Cartography in Creative Cloud

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Abstract

For more than a century, cartography has been explored and defined as a set of visual rules a cartographer must follow in order to create a highly effective map. In the late 1960s, civic geographers have aimed at leveraging academic expertise and technology to analyze the issues of urban communities through alternative data sources and cartography. In 1968, The Detroit Geographic Expedition explored issues of racial disparity in Detroit through the use of critically cartographic maps that utilized an entirely different set of tools and data collection methods than had been traditionally valued by trained cartographers. Since then, the landscape of technologies and data we use to make maps has drastically changed. It is now possible for someone with no technical training to create a map within a few minutes, and the legitimacy and cartography of these novice maps might never be questioned. While this poses a real problem for maintaining cartographic integrity and unbiased data representation, there are many best practices that can be introduced to lessen the inherent distortion of these alternative maps. This paper aims to utilize a range of geospatial technologies and Adobe Creative Suite to create cartographically sound maps that anyone with basic knowledge of these software can utilize. To practically demonstrate how these technologies and techniques can be operationalized, I produced a map series and topographic reference tutorial. By focusing on current data visualization and collection techniques and analyzing trending cartographic options I hope to inform best practices for anyone wishing to make a beautiful effective map.

1. Introduction

There has been much technological advancement in the realm of GIS, allowing anyone with some knowledge of a variety of product suites the ability to create a map. ArcGIS and the open source QGIS, along with an array of online products, are capable of generating a map with very little input from the user; with default settings in place there is little need for visual adjustment and the vast majority of maps leave cartography at best as an afterthought.

Cartography is simply the art and science of making maps. More than mere technical skill, it is an applied art determined by scientific law and subject to visual interpretation.

Eckert writes in *The Nature of Maps* (1908) that generalized maps, and in fact all abstract maps, should be products of art clarified by science. To make these visual interpretations, one must have a firm grasp on the theories of design and graphic visualization. This includes color theory, visual hierarchy and the understanding of concepts such as balance, space and alignment - all while remaining as true as possible to the geography being represented.

What my paper addresses is the lack of cartographic reason involved in these easily produced maps that tend to stay within the default settings zone, and therefore lack both the visual hierarchy and interest that are not just possible, but that comprise the tenants of good graphic design and cartography. My research includes a broad overview of basic cartographic principles and a brief history of conventional and alternative mapping techniques. Within this essay are a series of detailed tutorials containing both the instruction and reasoning that will allow anyone with some knowledge of GIS software to create more beautiful and cartographically sound maps.

My methods describe the task of choosing both subject matter and an organization to benefit from this study. The technologies used for obtaining an effective data visual representation are wide ranging and thoughtfully crafted for suitability to each project. Efficiency, resource availability and best practices are also taken into account. A range of industries can benefit from this research, with the example of government agency used to demonstrate color theory and other cartographic elements.

This study explores each subject matter in depth, focusing on the audience for each resulting visualization. Determining the intention of the map and the intended audience, a collaborative effort is used to decide on a presentation for a finished project and what technologies are most effective within the organizational needs. Taken into account are the main tenants of graphic design, using color, visual variables, and visual hierarchy.

1.1 Why the need for cartographic standards?

Can cartography in any way lay claim to the designation of art? Max Eckert wrote over a hundred years ago in his book *On The Nature of Maps and Map Logic*. He assesses that cartography is not merely a technical art, but that, "the majority of authorities on the subject recognize the existence of an artistic beside a scientific element in cartography" He believed that cartography is for the greater part an applied art, an art governed and determined by scientific laws. (Eckert, 1908) Traditional map-making technologies have evolved significantly in the past 40 years, but has cartographic method and logic followed? Aside from the default settings for symbology and style inherent in the software used by today's GIS professionals, it seems little thought is given to the design aspects that are an intrinsic aspect of cartography itself.

Map logic, as explained by Eckert, is the underlying laws which govern (map) perception. Much time has been devoted to the study of perception and cognition as it relates

to the visual interpretation of maps. The theory of cartographic communication was studied intensely in the 1960 and 70s, with a focus on the relationship between how cartographers' design decisions influenced the symbology and style, and to what extent those graphic decisions allowed a map user to perceive and extract information. Visual hierarchy, a basic tenett of graphic design, refers to the separation of elements into different depth planes in order to emphasis features while diluting those elements that are not as important to the message of the piece. In a map scenario, visual hierarchy is used to convey the important features of the map while background features (or noise) are de-emphasised.

Work within psychology on perception and cognition, the "meaning-making" functions of sensory interpretation, has further helped cartographers develop rules for creating visual hierarchy by identifying which visual variables are pre-attentively processed by the eye-brain system (Griffin, 2017). Psycho-physical map design experiments attempted to identify relationships between variations of symbology on a map, and measure how map users perceive these differences. Some tests to help improve cartographic logic included: discrimination of visual symbols, focused relationships between the area of a proportional-area symbol (comparisons between symbols shape, the area the map user perceived that the symbol covered eye tracking experiments and color choice (Griffin, 2017).

In response to the prescription of cartographic method was the rise of alternative mapping (critical mapping, and counter-mapping), that gained popularity in the late 1960s with the Detroit Geographic Expedition and William Bunge's alternative maps and data sources. Participatory mapping using alternative symbols and styles raised an awareness of cartography as extremely visually subjective. Maps as representations of geography and geographic phenomenon took on a style of their own that relied more on engaging the map user more through emotional response than cartographic logic. Bunge's War Atlas and the Fitzgerald neighbor maps embody this approach. (Fig. 1.1.1)

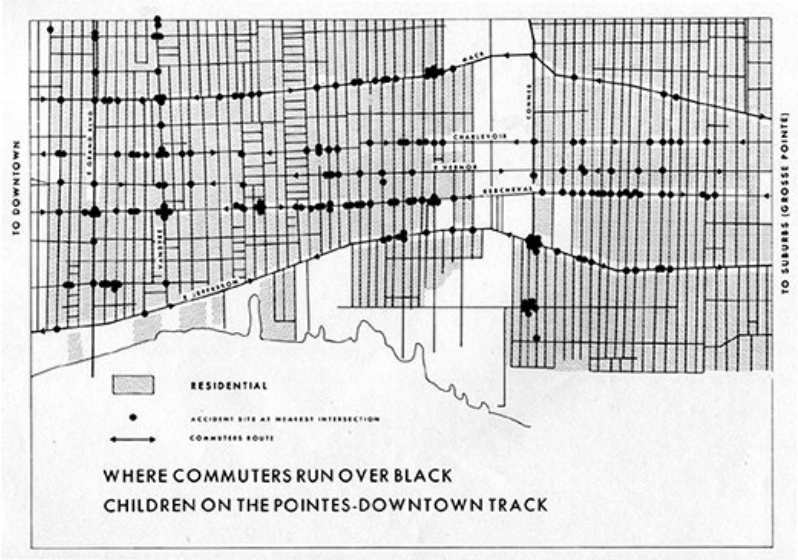

Figure 1.1.1. W. Bunge Map, 1970.

