complex but also less cluttered, as unpopulated areas are removed, and, in the case of the bivariate maps, populated areas are scaled to distinguish between sparsely and densely populated areas. The multivariate glyphs convey the four vulnerability themes and their quartile categories simultaneously, and eliminate the need for four separate univariate maps. Euler diagrams complement the spatial data by conveying the quantity of population affected by multiple types of vulnerability and show the overlap between multiple themes as an area can be affected by more than one type of vulnerability. Furthermore, a data filtering method can be combined with these techniques to isolate and highlight the areas with the highest vulnerabilities.

In addition to being helpful for planners and responders, these maps and diagrams can be a useful means for engaging the community. They can be shared at neighborhood meetings and residents asked for their input on the strengths of the neighborhood as well as its vulnerabilities. Discussions could be held on causes of vulnerability and means to address or mitigate them. The maps and other visuals can aid advocacy and provide political leverage for neighborhoods with fewer resources. From a planning perspective, these maps and diagrams can be useful in identifying areas in need of resources and infrastructure improvements. They can provide data for decision makers to allocate resources more objectively based on need.

In this article we have presented and described a method for mapping bivariate and multivariate data using the CDC's social vulnerability data. The next step is the evaluation of this method for policy, planning, emergency response, and research beyond ease of viewing and better understanding interrelationships of the variables. We invite readers to apply these techniques to their areas of interest and report on the outcomes.

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PEER-REVIEWED ARTICLE

Geographies of Empty Spaces on Print and Digital Reference Maps: A Study of Washington State

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J. B. Harley's insistence that "there is no such thing as an empty space on a map" invites critical inquiry into which places are being left blank in popular reference maps, and why. I discuss the myriad reasons that items may not appear on a map, and invite a rethinking of the way selection is conceptualized in cartographic education. In this study, several GIS-supported methods are used to identify and compare consistently empty areas in print and digital maps of Washington State made by Google, Microsoft, OpenStreetMap, Rand McNally, National Geographic, and the state Department of Transportation. I then examine the physical and human landscapes of these places using imagery overlays, queries of land ownership data, and observations from site visits. In the state of Washington, empty spaces on the map are highly connected with regional and global economies, and are essential for supporting the needs of urban life such as food, electricity, construction, and waste disposal. City dwellers may not ever see or recognize the intensive land uses occurring in these geographies, whose landowners include an intriguing mix of large industries, multiple levels of government, religious colonies, and individuals searching for space and solitude.

KEYWORDS: cartographic selection; critical cartography; empty spaces; cartographies of silence; digital maps; Google Maps; Bing Maps; OpenStreetMap; Washington State

INTRODUCTION

Ask an introductory cartography class why something might not appear on a map, and you'll get a lively discussion. For example, the data might not exist, because it's not considered important enough to be worth the investment of collecting it. Or it may be impossible to collect, due to difficult terrain, weather, armed conflict, or legal restrictions. Perhaps the data does exist, but we simply don't know about it, or it is censored by a more powerful authority.

But even in situations where sensors repeatedly traverse the full landscape and data flows liberally, empty spaces can persist on the map. The complexity of landscapes forces cartographers to make difficult choices about which features to include and exclude. Carefully exercised selection decisions can lead to efficient, memorable, and easy-to-read maps (Delano-Smith 2004; Krygier and Wood 2016). At the same time, the selection process, influenced by the limitations of the mapmaker's knowledge and their implicit or explicit cultural biases, inevitably leaves some areas of the map canvas devoid of any entities or labels. These blank spots constitute a *terra incognita* on the map: literally "lands unknown," about which nothing can be understood without resorting to some other source.

The critical cartographer J. B. Harley (2001, 71) cautioned that "there is no such thing as empty space on a map." Yet, every map, out of necessity, has some blank areas in between features. What Harley meant is that something is always happening on the ground in a space, and when that space is depicted as empty, a cartographer has either deliberately or unwittingly deemphasized features of the landscape. As examples, Harley pointed to the omission of indigenous geographies from European maps of colonial America (thereby inviting appropriation by new peoples), as well as the decision by the United States Geological Survey topographic mapmakers to prioritize terrain and mineral deposits over cultural features (Harley 1990).

Regardless of its cartographic depiction, no space is truly empty. At various scales, all spaces can afford a sense of place to the humans who interact with them and know about them (Tuan 1979). The terra incognita, then, exists only in our own minds (Wright 1947). Reference maps sharpen our perceptions of place by communicating about the human and natural events and processes occurring on the ground. They help us ascribe meaning to what was unknown or perceived as empty. Theorists in critical cartography have sought to understand how the contents of maps enlarge and limit our possibilities to know about places and act on them (Crampton 2001). These inquiries should be broad enough to consider both what is shown and what is not shown.

Consequently, the purpose of this study is to first identify which spaces are being left empty in modern reference maps (in both print and web formats), and then to use ancillary sources to better understand the physical and human landscapes in these places. These supplemental resources include satellite imagery, street-level imagery, cadastral fabrics, and field visits. A goal is to see how empty map spaces and their associated landscapes produce each other through the ways people think about, talk about, and act upon these places. As Harley observed, "There's no neat causal arrow that flows from society into the map, but rather causal arrows that flow in both directions" (2001, 44).

SELECTION

An item appears on a map because somebody knew about it and decided to include it. Cartography textbooks often contain several paragraphs of guidance on the process of selecting what to map. For example, Kimerling et al. instruct that, "based on the map's purpose and scale the cartographer will choose the relevant information to include on the map and determine what should be left off" (2012, 207). According to Robinson et al., "selection is the intellectual process of deciding which classes of features will be necessary to serve the map's purpose" (1995, 405). Borden Dent (1999, 16) describes selection as working with the client to make early decisions about which data variables and other characteristics would be most appropriate for the map's purpose. Kenneth Field (2018, 294) situates cartographic selection as a process that occurs in tandem with generalization and symbolization after data has been collected.

Each of these authors depict the cartographer as a powerful agent selecting the most relevant facts from a realm of existing knowledge to fit into the available space, in the same way one would fill up a dinner plate while walking along a buffet table. But the situation is somewhat more complex than this, requiring more inquiry about what is on the table and why. For example, limitations in funding or equipment may narrow a mapmaker's choices of data, or the cartographer may not know about some entities that could be mapped. Selection might also be steered by business decisions, paid placement of points of interest, political intrigue, bribery, or censorship. Finally, a cartographer might exclude otherwise useful data out of a desire to protect vulnerable cultural and environmental resources or to respect the traditional lands of people who live in the mapped geography. Seldom do textbooks contain guidance about what *not* to map, although John Krygier and Denis Wood (2016, 36–37) advise caution when depicting secret or sensitive facilities and infrastructure, communally held lands, and phenomena that are impossible to capture in Cartesian space.

These cartography texts emphasize the connection between the act of selection and the *purpose* of the map. In this article I will be examining general reference maps of Washington State that could be used in multiple ways including education, navigation, trip planning, or (in the case of the web maps) overlaying more data. Maps designed for more nuanced purposes (such as mining, energy infrastructure management, wildlife management, etc.) might favor a much different set of features, although all would need some set of base features to provide geographic context. Those base features are the focus of this study.

CARTOGRAPHIES OF SILENCE

Harley (1988) devoted much of his attention to maps of European colonial activity, studying the ways that what he called "cartographic silences" reflected the power relationships between early modern European states and their citizens, colonized lands, and political rivals. These silences could be either unintentional or intentional. For example, indigenous place names and locations were often disregarded in colonial maps of the Americas either out of ignorance of the geography or a desire to show these lands as available for settlement. In early modern maps of Europe, symbols of religious authority were sometimes deemphasized due to rivalries between Catholics and Protestants.

André Reyes Novaes (2014) argued that silences in modern maps also deserve scrutiny in order to understand how marginalized populations and places are represented. As evidence, he chronicled how Rio de Janeiro's official maps mostly ignored the city's informally settled favela neighborhoods until the 1990s. The controversy persisted with Google Maps, which incurred criticism for diminishing its representations of the favelas between 2011 and 2013. Stanley Brunn and Matthew Wilson (2013) lamented a similar dearth of digital geographical information about the majority-black township of Khayelitsha, in greater Cape Town, South Africa.

In these ways, empty spaces hide people and activities from public view, thereby perpetuating the process of marginalization. Kimerling et al. (2012, 488) describe how maps of combat targets in the Vietnam War omitted place names, using impersonal numerical codes that separated pilots from the places being bombed. Crowdsourced maps uniquely counter this type of silence by allowing people to place themselves on the map and emphasize aspects of their communities that may be omitted elsewhere. For example, residents of the largest informal settlement in Nairobi, Kenya, surveyed and placed their community into OpenStreetMap (Hagen 2011). The detailed map made it more difficult for the space to be ignored by local authorities. Elsewhere, plotting urban farms and gardens in OpenStreetMap has promoted the re-imagining of vacant lot spaces that often languish empty in digital maps (Quinn and Yapa 2016).

Yet, there are still many reasons why remaining off the map might be viewed as advantageous, especially by those who want to maintain their privacy or conduct activities outside the gaze of the camera (Novaes 2014). For example, in his inquiry into unmapped "black ops" sites used for interrogation by US intelligence personnel, Trevor Paglen (2009, 276–277) proposed that blank spots on the map have helped create blank spots in the law. What is not known can neither be regulated nor policed.

Nor can it be attacked. For this reason, British Ordnance Survey maps once omitted sensitive military and intelligence installations, depicting them instead as farms or vaguely-titled entities such as "depot" (Perkins and Dodge 2009). The ubiquity of satellite imagery eventually put an end to this deception, but debates about how to depict such facilities rage on. For instance, contributors to OpenStreetMap in Israel have engaged in edit wars over whether to digitize military-related facilities or leave them off the map.[1]

Some efforts to keep the map empty are motivated by the desire to protect cultural or environmental resources, as well as communities and individuals. Because place names attract attention and visitors, the United States Board of Geographic Names maintains a policy of rejecting new toponym proposals within federal wilderness areas (Julyan 2000). Among outdoor recreationists, the locations of caves, archaeological sites, and even favorite fishing holes are often viewed as sensitive information, not to be shared in public media. Multitudinous indigenous groups and religious communities have preferred for their surroundings to remain unknown, untraversed, or unmapped by others, often to protect their ways of life. Fearing state incursion and the privatization of communal lands, indigenous communities in Oaxaca, Mexico expelled a team of academic mappers after learning that the research was funded by the United States military (Bryan and Wood 2015, 142-161).

How are GIS and algorithmically produced web maps producing cartographies of silence? Craig Dalton and Jim Thatcher (2019) examined how the business missions of large companies such as Google and Apple influence the points of interest displayed on their map products, as well as the ways that users interact with maps online. They noted that Google Maps began including advertisements for large chain businesses on its maps and driving directions. Users often want to search for these landmarks and navigate based on them; and yet, the deemphasis on local shops and cultural features has a cumulative effect on users' geographic knowledges, spatial behaviors, and imprints on the landscape.

Digital maps are typically composed of multiple data layers, each representing a certain class of entity on the landscape. For example, a map might be composed of a water layer, a shaded relief layer and a cities layer. However, any cultural or landscape feature that does not appear in the selected layers must be added manually by the cartographer, a costly endeavor for web maps that are automatically generated to cover many countries at many scales, often down to the neighborhood level. Harley (1988) foresaw this when he predicted that the "technologizing of the map" would lead to a narrowing of types of things being mapped, thereby creating "silences of the unique."

1. forum.openstreetmap.org/viewtopic.php?id=23026.

It was perhaps for its ability to overcome these silences that Dave Imus's print map *The Essential Geography of the United States of America* drew so much critical acclaim (Stevenson 2012). The map contained the elements commonly expected in a wall map, such as state boundaries, shaded relief, and city locations; however, it also included influential cultural and environmental sites that fell outside the set of widely available GIS data layers. Examples include the locations of the Deepwater Horizon oil spill, World War II-era Japanese internment camps, and the Burning Man festival.

Imus was able to add these touches manually, but they required a degree of knowledge about the local cultural landscape that no algorithm can easily grasp. In automated cartography, features not deemed regular or repetitive enough to merit their own datasets or categories are in danger of being left off, thereby limiting an understanding of the complexity of the landscape (Wilmott 2019). Even though the crowdsourced nature of OpenStreetMap provides an avenue for myriad local knowledges to be added into a public geographic database, the map on **OpenStreetMap.org** is still limited by the demographics of the contributors and the set of feature types and tags agreed upon for the default tile renderer. For example, only recently were native reservations added to that map, an endeavor which took years of discussion (McConchie 2019; Wilmott 2019).

LANDSCAPES OF EMPTY MAP SPACES

Once the map's empty spaces have been demarcated, what approaches can we take to better understand these landscapes? Certainly, elements of physical topography should be identified; yet it is the human transformation of spaces that constitutes the most important morphologic factor in the study of landscapes and thereby influences most of the features in reference maps (Sauer 1925). People constantly use the landscape and alter it to meet their ends, sometimes in destructive ways. Even a seemingly barren or empty landscape in the "middle of nowhere" has likely been influenced by humans over time through processes of appropriation and transformation. Cultural meanings of the landscape, and the processes that shaped them, can be decoded through field visits, mapmaking, studies of historical maps, and scrutiny of promotional tourism literature (Lewis 1979; Cosgrove 1989). This process "allows us to reflect upon our own roles in reproducing the culture and human geography of our daily world" (Cosgrove 1989, 131).

In this tradition, Lester Klimm (1954) undertook a study of the "empty areas" of the northeastern part of the United States, which he defined as spaces without human settlement, agricultural activity, industry, roads, or mineral extraction. Klimm's team identified these areas primarily using government-produced topographic maps and state highway planning maps, although some photomaps supplemented the efforts. They then drove over 47,000 kilometers to field check the results. In Klimm's study, the major influences leading to an "empty" landscape were physical isolation from major economic centers and distance from historical routes of circulation. Although some discussion was offered about the origins of these centers and routes, Klimm attributed the cultural layout of the landscape to the "'frozen history' of decisions—once with some rational explanation but now incomprehensible—by people long since dead" (343).

More recent scholarship has argued that a landscape is never stuck in time, but is constantly being forged by competing social actors. Don Mitchell (2008) cautioned that inquisitiveness and field visits alone cannot fully replace archival research, ethnography, and a grasp of social theory when it comes to understanding the ways that landscapes constitute social compromises and mediations. Observers of the landscape should also be attuned to the influences of capital and how spaces are used to generate revenues. These considerations are just as true in rural areas as they are in cities, as Mitchell demonstrated in his studies of the landscapes of agricultural labor in California (1994). Interestingly, Klimm designated areas of commercial forestry as empty and "passed over," yet as will be shown later in this paper, such areas are active sites of economic activity that influence major urban areas both near and far.

METHODS

To IDENTIFY AND STUDY the kinds of areas being omitted from popular reference maps, this study examines maps of Washington State (not to be confused with Washington, DC), located in the northwest corner of the contiguous United States of America with a land area of 66,455 square kilometers and a population of over 6.7

million people. The variety of landscapes in this region of the US makes Washington an ideal area to study. The state is sharply divided physiographically and culturally by the Cascade Range, which runs north-south through the entire length of the state. Most residents live in the western side of the state along Puget Sound and the Interstate 5 highway. This area is heavily forested with a maritime climate. The eastern inland side of the state is generally much dryer and more sparsely populated.

Six maps of Washington State were chosen for this study: three web maps and three designed for print. All of them are used by the public for navigation, tourism, and general geographic context and education. The three web maps were Google Maps, Bing Maps, and OpenStreetMap (with the default styling from **OpenStreetMap.org**). Several lab assistants and I captured and mosaicked screenshots of the entire state from the browser version of these maps in April 2019 at the approximately 1:1,156,000 scale. This scale is part of the traditional set of levels (zoom level 9) used for building multiscale tiled web maps.

The three print maps were:

- *National Geographic Washington Guide Map*, published in 2018 with a scale of 1:1,267,000.
- The two-page Washington spread from the *Rand McNally 2019 Road Atlas*, with a scale of approximately 1:1,267,000.
- The *Washington State Highways 2014–2015* map, published by the Washington State Department of Transportation (WSDOT) at a scale of 1:842,000. This is the most recent year that WSDOT has published a print edition of its highway map.

We scanned the National Geographic and Rand McNally maps and obtained a digital version of the WSDOT map, identical to the print version, from WSDOT's website. We then georeferenced the maps by matching control points with features on the Esri Streets basemap; we typically used land boundary corners and road intersections as control points. Because of the scale of the maps and the resolution of the scans, there were, as expected, slight positional errors in the georeferenced maps; however, none of these was larger than the 5 km fishnet cell dimension used later in the study.

An early challenge in this study was deciding what should constitute "empty space." Take a look at any map and it soon becomes clear that the empty space isn't neat and compact: it's irregular and sinuous, winding around isolated features and labels spread out by cartographers who were trying to avoid placement conflicts. Should text disqualify a place from being empty? How about homogeneously tinted areas inside of large polygon boundaries, such as national forests or native reservations? Do background areas of shaded relief count?[2]

Because the topic of empty space is complicated in this way, two different approaches are detailed below: a manual method and an automated method. Using them together provides a picture of which areas are consistently left empty and deserve further study, although it doesn't arrive at a definitive boundary.

MANUAL METHOD

The first approach required the active participation of a human analyst to "manually" check over each map. To begin, all maps were projected into the Washington State Plane South coordinate system, and then overlaid with a grid of 5 km cells.[3] We scrutinized each cell systematically and marked the ones that contained no map features. This process took about one to two hours for each map.

For this exercise, the intent was to identify "placeless" spaces, about which nothing would be known if the map were the only instrument; therefore, the only allowed markings in an "empty" cell were graticule lines, inset map extent boundaries, background shaded relief, and markers indicating distances between points on a road (although not the road itself). State and county labels and boundaries were also allowed, since all land is encompassed by these, and county labels are often used to fill empty space. The presence of other polygons and text disqualified a cell from being considered empty, since these items communicate something about the place. Ocean was excluded from both this analysis and the automated method described below.

2. The Bing, Google, and National Geographic maps contained shaded relief in the background, while the rest did not.

3. Statewide spatial datasets distributed by the Washington State government use the Washington State Plane South zone coordinate system. We chose this one in order to match their well-known practice.

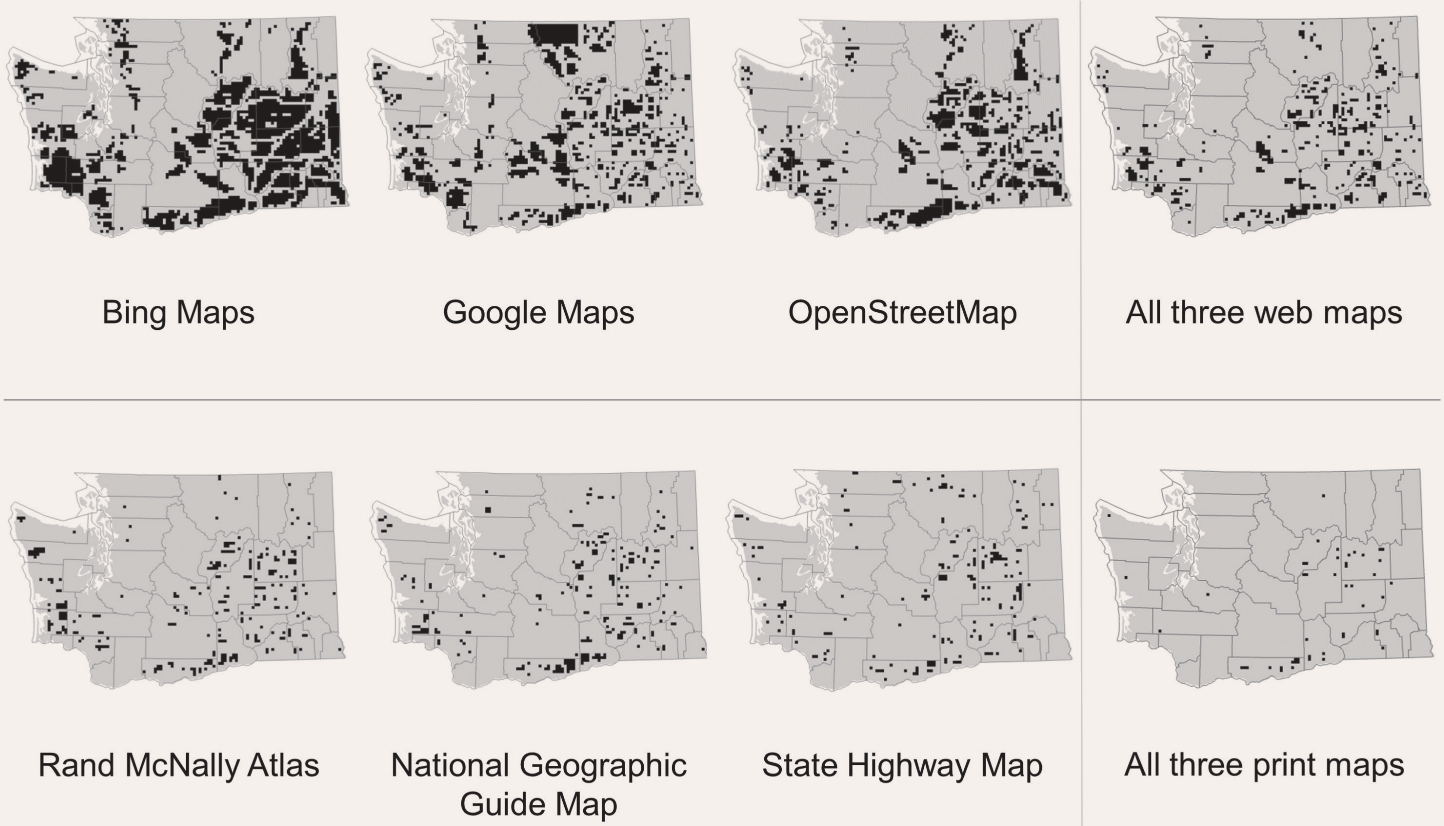

Figure 1. Empty spaces identified on each map using the manual method.