Participatory maps, counter-mapping, crowd sourcing, and critical cartography all elude to a more social experience in mapping and data collection. Anyone with internet access is able to easily produce a map on websites such as MapChart and ScribbleMaps. Anyone with basic GIS knowledge can produce a map using open source products like MapBox, OSM, and even do complicated geographic data analysis with QGIS. Though all software has set defaults, there is much room for creativity in symbolizing and styling a map. This can be problematic in adherence to known cartographic and basic graphic design tenants such as visual hierarchy, color theme, balance, contrast and more.

In an ever-broadening world of available technologies and variations of map creation techniques, Menno-Jan Kraak notes that the map has undergone many transformations mirroring the spatial turn in society. He writes that "the traditional 'authoritative' view of the map being a carefully crafted product by the cartographer, aimed at visually communicating a complete, mostly static database of known geographic facts to a user, has turned into a participatory and collaborative perspective" (Kraak, 2017). Because of the multitude of environments available to map makers, an effort to redefine cartography was published by the International Cartographic Association in 2011 as, "Cartography is the art, science and technology of making and using maps." This new working definition incorporates every aspect of each word so as to align with changing technologies. Ultimately, Kraak understands that, "a strength of cartography might precisely mean to constantly adapt to societal and technological change, without compromising on fundamental cartographic values." (Kraak, 2017).

While the ICA is defining the meaning of cartography to keep up with all the changes in the map making world, Terry Slocum recognizes that as technologies become more sophisticated, they will be of little use if people cannot utilize them effectively. He addresses specifically the technology of interactive web mapping, or dynamic maps, and the way users interact with the information across of full range of technical options and devices. He suggests in his essay, "Cognitive Usability Issues in Geo-visualizations," that cartographers need to take a two-pronged approach to maintaining cartographic logic when making interactive maps. Those are a) theory driven cognitive research, which refers to the previous studies that have sought to seek understanding in how humans create and utilize mental representations, and b) usability engineering, which are the methods for analyzing and enhancing the interaction of the map to the map user. (Slocum 2005). Ultimately, he points out that, "Theory-driven cognitive research provides the basis from which a framework for designing methods can be developed. Usability engineering principles will be critical in insuring that applications are both easy to use and meet their intended tasks; additionally the iterative design process should assist us in developing cognitive theory."

Dennis Wood states that the future of mapping is "rooted in map art practices - mental maps, indigenous and bioregional mapping and critical cartography - with all kinds of fusion, interbreeding, and boundary crossing; fueled by a widening perception of global injustice, it is counter-mapping that shows us where mapping is headed." Equally important to the new

technologies available to create maps are the "new attitudes, visions, and radical philosophies of the counter-mappers that are really taking maps and mapmaking in a while new direction." (Wood 2010).

Surely there is no standard cartographic prescription that could encompass the ideologies of the artists and scientists who over the past century have proposed their best practices. With the vastness of available technology, and the visions of alternative cartography, how can cartography be kept in the forefront of map making practice? That challenge is the focus of my study.

2. Intervention

The technical portion of my research seeks to address the most effective visual representation through cartographic best practices and adherence to the basic tenets of graphic design. Cartography is often an afterthought for many GIS users, and choosing to create maps using the default setting in GIS software tends to render maps that are at best visually unappealing, and all too often ineffective for ease of use. Not only are different data types best represented with distinct visual solutions, color, space, typeface, and layout must all be considered when creating a map that is intended for an audience.

There are two web-based portions of my research that consist of a series of health equity maps of Pierce County, WA, using data from the Washington State Department of Health, and the Tacoma-Pierce Health Department. These maps are a comparative series that show a number of health indicators including life expectancy and rates of disease. The cartographic aspect is shown with choropleth maps that use a color ramp specifically designed to draw the observer to areas of importance. These maps are displayed on a story map based template that was created using ArcGIS Online embedded as an iframe on my portfolio website. The second aspect of my intervention is the High Park Fire map technical overview, that is also located on my portfolio website as a tutorial a featuring how-tos for different aspects of its design, both in GIS software and Adobe Creative Cloud.

3. Methods

Backed by scientific research on visual perception, along with close adherence to the tenants of design, a series of maps were created highlighting best practices: these include a web-based health equity assessment and a static map intended for large format print. The goal was to find opportunities for cartographic need, collaborate with community partners and develop a GIS plan that would yield a highly effective map product. Dependent upon organizational goals and resources, a plan was put in place to utilize available data sets to achieve a specific GIS outcome through a varied use of geospatial technologies including custom interactive web maps, and a static informational map. These map series cover the process of creating these projects as they relate to cartographic methodology and are intended

for use by GIS professionals and hobbyist map makers alike. The tutorials focus on the design theory of cartography as prescribed by visual cognitive and perception research.

The methods I used for my project are various cartographic technologies - both online and desktop. These include: ArcGIS Pro, ArcOnline, and Adobe Creative Suite. For data, I used everything from basic shapefiles, to csv and geojson. Following, I cover the functions in both Arc and Adobe Create Suite for displaying different file formats, and exporting into new formats. The data sources for these maps are taken from many sources, and data gathering methods and best practices for displaying different types of data (normalizations, etc). For each map created, there is a discussion of the following: data source integrity; feature representation options / symbolizations options, best practices and considerations; and other cartographic best practices where appropriate (graphic hierarchy, labels, etc).

The data sources I used are: Esri Open Data, data.gov, Natural Earth, NASA, Open Street Map, and other state/local government agencies. The area of interest was determined by the availability of data sources and community collaboration. The maps I made are: a series of comparative health equity maps using the same data source normalized in different ways; and a static map of the High Park Fire burn area from the 2012 wildfire in Colorado's Roosevelt National Forest.

The technical portion is a web-based series of health equity maps of Pierce County, WA, using data from the Washington State Department of Health, and the Tacoma-Pierce Health Department. These maps are a comparative series that show a number of health indicators including life expectancy and rates of disease. The cartographic aspect is shown with choropleth maps that use a color ramp specifically designed to draw the observer to areas of importance. The High Park Fire map technical overview is also located on my portfolio website as a tutorial a featuring how-tos for different aspects of its design, both in GIS software and Adobe Creative Cloud.

3.1 ArcGIS Product Suite

Both the health equity map series and the High Park Fire Map began in ArcGIS Pro. This program was used to identify the area of interest at the desired scale and orientation that would appear in the final map product. ArcGIS Pro contains functions for importing data sets directly from both online and desktop sources, and many of the data options in the online portal are available as ready-to-use feature layers that do not require any direct downloads.

From the catalogue pane in ArcGIS Pro, the options for online data sources are the all portal and the living atlas. The search bar at the top of the catalogue pane allow for easily identification of desired data sets, and the right-click option allows the add to map function that automatically adds the data to the existing map. An important first step after adding any data from either portal is to check and correct any projection differences, that is done by

opening the layer options, choosing coordinate system and applying the same projection to each new layer. For the health equity series, this process was done by adding data through the catalogue pane not from an online portal, but from the data that existed on an external hard drive provided to me by the Pierce County Health Department

For the health equity maps, the data was quickly exported for use in Adobe Creative Suite, where the maps styled and labeled, however, ArcGIS Online was employed in the final creation of the technical online portion of this project as a story map. After the maps and legends were finalized, the graphics were uploaded to ArcGIS Online and a tabbed, side-bar story map was assembled for easily viewing and comparing the maps. (Fig. 3.1.1)

The health equity map series was added to my portfolio website on its own page using an iframe that links directly to the Arc-hosted map. The original Tacoma-Pierce Health Department maps example are also shown for comparison, not just in design, but also for display and ease of use. The original maps exist on the Tacoma-Pierce website as downloadable pdf files and are difficult to find. There is no discernable way to view multiple maps in order for the user to compare areas so a side-by-side comparison of my series to the original series offers the viewer a before and after impression of how applied cartographic technique can improve a map.

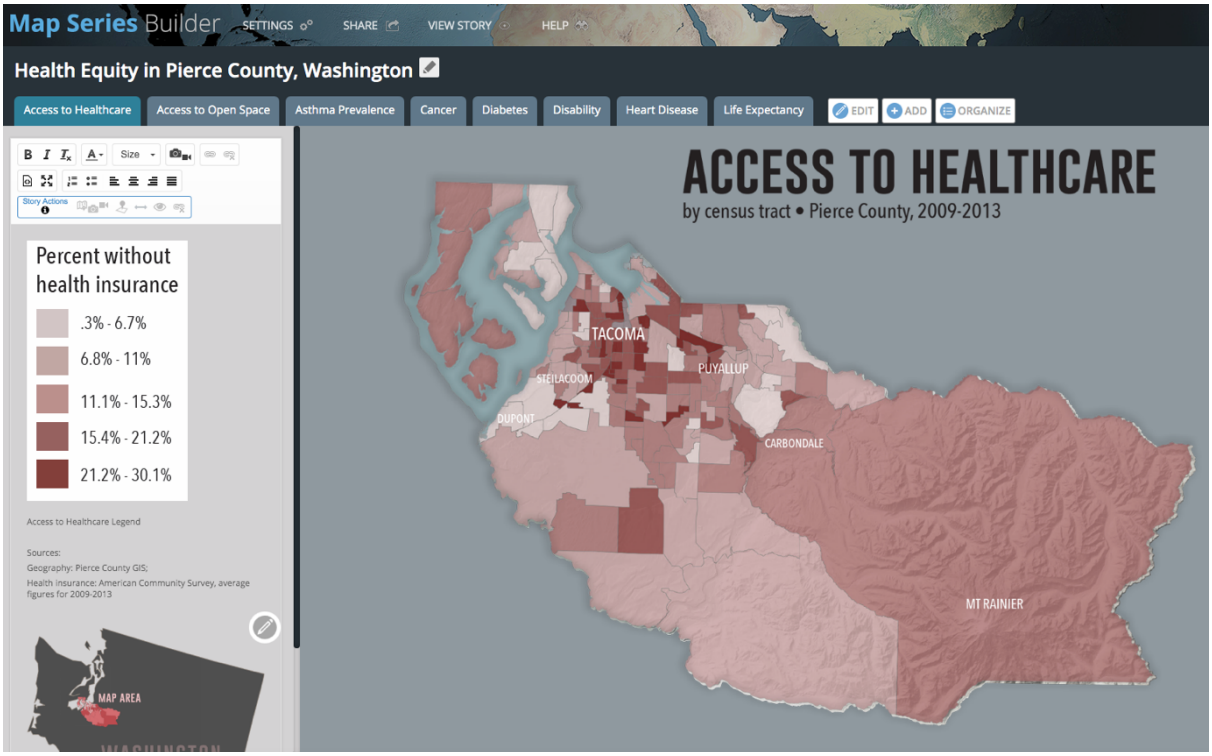

Figure 3.1.1. ArcGIS Online story map editor.

After initial creation in ArcGIS Pro, these maps were exported as pdfs and opened in Adobe Illustrator. Although exported pdfs are able to be opened, the layers do not remain intact, nor do the lines (for example, roads) appear as contiguous, rather as small line

segments. In order to apply styles to feature layers, new layers must be created from the bits and pieces that have appeared in the one layer that at first contains all the images. During exportation, clipping paths were also applied to every layer, so these must also be sorted through and deleted before new layers can be created. Some important tips on preparing the data in ArcGIS before exporting will help make this transition easier:

• Do not apply any styling in the symbology pane in ArcGIS. This includes halos, extra strokes, or any other graphic effects such as drop shadows or transparency.

• Graphics, such as circles, and other symbols, consist of two elements: a fill and an outline. It is best practice to export maps with only one of these options applied. Otherwise in Illustrator they appear as separate images which may not be manipulated individually. This is also redundant since the functionality exists in Illustrator for adding outlines or fills to these symbols as one graphic.

• Set up the layout in ArcGIS Pro to the exact size you desire for the finished map. This way, when exported there won't be the need to resize or guess on placement of features.

The High Park Fire map included data gathered form the ArcGIS online portal and living atlas, the USFS and the USGS National Map Download. (See Fig 2.1.2 for drawing layers of the High Park Fire map in ArcGIS Pro). For the High Park Fire map, each layer was exported separately and then reassembled in Illustrator. The burn area outline was included on each individual layer export and used to align the layers. This was less tedious than having to extract all the graphics from one layer especially while being constrained by a multitude of unnecessary groupings and clipping paths. (For Illustrator layers, see fig 3.2.2)