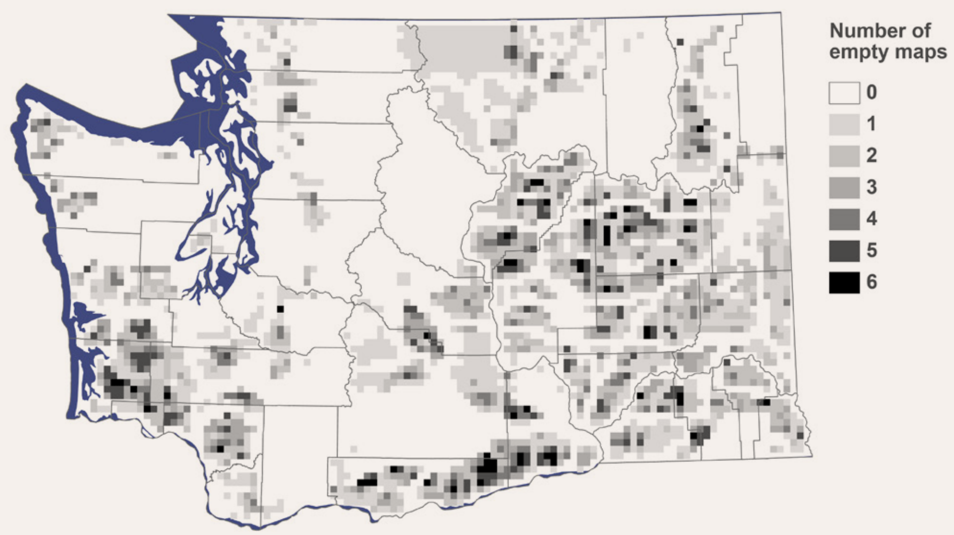

Figure 2. Composite result for the manual method showing number of maps marked as empty in each fishnet grid cell.

The process was repeated for all maps, with each receiving its own column in the grid's attribute table, marking whether that square was empty on that particular map. Figure 1 shows, in black, the empty cells for each individual map, as well as cells that were empty in all three maps of each type (web and print). The web maps had much more empty area than the print maps, likely because they were generated with the idea that the reader could zoom in to see more detail (it is unclear, however, how often map readers would zoom in to areas that were blank in the first place; this merits further study). The desire to avoid conflicts in automatic label placement might have also contributed to fewer features appearing in the web maps. In contrast, the print maps were limited to a single scale onto which the cartographers manually positioned as much information as possible. The WSDOT highway map has the least empty space, perhaps a reflection of the local knowledge and databases of the agency that produced it. Figure 2 shows, for each cell, how many maps were identified as empty, to provide an idea of which areas were consistently empty across the whole set of samples.

AUTOMATED METHOD USING INTERPOLATION

Although the manual method described above reliably identifies the major empty spaces, it requires much time and attention from a human analyst and may be difficult to scale up to large map sets. It is also subject to the modifiable areal unit problem, meaning that different results could be obtained if the grid were shifted or the cell shape or size were changed.

We originally hoped that automated image processing methods could be used to determine the map background color and isolate homogeneous regions of that color; however, identifying these contiguous regions turned out to be complicated due to creases, shadows, bleed-through, and other artifacts in the scanned paper maps. The presence of background shaded relief likewise caused problems. To address these issues, it was necessary to generalize the patterns in the maps in order to identify regions that were *more empty* than other regions.

Since all the maps used a light background with darker features and labels on top, it followed that generally lighter areas of the image would be more devoid of features. In some kinds of mountain cartography, bold tones of shaded relief might interfere with this line of thinking; however, the shaded relief in the study maps was relatively light in color and nondescript.

To identify generally light and dark areas, we converted the maps to grayscale using the *r.composite* function in GRASS GIS (accessed via the QGIS processing toolbox). This resulted in each pixel having a single integer value indicating its amount of lightness. Next, the map patterns were generalized by extracting random pixel values and using these to interpolate a surface, effectively re-creating the map in blurred form. To carry this out, we buffered a Washington state boundary polygon by 5 kilometers to mitigate edge effects in the eventual interpolation. Then, 100,000 random points were generated within this polygon. To force a more spatially even distribution, points were required to be at least 0.5 km from any neighboring point.[4]

For every map, a copy of the random points layer was made, each with an attribute table recording the grayscale

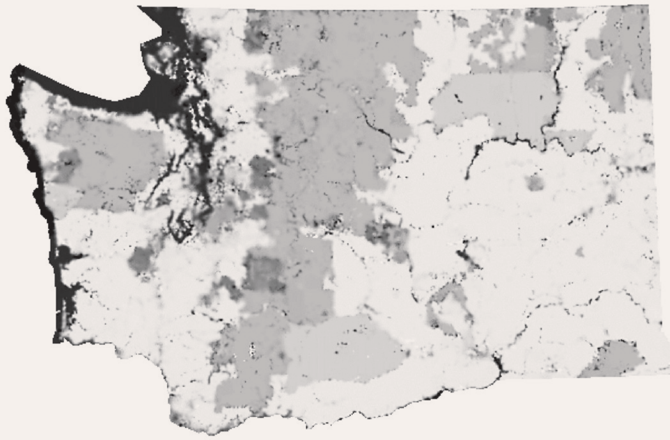

Figure 3. *Interpolated surface for OpenStreetMap, showing generally light and dark areas.*

pixel values intersecting each point. These points, now enriched with their underlying lightness values, were fed into the Empirical Bayesian Kriging tool in ArcGIS. Kriging is an interpolation method that uses trends in variance to generate custom weights for each neighboring point contributing to the interpolation (O'Sullivan and Unwin 2003, 265–281). Kriging was useful in this workflow because of the relatively smooth surfaces it generated; however, other kinds of interpolation methods could be used.

The kriging created a continuous interpolated surface that was then clipped to the Washington state boundary (with no buffer). The result was a smoothed or generalized version of the original map that made it easier to identify generally light and dark areas. The resolution of this surface was set at 1 km, making its output more nuanced than the manual method. Figure 3 shows an example of one of these kriged surfaces (resulting from OpenStreetMap).

Next, the surfaces were reclassified to isolate the lightest pixels. Since all the maps had different distributions and ranges of grayscale values and some maps included shaded relief, it was not practical to apply a universal cutoff value separating light and dark. Instead, since higher pixel values indicated lighter areas on the map, any pixel falling more than half of one standard deviation above the mean pixel value in the map was reclassified as light and given a value of 1, while all other pixels were reclassified 0. Cutoffs higher than half a standard deviation tended to rapidly eliminate area to the point of not being useful.

4. Interpolation tests involving lattices of evenly-spaced points yielded comparable results to the random points. The evenly-spaced lattices were somewhat better at preserving shapes and linework in the interpolated surfaces, although the surfaces derived from random points detected some features that were missed in the gaps of the lattice.

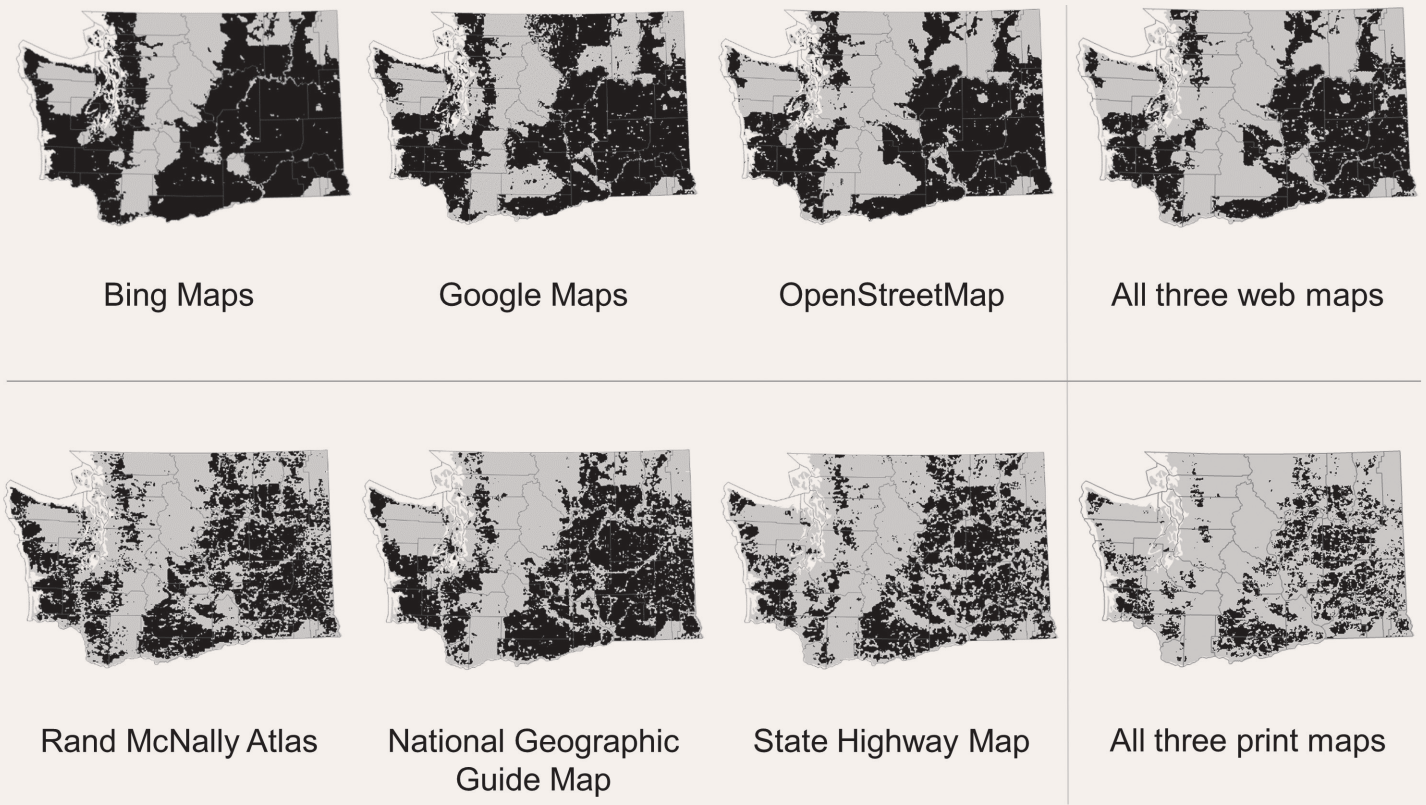

Figure 4. Empty spaces identified in each map using the automated method.

Figure 4 shows the six maps with "empty" areas above the cutoff symbolized in black. Again, the web maps show more empty area than the print maps.

The reclassified layers for the six maps were added together, indicating which areas tended to appear consistently empty (Figure 5). The 1 km cells of the automated method resulted in more nuanced spatial patterns than the 5 km cells of the manual method. Major highways like Interstate 90 and US 395 create discernible cuts through the empty spaces in eastern Washington. Differences in the inclusion of federal- and state-managed public lands are also apparent along the crisp vertical line dividing light and dark near the geographic center of the state (indicated by the red arrow in the figure). On the west side of the line, the Okanogan-Wenatchee National Forest is symbolized on most of these maps, while to the east, state-managed lands such as the L.T. Murray and Wenas wildlife areas are largely omitted.

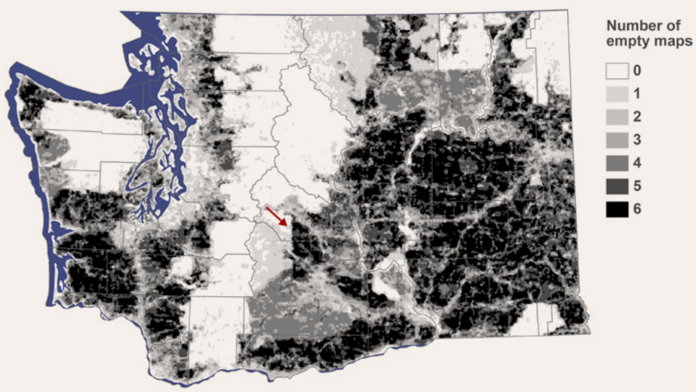

Figure 5. Composite result for the automated method showing number of maps that were empty for each raster cell. The arrow indicates a division between state- and federally-managed public lands.

COMPARING AND COMBINING THE METHODS

The automated method brings a potential for higher-resolution output, since using 1 km cells in the manual method would have been prohibitively time consuming. The lower resolution of the manual method also meant that very few cells were found to be empty in all six maps; to see more useful spatial patterns, it was better to also examine cells that were empty in four or five maps. The manual method, however, does result in greater certainty that the identified empty spaces are indeed empty on the map.

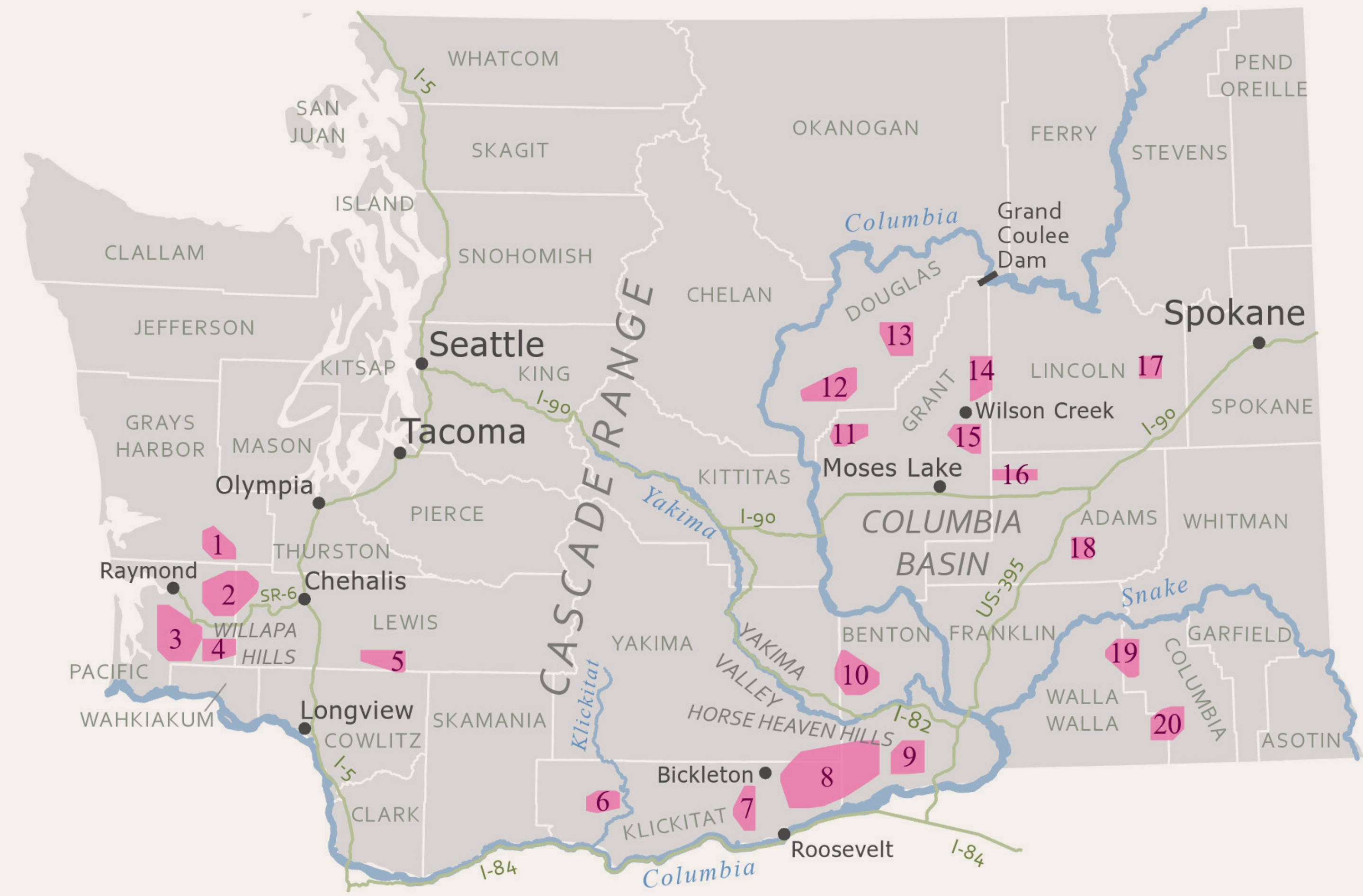

Figure 6. *The most empty areas on the Washington State maps as identified by the methods in this study. Numbers are for referencing the areas, and do not indicate a quantitative metric.*

With these things in mind, we combined the two methods by taking the areas found empty in all six maps when using the automated method, and then intersecting that with the areas found to be empty in four or more maps when using the manual method. The resulting polygons were very irregular in form, so convex hulls were drawn around the 20 largest to give them more comprehensible shapes. The polygons are shown in Figure 6, along with other geographical landmarks mentioned in this study.

Although there are scattered outliers, most of the polygons fall within three regions: (I) Willapa Hills timber country (areas 1–4), (II) high plains and plateaus between the Oregon border and the Yakima Valley (areas 6–9), and (III) dryland farms and shrub steppe on the periphery of the Columbia Basin Project (areas 11–18). The remaining outlying polygons (areas 5, 10, 19, and 20) each share characteristics with at least one of these three regions.

EMPTY SPACES ON THE WASHINGTON STATE MAP

In order to better understand the human and physical geography of these three regions, I overlaid additional GIS layers such as satellite imagery, tax parcels, and zoning. Street-level imagery such as that available on Google Street View was also examined where it was available, although many minor roads in the identified areas did not have any coverage. This information guided my visits to the three regions during September through November 2019. During these trips, I looked for signage about ownership and access, observed current land use practices, field checked information from the GIS layers, and toured industrial facilities. Following is a summary of the landscapes found in the three regions and how they connect with the regional, and even global, economies.

WILLAPA HILLS TIMBER COUNTRY

Some of the largest contiguous regions of empty map area are in Southwestern Washington's Willapa Hills, mostly in Pacific County and the southern part of Grays Harbor County. The moderate temperatures, heavy rainfall, and old soils of this area all contribute to rapid tree growth. Nearly all of the "old growth" present at the arrival of white settlers has been felled, and nowadays the forests are planted, nourished, thinned, and then entirely cut down on a roughly 50-year cycle. A view of satellite imagery in the area (Figure 7) shows a patchwork of timber lands in all stages of growth, from clear cut to ready-to-harvest trees. Figure 8 gives a view of this landscape on the ground.

Empty map areas in the Willapa Hills are owned primarily by Weyerhaeuser (which holds over 20% of the land area of Pacific County) and the State of Washington (which relies on timber revenue as source for local budgets).

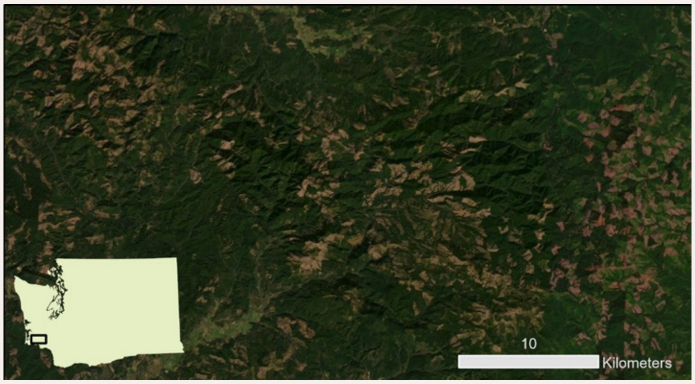

Figure 7. *Commercial forest in various stages of growth in southern Pacific County. This image includes parts of areas 3 and 4 from Figure 6. Source: Esri Imagery basemap.*

Figure 8. *Clear-cut and other managed forest land in different stages of growth, Pacific County. Photo by author.*

Rayonier, Hancock, Forest Investment Associates (FIA), and a handful of other private timber companies also manage lands in the empty spaces. The companies engage in strategic land swapping with each other to try to consolidate holdings and achieve the most profitable supply chains. Figure 9 shows the five largest landholders in Pacific County.