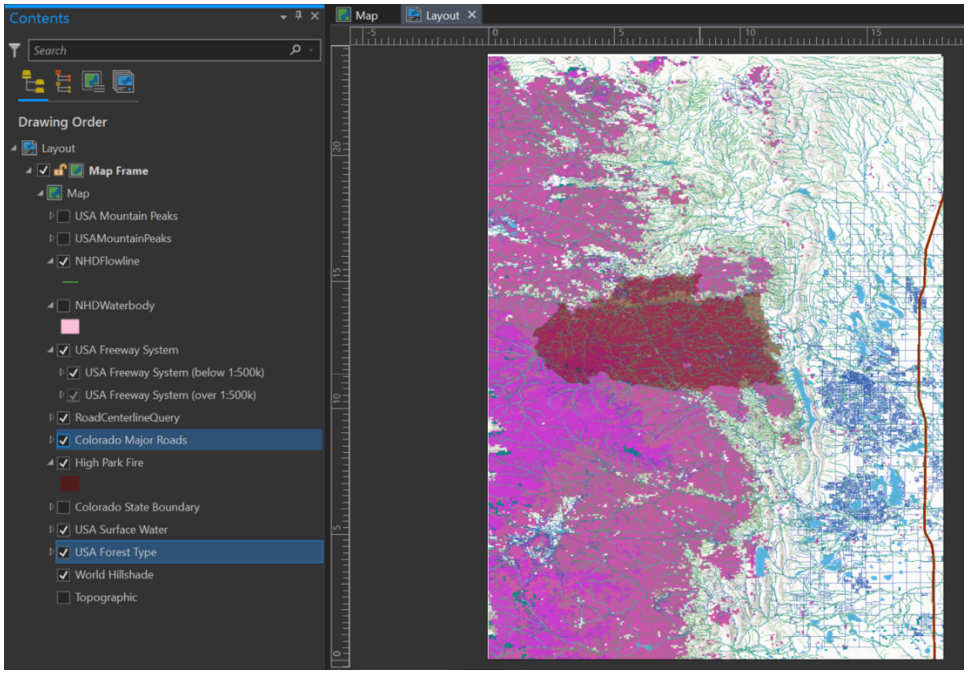

Figure 3.1.2. ArcGIS pro drawing layers for High Park Fire map.

3.2 Adobe Creative Cloud

Professional cartographers create maps using the Adobe Creative Suite of software that includes Illustrator, Photoshop and InDesign. Even GIS professionals that utilize cartographic techniques and styles inside the ArcGIS product suite are using styles and symbols that were created with an Adobe product (Illustrator for vector graphics such as svg or eps; Photoshop or jpgs, gifs and both for pngs). In *Mapping with Style*, a technique is presented for creating a Middle Earth style map (among others), where the style set is imported for use in ArcGIS Pro – a style set created in Illustrator (Nelson, 2018). A recent conversation with an Esri Map Authoring Team Manager informed me that a graphic creation function had been considered for inclusion in ArcGIS Pro, but decided against for reasoning that the audience who would utilize such tools are already using Illustrator to create maps.

With the release and encouraged transition from ArcGIS Desktop (ArcMap) to ArcPro, serious cartographers were disappointed to find that there is no export option directly to Illustrator. In ArcMap, the functionality exists that allows for easy transition from the GIS platform to the Creative Cloud, where layers are kept intact and there is minimal layer restructuring; when opened in Illustrator, the layers with their previous naming conventions appear in the groups assigned in GIS software. Not so with ArcGIS Pro. Software developers at Esri informed me that this is a functionality they are working on but had no information on when it might become available. For now, exporting data for use in Adobe Creative Suite remains clunky with time-consuming tedium for preparation to style cartographically.

It should be noted that Esri has created a product called ArcGIS Maps for Creative Cloud, which is a plug in for Photoshop and Illustrator. The basic version is included with your ArcGIS subscription however for the cartographic functionality such as the ability to save your work, or use a high-resolution setting, there is an advanced user's fee. Important styling functions are not supported at all such as layer and feature transparency and raster marker symbolization.

The Pierce County health equity maps existed in Illustrator as the county outline with one of two boundary options, demarcated by zip code or Census tract. The sections were re-colored appropriately and then transferred into a Photoshop template where a transparency, and inner glow effect were rendered on the map. Inner glow is a style effect that is used on water bodies to accentuate the water's edge and give the appearance of depth. (Fig. 3.2.1) There is also a hillshade layer that is part of the photoshop graphic file that was originally exported from ArcPro. The hillshade was added in Photoshop because it is easier to select and delete the other areas outside of the Pierce County boundary, a function that is not possible in either ArcPro or Illustrator. This graphic was saved as a png, and placed in an InDesign template where the legend, labels and text were added to the map. The legends are graphic files created by taking medium resolution screen shots of the pdf created from the InDesign file. Finally, all these individual graphics were uploaded to the ArcGIS Online story map editor, where the legend and the map area graphics appear as a sidebar, and the maps are controlled by tabs at the top of the page. (Fig. 3.1.1)

On the sidebar of the story maps online is also a map area graphic. This was created in Illustrator by copying and resizing the Pierce County graphic onto the Washington state graphic, and labels were added. The graphic was saved as a png and added to the story map sidebar under the legend.

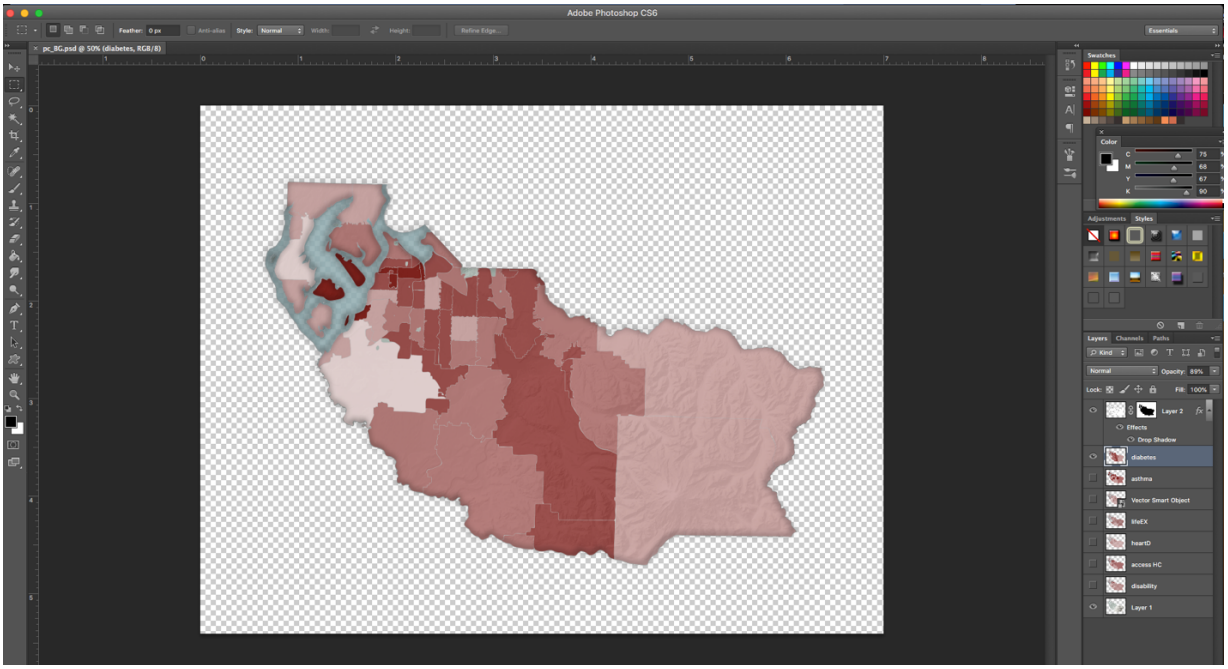

Figure 3.2.1. Adobe Photoshop transparency and water effects.

For the health equity maps, a choropleth visualization was created because this type of map is the most effective for viewing values of statistical variants, such as disease rates in a community.

The choropleth color ramp is composed of 5 variants of red, with the areas of least concern skewed in the direction of very little tint. The tint increases as follows in accordance with risk level: category 1 (most risk) = 100% crimson; category 2 = 75% tint; category 3 = 50% tint; category 4 = 15% tint; category 5 (least risk) = 5% tint. The alternative to use a 10% tint of black for areas where the viewer is not intended to initially notice is also an option. In section 5 (Resources), there are suggested online resources for cartography specific color ramps. Alternatively, any one hue can be tinted, or a transparency applied, that will have the same effect as assigning each value a distinct color.

The High Park Fire map was assembled from layers exported from ArcGIS Pro, and rendered in Illustrator and Photoshop. Although the layers all came from ArcPro, the vector graphics were stylized in Illustrator – these include the roads, labels, boundaries, hydrology, and icons. (Fig. 3.2.2) By creating separate layers, stylizing each feature is simple and

orderly. This is also the only way to make the roads "connect." Once the roads (or any route, i.e. trails) is assigned a layer, a graphic style is applied to the layer that allows the individual lines to join. (This function exists in ArcPro as an on-off option with no further functionality or appearance control.)

The raster layers of forest type and hillshade were rendered in Photoshop, with the forest type layer highly edited for hue-saturation. This layer appears in ArcPro as magenta due to the many variations of forest type (Fig 3.1.2); this level of detail is not needed for this map and the goal was to show that it is a forested area while maintaining accuracy.

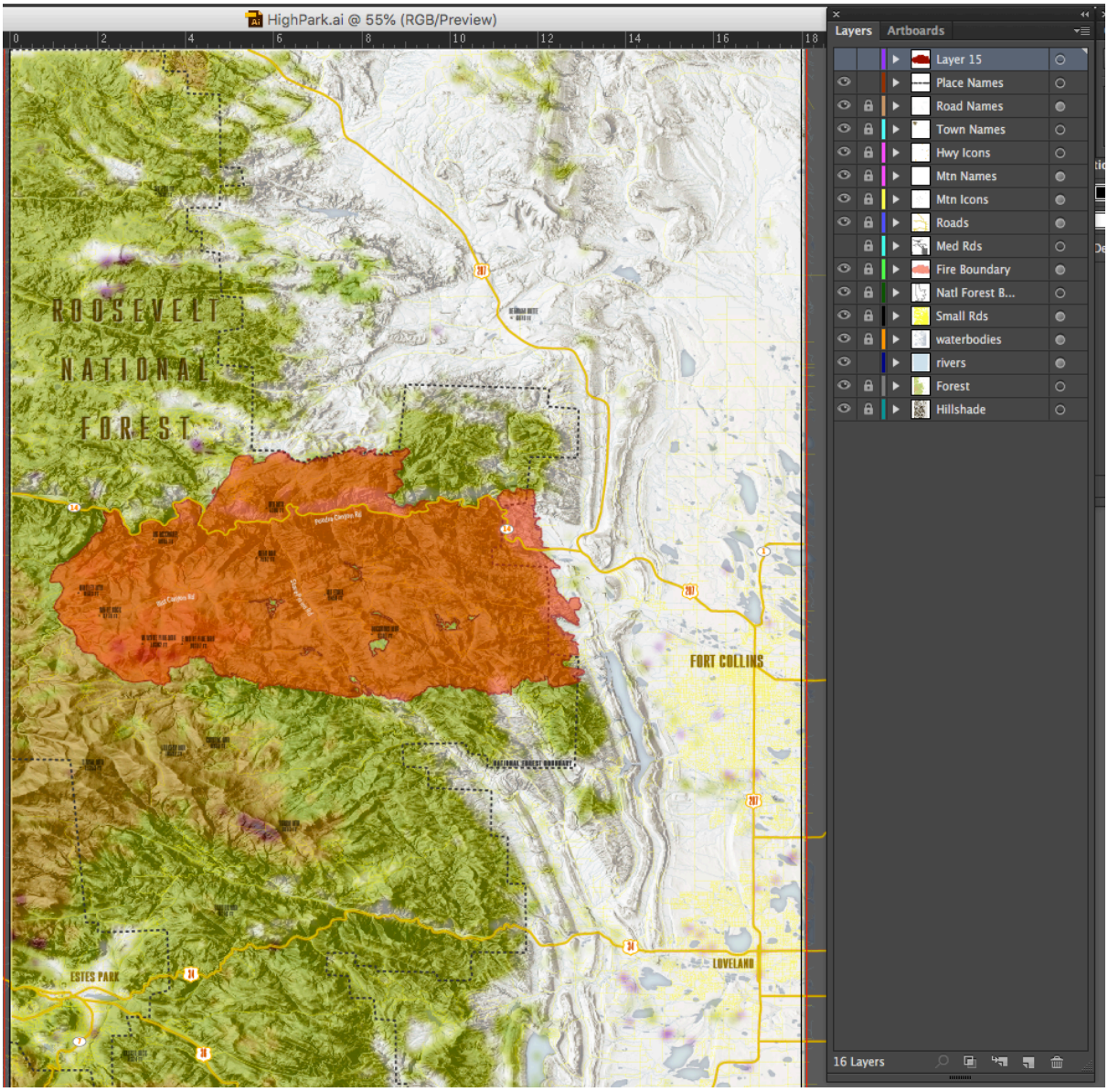

Figure 3.2.2. Adobe Illustrator High Park Fire map layers.

4. Discussion

Cartographic standards are imperative, and map makers must follow the initial first questions, *who is this map for* and *what am I trying to convey with this map?* With the equally important *how can I best display this data?* There are so many options available to cartographers, that going beyond the default setting, and utilizing different image rendering technologies ought not be an afterthought, rather an integral part of the map planning process.

There are a few basic design concepts to consider when planning the type of map you'll create, aside from color is symbology. This employs an understanding of visual variables (the differences in map elements as perceived by the human eye) that is the choice a symbol implies or doesn't imply regarding patterns, groups, order, and quantity. These variables that weigh on perception are position, size, shape, color value, hue, orientation and texture. (Bertin, 1977) When size and color values are changed among symbols, it breaks the perception of "sameness," and should be avoided when symbolizing within groups. Size and color are also used as ordered symbols in order for the user to immediately recognize an order of values. Quantitative values are the differences between the ordered symbols, for instance the difference in hue or saturation of the steps in a classified color ramp.