Only one major highway crosses this part of Washington. State Route 6 winds through the hills from Chehalis to Raymond, where a Weyerhaeuser mill takes in raw logs and outputs plastic-wrapped packages of lumber headed for The Home Depot and other domestic outlets. Still, this is a relatively small mill, and many of the ubiquitous logging trucks on the highway head west to Chehalis or Longview where they can fetch a higher price. Some of the trees wind up being shipped internationally. Piles of logs at the Port of Olympia await transport to Asian markets, where they will be milled according to metric standards.

On both sides of State Route 6, a vast labyrinth of narrow logging roads blankets the Willapa Hills. Traditionally,

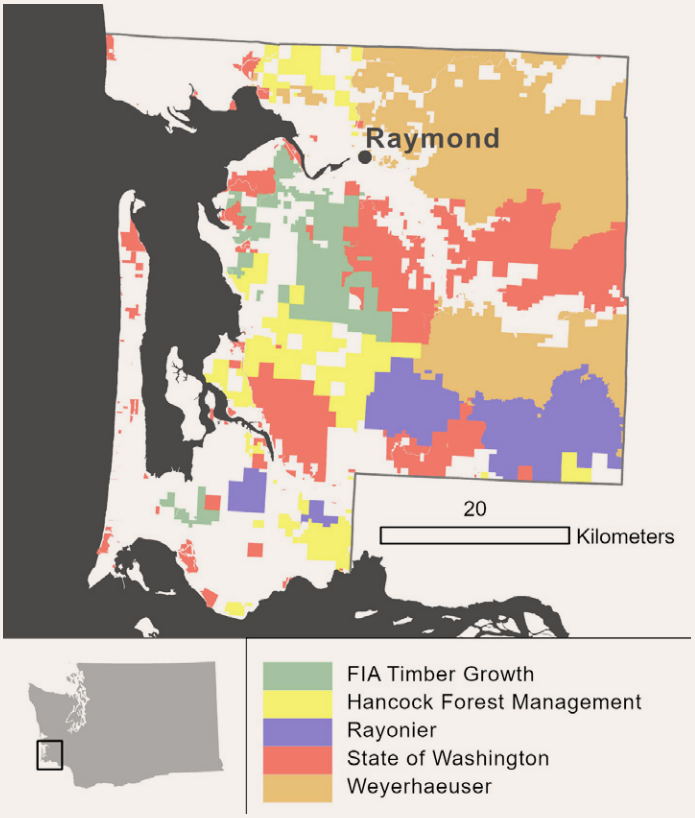

Figure 9. *Land owners with the largest holdings in Pacific County, as determined from GIS tax parcels data obtained from the county in 2019.*

most private timber lands in this area were open for the public to roam, but in the past decade the companies have installed locked gates at their road entrances to deter dumping, poaching, and other destructive activities. Weyerhaeuser now operates a recreation permitting system that allows the company to claim some revenue from the use of the lands while keeping track of who enters. State roads are still open, although they are often narrow, unmarked, and difficult for ordinary passenger vehicles to navigate. Thus, much of the empty space on this part of the map is impenetrable by most of the local population, even though these people rely on the timber resources for economic support and public service funding.

In this part of Washington, clear-cuts are common sites. The denuded landscape can be a shock to visitors unaccustomed to the practices of commercial logging. It is more economically efficient for companies to harvest an entire stand, and the full sunlight allows the stand to regenerate more quickly, at an even pace. Such clear-cuts have recently been avoided in forests visible from the most urban parts of the state. Outside this view, in the empty areas of the map where rural economies and local budgets rely on logging, there is greater social license for clear-cutting and other rotational forest management practices.

HIGH PLAIN BETWEEN THE OREGON BORDER AND THE YAKIMA VALLEY

A second notable cluster of empty areas is found in South Central Washington, bounded by the Cascade Range to the west, the Horse Heaven Hills and Yakima Valley to the north, and the Columbia River to the east and south. Most of this land is situated on a sparsely-inhabited, high, and dry plain, punctuated only by the deeply gouged drainage systems of the Klickitat River, Rock Creek, and Alder Creek. These gulches hinder travel, and there is little reason for people to traverse them when Interstate Highways 82 and 84 offer quick east-west routes on either side.

The landscape in this area consists of large farms, ranches, and vineyards, as well as uncultivated rangeland. Coniferous forest appears in the higher elevations skirting the Cascades. Some of the farms are close enough to the Columbia to be fed by pumped water. Irrigation is often applied through center pivot systems that result in emerald circles on a satellite image. Potatoes, corn, onions, carrots, and other row crops flourish in this environment.

The largest of these irrigated farms in the study area (partially intersecting area 9 in Figure 6) is operated by AgriNorthwest, a for-profit subsidiary company of The Church of Jesus Christ of Latter-day Saints. The church's farmland holdings in Benton County alone total over 350 square kilometers, with additional land in Walla Walla County to the east. Latter-day Saint leadership has viewed agriculture as a safe and profitable investment for a portion of the church's finances, one that could be repurposed to bolster existing church welfare farming activity in times of extreme need (Deseret News 1991). Similar farms and ranches can be found throughout the United States, and in other countries such as Canada and Argentina.

To the northwest of this farm, the Horrigan family holds land and ranches totaling over 180 square kilometers in Benton County (straddling area 8 in Figure 6). Their wheat crops sit outside the irrigated region and depend on whatever moisture falls from the sky. In the early 1950s, then-owner Leo Horrigan was one of the first to experiment with hiring "rainmakers" who seeded clouds with silver-iodide particles in hopes of increasing raindrop production, an experiment that according to Frank Taylor (1954) was successful.

Further west, in Klickitat County, sprawling wind farms take advantage of air masses forced through the Columbia River Gorge (Sharp and Mass 2004; Figure 10). In 2005 the county designated an "energy overlay zone" to expedite the permitting process for wind power projects. This zone covers the entire eastern part of the county, which is otherwise empty space on the map, occupied by a few scattered farmers and ranchers. Wind developers flocked to the area, and within four years of the zone's creation, the county's taxable property base grew from $1.7 billion to $3 billion (Mulkern 2010). The revenues were enough to

Figure 10. *Wind power production in Klickitat County. Photo by author.*

finance a new high school in the only town in the county's eastern interior, Bickleton. At the time of this writing, the county's web site lists 14 permitted wind farms (**klickitatcounty.org/273/Wind-Projects**), which supply power to public and private utilities all over the Pacific Northwest. One of these intersects area 7 in Figure 6.

The region has also caught the eye of solar developers, and nearly seven square kilometers of mixed public and private land in Klickitat County are slated for the construction of half a million photovoltaic panels that will supply power to Puget Sound Energy (PSE). Financing stems from PSE's "Green Direct" plan, which allows its municipal and corporate customers (most of whom are located in suburban Seattle and Tacoma) to purchase 100% of their power from local renewable sources (The Columbian 2019).[5] The project, located fewer than 5 km west of area 8 in Figure 6, would be the largest solar power endeavor in Washington State.

In addition to supplying electricity to urban households, eastern Klickitat County also receives a substantial portion of their trash. Each day, multimodal shipping containers full of the Pacific Northwest's garbage arrive on rail cars at the small town of Roosevelt and are trucked up the hill to Republic Services' Roosevelt Regional Landfill, which takes refuse from as far away as Alaska. The ashes of burned trash from the city of Spokane are also brought to the landfill, where they are mined for metals before being laid to rest. Methane gas from beneath the landfill is harvested and converted into a natural gas product like that used for powering vehicles. The landfill itself sits in a natural bowl and is invisible to passers-by on paved county roads. Its underlying geology of low-permeability clay and basalt rock make it ideal for depositing trash, and Waste Management operates a facility of similar magnitude just across the river in Oregon.[6]

DRYLANDS ON THE PERIPHERY OF THE COLUMBIA BASIN

The third region abounding in cartographic empty spaces is arid farmland on the far reaches of the Columbia Basin in Douglas, Grant, Lincoln, and Adams Counties. The more populous, central part of the basin is irrigated through the Columbia Basin Project, a program run by the United States Bureau of Reclamation to distribute water extracted at Grand Coulee Dam (**usbr.gov/pn/project/brochures/columbiabasinproject.pdf**). Beyond the extent of this project, the agricultural landscape changes to mostly dryland wheat farming, in which fields are frequently left fallow to absorb a year of the region's scant precipitation before replanting (Delevingne and Turner 2011, xiv). Most of this wheat is exported, with Asian countries such as the Philippines, Japan, and South Korea being top buyers from Washington State (Granillo 2019). Farmers must work around enormous "erratic" boulders left by ancient glaciers (Figure 11), and land too steep or rocky for cultivation is often given over to cattle grazing.

Figure 11. *Cultivation around glacial erratics in Douglas County, Washington. Photo by author.*

Infrastructural connections with the more urbanized western side of the state are still strong here, although perhaps difficult to see at first glance. Since 1992, wheat, hay, canola, and sunflower farms in rural Douglas County have received over 2 million tons of treated sewage sludge from around Washington State as "biosolid" fertilizer (King County and Boulder Park, Inc. 2019). The majority of this comes from the Seattle and Tacoma metro areas in tanker trucks that make their way over the Cascade Range. The program is operated as a public-private partnership between King County (which contains Seattle) and Boulder Park, Incorporated. Some of the participating farms fall within area 12 of Figure 6, and others adjoin area 13. Such applications of biosolids are generally accepted as an economical way to dispose of human waste while improving soil properties and providing an organic fertilizer option, although efforts are ongoing to understand the ways that long-term accumulation of pharmaceuticals and personal care products (PPCPs) in the biosolids might affect human food and drinking water supplies (Lu, He, and Stofella 2012; Clarke and Cummins 2015; Healy et al. 2017).

5. For information on the Green Direct program, see **pse.com/green-options/Renewable-Energy-Programs/green-direct**.

6. Much of this information comes from my notes taken at the facility during their annual public open house in 2019.

People have sought out the sunny reaches of the Columbia Basin periphery as a place to get away. A stark example is in area 15 of Figure 6 in the northern part of Grant County, just south of the town of Wilson Creek (imagery shown in Figure 12). Here, uncultivated rocky shrublands have been carved up into parcels and sold off as part of a development called Eagle Springs Ranch. "Private Road - No Trespassing" warnings adorn each road sign. According to local real estate agents, many owners have purchased these parcels in order to have their own slice of the wilderness where they can pursue rest or recreation in solitude. An advertisement for one such lot (now on the market for about 4 years) proclaims that the space is "perfect for horse riding, hunting, or just bring the RV and get away." A look through local tax records shows numerous owners from Seattle, Tacoma, and Southern California who have apparently been trying to do just that; however, the land is perhaps more remote than people bargained for and occupants must bring their own accommodations for electricity and water. Most lots have no vehicles or structures on them.

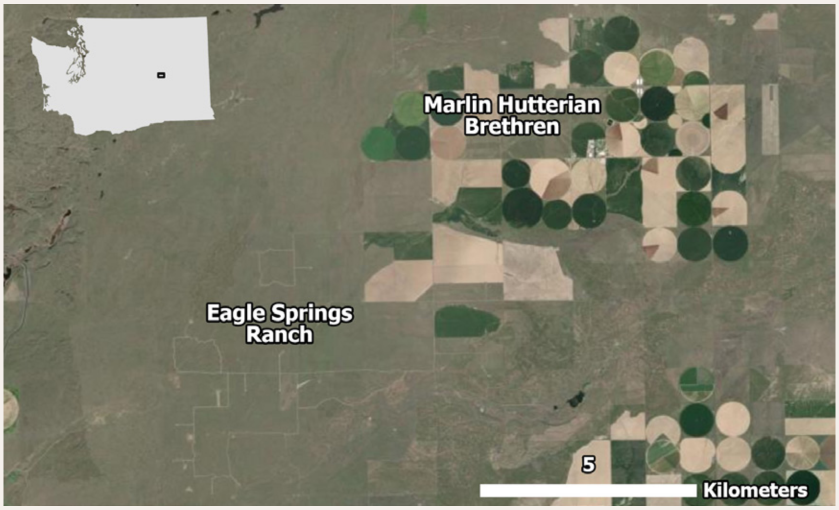

Figure 12. *Eagle Springs Ranch and Marlin Hutterian Brethren neighboring each other in one of the map's empty spaces. Source: Esri Imagery basemap.*

Next to this mostly absentee neighborhood lives the community of the Marlin Hutterian Brethren, surrounded by their farmlands. The Hutterites are a Christian sect that share roots with the Amish and Mennonites in the Anabaptist movement of the 1500s. Early Hutterite settlement in the Americas was largely confined to the Dakotas and the Prairie Provinces of Canada; however, in the 1950s and 60s, some Hutterites moved from Alberta to Washington State to take advantage of the longer growing season and fertile soils (Youmans 1995). Hutterite colonies regularly break off and migrate in this fashion to ensure that no one group grows unmanageably large. This pattern has produced four Hutterite colonies on the periphery of the Columbia Basin Project (Warden, Stahl, Marlin, and Schoonover), all established between 1972 and 1980 (Janzen and Stanton 2010, Appendix).

Figure 13. *Hutterite colony in Eastern Washington filling space in Google Maps (January 2020). Overview map added by author.*

Hutterites live in colonies of typically 50–120 members, sharing material goods, favoring conservative dress, and attending daily religious services. They use modern farming technologies to provide the best yields possible for their communities, but prefer to avoid extensive contact with the rest of society. In some respects, they have sought out the empty spaces on the map to practice agriculture and live a life unsullied by outside interference. Ironically, the Warden Hutterian Brethren colony appears prominently on Google Maps at the scale studied here, due to what appears to be an algorithm filling empty spaces with places from the USGS Geographic Names Information System (GNIS) database. The colony is labeled with the same font size as the nearby city of Moses Lake, which has a population of over 20,000 (Figure 13).

OBSERVATIONS AND DISCUSSION

What created these empty areas on the Washington State maps? In some cases, physical geography impeded human settlement in the area by making the spaces difficult to reach or traverse; yet, the areas also escaped any kind of protected status that would cause them to appear on a map. Such is the case with the Alder Creek watershed previously discussed (area 8 in Figure 6), or a feature marked on topographic maps as simply "The Plateau" nestled between the Cascade Range and the Klickitat Canyon (area 6 in Figure 6). Eastern Washington's glaciated landscape of deep coulees and river gorges creates a lot of "dead ends" with relatively little human settlement. Klimm (1954) noted a similar effect in the peninsular southern part of New Jersey.

Empty spaces also resulted from cartographers who chose to not to collect or include information about certain kinds of human activities and land uses. For example, it is not customary in these maps to describe private land ownership or development, even when tracts cover hundreds of square miles. Such practices could reflect cultural respect toward privacy, an unwillingness to be held liable for depictions of cadastral boundaries, or a hesitance to appear overly favorable or hostile toward any particular owner or activity.

The identified empty spaces in the Washington State maps play a role in shaping the landscape through public discourse, imagination, and activities. Since many of these spaces are used for energy production, waste disposal, and other NIMBY activities that sustain urban life, the blank spots on the map help perpetuate the shortsighted ideas that sewage and trash just "go away," and that electricity magically originates in the wall socket. The omission of large-scale energy and industrial projects on the map plays a role in keeping these activities outside of the public mind and scrutiny, while also discouraging personal visits to or explorations of the landscapes.

When it comes to protected areas, the empty spaces on the map may play a role in perpetuating myths of "wild nature," or the idea that broad swaths of the rural landscape remain unaffected by human activity. And although the frequent omission of locally protected landscapes such as state wildlife areas may keep people away from these places and thereby reduce human impact, the cartographic silence may become a liability if the protection is able to be rescinded or sold off with less public awareness.

GEOGRAPHIC CONNECTIONS

Despite their sparse populations, empty spaces on the map should not be considered isolated or excluded from regional or global economic processes. Everyday urban activities such as flipping on a light switch, throwing something in the trash, flushing the toilet, or cooking dinner are dependent on activities in these places. At the same time, town and county governments near the empty spaces have developed some fiscal reliance on urban consumption.

Driving to Washington's empty spaces is a good way to see trucks. These roaring behemoths transport trees, vegetables, garbage, and treated sewage all around the Northwest, passing every couple of minutes on some roads I traveled. Some of the food and timber produced in Washington's empty spaces is taken to ports and shipped overseas to international markets. Events thousands of miles away can and do affect daily life for residents of the empty spaces who depend on these markets.

Mitchell (2008) observed that landscapes are deeply functional in the capitalist society. This is true of the empty spaces on the map, many of which have been acquired by big industries who can use them to achieve economies of scale and conduct activities away from the public view. Examples mentioned in this study are Weyerhaeuser, Rayonier, AgriNorthwest, Republic Services, Boulder Park, and the myriad energy companies operating wind (and soon solar) projects.

Areas not swallowed up by industry have been sought out by people desiring a few acres of their own to live or play in solitude. Intruders are not always welcome. Even while driving on a public road, my effort to visit one of the empty map spaces was interrupted by a man suspicious of what I was doing near his property (turns out that theft had been a problem). The smaller individual parcels intermingle with the large projects to create an intriguing patchwork of individuals and corporations that want to remain unbothered.

POTENTIAL INTERVENTIONS

These many examples prove Harley right: even in the map's silences, there are consequential things happening. How, then, should cartographers make decisions about what to show in these spaces? Communicating some element of land use or land cover is one way to begin. The Esri Topographic basemap does this, using green tints to depict areas covered by forest and irrigated agriculture. The main map on **OpenStreetMap.org** also shows various land use categories, although many remain to be filled in by users. In early 2020, about the time this paper was going to press, Google Maps added green tints on thickly forested areas. This effectively "filled in" some of the blank areas in southwestern Washington, while revealing rotational patterns of forest management.

This study has demonstrated that protected areas at the state and municipal levels are sometimes overlooked in maps. Giving more prominence to these areas would increase map readers' awareness of their connections with the Earth's resources and how those are conserved, used, or exploited. National forests and parks were prominently symbolized on the studied maps, but common citizens might be able to exercise a more direct influence on the management and use of local parks, refuges, and reserves if these places become more widely known and recognized.

Cartographers working on algorithmically-generated maps can look to expand their databases of points of interest beyond pizza restaurants and public buildings to include some of the vital industry and infrastructure (both public and private) supporting day-to-day life, such as major farms, landfills, energy projects, and commercial forests. Crowdsourcing provides opportunities to infuse local context and variety into the set of map features. Web maps could also invite users to interactively explore the landscape, to click any map area and learn more. Google Maps's "What's here?" option allows the user to retrieve an address and street-level imagery thumbnail (where such images exist). Such options might be expanded by ancillary text, user-contributed photography, alternative map depictions (even countercartographies), and so forth.

SUGGESTIONS FOR FURTHER RESEARCH

This study has only examined a single scale and type of map. Since web maps change their representation as users zoom in and out, research is needed about which areas persist as empty at each scale. Such an inquiry from the top scale down might result in empty "volumes" that could then be further interrogated for connections with land ownership and use, following the patterns presented in this study.

Finally, it would be useful to understand how map readers interact with and interpret empty spaces. Danyel Fisher's (2007) "Hotmap" of Microsoft's online map tile access showed that user attention focuses on urban areas, coastlines, and highway networks. People interact most with the lands they know and traverse. Outside of those areas, does the lack of features at one scale prevent users from zooming in further to discover more, or does the emptiness encourage them to drill in and explore? These are related to larger questions about how web maps and their empty spaces are associated with geographic literacy and understandings of place. This is an important topic for a generation that has grown up with online maps, where companies like Google, Microsoft, and Apple define the empty spaces and shape human perceptions of the world.

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Evaluating Methods for Downloading OpenStreetMap Data

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INTRODUCTION

Often, one of the greatest limitations in creating maps or performing spatial analysis is acquiring data. OpenStreetMap (OSM) is useful resource which offers a wide variety of easily accessible datasets under an Open Database License (ODbL), including those that can be hard to find for some areas, such as parks, building footprints, and street centerlines. There are several ways to access and download OSM data, but many of these methods can be difficult to use due to their limited functionality or complexity. Additionally, they may require users to process the data, or purge unnecessary portions. In this piece, I explore multiple methods for downloading OSM data and evaluate them alongside the QuickOSM plugin for QGIS.