4.1 Using color on maps

Choosing colors carefully based on the nature of the data being mapped will ensure your map's efficacy. The dimensions of color for systematically encoding geographic data are hue, lightness and saturation and the nature of your data dictates what type of color scheme to use:

Table 4.1. Choropleth Color Schemes

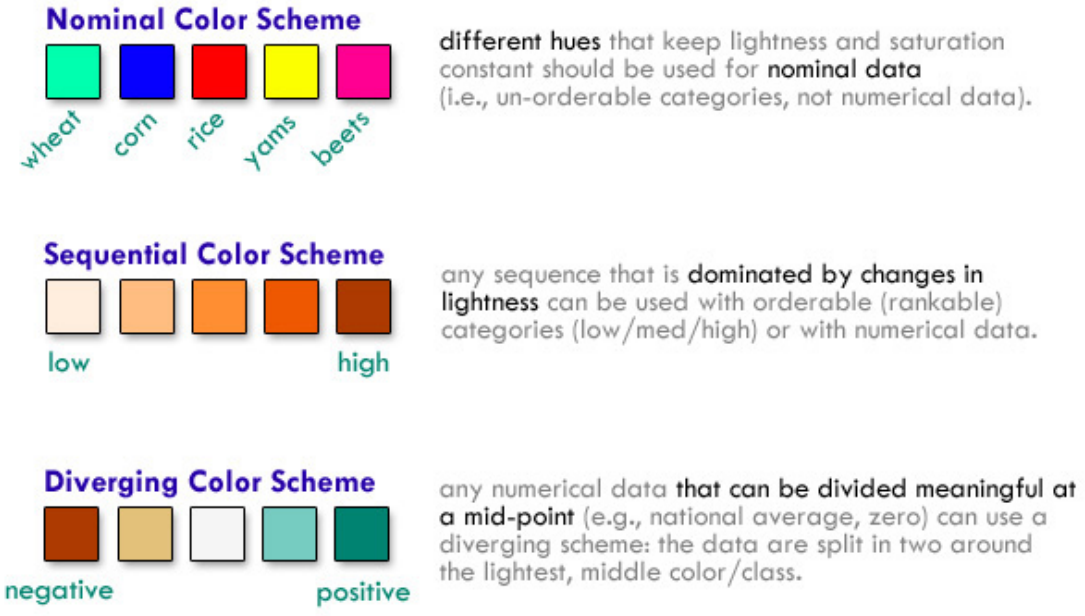

Table 4.1 University of Wisconsin Dept. of Geography at axismaps.com

Choropleth maps are a type of thematic map typically used to highlight variations in a specific value. Tacoma-Pierce Health Department had a series of similar health equity maps available as pdfs on their website (Fig. 4.2.1). These maps were created using census data, and utilize a green to red color ramp to show a range in values. The green to red color ramp is the default in ArcGIS for symbolizing ranges of unique values. While the eye may be drawn to the color red as an area of interest, the use of this nominal color themed ramp is not a good choice for sequential data, such as the increasing percentage of disease rates. A sequential color schemes can be single or multi-hue, but is dominated and ordered by differences in lightness/saturation. Similarly, a sequentially diverging schemes should only be used when your data has a natural mid-point such as a zero or if you want to compare places to something like the national average. (Brewer, 2015).

4.2 Visual variables

Visual variables are the differences in elements as perceived by the human eye. Retinol variables were proposed by Bertin in 1977, and expanded by Robert Roth of the University of Wisconsin Department of Geography to include color, saturation, texture, crispness, resolution and transparency.

Table 4.2. Bertin's Visual Variables

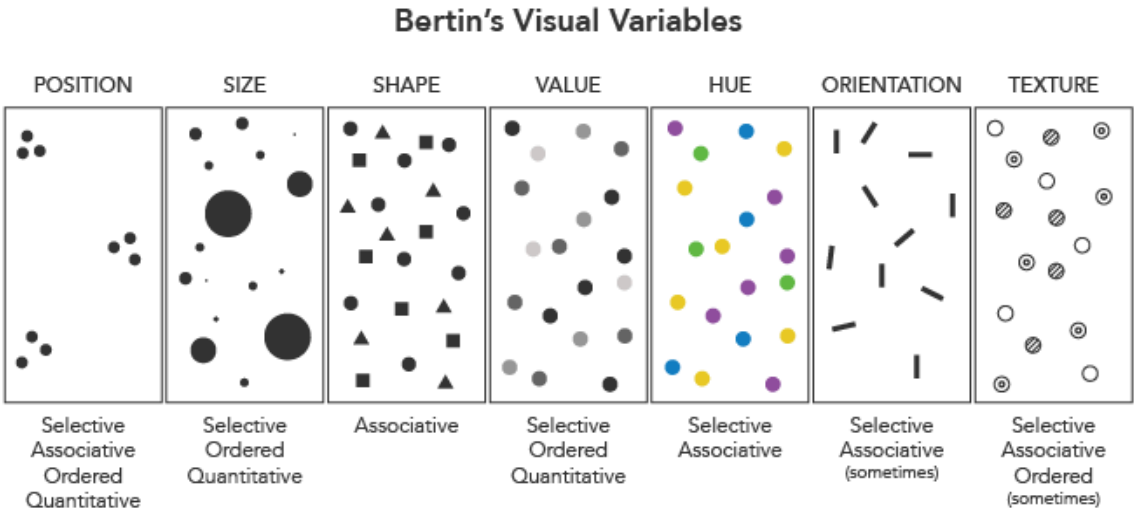

Table 4.2 University of Wisconsin Dept. of Geography at axismaps.com

4.3 Visual hierarchy

Visual hierarchy is the organization of design that allows for the prominent map elements to appear as more important and enables the viewer to immediately discern the map's intent. Visual hierarchy should answer the question *what is this map meant to show?* without the user having to first consult the title or legend. A key understanding of the figure – ground relationship is required to successfully achieve visual hierarchy. Color, size and contrast play a large role in assigning elements to the foreground or background; larger,

darker objects will draw the eye while lighter, non-contrasting elements will fade into the background. Page layout, including title, legend, text or chart placement is also important to consider when creating you map.

4.4 The maps

The health equity maps that were created for my research intervention use a sequential color ramp with tints of crimson. As attention is still focused on the area of interest with dark red (for this map series it is the areas with the most concerning values), the color ramp moves to the lesser areas of concern that are colored with lighter shades at increments distinct enough to easily recognize their corresponding values. The Puget Sound is represented with a lighter blue and an inner glow effect to visually give it depth ,yet it remains low in the visual hierarchy of the map. The entire color ramp has a transparency applied and a hillshade layer is visible behind, giving the viewer a sense of depth and some reference to the terrain. Like the original maps (Fig. 4.4.1), Pierce county is contained within its boundary, however I have added an area map to the story map online to give the viewer spatial reference of the study area.