OPEN SOURCE DATA AND OSM

OSM, supported by the OpenStreetMap Foundation (OSMF), is a community-driven collection of global geospatial data portals that is maintained by a diverse range of enthusiasts and professional geospatial users (**openstreetmap.org/about**). One of the main advantages of OSM data is that it is open source, meaning it is free for anyone to use, access, modify, and share, as long as they preserve the origin attribution and openness. This enables its contributors to build large, complex datasets that would be impossible to create by small groups or with limited funds.

While open source data has many advantages, it is not without its limitations. The data quality is inconsistent when compared to proprietary data. Some geographic locations might have more accurate and detailed information due to more people adding and updating data, while other areas may have little to no data at all. Additionally, the lack of standards or methods for data entry, along with contributions from users with limited skills, sometimes makes open source data less accurate when compared to proprietary data. For example, Figure 1 shows some of the limitations of OSM data: each marker represents unresolved notes or known errors in the data. Nonetheless, open source data can be a viable source of spatial information that can be beneficial even with its limitations, especially in instances where it is more up-to-date than or has information that is not present in other sources.

Accessing, editing, and downloading OSM data can be achieved in several ways through different Application Programming Interfaces (APIs). Editing data is handled by the main OSM API, through which users can add and modify data. In contrast, the Overpass API is a read-only option, and is optimized for consuming selected portions of the data. Clients are able to send a query to the Overpass API with parameters such as location, object type, or other desired properties, and receive a response

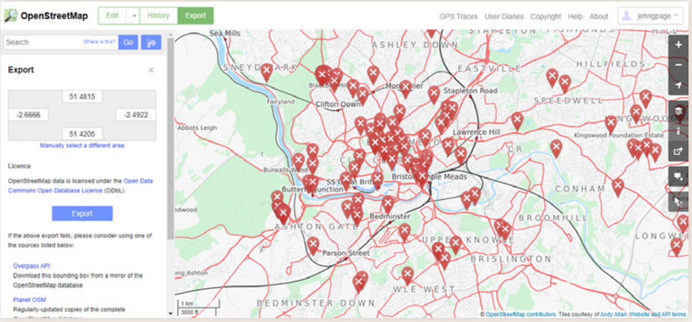


Figure 1. OpenStreetMap web portal. Red X markers represent unresolved notes and errors, demonstrating the potential issues with OSM data.

containing information for the features that satisfy the query. Though OSM's APIs allow interaction with the data, using them successfully can require extensive knowledge in programming and coding, making them difficult to use for many users.

Alternatively, users may use the OSM website to export data in the OSM file format, which can be opened in some GIS software, such as QGIS. While its use does not require programming skills, the tool is basic and limited. First, there are no options to filter the data by layer type (e.g., roads, natural features, etc.) and the location selection tool is limited. This means that users will have to remove unwanted data after it has been downloaded. Furthermore, the tool is limited to downloading datasets that include fewer than 50,000 nodes. The ability to download more nodes is essential where a user needs to acquire significant amounts of data for large regions or highly dense urban areas where nodes would commonly exceed this limit.

The OSM web portal suggests using one of many third-party options to access OSM data, such as Planet

Sub Region	Quick Links			
	.osm.pbf		.shp.zip	.osm.bz2
Africa	[.osm.pbf]	(3.9 GB)	✖	[.osm.bz2]
Antarctica	[.osm.pbf]	(29.0 MB)	[.shp.zip]	[.osm.bz2]
Asia	[.osm.pbf]	(8.3 GB)	✖	[.osm.bz2]
Australia and Oceania	[.osm.pbf]	(790 MB)	✖	[.osm.bz2]
Central America	[.osm.pbf]	(383 MB)	✖	[.osm.bz2]
Europe	[.osm.pbf]	(21.7 GB)	✖	[.osm.bz2]
North America	[.osm.pbf]	(9.4 GB)	✖	[.osm.bz2]
South America	[.osm.pbf]	(2.1 GB)	✖	[.osm.bz2]

Figure 2. *The Geofabrik portal's list of OSM data by "Sub Region," showing file sizes and data formats.*

OSM or Geofabrik. Due to their large sizes, the datasets will typically be grouped into regions. For example, Geofabrik offers datasets broken down by continents, countries, and sub-national regions (see Figure 2). The whole of Europe is currently around 21.7 GB, while Great Britain is about 1 GB of data. Geofabrik does not offer data at the city level, thus country or sub-national data has to be downloaded, with users then needing to extract the portion in which they are interested or manually delete the excess. These data portals are viable options in obtaining data that users may need, but they do not provide extensive tools to filter data and select the relevant portions.

QGIS

QGIS is a widely used program that supports OSM data and, like OSM, it is free and open source (qgis.org/en/site/about). The software is a volunteer-driven project maintained by a community of dedicated volunteers and organizations who develop its code and maintain documentation. The software allows users to create, edit, visualize, and analyze data from several vector, raster, and database file formats—including OSM files—and can be used on a variety of platforms including Windows, Mac, Linux, and BSD.

QGIS can also be enhanced with a series of plugins that perform a variety of tasks that are not part of the core QGIS software. These plugins have been developed to streamline workflows or perform a specific type of analysis. The QGIS plugin manager (Figure 3) accesses a collection of ready-to-use plugins that can be directly installed. As of November 2019, there are several QGIS plugins that utilize OSM data, but only two (QuickOSM and OSMDownloader) are designed to download the data. Other plugins, such as Pelicas Geocoding and ORS Tools, may query OSM data to pull additional geospatial information or provide geocoding services.

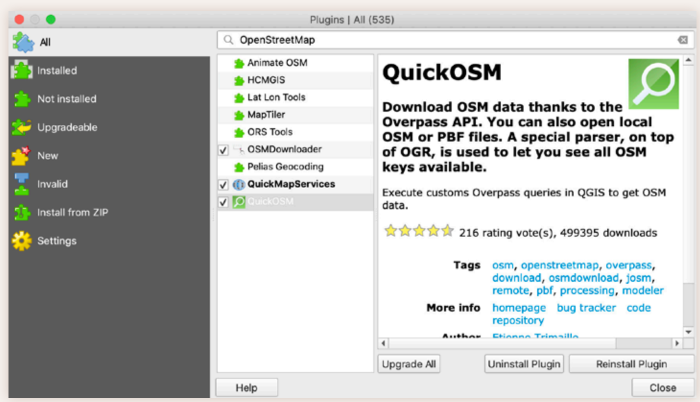


Figure 3. *QGIS Plugin Manager showing OSM plugins.*

OSMDOWNLOADER

OSMDownloader is a plugin developed by Luiz Andrade (Github username: lcoandrade) that uses the Overpass API to download OpenStreetMap data. It features a simple user interface that is easier to use than the Overpass API itself. To use the plugin, the user draws a rectangular area on the QGIS map window using the selection tool. The plugin then queries the Overpass API and downloads all spatial data within the designated rectangle. In Figure

4, for example, I've specified an extent covering the area around Bristol, in the United Kingdom. The plugin provides an easier interface than either the OSM web portal or Geofabrik, and the custom extents keep file sizes manageable; the data for the Bristol area added up to only about 513 MB.

Although the OSMDownloader plugin provides access to OSM data, it combines all the data into a few layers that are separated only by geometry type (points, lines, and polygons), as shown in Figure 5. Datasets that might normally be separated into discrete layers, such as streets and rivers, are grouped together. Simliar to Geofabrik and Planet OSM, this requires additional data processing to separate out the feature types that are needed and removing those that are not. This additional process can be very time-consuming.

QUICKOSM

QuickOSM is a plugin that, like OSMDownloader, provides access to OSM data using the Overpass API. Developed by Étienne Trimaille (Github username: Gustry), QuickOSM provides a GUI to build Overpass API queries. Additionally, there is a tool for loading OSM or PBF files. PBF files, like OSM files, store spatial data and the format was created to support future extensibility and flexibility.

The QuickOSM tool has several options for adding data to QGIS. The **Quick query** (Figure 6) is a fast and easy tool to search for different datasets, allowing them to be filtered by the extent of whatever data are currently loaded into QGIS, or by querying based on location information

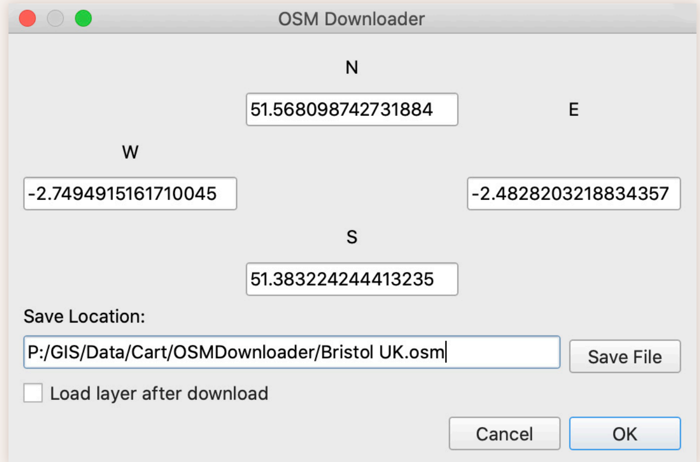


Figure 4. *OSMDownloader user interface, showing the extent of the selected area.*

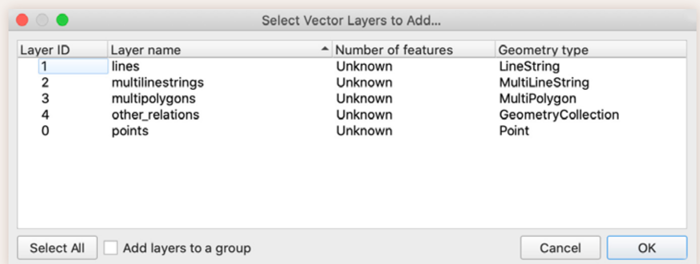


Figure 5. *The file obtained through OSMDownloader contains layers differentiated by geometry type.*

found in those data. The second option is to use the **Query** tool to build your own custom query scripts. When using the **Quick query** option, such scripts are created automatically for the **Query** tool in QuickOSM. The third option QuickOSM provides is the ability to open data in the OSM file format. While QGIS already supports the OSM file format, the QuickOSM plugin allows the user to filter the file by geometry type.

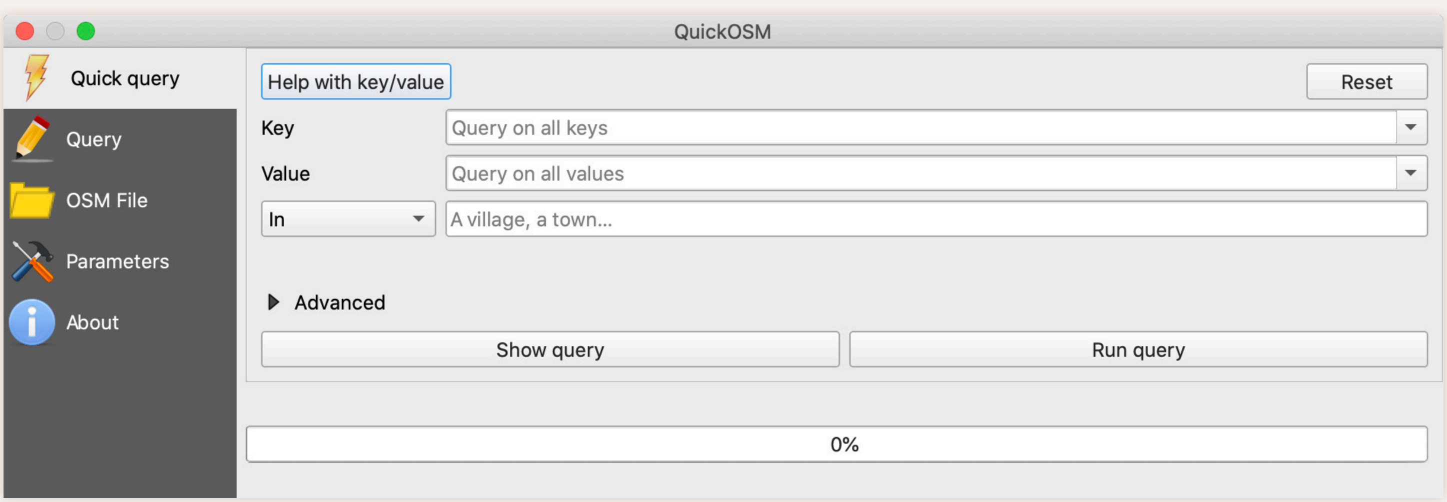


Figure 6. *QuickOSM **Quick query** user interface, showing options to filter data.*

Figure 7. *A map in QGIS, showing datasets before the addition of OSM data.*

QUICKOSM WALKTHROUGH

The QuickOSM plugin user interface allows users to query data and filter results using multiple inputs. This helps them quickly access only the data and information needed for a specific project. In order to further evaluate the QuickOSM tool, let's walk through a sample project to show the benefits of using the tool. In this project example, we begin by loading data showing parks and green spaces in the city of Bristol into QGIS, obtained through Bristol's open data portal (**opendata.bristol.gov.uk**). The resulting map (Figure 7) is somewhat sparse; road and building data would provide additional context to the map. Using the QuickOSM plugin, we will add this data.

QUICKOSM - QUICK QUERY

The plugin offers three main fields to filter data: **Key**, **Value**, and option to choose a spatial location. Under the

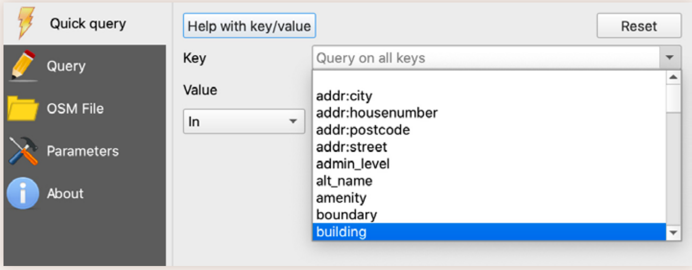


Figure 8. *Selecting building data from OSM.*

Key dropdown menu (Figure 8), there are options for the type of feature to select. We will choose **building** from the list. Just below **Key**, the **Value** field (Figure 9) allows the user to filter by specific types of attributes. This option is only available on certain feature types after the **Key** is selected. In this case, we can select **Query on all values** to capture all building types.

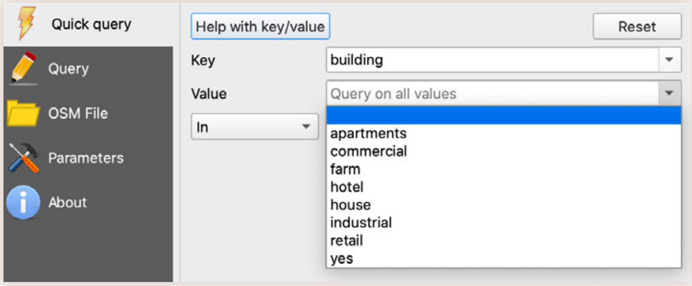


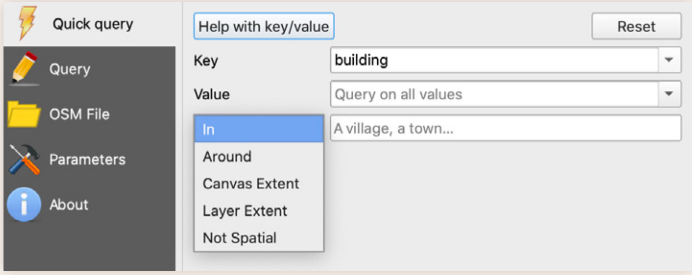
*Figure 9. The **Value** dropdown allows users to specify building type.*

Once we have described what sort of data we want, there are several methods for selecting data in a specific area. For this example, only buildings within Bristol are needed, and downloading a larger area would be unnecessary. The options for selecting a target area, using the dropdown menu below **Value**, are shown in Figure 10.

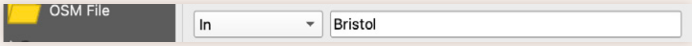
By clicking **Advanced**, a series of options appear (Figure 11) that allow greater customization of what type of data is returned, as well as letting the user specify how long to wait if the server cannot process the request, and a permanent file location in which to save the data.

QUICKOSM - QUERY

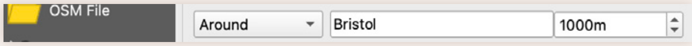
Once a query is created through the **Quick query** window, we can switch to the **Query** window (Figure 12) to view the script that will be sent to the Overpass API. Advanced users can edit the script, fine-tuning the output.



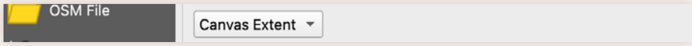
In: Select data within a specified location. This example will select buildings within Bristol.



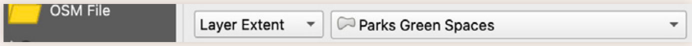
Around: Select data within a specified buffer distance of a specified location. This example will select buildings in Bristol and within 1000m of Bristol



Canvas Extent: Select data within the current map canvas (map view).This example will select only buildings visible in the map view.



Layer Extent: Select data within the extent of a currently loaded dataset. This example will select buildings within our public spaces and not outside of them.



Not Spatial: Select data without any boundary limit. This example will select all buildings in OSM, worldwide.

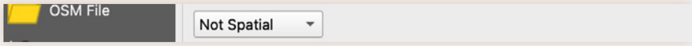


Figure 10. Options for selecting by location.

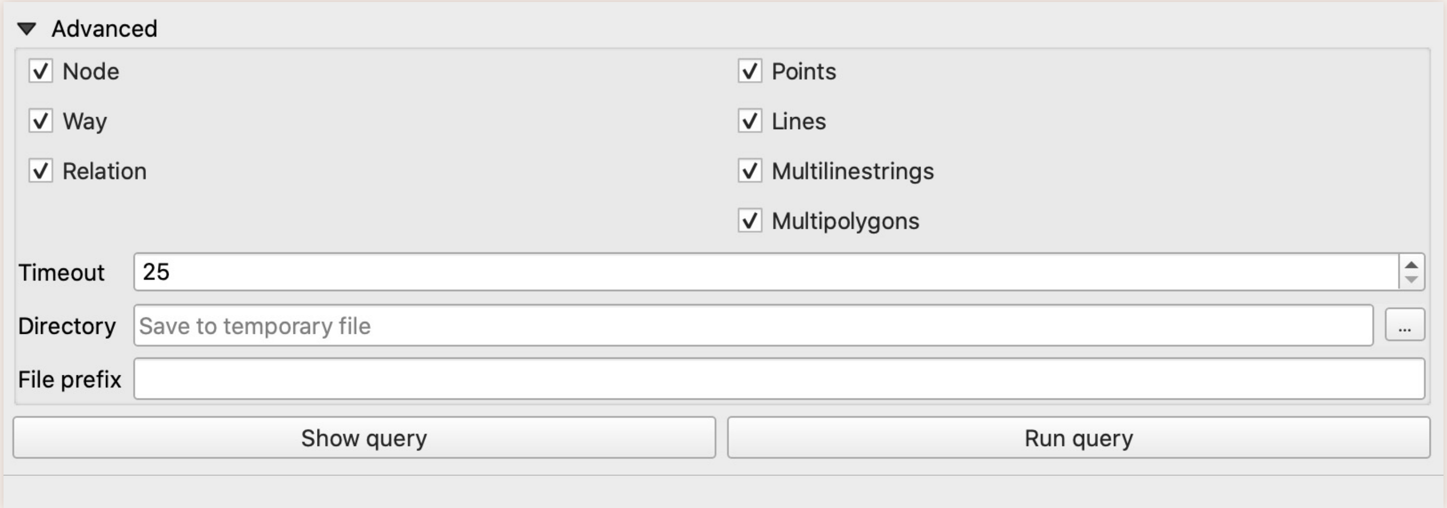


Figure 11. Advanced settings let us select data types, specify timeout settings, and choose where to save data.

Combined with the **Quick query** tool, users can quickly use the **Query** tool to create customized queries.

The advanced options of the **Query** window (Figure 13) are similar to **Quick query**, allowing for additional conditions on what data is returned. Using them, we can control the type of data returned and specify where it is saved, and we can additionally limit the geographical extent of the data.

EXECUTING QUICKOSM QUICK QUERY AND QUERY TOOLS

Running the query will execute the request to an Overpass database. If a file location is designated in the **Directory**, the file will be saved to the disk. Otherwise, if we leave it blank, the file will be stored in a temporary file location

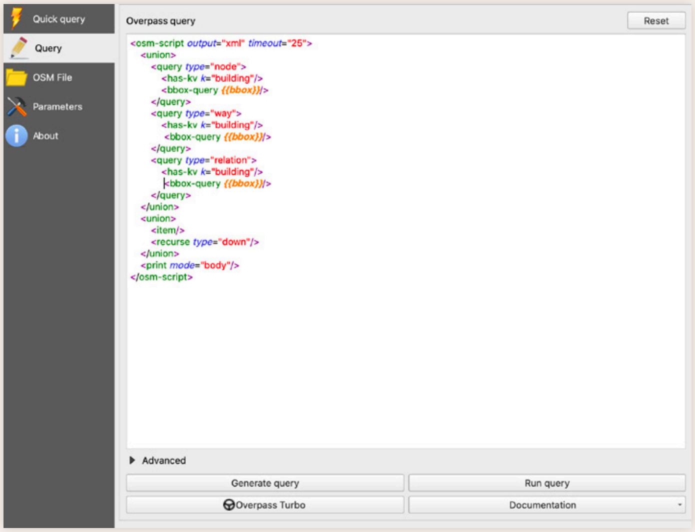


Figure 12. *The* ***Query*** *text editor allows the user to further customize the query.*

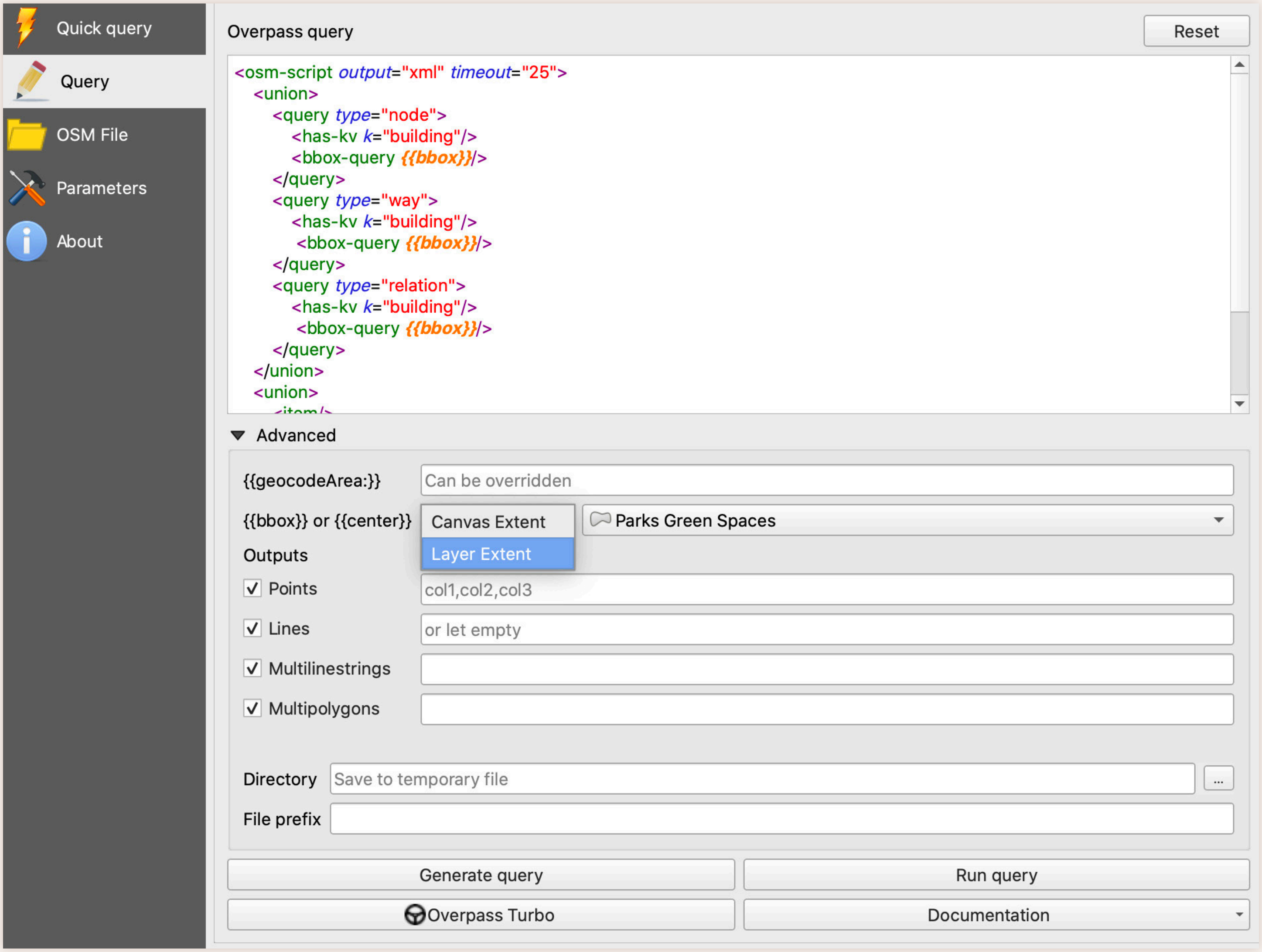


Figure 13. *Advanced options to select data extent and type, as well as save-as options.*

and be removed once QGIS is closed. Once the process is complete, we can close the plugin tool to view the new layers in the map and the **Layers** panel. Figure 14 shows that the building layers have been added as temporary files. These new OSM layers deliver additional spatial context and augment the parks and green spaces layers.

QUICKOSM - OSM FILE

The QuickOSM plugin has an option to add OSM data in OSM format (Figure 15). As noted earlier, both PlanetOSM and Geofabrik allow users to download OSM data in this format. However, QGIS already supports the OSM format, so this part of the plugin does not offer anything new outside of the core application capabilities. Like the other QuickOSM tools, there are options to import specific data types and to open the data as a temporary file.

SAVE OSM DATA

There are two methods to save OSM data accessed through the QuickOSM plugin. The first one is one mentioned previously: the plugin allows the user to designate a location in which to save the data as it is downloaded. However, QGIS also allows a user to work with data files in a temporary state. This method stores data to

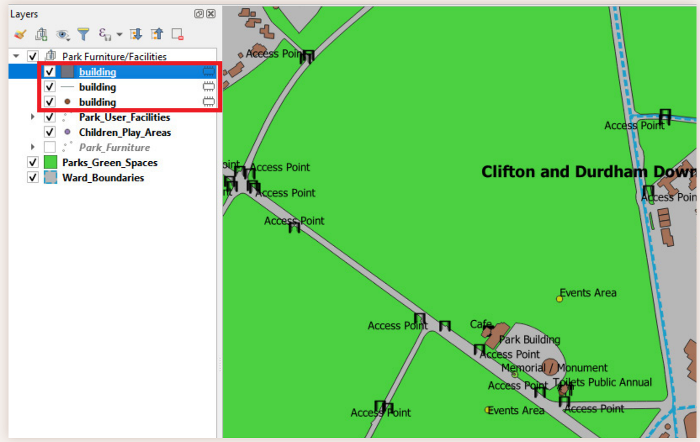


Figure 14. QuickOSM temporary layers. The red box highlights the temporary layers added.

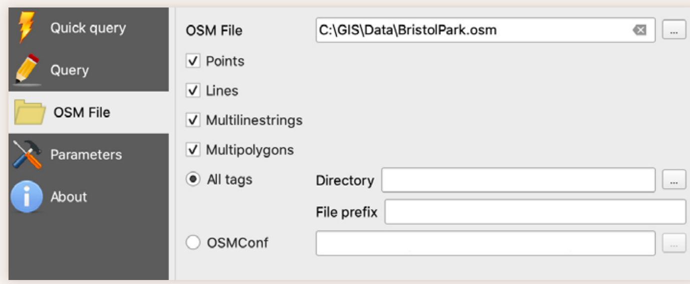


Figure 15. OSM file import options.

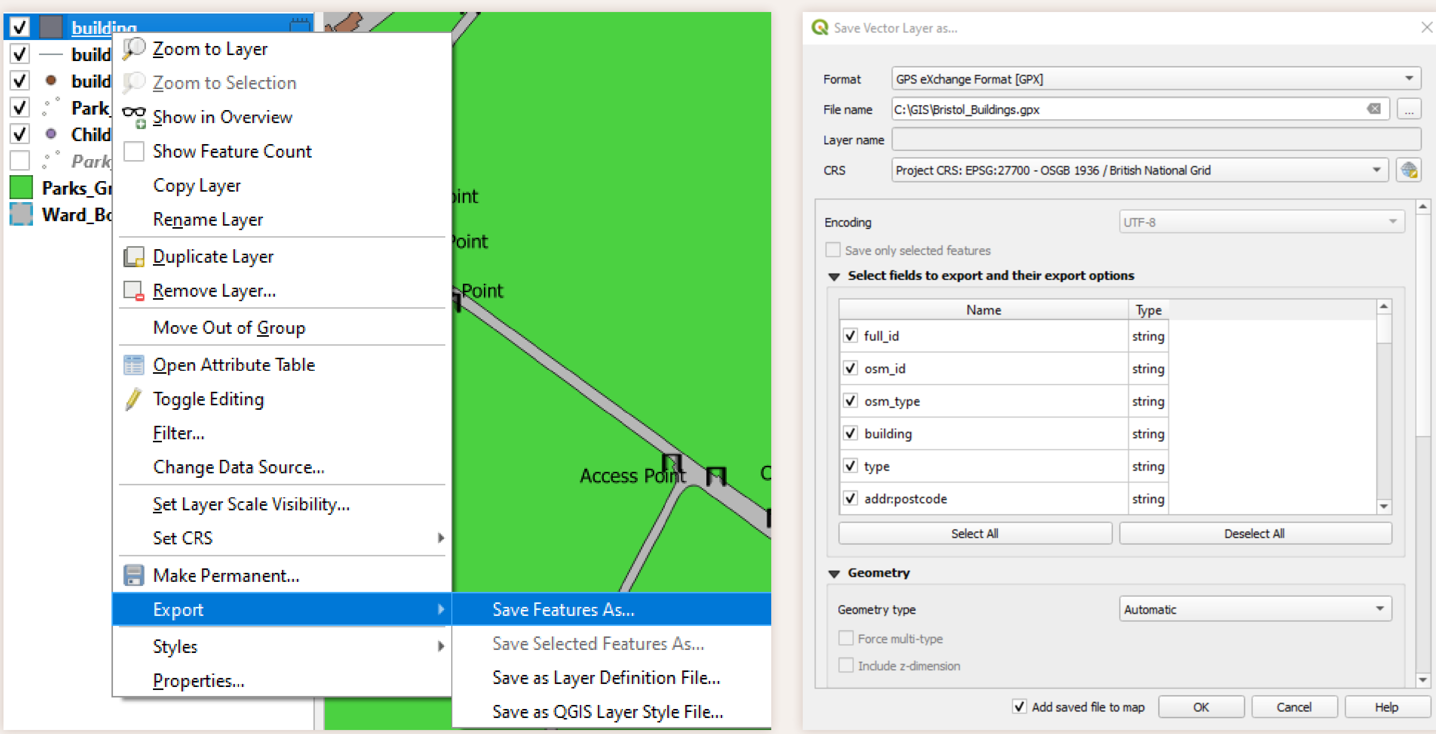


Figure 16. Saving temporary layers from the QGIS table of contents.

a temporary folder on the local computer, which requires disk space. However, if the downloaded data is not needed, it can be discarded without having to remembering to remove the associated file. QGIS will display an icon in the **Layers** panel next to any layer that is stored temporarily, as can be seen in Figure 14. The second option for saving the OSM data is to simply save the temporary layers, by right-clicking the layer, selecting **Export**, then **Save Features As…**, and then selecting a location in which to save the data and specifying a file format (Figure 16).

FINAL MAP

In our example, the data we obtained from OpenStreetMap can give additional context to existing data we obtained from Bristol's open data portal. In Figure 7, there is data on public spaces, but there is no information in the map regarding the spaces in between the public spaces. Figure 17 shows additional context using OSM data: buildings, roads, bus stops, and crossing locations have all been added, offering information about accessibility, and the setting of the public spaces.

SUMMARY

Although QuickOSM and OSMDownloader both provide fast and easy tools to access and download OpenStreetMap data, QuickOSM is the more versatile of two, allowing a user to select specific data types and datasets. The interface in QuickOSM is easy to use compared to OSMDownloader and has options for selecting specific datasets and locations. Additionally, the interface in QuickOSM does not limit the user to a specific menu of options when selecting a dataset, instead allowing experienced users to customize the data query. Using QGIS and the QuickOSM plugin greatly enhances the accessibility of OpenStreetMap data. They can save considerable time by eliminating much of the post-processing needed when downloading data using other methods.

Figure 17. *Map after the addition of OpenStreetMap data.*

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Madison and Vicinity: A Tangible Map Quilt

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INTRODUCTION

Technology imposes a range of constraints on our design vision. This can be frustrating, especially in the classroom where students are connecting abstract cartographic design concepts to complex digital technology for the first time. However, constraint stimulates creativity, and many innovative maps inspire us because of, not despite, the technological constraints they overcome.

The advanced cartography class at UW–Madison offers a deep dive into narrative & storytelling, aesthetics & design, and ethics & critique in cartography. In the fall semester of 2018, we added a sequence of four sketch mapping activities to this class to enable creative exploration as a warm-up to each technical lab assignment. Sketch mapping is a well-established research method in which participants translate their experiences, emotions, and memories of place into visual representations, with the resulting mental maps taking many possible, equally acceptable forms (Gieseking 2013; Kelly 2016). From a cartographic standpoint, sketch mapping is an important, formative stage in the design process for many practitioners, and arguably a cartographic skill in its own right, with early whiteboarding or wireframing enabling rapid brainstorming, collective discussion of alternatives, and development of storyboards and specification sheets to streamline subsequent design (Lloyd and Dykes 2011; Tyner 2014). As Tierney (2018, 45) writes, "even the roughest sketch is critical to getting into the creative mindset needed to begin a project before getting locked down in the software."

Beyond research and design, sketch mapping can enable inclusive classroom instruction as well as participatory community engagement, by allowing participants "to be vulnerable without being verbal" (Iverson 2019, 2). For this advanced cartography course, the sketch mapping activities allowed students to tinker and play with lecture concepts in a low-risk environment using familiar, tangible materials such as pens, markers, graph paper, etc. Without the pressure of data wrangling or learning new software, they were able to be more intentional and reflexive during the design process. Students then drew from this creative experience in their four linked lab assignments, which introduced new datasets, technologies, and workflows.

Figure 1. Madison and Vicinity*, a tangible map quilt created collectively by an advanced cartography class at the University of Wisconsin–Madison. Shot at an angle of approximately 60° to capture the verticality of the design, with some roads and water features superimposed for context. Data source: OpenStreetMap; Photo: Robert Roth.*

The sketch mapping activities culminated in a tangible map quilt assignment (Figure 1) that took inspiration from two fantastic NACIS collaborative design projects: the 2015 Tangible Map Exhibit (Dooley, Coolidge, and Rose 2016) and the annual NACIS Map Quilt. With a focus on design diversity across the quilt patchwork, this final "sketch" mapping activity used a range of tangible but *un*familiar materials. As Dooley, Coolidge, and Rose write, "By making in a new, unfamiliar medium, we can create judgment-free spaces that allow for experimentation, risk-taking, and the unexpected" (2016, 25). The tangible map quilt activity aligned with several weeks of lectures on aesthetics and style—drawing heavily from the *Cartographic Perspectives* special issue edited by Buckley and Jenny (2012) and Nestel's (2019) GIS&T Body of Knowledge entry. It also was paired with an associated multi-week lab assignment introducing Mapbox Studio that required students to deconstruct the style of a prominent artist or designer and replicate the style in a basemap tileset using OpenStreetMap (OSM) data (after Christophe and Hoarau 2012). Thus, the tangible map quilt activity directly reinforced the conceptual and technical learning objectives of the aesthetics and style course module.

ACTIVITY PREPARATIONS AND PROCESS

In the fall of 2018, the class instructors (Rob and Chelsea) prepared the tangible map quilt activity by downloading and projecting unstyled OSM linework for the city of Madison, Wisconsin (USA) and vicinity. We originally downloaded buildings, natural features, points of interest, and transportation infrastructure, but ultimately retained only roads, railways, water, and waterways in the final reference map to reduce complexity. However, we encouraged students to research other features that were not included in the reference basemap. We maintained a minimalist design for the visual hierarchy given the objective of adding tangible styling atop this basemap (Figure 2).

We printed the map quilt basemap on the University of Wisconsin Cart Lab's large format plotter and sliced the poster into sixteen quilt tiles, each roughly 12×16 inches in size. From this experience, we recommend limiting each tile to a maximum size of A4 or letter to allow students to print their own tile if needed. Reprinting the tile allows a tangible "undo" and supports online instruction.

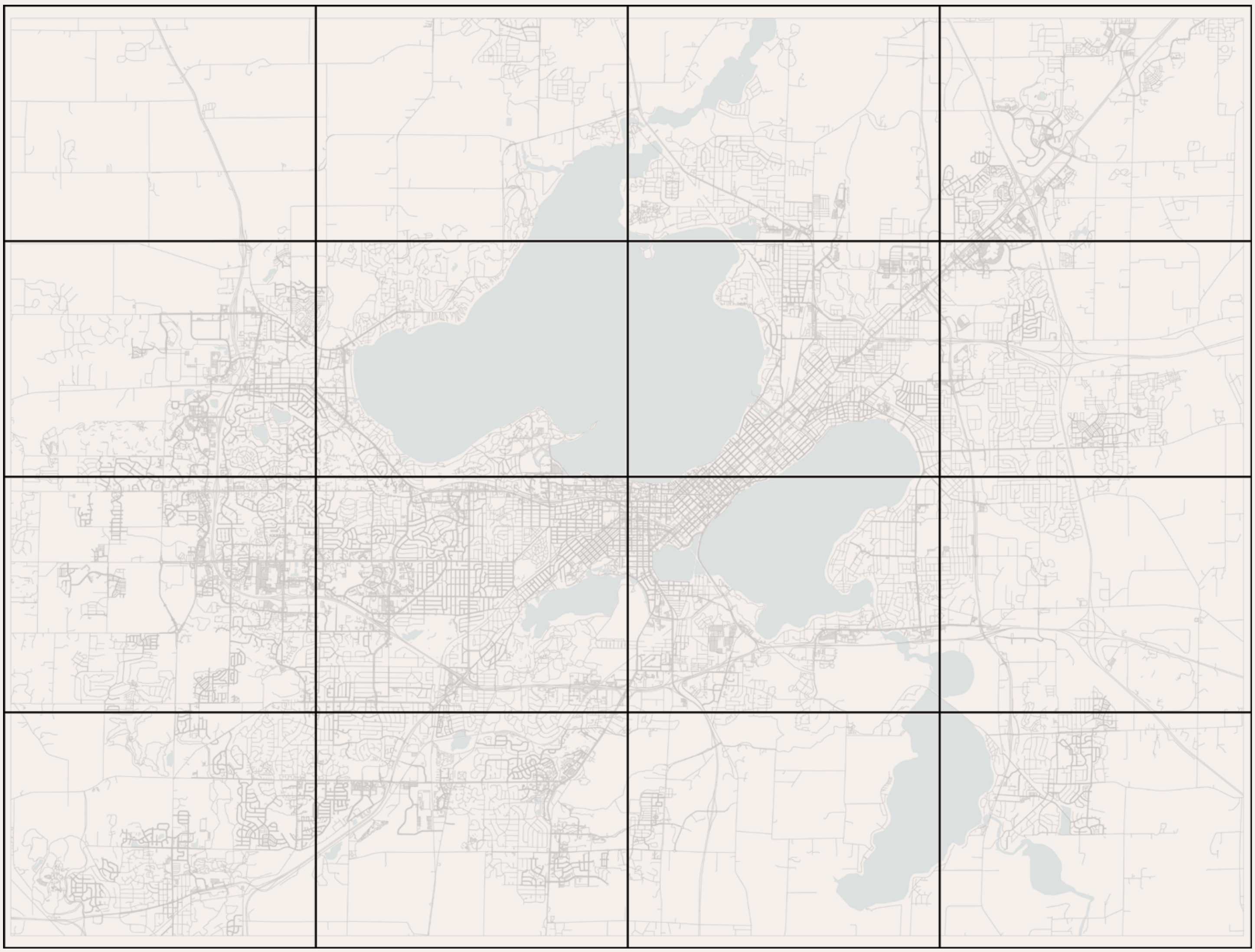

Figure 2. *The initial tangible map quilt basemap of Madison with an overlay showing the location of slices for the individual tiles. Data source: OpenStreetMap.*

We then staged the tile and materials selection process around a UW Cart Lab light table (Figure 3). We selected materials to promote diversity in the tile designs across four overarching stylistic dimensions discussed in lecture (see Roth, forthcoming, for discussion), producing a range of tangible but *un*familiar material combinations:

- **form:** variation in the linework generalization and symbolization (e.g., smooth vs. jagged, curved vs. blocky, thin vs. thick);
- **color:** the overall palette of primary and accent colours;
- **type:** any typefaces included as branding and their microaesthetics; and
- **texture:** additional tactile features (e.g., flat vs. raised, rough vs. smooth, matte vs. shiny).