The most obvious difference is the use of color between my series and the original health department maps. Because of the bold, nominal colors used on the original maps the viewer cannot immediately discern the intent of the map. Historically, green hues are used to represent natural areas, so this is misleading, and without studying the legend, these colors are meaningless. When there are so many design functions available, even in GIS software, a transparency can be used to control both saturation and layer visibility. To give a map more depth, a hillshade is encourage even if it is comparatively light. As seen in both the health equity and High Park maps, a hillshade both improves the visual interest aspect of the maps and gives the user an idea of area topography. Use of only flat and bold colors have their place in cartography for use in cartograms, or other types of general interest map styles however when representing physical map features a hillshade is recommended. (Rosenberg, 2019)

The sequential color ramp used for the health equity maps was created in Illustrator by differing the tint of a single hue. The option to create color ramps of different but sequential shades is an option, especially when using multiple colors such as a purple to cream color ramp. The important aspect of choosing a color ramp is that one end of the ramp is markedly darker and the colors increase in lightness at a rate discernable to the user without having to reference the legend. Often there is not enough change in color value to easily perceive and correlate on the map, this results when there are either too many tints of a single color, or the values are too close together (for example, a 50% tint versus a 60% tint.)

Finally, the story map online allows for a quick and easy comparison between the maps in this series. The maps are all at the same scale and placement on the page. Using the tabs, the user can alternate between the maps with minimal visual breaks and the titles are bold and easy to read. Overall a much more user-friendly map series.

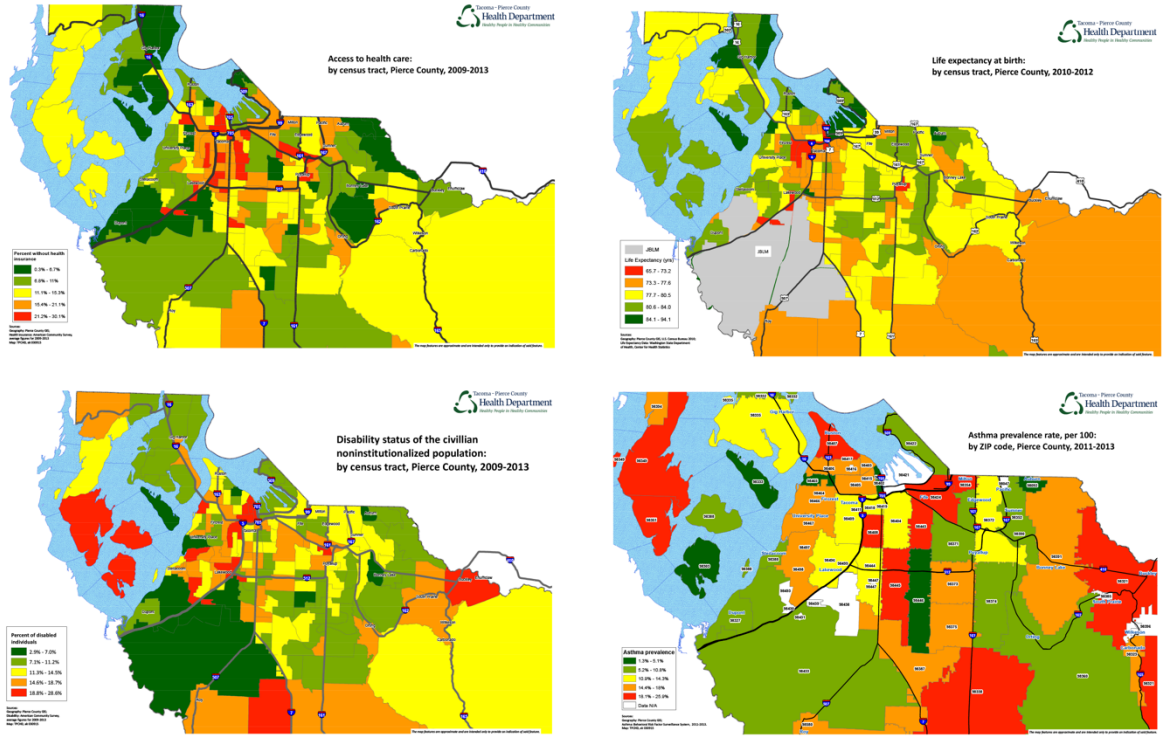

Figure 4.4.1 Tacoma-Pierce Health Dept. choropleth maps

The High Park Fire map is a topographic reference map created to show the boundary and the surrounding area of Colorado's second largest wildfire to date in 2012. This fire burned over 87,000 acres and destroyed 259 structures inside the Roosevelt National Forest that lies about fifteen miles west of Fort Collins in northern Colorado. Cartographically, this map resembles a typical topographic map however each layer was chosen and symbolized to best emphasize the map's purpose: to easily determine the size and location of this fire.

This map was made not as a cartographic improvement to an existing map, however there were many reference maps used in its creation. Most of the reference map were standard topographic maps with the fire boundary outlined. These less technical maps were used by news outlets while the forest incident management organizations used aerial imagery over-layed with more specific location information. The purpose of my map was to show the fire boundary and surrounding area of this fire. It includes a fire-progression graphic and an area map as well as information about the fire such as burn area, temporal information and structures burned. The High Park Fire map was made specifically as a product to be entered into map gallery competitions and displays.

The reason for making the map aside, producing it was an opportunity to experiment with cartography tools in both GIS software and Adobe Creative Cloud. The goal was to make a map that was visually appealing, effective, and informative all while using cartographic best practices and examples from other successful maps. For GIS people and serious cartographers alike, there are simple tools to employ, and design elements to consider when starting your map. There are often additional concerns of organizational branding or technology limitations that may seem limiting but with proper design technique any obstacle can become an asset if sound cartographic techniques are employed.

This being a physical map used for reference while featuring topographic illustration there was little need to consider color choice other than for physical features such as forest, water and roads. While keeping in mind cartographic conventions (blue for water, green for natural areas, etc.), the choice of color scheme was chosen based on the desired aesthetic, the medium and purpose. (Bretin, 1977)

A layer that needed extensive color adjustment was the forest type layer. In ArcGIS Pro, this data layer is representative of over 100 different forest types symbolized by unique value using a default color scheme. Since there were only a few forest types that appeared in the region of interest (as shades of magenta, Fig. 3.1.2) there were options in correcting the symbology colors – either in the GIS software or in Adobe Creative Cloud. I chose to render this layer in Photoshop, because it was to appear as a background raster layer, and the color adjustment could be done easily to the entire layer at once. Once in Photoshop, the image > adjustment function was utilized for hue/saturation and the color scheme was altered to green. (Fig. 4.2.2) The alternative way to change the colors is in the GIS software program, by selecting each forest type feature's symbology and choosing a new color. This is time consuming and problematic because each distinct forest type would need to be selected and changed individually; incompatible or thoughtless color choices could easily affect the accuracy of the representation. Using the image > adjustment function in Photoshop retains the visual separation of forest type colors while changing the entire layer color scheme in a uniform and complimentary fashion.