Students drew a random number to determine the order they could select their tile location, with areas on campus and along the Madison isthmus selected first. Students then selected their materials in inverse order to compromise preferences between the selected tile and material. We staged the materials like Monty Hall's *Let's Make a Deal*, with one material uncovered and the rest hidden inside separate boxes. Students could select the visible material, or risk selecting a hidden material behind "Door Number Two." After the selection process, students were given time to make trades, adding cooperation and fun to the activity, but were instructed that they must trade both tile and material together. Ultimately, only one trade was made despite the large amount of humorous brokering.

Since there were sixteen tiles available, and only thirteen students in the class, the students gained revenge upon Rob and Chelsea by assigning each of them one of the remaining tiles and materials. We left the sixteenth tile open as a collective design opportunity for others in the UW Cart Lab.

Figure 3. *The tile and materials selection process. Photo: Tanya Buckingham Andersen.*

	Water	Roads	Other?	Other?	Other?
Form					
Color					
Type					
Texture					

Figure 4. *The worksheet used to inform style deconstruction. Image: Robert Roth.*

Before starting on their tile, students first evaluated their materials according to the forms, colors, types, and textures they afforded. To facilitate this deconstruction process, and to help students consider how best to apply these stylistic dimensions to the OSM linework and any other prominent features they wished to depict, we provided the worksheet seen in Figure 4. We assigned this worksheet as the first deliverable for the Mapbox Studio lab, where it was described as a spec sheet. Starting from the selection process, students were given the remainder of the lecture period, and the entirety of the following lecture (approximately two hours total) to work on their tangible map quilt tiles (Figure 5).

Figure 5. *Tangible map quilting in the UW Cart Lab. Photo: Tanya Buckingham Andersen.*

DESIGN & REFLECTION

Figure 6. *Materials used for the* Madison and Vicinity *tangible map quilt.*

Madison and Vicinity is a tangible map quilt combining aging office supplies from the UW Cart Lab with discount items from a local Dollar Tree store (Figure 6). The colors are diverse and vibrant, ranging from bold popsicle sticks, tissue paper, and friendship string to shimmering glitter, paper clips, and tin foil. Pricing stickers show the socio-demographic composition of West Madison and melted birthday candles dot the green spaces in East Madison. Many tiles are truly three-dimensional, with the terrain of Madison emerging from a crinkled Space Jam™ poster, contoured modeling clay, interwoven fuzzy balls and pipe cleaners, and screws twisted into a wood plank (one full rotation per five feet of elevation, which created a sawdust mess in Rob's apartment for weeks to come; Figure 7). A styrofoam head enchants as the Lady of Lake Mendota and a macaroni map monster emerges in Lake Monona. In great irony, an ActionScript programming textbook is repurposed as a tangible typographic map of Madison's west side. And yes, the north arrow is made from the "L" in a Leonardo Teenage Mutant Ninja Turtles™ children's Halloween costume.

Reflecting on the activity, we (the instructors, Rob and Chelsea) believe that completing the tangible design

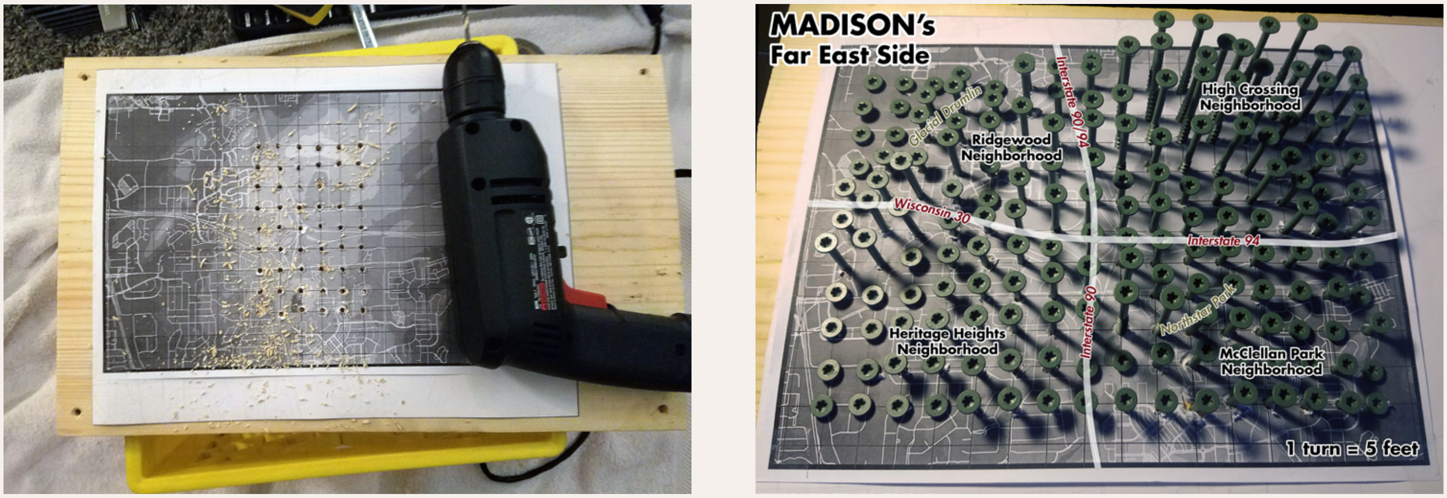

Figure 7. Madison and Vicinity *detail view. Photos: Robert Roth.*

process before jumping to digital technology led to less frustration and more experimentation in the subsequent Mapbox Studio lab assignment. Overall, students were more willing to lean into the styling constraints of OSM data and ultimately produced extremely creative designs. We also believe that the tangible map quilt activity led to better comprehension of lecture discussion regarding aesthetics and style on the final exam (a hint to future students finding this article: the final exam now includes an essay question comparing and contrasting your tangible map quilt and Mapbox tile designs). The activity also reinforced the inclusive and supportive community we promote in the UW Cart Lab, as the majority of students from the class continued to work in the Cart Lab the remainder of the academic year without having done so before the activity. Finally, the tangible map quilt activity proved to be a multi-generational success, as the UW Cart Lab's youngest cartographer and now the youngest

Figure 8. Detail images of Madison and Vicinity*. Photos: Robert Roth.*

published author in *Cartographic Perspectives* (Athena, age 3) contributed to the collective tile in the bottom-left corner. Thus, we believe the tangible map quilt activity extends well to K–12 education for cartographers of all ages.

Madison and Vicinity currently resides on the third floor of Science Hall on the UW–Madison campus, where it garners a great deal of attention from future cartographers passing by.

ACKNOWLEDGMENT

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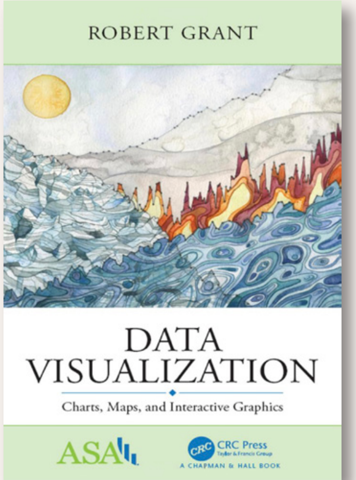


DATA VISUALIZATION: CHARTS, MAPS, AND INTERACTIVE GRAPHICS

by Robert Grant

CRC Press, 2019

218 pages, 125 figures

Hardcover: $79.96, ISBN 978-1-138-55359-0

Paperback: $23.96, ISBN 978-1-138-70760-3

eBook: $23.96, ISBN 978-1-315-20135-1

Review by: Sarah Kelly, University of Colorado Boulder

Daily, we encounter an overwhelming amount of quantitative data presented through figures, graphics, and maps, and yet we often underestimate or neglect the power of visualization to meaningfully summarize data. Visualizing data requires summarizing its complexity into something easily digestible. But details are lost during the process, and so it's important to understand how different visualization techniques affect what is finally presented to the reader. Being that there is no single best way in which to visualize any particular dataset, familiarity with a variety of techniques is imperative. Robert Grant's book, *Data Visualization*: *Charts, Maps, and Interactive Graphics*, provides the reader with a wealth of techniques to effectively visualize different types of data, and discusses how to avoid common visualization pitfalls. With seventeen short chapters, along with 125 illustrative graphics, the book is a quick read and immediately useful to anyone who needs to communicate data—including, the author tells us in his preface, data managers, data scientists, and journalists.

The preface explains how and why the book is broken down into its three main sections. Section I is titled "The basics," and has two chapters that discuss why we should visualize data. Section II, "Statistical building blocks," consists of four chapters that introduce the reader to basic statistical theory, and can serve as either a refresher for those familiar with statistics or as a very brief overview for those who are not. Section III, "Specific tasks," covers a wide variety of topics—including uncertainty, time analysis, and machine learning—spread over ten chapters. The author recommends that everyone should read Section I; Section II could be skipped entirely by readers with some experience with statistics; and a reader might, based on their interests, pick and choose which chapters to read in Section III. The preface then goes on to explain that the main goal of the book is to "provide a brief overview of techniques and tools, while all the time emphasizing statistical reasoning…" (xxiv). The author also makes clear what is *not* included in the book—topics such as the visualization of qualitative data, the representation of data with sound, and the affordance of accessibility for the visually impaired. The preface wraps up with a short list of definitions for a few of the terms used in the book, a reference that is particularly helpful for those new to data visualization or statistics.

Chapter 1, entitled "Why visualize?", introduces the science behind the human brain's ability to recognize and interpret patterns. Grant explains that data analysts should create visualizations that can guide the reader through the data while still allowing them to make their own interpretation of the information presented. The way to accomplish this, he stresses, is to favor simplicity over complexity. He illustrates this principle with a simple scatterplot, annotated with information about its respective parts, and discusses how a reader is meant to interpret the information contained in it. The chapter continues with a section on best practices for communicating whatever message an analyst wishes to present without overwhelming the reader. The need for visualizations, and the importance of knowing your audience before selecting the type or types of visualization to use are both noted, along with the four questions that all data analysts should ask themselves before making any visualization decisions (12):

1. "What is the message?"

2. "What parts of the data are evidence for it?"

3. "What other parts need to be shown for contrast/context?"

4. "Do I/we know how to do this, or can we learn it/adapt someone else's work, or do we need to hire in?"

The author recommends that data analysts be familiar with a wide range of tools and methods, rather than any one particular software or technique, and, in any event, suggests sketching out ideas for visualization before moving to a software platform.

Chapter 2, "Translating numbers in images," focuses on a visual design process for presenting data successfully. By showing the same data on different types of plots, the author demonstrates how simple changes can make visualizations easier to understand and more effective. In his first example, Grant shows how a graph can reveal trends in data over time by translating a scatterplot of train delays to a line plot. The same train delay data is then plotted on a year-period grid that uses changes in color to highlight when most delays occur, by year, and by time within the year. This graphic segues into a discussion of visual parameters—such as symbol length and rendering volume in two dimensions—and of the data types these parameters are best used to represent. The author touches again on the need to know the target audience, and specifically on the importance of knowing with which visual parameters the audience will be familiar. Color hue, value, and saturation are discussed in a bit of useful detail, but not in enough detail for someone unfamiliar with color systems to be able to successfully apply them to graphics. The depiction of volumetric data as a two-dimensional symbol is always problematic, and the author explores a few interesting alternatives, such as what the author calls pictographic and photographic "montages" (or what I might call "composites") to show some kinds of data, such as percentages of delayed trips or levels of traffic congestion. The use of pie and donut charts is discouraged as potentially misleading, but some alternatives are offered that may be easier for viewers to interpret. Grant concludes the chapter by briefly mentioning the importance of effectively annotating graphics and of including user testing in the design process.

"Continuous and discrete numbers," the third chapter—and the first in Section II, "Statistical building blocks"—starts with a very brief discussion of the difference between these two types of numbers and how to tell them apart. The first section of the chapter presents examples of various ways to display one continuous variable, including the use of histograms and kernel density plots, along with a sidebar on how to read such distributions. Methods for transforming skewed data are mentioned, but very little explanation is provided about which transformations would be most appropriate to use in which situations. The author then moves on to discuss matched and unmatched data, and provides examples of datasets and graphics for both situations, including a graphic showing small multiples. The chapter concludes with a section on one of the

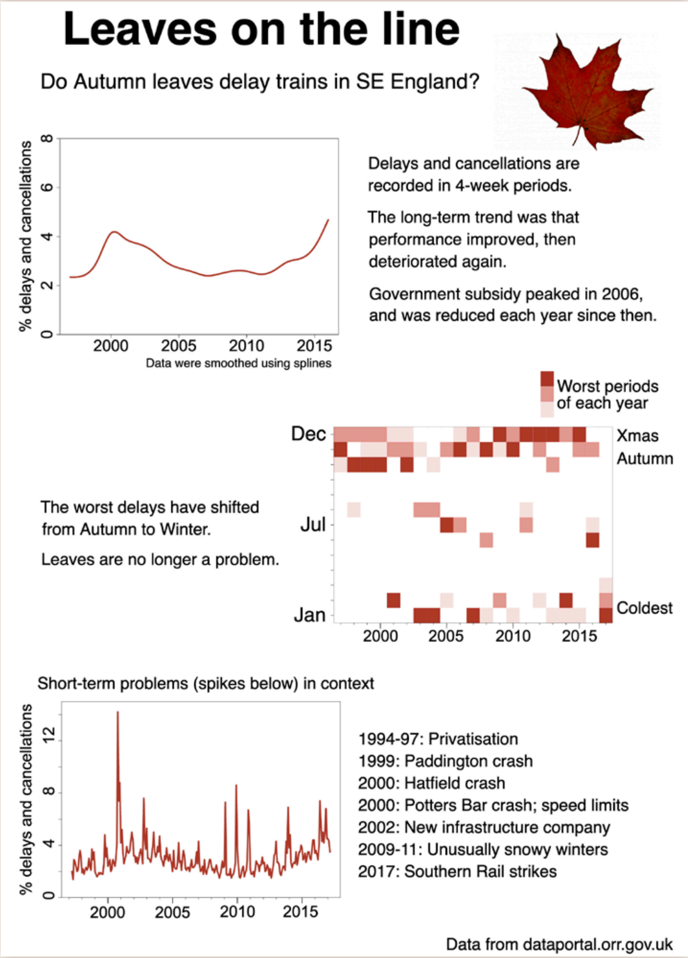


Figure 1. *Different visualizations of train delay data.*

most important concepts for those new to statistics: correlation versus causation.

Chapter 4, "Percentages and risks," is similar in format and breadth to Chapter 3, with a different focus. Simple concepts such as percentages versus proportions, the importance of sample size, and binary versus non-binary response data are presented. Matched and unmatched data are again compared, illustrated with examples of waffle plots, ternary plots, stacked bar charts, and clustered bar charts. Associations between variables are also mentioned once more, but here it is specifically in regard to percentage and risk data, with decision trees and waffle plots used to demonstrate effective visualization. Finally, risks, rates, and odds are succinctly discussed.

The next chapter (Chapter 5), "Showing data or statistics," aims to guide the reader through the process of deciding whether the raw data, or statistics created from the data, should be visualized. The reader is warned against using statistics that just appear interesting, or using them only because they show the conclusion desired. Next, the chapter explains some of the most commonly used statistics, including standard deviation (along with the fact that it requires normally distributed data). Quantiles and skewed data are discussed with a complex box-and-whiskers plot given as an example. Data trimming is first mentioned in this section, but it is not made very clear when or if such methods should be employed. Finally, the smoothing of data for showing long-term trends is explained, but, as with trimming, it is not discussed in enough detail to allow one to understand which method to use and when to use it.

"Differences, ratios, and correlations" (Chapter 6) discusses each of these concepts, but of the three, only correlations are addressed in sufficient detail for anyone not already familiar with such statistics to be able to grasp the concepts. Making up the bulk of the chapter's content, they, at least, are explained well, with multiple graphics used to display the strength of association of correlation coefficients, and the different methods for determining correlations.

Chapter 7, "Visual perception and the brain," is the start of Section III, "Specific tasks." The author begins by discussing the need for graphics to be clear and to draw attention to the specific message that the analyst wants to convey. Data smoothing is specifically recommended as a good way to visualize overall data trends, even when the background data is also displayed; unfortunately, the technique is still not discussed in useful detail. In reviewing some of the perceptual challenges, Grant once again notes some of the challenges in representing volumetric data, and touches on other representation issues, such variations in cultural associations (for example, in some cultures red means danger, and in others, happiness). Finally, optical illusions such as the café wall (in which parallel, straight dividing lines between staggered rows with alternating contrasting elements can appear to be sloped) and the Ebbinghaus illusion (where the perception of the relative size of an element is affected by the size of surrounding shapes) are presented.

The representation of uncertainty is an often overlooked subject within data visualization. Thankfully, Chapter 8, "Showing uncertainty," provides an overview of the sources of uncertainty and the importance of showing it, as well as several effective methods for doing so. Bootstrapping, confidence regions, and Bayesian statistics are all discussed here.

Chapter 9, "Time trends," examines how to visualize data over time using more advanced graphics. Examples here include the use of color on connected scatterplots and the employment of arrows to represent the direction of change through time. Using statistical information that describes change over time raises some special considerations; these are dealt with in their own section within the chapter, along with methods for displaying uncertainty over time.

The tenth chapter, "Statistical predictive models," moves into more robust statistical methods that can be used to predict future outcomes. The simplest and most straightforward model presented is linear regression. Residuals, root mean squared (RMS) error, and cross validation are also explained. Next, the slope of the regression line and the meaning of the regression coefficient are discussed. The chapter then moves on to logistic regression. Binary outcomes and odds ratios are explained, along with the difficulties one might encounter in presenting them. How and why an analyst should consider using interaction terms in regression are mentioned as well. Semi- and non-parametric models are introduced briefly before the book moves on to determining model fit. The chapter concludes with a section on computer simulation for statistical modeling.

The "Machine learning techniques" chapter introduces the reader to a myriad of unique and advanced technological approaches for modeling and displaying data. Each topic presented—including regression trees, random forests, and support vector machines—is succinctly described. Neural networks and deep learning are also mentioned, along with a detailed illustration of a TensorFlow playground used to visualize how neural networks fit predictions to a data set.

In the next chapter, "Many variables," Grant introduces a variety of visualization methods and graphic examples for working with multivariate data. The chapter begins by touching on some of the decisions an analyst must make, such as what variables (if any) to leave out, which visual parameters to utilize, and whether or not multiple visualizations better suit the data than a single graphic. Small multiples—one of the simplest and most straightforward methods—is the first one presented. Wireframe plots and 3D bar graphs are recommended for visualizing three continuous variables, heat maps for visualizing distances, and dendrograms for cluster analysis.

Chapter 13, "Maps and networks," starts by going over some of the basic concepts, such as coordinate projections, map context, user testing, and generalization, to be considered when mapping data. However, these topics are not described or discussed in enough detail to be very useful to even a novice mapmaker. The example maps presented in the next section help make up for the lack of discussion of basic mapping concepts, but are not enough to replace formal cartographic visualization training. Choropleth maps, cartograms, dot density maps, flow maps, small multiples, and contour plots are discussed briefly, but proportional and graduated symbol maps are not—although there is again reference to issues concerning the perception of relative area. Uncertainty, too, is referenced again, but this time in regard to spatial autocorrelation. Lastly, flow maps and radial networks are given as examples of the spatial representation of networks.

Several ways of incorporating interactivity into data visualizations, specifically in web applications, are covered in Chapter 14, and live, interactive examples of the options discussed are available through links to the author's website (**robertgrantstats.co.uk/dataviz-book.html**). He explores a range of interactivity levels, from simple to moderately complex, and briefly goes over online methods for analyzing spatial data as well. The chapter concludes with the important topics of online security and data confidentiality.

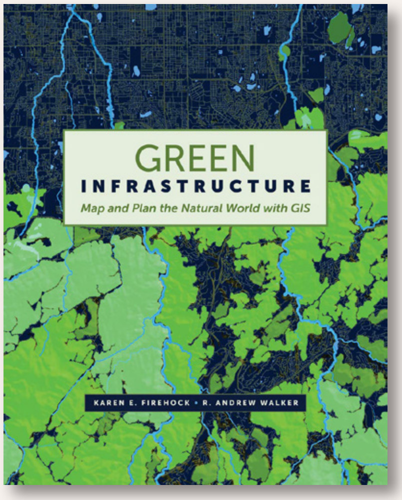
The last two chapters round out the book with a look at "Big data" (Chapter 15), and "Visualization as part of a bigger package" (Chapter 16). The concept of big data is explained, and recommendations are made on how to visualize data that can be "too big" and/or "too fast." The author also discusses how to combine and juxtapose multiple types of visualizations into a bigger package such as a dashboard or a poster, and how to incorporate user testing into the project development cycle to ensure the package is successful in getting the information across.

Not mentioned in the book's preface is Section IV, "Closing remarks." It provides the reader with a list of skill-developing resources and a chapter-by-chapter list of websites and books for the data and graphics used along with additional books for future reading specific to chapter topics. There are, however, neither any actual remarks, nor any neat wrapping up of the concepts presented—and while the book may not need such remarks, this final section should be renamed to match its content more appropriately.

Overall, this book is a great resource for anyone working in data visualization. With just over two hundred pages, many dominated by graphics, it is a quick read that introduces a plethora of visualization techniques. Most of the example graphics are simple and effective demonstrations, and are taken from a variety of fields. The importance of clear and effective graphics, driven by a clear understanding of the visualization's target audience, is emphasized throughout the book. The lists of further readings and the materials available in the final section of the book and the author's GitHub site (**github.com/robertgrant/dataviz-book**) serve as great resources for deeper dives into the information and graphics presented.

However, many of the book's topics are covered in such brevity that the reader is often required to utilize additional resources, such as those provided in Section IV, for further explanation; readers without a background in statistics will likely need to look even further afield. Furthermore, some of the example graphics seem obscure and will likely be confusing to any novice data analyst. It was also disappointing to find that, despite having the term "Maps" featured in the title, *Data Visualization: Charts, Maps, and Interactive Graphics* has only 14 pages dedicated to mapping.

Despite the brevity with which each topic is covered, this book serves as a great primer to the multitude of techniques available to data analysts and meets its goal of providing a "broad overview that covers a lot but not in great detail" (xxiii). With so many practicing data science professionals having never received any formal training in visualization, there is a clear and pressing need for it to be read widely. Whether new to the field of data science or an experienced practitioner, all readers can benefit from *Data Visualization*: *Charts, Maps, and Interactive Graphics*, and I expect that it will inspire many analysts to explore the broad field of data visualization even further.



GREEN INFRASTRUCTURE: MAP AND PLAN THE NATURAL WORLD WITH GIS

By Karen E. Firehock and R. Andrew Walker

Esri Press, 2019

282 pages

Softcover: $49.99, ISBN 978-1-58948-486-3

Review by: Yanning Wei, University of Connecticut

Even though Green Infrastructure (GI) is definitely not a newly arrived concept, it is commonly oversimplified by laypersons and even some planning practitioners as merely adding plants to our cities: green roofs, rooftop gardens, tree-lined roads or streets, rain gardens, home gardens, and the like. The authors of *Green Infrastructure: Map and Plan the Natural World with GIS*—Firehock and Walker, an environmental planner and GIS practitioner, respectively—remind readers that GI is not just a collection of greenish elements, but instead represents a coherent and systematic approach to building and maintaining a livable and sustainable urban environment. Drawing on the germinal work of Ian McHarg (1995) and utilizing their own hands-on experience from years of work in environmental planning, community design, and GIS, the authors call for implementing McHarg's ideas about "Designing with Nature" to build GI as a means of tackling the pressing environmental issues we face such as water quality degredation, urban flooding, shoreline erosion, and habitat loss.

Maps and spatial data play a unique and indispensable role, alongside a plethora of other components, in the process of environmental planning, and the authors suggest that "by identifying and integrating a network of critical landscapes" using spatial data management, "communities can protect the places and resources that help people, wildlife, and economies thrive" (1). This book is about modeling "critical landscapes" using GIS, with the goal of replacing the conventional "gray infrastructure" with a green one, and in its eight chapters the reader learns how to design with nature by mapping landscapes and managing data.

The first chapter introduces what GI is, why it matters, and the theory and practice of GI planning. It also provides readers with a brief history of GI planning in several parts of the world, including the United States, Japan, and the European Union. The second chapter deals with the conceptual design of a GI model, and the major design components that should be considered. The chapter highlights effective ways of modeling connectivity among such key conceptual landscape elements as core, edge, corridor, and so forth. With Chapter Three, "The six-step process," the focus of the book shifts to the technical details of GI planning: how to actually create a GI plan with GIS. This chapter is a bullet-point outline for creating a GI model, with six key steps: setting goals, reviewing data, making asset maps, assessing risks, determining opportunities, and implementing the plan. This chapter provides readers with a practical framework for planning GI, and the essential strategic actions required to carry the plan out.

Technical specifics regarding relevant data are found in Chapter Four, "Getting the right data," which dives deeply into the details of spatial data acquisition. It provides readers with a detailed list of key spatial features to be included—in particular, local natural and cultural assets such as water resources, forestry, parks and recreation areas, and historic and cultural heritage sites. With the completion of this phase, the datasets are ready to be integrated and mapped in a GIS.

Chapter Five, "Making asset maps," is pleasingly filled with a number of colorful images and maps, and is rich in technical details. It tells about how to make thematic maps and how to use them to identify connectivity among the key elements of GI. Next, Chapter Six describes how to use GIS to evaluate and reveal risks to natural and cultural assets. Starting with an outline of the major types of risk, both natural and human-made, the chapter presents a comprehensive introduction to the methods that could be used by planners to evaluate and deal with location-specific risks.

Completion of the mapmaking stage is not the end of GI planning, and in Chapter Seven, "Determining opportunities," the authors discuss the importance of also planning for risks, potential damages, and possible mitigating actions that may need to be taken. In addition, they emphasize that a GI planner's task is identifying opportunities even in scenarios not commonly considered environmentally friendly, such as plans for new transportation systems or for landfills and dumps.

"Implementing GI plans" is the last chapter, and, as the title suggests, is about implementation of the plans discussed in the previous chapters—what to tackle, who does what, and how to go about it. The authors strongly suggest that the effective use of maps to support GI-related decision-making processes is critically important to any implementation.

The book includes three appendices: one on the history of the landscape connectivity theory of modeling, another on technical specifics regarding spatial data modeling, and a third with some useful online sources.

Conventional "gray infrastructure" planning is based on the postulation of a fundamental human/nature dichotomy and a corollary view of humanity as the conqueror of nature, but *Green Infrastructure* presents an alternative wherein humans are an integral part of the natural system instead of an adversarial manipulator of it. The authors remind us that while Earth can continue to exist without humans, humans cannot survive without a healthy Earth—not even for a very short time—so we need to adopt a workable plan to keep the Earth healthy. We should, as Ian McHarg famously put it, "abandon the self-mutilation" and "must design with nature" (quoted in Fleming, et al. 2019) and this is because, with no place else to go, we have no other options available. Thus, the authors suggest, we need GI planning and practice to make the world a better place to live. They further suggest that we have to know how the environment works as a complicated, dynamic system before we can make better plans for a sustainable future.

It is true that GI planning is much more than just planting trees, greening roofs, and announcing new nature reserves. For example, it has come to light that the flawed infrastructure planning in and around the city of Houston, Texas, was partially responsible for the enormous environmental and economic loss the city suffered during the devastating 2017 hurricane season (Campoy and Yanofsky 2017). Put simply, when new homes and other buildings are built on the floodplains of natural waterways, it is not hard to predict what will happen when natural hazards like hurricanes strike—despite any number of green-roofed buildings, rain gardens, and tree-lined neighborhoods. This book suggests that we urgently need more data, and more data-driven systematic insights, in order to build a better understanding of the environment and our relationship with it.

The main body of the book, Chapters Four through Eight, can be seen as a useful and convenient cookbook showing how GIS and spatial models can be used to simulate the real-world environment, manage spatial data, and help make critical decisions. While GI planning can, no doubt, be conducted without GIS software, GIS is, in many ways, an ideal platform for environmental modeling and sustainability studies. The environmental movement in the 1960s was, in fact, a significant driver for the development of GIS as a technology, and, by extension, for the founding of Esri (originally known as Environmental Systems Research Institute). One could say that GIS was born for modeling the environment, and its superb capability of modeling features on the surface of the Earth through the layering of complex spatial data has made it a popular tool among environmental planning practitioners since its birth (Fleming et al. 2019).

One potential drawback to a conventional GIS approach to any question is the tendency to reduce everything to quantitative terms. Enumerated quantities are, after all, what computers handle best, and the ability to find correlations by overlaying spatial data sets is one of the great strengths of GIS. These very strengths also lend themselves to oversimplification, a tendency promoted by stories told to the young—like that of John Snow's identification, by means of simple data overlays, of a single source point for an 1854 cholera outbreak.

In contrast to this, one of the strengths of this book lies in its effort to strike a balance between holistic and reductionist perspectives. For example, the authors of *Green Infrastructure* stress the value of local knowledge and the vital, "driving force" (95) role of community support—factors hard to quantify or digitize as geographic features—right alongside spatial data modeling and data acquisition. Yes, there is a heavy emphasis on the technical specifics of using GIS tools, but the reader is constantly reminded that GI planning is about sustainable community development—and that tools are just a means of getting there.

The only vital piece missing from this book, from my perspective, is a discussion of how GIS can be used as a tool to mobilize local communities and get people engaged in the process of GI planning.

Overall, this book is exactly what the authors tell us they intended it to be: an excellent reference for anyone who cares about the environment and sustainable development, and who wants to use GIS applications to help achieve their goals in these fields. The authors deliberately avoid jargon, and the chapters are written in plain language. Readers who are not GIS professionals can skip the technical parts, but those parts will be of great importance and value to those who can profit from them.

This book also can serve as an excellent reference book for intermediate and advanced GIS courses. As an educator myself, I have, over the past two decades, noticed that it can sometimes be quite hard for some students, even with several courses under their belts, to come to grips with complex assignments involving spatial modeling or database management, let alone conceptualize the potential for what GIS can do. I believe that *Green Infrastructure*: *Map and Plan the Natural World with GIS* can, if used properly, help anyone to understand both the GI planning challenge, and the challenges of better using GIS tools.

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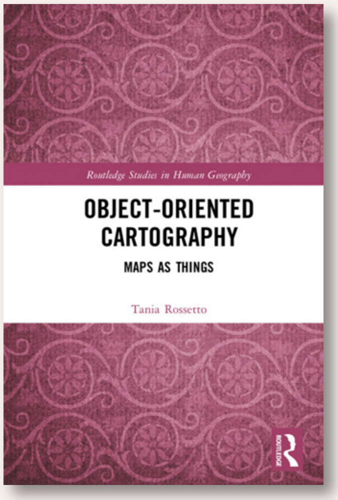

OBJECT-ORIENTED CARTOGRAPHY: MAPS AS THINGS

By Tania Rossetto

Routledge, 2019

149 pages, 34 black and white images and photographs

Hardcover: $155.00, ISBN 978-1-13-834615-4

Review by: Douglas Robb, University of British Columbia

Object-Oriented Cartography: *Maps as Things,* by Tania Rossetto, invites the reader to consider new ways of relating to cartographic images and practices. Drawing from recent advances across diverse academic fields such as object-oriented ontology (OOO), critical cartography, and visual studies, Rossetto provides a deeply personal account of our everyday interactions with maps. Over the course of eleven chapters (plus an Introduction and Conclusion) she develops an innovative research methodology that foregrounds the relational, phenomenological, and agential capacities of spatial representations. She accomplishes this through synthetic academic research illuminated by practical examples and inventive case studies. The book's overarching project is to re-imagine maps as more than flat representations of an external reality, and to see them instead as lively actors that shape our world in powerful and intimate ways.

Therefore, it seems only appropriate to begin a review of the book with a discussion of its own "thingness" as an object in the material world.

The seven by ten inch, 149 page, hardcover volume is disarmingly slim, and the publisher's stock purple damask pattern cover design is modestly understated. The terse, somewhat obscure title—in bold, condensed, sans serif capitals—catches the eye, and gives just a hint of the rigorous intellectual work contained within. A casual reader might be put off by the stark title, but it is balanced by the straightforward (though by no means simple) subtitle promising a discussion of *Maps as Things*. Opening the book, one finds: quotations of favourable reviews from leading researchers in the field of map studies, a short description of the book, the bibliographic information, and a concise table of contents. There is, unfortunately, no index of images or photographs.

The "Introduction" briefly charts a recent history of cartographic thinking as it has developed alongside the author's own academic trajectory. This section sets the stage for the discussion to come, and is vital in order to fully appreciate Rossetto's intellectual motivations and unique multidisciplinary approach. Caught between a fascination for maps and the pervasive late-90s tendency to "deconstruct" and "distrust" spatial visualizations, Rossetto allows her curiosity and intuition to lead her through a discovery of image-making practices ranging across geography, photography, architecture, and visual studies. These novel explorations coincide with a period of rapid innovation in the technical production, theorization, and cultural dissemination of maps (the author cites various examples, such as the rise of Google Maps and the development of post-representational cartographic theory). While these historical touchstones are useful for orienting the reader to the author's key references and areas of interests, the salient takeaway from the Introduction is that *Object-Oriented Cartography* is, first and foremost, a love letter to maps.

The chapters that follow can be divided into three broad categories. Chapters One through Three provide a detailed overview of object-oriented ontology (OOO), its major figures, arguments, and debates, and their relationship to cartographic studies. OOO is a twenty-first century school of thought that rejects the privileging of the social and political agency of humans over the agential capacity of nonhumans and nonhuman objects. Rossetto also uses these opening chapters to develop her own innovative and eclectic research methodology. Chapters Six through Eleven offer a series of empirical case studies and vignettes that illustrate the key theoretical contributions put forward in the opening chapters. In between, Chapters Four and Five act as a fulcrum between theory and practice through a discussion of the various images, surfaces, and interfaces that connect map-objects to their surroundings.

Chapter One considers the objecthood of maps through an overview of major works by key theorists engaged in topics related to cartography and phenomenology. This review covers relatively recent scholarship, presumably with the goal of focusing the reader's attention on the rise of digital mapping and its implications for the ubiquity, accessibility, and rapidly changing materiality of map-objects. The author presents these technological and intellectual developments in order to link longstanding work on the performativity and materiality of maps to more recent philosophical trends in OOO. A recurrent theme in this chapter—and throughout the book more generally—is an emphasis on questions of ontology over epistemology: Rossetto is more interested in the work that maps *actually do* rather than how humans perceive and interpret them as representational or semiotic surfaces.

Chapter Two addresses OOO directly. For readers unfamiliar with this particular current of philosophical thought, the chapter opens with a concise overview of its key figures, arguments, and internal tensions (a daunting task that Rossetto accomplishes gracefully and succinctly). In short: OOO treats material objects as autonomous beings who possess their own agency to engage with and intervene in the world. While the OOO literature is rife with cartographic vocabulary and metaphor, Rossetto repeatedly states that her project is not metaphorical; she is not proposing an approach to map theory that slavishly follows the tenets of object-oriented philosophy. Rather, the book articulates an experimental and open-ended questioning of the social and political life of cartographic objects. Citing an example put forward by the philosopher Jane Bennett (2010), Rossetto argues that a "plastic topographical map is not a tool for knowledge, nor a social construction, nor a philosophical way of approaching material beings. It *is* a material being" (26). This claim represents a radical departure from the more conventional social constructivist perspectives mentioned in Chapter One. Yet Rossetto's palpable curiosity and passion for the subject matter (enhanced by her appropriate use of the first-person pronoun) will surely entice skeptics to continue.

Chapter Three, entitled "Stretching theories," is poised to address the skeptical reader's queries and potential objections. Rossetto begins by invoking familiar debates from post-representational cartography—in particular, that maps are not stable entities but processes that come into being through embodied social and technical practices (Kitchin and Dodge 2007). This framing enables Rossetto to find common ground between her eclectic use of OOO and longstanding conversations in cartographic discourse on the affective and ontological nature of maps. It also allows Rossetto to articulate a more nuanced description of her project: while she is primarily interested in the "thingness" of maps, the book "notices mapping practices/processes as well" (30). This nod to the relational and performative dimensions of practices and processes may appear to contradict Rossetto's primary focus on the map-object itself, however, it succeeds in strategically bridging the book's inventive research methodology with more familiar academic terrain. The chapter closes by returning to the objecthood of maps, and suggests that in order "to do justice to objects . . . we have to grasp their existence outside human experience" (34). As Rossetto acknowledges, this is no small task given that maps are (often) human-made objects.

Chapters Four and Five link the theoretical contributions in the opening chapters to the more empirical experiments presented in the latter half. However, before embarking on these case studies, Rossetto first addresses some of the conceptual difficulties that arise in attempting to understand maps through her object-oriented approach (How do maps *experience*? How do maps *relate*?). Drawing upon her personal encounter with a large You-Are-Here map in Padua, Italy, Rossetto muses on the nature of surfaces and interfaces as the point of contact between the map and its surrounding environment. Traces of environmental weathering and previous tactile encounters offer clues into the lifeworld of the map: it becomes partially knowable, yet remains fundamentally autonomous (media archeology enthusiasts may find this chapter particularly interesting; see Mattern 2017). Rossetto uses this tension to juxtapose her OOO methodology with Marxist and humanist approaches to cartographic analysis that seek to dismantle the map in order to reveal its hidden ideologies or power structures. For Rossetto, the cartographic surface is not a barrier but a place on which to rest and reflect upon the radical alterity (or "otherness") of, and imperfect communication between, human and nonhuman objects.

Chapter Five continues this line of thought by asking: "what counts as a map today?" (49). How might an object-oriented cartography contend with our contemporary geovisual culture (Rossetto 2016) where the lines between the visual and the cartographic are blurred? Rossetto embraces this blurring as evidence of cartography's capacity for wild hybridization, which she explores through a photo essay of two map-like objects: *cartifacts* (maps that are produced on a carrying media not usually associated with cartography) and *mapscapes* (cartographic materials perceptible as part of a city or landscape). Rossetto gives multiple examples of cartifacts, including wallpaper and wine bottle labels featuring maps as a kind of decorative element. The use of Google Maps on a smartphone is perhaps the most salient example: it reveals how map-objects are able to leave the flat page and take on a performative and phenomenological dimension. Similarly mapscapes, such as digital wayfinding infrastructures in airports or train stations, weave the semiotic and navigational function of maps into the urban fabric itself. According to Rossetto, these hybrid typologies are valuable because they defamiliarize conventional academic cartography and stretch it to a conceptual breaking point. The proliferation of these hybrid typologies, she argues, necessitates new approaches and methodologies to map studies.

Chapters Six through Eight illustrate potential applications of an object-oriented cartography approach in static and pre-digital maps. Each of these three chapters is organized around a core theme or idea that links cartography and map-making practices to parallel discussions in literature, architecture, and the pictorial arts. In each chapter, OOO's core concepts of relationality and "otherness" are explored through both familiar case studies and more experimental approaches to research. For example, Chapter Six applies object-oriented cartography to literary maps. Using Cormack McCarthy's *The Road* (2006) as a case study, Rossetto explores how maps serve to forge intimate bonds between the story's characters, thereby entering their relational world as a powerful, yet autonomous force. Similarly, Chapter Seven uses the technique of non-human narration to give voice to the experience of Fonteuropa, a mosaic map in Padova. In both of these examples, the experiences of map-objects are neither treated as metaphorical nor literary devices; Rossetto attempts to imagine their embodied subjectivities in order to interrogate their social agency. Lastly, Chapter Eight explores similar themes through maps featured in paintings, postcards, photography, and film. Some readers may object to, or dismiss out of hand, Rossetto's novel methodologies as mere anthropomorphism—a narrative technique commonly found in children's books—yet Rossetto approaches the subject with seriousness and academic rigour. While each of these chapters takes a decidedly speculative turn relative to the previous sections of the book, they succeed in inviting the reader to consider the dynamic, if somewhat inscrutable, lives of cartographic objects.

Chapters Nine through Eleven transition from pre-digital to digital maps, and shift the focus of the book away from the specific "thingness" of maps towards our vital and dynamic interactions with cartographic objects. Chapter Nine explores how individuals enter into dialogue with the "living images" (98) they encounter on TV, smart phones, and computer screens. Told through four narrations by different map users, Rossetto captures the deeply personal and idiosyncratic ways that maps enter our everyday lives and transform our relationships with our surroundings. Chapter Ten advances this line of inquiry through a discussion of human-digital intermediation through cartographic objects. The implications of new spatial technologies have been widely discussed across a range of disciplines (see Braun 2014; Kitchin and Dodge 2007), however, Rossetto's contribution is unique for its consideration of technology's potential impacts on humans, as well as how these technologies might transform humanity's coexistence with "digital others." This theme carries over into Chapter Eleven, which focuses not on the dynamic qualities of maps, but on their capacity for decay and dormancy. Using the technique of repeat photography (i.e. re-taking the same photograph at different times), Rossetto captures multiple periods in the life cycle of a map in order to reveal how it can accumulate a patina of memory through different modes of contact and interaction.

Following the experimental case studies presented in Chapters Six through Eleven, the Conclusion feels refreshingly focused. Rossetto uses the closing pages of

Object-Oriented Cartography to reiterate her primary objective: that we must pay attention to maps as lively things in and of themselves. I would argue that the book is successful in this mission, and that it offers both academics and students a fresh, captivating, and deeply personal approach to cartographic study. While some of the chapters could have better engaged with the evolving orthodoxies and internal divisions in speculative realist philosophy and OOO thinking, Rossetto takes time to acknowledge these potential oversights in the Conclusion. In the end, we are reminded that object-oriented cartography is fundamentally open-ended and tentative, and as readers, I believe we should not mistake brave intellectual experimentation with—as Rossetto self-deprecatingly suggests—sentimentality or naivete. As an exercise in true multidisciplinarity, *Object-Oriented Cartography* provides researchers of cartography, geography, aesthetics, visual studies, media theory, and science and technology studies with a renewed appreciation for the lives of maps.

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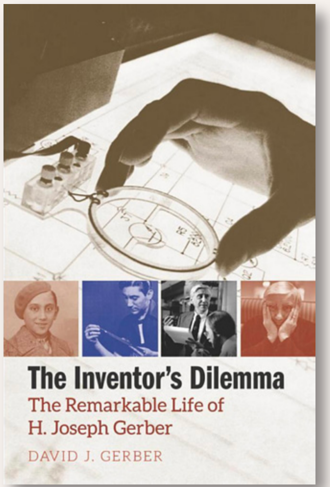


THE INVENTOR'S DILEMMA: THE REMARKABLE LIFE OF H. JOSEPH GERBER

By David J. Gerber

Yale University Press, 2015

400 pages

Hardcover: $38.00, ISBN 978-0-300-12350-0

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

When first asked if I would be interested in reviewing this book, I wondered to myself, "Who was H. Joseph Gerber?" and "What did he have to do with cartography?" A quick internet search revealed thumbnail answers that led me to accept the review invitation: Gerber was a remarkable scientist, engineer, and entrepreneur, whose inventions literally set the stage for the advent of digital cartography. In fact, the Gerber Automatic Plotter and Reader was the first commercially available machine that could plot graphics digitally, and it is likely that his inventions in electrical engineering enabled the field of automated mapping to emerge several years earlier than it otherwise might have.

The book's title refers to a term coined in the 1990s by Clayton Christensen; an *inventor's dilemma* comes about when a disruptive innovation or invention creates new markets and displaces older technologies—often changing the business landscape in the process. Businesses face the dilemma of continuing to focus on products and services that customers need or can use now, versus developing or adopting technologies that will create or meet customer demands in the future. As recounted in this biography, Gerber had, on numerous occasions throughout his career, the perspicacity and vision to identify the opportunities presented by his innovations and technical developments, and the boldness to gamble that his customers would follow his lead—or that new customers would appear.

This book is at once both a biography of a remarkable scientist and entrepreneur, and a history of technological developments in engineering and computer peripherals in the latter half of the twentieth century. Written by Gerber's son, David J. Gerber, the narrative chronicles Gerber's life and work, as well as his legacy in the years following his death in 1998. Starting with his early years in pre-World War II Vienna, Austria, it follows his post-war transition to life as a refugee in the United States, and his development as an inventor and entrepreneur—including the history of the company he founded, Gerber Scientific. While the book is biographical in nature, this review focuses on those aspects of Gerber's career of special relevance to the fields of cartography and GIScience.

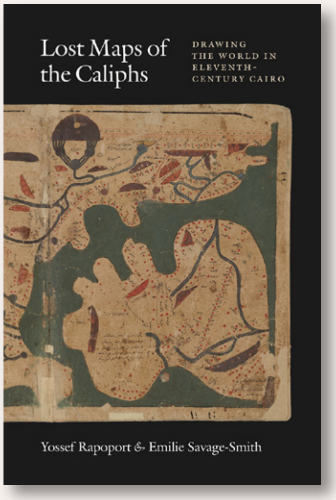
Joseph Gerber trained as an engineer, and developed several practical inventions while still a student. Beginning with the Gerber Variable Scale, he developed a series of mechanical computation devices for scientific and engineering applications, including the GraphAnalogue, the Derivimeter, and the Equameter. From the perspective of GIScience, Gerber is perhaps best known as the inventor of the digital plotter.

What set Gerber apart from many inventors was his interest in developing new tools and devices within the context of commercial processes—rather than as stand-alone inventions to be marketed in their own right—and he produced a series of new devices for specific purposes, including the automation of apparel and shoe manufacturing. His plotting devices, for example, were used to draw digital graphics onto film for the production of integrated circuit boards, using a photo-plotting method he developed.

These tools and methods formed the basis for electronics fabrication, and led eventually to the advent of computer-aided design, or CAD, a field that Gerber Scientific pioneered.

Gerber neither invented GIS nor automated cartography, but it is hard to imagine these endeavors developing as they did without the devices he created or the insight he had into how technology could transform manufacturing processes. Nowadays, few cartographers or GIScientists use digital plotters, and technological advances in printing methods have rendered these devices largely—though not entirely—superfluous. From the 1970s into the 1990s these devices were ubiquitous anywhere computer cartography was done, and many larger laboratories and agencies still have a few set aside in case they may be needed. Even the large-format, high-resolution printers we use today to print maps and posters incorporate inventions patented by Joseph Gerber, if not in their works, then at least in their DNA. So, while Gerber would never have considered himself a GIS pioneer, the field we know today could not have come into being without his work.

The Inventor's Dilemma is part biography, part personal reminiscence on the part of its author, and part contribution to business history and the history of science. The book is very readable, with illustrations and photographs, notes, a bibliography, and an index. Those interested in the history of technology as it applies to the development of computer cartography and, eventually, of GIS may wish to read this book. Geography and map libraries may wish to acquire it, as most GIS professionals will likely prefer to borrow rather than own it.



LOST MAPS OF THE CALIPHS: DRAWING THE WORLD IN ELEVENTH CENTURY CAIRO

By Yossef Rapoport and Emilie Savage-Smith

University of Chicago Press, 2018

349 pages

Hardcover: $55.00, ISBN 978-0-226-54088-7

eBook: $55.00, ISBN 978-0-226-55340-5

Review by: Barbara Harrison, Tom Harrison Maps

In the fall of 2000, a representative of Christie's auction house in London contacted Emilie Savage-Smith about an Islamic manuscript that was due to be sold, entitled *The Book of Curiosities of the Sciences and Marvels of the Eye* (romanized as *Kitāb Gharā'ib al-funūn wa-mulah al-'uyūn*, and shortened in this book to *Book of Curiosities*). Savage-Smith, Professor of the History of Islamic Science at the University of Oxford's Faculty of Oriental Studies, examined the text, maps, drawings, and diagrams of the manuscript, and declared it authentic. It was subsequently purchased by a London dealer in rare manuscripts, who, after realizing its historical importance, sold it to Oxford's Bodleian Museum/Library at well under its fair market value. Although a few scholars had previously known of the treatise, none had apparently known about the fourteen unique maps it contained, or about its wealth of information concerning travel and communications between Byzantium and the Islamic world in eleventh century. The ancient document also, as Savage-Smith discusses in the second chapter of *Lost Maps of the Caliphs,* shows valuable evidence of the importance of both astrology and astronomy in medieval Islam.

Savage-Smith's co-author, Yossef Rapoport, is Professor in Islamic History at Queen Mary University of London. A historian of various aspects of Islamic life in the Middle Ages in the Arabic-speaking part of the Middle East, he contributes most of the detailed discussions of the maps and related geographical and trade information to be found in *Lost Maps of the Caliphs*.

I offered to review this book for *Cartographic Perspectives* for several reasons. I am not a cartographer myself—although I am married to one—but I was born with the wanderlust curiosity about the world that I have recognized in so many of the cartographers I have come to know. As a child I was always reading books about other countries and cultures, and my parents even bought me a school binder with a map of the world on the cover, a map I pored over regularly. In addition, although I have never been to Egypt—where the *The Book of Curiosities* was compiled—I have spent time around the Middle East, in Beirut, Istanbul, and Iran. It was, in part, these formative experiences that prompted me to undertake this review, and I am glad that I did, even though—despite some brief mentions of Persian cartographers—it contained less information on these places than I had hoped.

Until a few years ago, little to nothing was known about the *Book of Curiosities*, but the authors of *Lost Maps of the Caliphs* undertake to fill that gap with this detailed account of its history and the story behind how it came to be made. They find the wide range of material in the *Book of Curiosities* offers numerous insights that prompt us to reconsider our assumptions about how the structure of the cosmos and celestial phenomena were understood in the first four centuries of Islam, and how that understanding affected the development of astronomy, astrology, geography, and cartography.

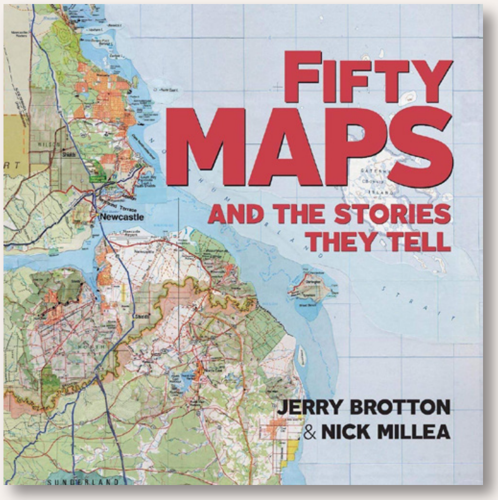
The *Book of Curiosities* serves not only as a history of global communication networks, but it also provides one of the first glimpses into how Muslim seafarers saw the world and depicted it in their maps. In addition, it shows how sailors navigated, particularly in the Mediterranean, before the invention and adoption of the compass. Based on the authors' research, the maps in the *Book of Curiosities* show evidence of the use of coordinates to plot location, despite the lack of such navigational tools. In Rapoport's view, these early cartographers were apparently drawing from the works of Ptolemy, the Greek astronomer/astrologer who was also the first known geographer/mathematician to use longitude and latitude lines based on celestial observations to specify locations.

The question is raised in the Conclusion as to who it was that authored the *Book of Curiosities*. The comprehensiveness of approach and large number of diagrams and maps in the treatise suggest to the *Lost Maps* authors that the author may have been a military man and mapmaker rather than a scholar or merchant.

Lost Maps of the Caliphs includes photographic reproductions of several maps in each chapter. Some are in color and others are in black and white. Quite a few of them—like the one on the cover—are taken from the Bodleian Library's collection in Oxford. At first glance, the maps may look, to modern-day Western eyes, more like intricate ,abstract drawings than maps, and it could, in many cases, be hard to determine what is being depicted. However, the authors provide informative notes that are interesting in themselves and a real help to anyone who cannot read Arabic.

I found the book's use of endnotes, rather than footnotes, a major drawback that distracts from the flow of reading. Some of the notes added to the narrative, but many were source citations—and I could not tell which it was until I had stopped reading to look it up. After having read several chapters while flipping back and forth, I gave up and only referred to a footnote if it seemed like it might be of particular interest.

Although the narrative of *Lost Maps of the Caliphs*: *Drawing the World in Eleventh Century Cairo* was a bit confusing at times, the story behind the *Book of Curiosities* was interesting and informative. The medieval maps that were included were both fascinating and unusual, perhaps especially so because they bear only a slight resemblance to modern maps. This book is worth a look for the maps alone, and scholars of medieval history, geography, or cartography may well wish to purchase it. Casual readers, as I can attest, may also find it fascinating—but may find the $55 list price just a bit steep.



FIFTY MAPS AND THE STORIES THEY TELL

By Jerry Brotton and Nick Millea

Bodleian Library/University of Oxford, 2019

144 pages, 80 color plates

Softcover: $20.00, ISBN 978-1-85124-523-9

Review by: Jörn Seemann, Ball State University

The interest in old maps and the history of cartography seems to be increasing, and this trend is reflected in the book market. A large number of volumes on historical maps, the history of cartography, and the life and work of specific mapmakers have been published in recent years, and the up-tick shows no sign of slowing. Interested readers can choose from books with such catchy titles as *Theater of the World: The Maps That Made History* (Berg 2018), *Maps: Their Untold Stories* (Mitchell and Janes 2014) or *Maps: Finding Our Place in the World* (Akerman and Karrow 2007). Some titles promote the quantity of their contents, along the lines of trendy clickbait articles advertising "[some number] of [places or things] to [somehow experience] before you die"—among them one finds: *A History of the Twentieth Century in 100 Maps* (Bryars and Harper 2014), *A History of America in 100 Maps* (Schulten 2018) or *100 Maps That Changed the World* (Harwood 2012). Some famous map libraries have also jumped on this cartographic bandwagon and released their own picture books, where they highlight the most celebrated and/or curious pieces in their collections (Barber and Board 1993; Rumsey and Punt 2004; Virga 2007; Hall 2016; Harper 2019). This very journal, *Cartographic Perspectives*, regularly publishes reviews of this type of book. How does *Fifty Maps and the Stories They Tell* fit into this publishing trend? Is it just another map book, or does it present a different approach to map history? It certainly promises a lot, and shows a good leg, but it is no exhaustive coffee table volume.

The editors of this compilation are well-known history of cartography scholars. Nick Millea has been the map librarian at the Bodleian Library at the University of Oxford since 1992. He is a contributor to the journal *Imago Mundi* and has been organizing the renowned and ongoing *Oxford Seminars in Cartography* lecture series. Jerry Brotton is a Professor of Renaissance Studies at Queen Mary University of London, a television and radio host (notably, of the British Broadcasting Corporation series *Maps: Power, Plunder, and Possession*) and a curator of exhibitions. He has written an insightful book on the mapping of the early modern world (*Trading Territories: Mapping the Early Modern World*, 1997), edited a popular coffee table book with the title *Great Maps: The World's Masterpieces Explored and Explained* (2014), and is the author of the bestselling *A History of the World in Twelve Maps* (2012).

Fifty Maps and the Stories They Tell comes as a seven-by-seven-inch softcover, and presents 50 maps from the Bodleian Library that are arranged in chronological order. With a few exceptions, each entry is given a two-page spread containing an image of the complete map, with a caption and one paragraph of text to place the map in its historical context and to describe its contents. Some maps, such as Al-Idrisi's twelfth-century *Nuzhat al-mushtaq ("Entertainment for he who longs to travel the world")*, the Gough map of Great Britain (c. 1390–1410), a Tudor tapestry map (c. 1590), and Selden's early seventeenth-century ink-on-paper map of China by an anonymous Chinese mapmaker, get two-paragraph discussions with zoomed-in image details laid out over four pages.

The selection of maps includes cartographic "staples" such as the fifteenth-century print of Claudius Ptolemy's world map, European and Arabic medieval *mappae mundi*, early maps of Dante Alighieri's Hell and Thomas More's Utopia, an Aztec map of Tenochtitlan from the Codex Mendoza (1542), a Marshall Islands stick chart, and hand-drawn sketches for both J. R. R. Tolkien's Middle-Earth and C. S. Lewis's Narnia. The authors admit it was not a simple matter to select just fifty maps from the Bodleian's impressive collection of more than 1.5 million, and they are eager to point out the diversity and pluralism to be found in cartography by selecting maps from different times, backgrounds, and places that showcase a variety of different narratives, purposes, themes, and worldviews. I was pleased to find that the book was not an account of exclusively Western cartographic history, and included maps and mappings from other cultures. Western, or European, cartography has long focused on the precision of measurements, coordinates, and location, but of these fifty maps, almost one quarter are non-European cartographic renderings of topics and values such as cosmology, mythology, and indigenous conceptions of space that—in conventional "Western" terms—would be considered immeasurable or even "unmappable." For example, a page from an eighteenth/nineteenth-century copy of *The Tibetan Book of the Dead* does not resemble a conventional Western map at all, but is "a spiritual route map to salvation" that serves as a "funerary manual shown to the dying to help the soul navigate through the liminal world … between death and rebirth" (81). The sealskin map appearing on page 86, made by a member of the Chukchi people in Siberia (c. 1860), with its depiction of hunting grounds, fishing areas, and fur trade routes close to the Bering Strait, can be read as both a calendar of economic activities throughout the year and a narrative of daily life and customs. These examples definitely broaden the idea of maps beyond traditional Western ideas.

Another positive surprise is the inclusion of unconventional maps from the twentieth and twenty-first centuries. Of course, there are thematic "regulars" that appear in almost every book on the history of cartography: a map of the British Empire (here, it is Philip's *Mercantile Chart of the Commercial Routes to the East*, 1906), a trench map of the Belgian front during World War I (1917), a D-Day landing map, and a shockingly accurate topographic map sheet of English towns produced by the Soviet military during the Cold War. But, beyond these, the reader can also find curiosities that are likely unavailable outside the Bodleian Library, and might not even be found on the internet. The map of the working-class neighborhood of Cutteslowe in Oxford (1933) includes handwritten notes and corrections, including walking times to bus stops, and the addition of two massive brick "protection walls" that separated a low-income housing project from an affluent urban development—cartographic testimony to an "urban apartheid in Oxford" (104–105). Other unusual selections include sketch maps handed out to soldiers participating in the 1951 British military operation "Exercise Surprise Packet" that showed an imaginary United Kingdom where Scotland and the northern part of England are labeled as Fantasia and connected with Scandinavia by a land bridge (122–123).

No one said that "historical" maps must be "old," or even on paper, so Brotton and Millea do not exclude examples from the most recent chapters in cartographic history. A cartogram of the 2017 British general election (134–135) and a wildly distorted grid map of the world population (138–139) point out new directions in cartography.

In addition to these cartographic surprises, the editors also include three artistic works that establish a link between maps, society, and the arts. Layla Curtis's *NewcastleGateshead* (2005) is a map collage that merges the Tyne and Wear region in Northeast England with cut-out pieces from maps of other places (128–129). A light green area northwest from Newcastle features parts of the Australian desert near Alice Springs, and the name of Newcastle appears fifty-two times on the map. Grayson Perry's *Map of Nowhere* (2008) simultaneously imitates the Ebstorf *mappa mundi* with its body-of-Christ shape and mocks both medieval theological worldviews and present-day self-centeredness (130–131). Another Perry work, *The Red Carpet* (2017), is a tapestry map in the style of an Afghan war rug—a traditional motif in Afghan rug-making dating back to 1979 that incorporates military and battle imagery, and often includes maps—with embroidered buzzwords portraying the *zeitgeist* of the pre-Brexit society in Great Britain (136–137).

Although *Fifty Maps and the Stories They Tell* is a nice read—and a quick one—that introduces a general audience to the fascinating world of historical maps, it remains rather superficial. The authors present ideas and clues on maps and mapmaking, but they do not explore them at all deeply. I was expecting more on the story-telling potential of maps or on the specific uses and purposes of maps in different societies, but, unfortunately, the authors missed their opportunity. Without a more comprehensive explanation, statements in the Introduction like, "Every map tells a story, and *Fifty Maps* is a celebration of the sheer variety of those stories, told by travellers, sailors, merchants, pilgrims and many others" (7) come across as shallow and oversimple, and fail to reflect the complexity, density, and diversity of mapping the world.

Fifty Maps was assembled to accompany the Bodleian Library's *Talking Maps* Exhibition (July 2019–March 2020), a show that also resulted in a far more detailed and weightier catalog, *Talking Maps* (Brotton and Millea 2019). As well, in keeping with the publication trends mentioned at the beginning of this review, the Bodleian Library has recently brought out another book showcasing their extensive collections, *Treasures from the Map Room* (Hall 2016; **reviewed in** *Cartographic Perspectives* 89). As a result, there are many repetitions and overlaps between *Fifty Maps*, *Talking Maps*, and *Treasures*. All in all, *Fifty Maps and the Stories They Tell* comes out as an ultralight variant of the new crop of Bodleian books. The text is informative, but really only scratches the surface of map history. I expect that most *CP* readers would like to know more about the topics and maps it touches on so lightly. The general "further reading" bibliography at the end of the book can only partially make up for this shortcoming.

So is this just another map book? Maybe. It is definitely targeted at those who really only want a quick sampler or are not yet ready for a bulkier tome on the history of cartography. If, as seems to be the case, the Bodleian Library intends to provide a map collection product for every level of interest, expertise, and pocketbook, they should seriously consider offering a map postcard book like *Antique Maps* from the Library of Congress (1999), as well as upgrading their singularly disappointing website (**bodleian.ox.ac.uk/maps**). At any rate, *Fifty Maps* is an entry-level, budget book that piques the reader's curiosity to explore other works on the topic. Needless to say, there is much to discover.

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

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

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

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

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