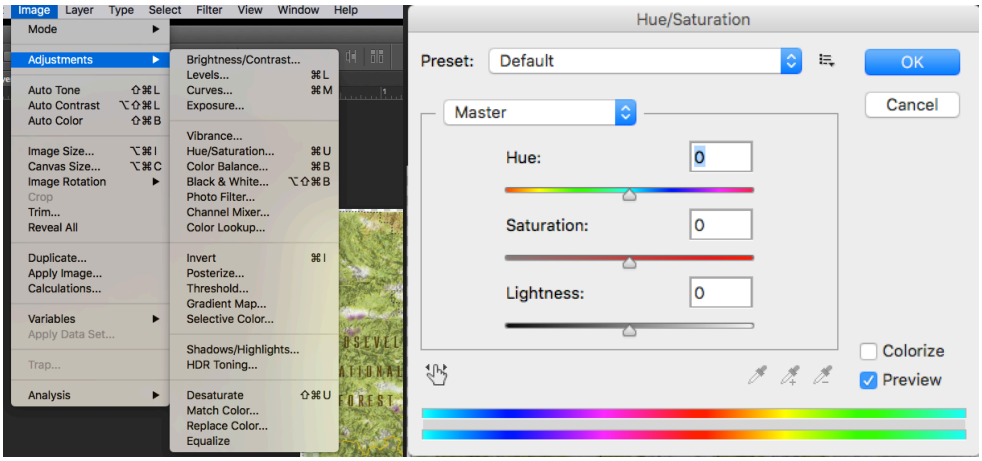

Figure 4.2.2 Photoshop image adjustment for hue/saturation

Symbolizing vector layers in Illustrator, and adjusting layers for color and transparency in Photoshop created a more visually appealing map than is achievable in ArcGIS Pro. Many of the design functions and filters are available only in design software, these add interesting cartographic effects and push your map past the default setting of GIS software. Many of the advanced functions such as glows, layer effects, 3D effects, sharpens and blurs, and different types of transparencies have not been detailed in this paper but are available as cartographic tools in design software. Finally, there are other considerations for using Creative Cloud such as the final presentation medium of your map. If a map is to be printed, there is no better software than Adobe InDesign for prepress preparation for the print layout functionality and pre-flight features that professional printing companies expect. If a map will end up online, there are sizing, resolution, screen color and file format functions that are best executed in Photoshop.

5. Conclusion

With this paper, and intervention comparison and tutorial I hope to show that creating cartographically sound maps is easily attainable with alternative settings beyond the defaults for software such as Arc and QGIS. The information attained through use of my cartographic tutorials has the potential to instill basic design theory in map makers; going forward design decisions can be implemented based on some of the principals I have presented.

Visual thinking is a scientific research area that has been studied since the 1950s. Before that, Eckert and others proposed cartographic standards based on map logic (Griffin, 2017) In 1995, the United States Geological Survey organized and published map standards in *Cartographic and Digital Standard for Geological Map Information* as a guide for map makers and since then there have been many others.

How does design theory intersect with cartography, and why the need for cartographic standards? Cartography is most simply defined as the art and science of making maps, and visual art is based on human perception. Whether a map is functional or not depends on the ability of the user to interpret its meaning and a maps effectiveness is determined through the choices made by the cartographer. Much of the art of making a map is subjective, depending upon the use of the map, and even ones definition of what constitutes a map. However, without cartographic standards, there is no immediate map logic that can be perceived and mentally categorized so as to give meaning to a map. (Slocum 2005)

Color theory was presented in this paper, as was cartographic use of color for thematic maps. The default setting of a green to red color ramp were shown as an example of a nominal color ramp choice that is not appropriate for sequential data. (Fig. 4.2.1) in the original Tacoma-Pierce Health Department health equity maps. The online story map intervention was created to appropriately apply a color ramp that highlights areas of interest in a logical way representative of the data values. The colors of this map series are also desaturated and made less bold, a transparency was applied to make hillshade visible and inner-glow effect added to the water layer to give the appearance of depth. In the High Park Fire map, use of color followed the prescribed cartographic color standards – green for

natural areas, blue for water, etc. The stroke and outline stroke color for the roads, as well as the highway icons were a choice based on both complimentary yet contrasting hues that set the roads apart from the background while not making them a prominent visual feature.

The ways by which to adjust colors were also detailed, in both GIS software and in Adobe Creative Cloud. Color ramp choices are available in ArcGIS, and in design software they can be created or imported from color scheme creators online. The types of color ramps were identified and details regarding their use explained. Colors choices as they relate to feature symbology icons are important should be considered within the overall style of your map. Transparency as it relates to color is useful for hue and saturation manipulation and makes a map more visually appealing.

Visual variables were discussed in reference to symbology choices for size, spacing, shape and texture. The way in which the human eye creates recognizable patterns and categorizes groups is important to consider when symbolizing features. The ways in which visual variables are perceived have implications for their use as map symbols. Selective variables represent groups, while associative variables allow for grouping across changes in variables (for example, purple circles for homes versus purple triangles for businesses.) Ordered variables have a recognizable sequence, for example changes in symbol size can be inferred without having to consult the legend. (Bertin, 1977) It is important to understand how map symbols imply groups, patterns, order and quantity.

Finally, visual hierarchy, was referenced throughout by every color, size, pattern and placement choice of the elements on a map. A map's visual hierarchy should match the intellectual hierarchy in that the meaning, or intent of the map should be obvious. The elements are ordered by importance and visually they are what is immediately perceived versus what can be considered the background. Answering the question *what is the intent of this map?* is the first step in determining your visual hierarchy and every choice that follows. In making these thoughtful cartographic choices, a map can be exponentially improved for clarity, beauty, and most of all efficacy.

6. Resources

This paper describes use of Esri's ArcGIS product suite and Adobe's Creative Cloud suite. These software suites both incur a monthly fee for usage. Although there are discounts for varied user groups (the Adobe student discount is worth checking out), they are not free. There are open source software alternatives that offer similar functionality. These include QGIS for geospatial data representation, and Inkscape (Windows), Affinity Designer (Mac) and GIMP (Windows, Mac and Linux) for raster and vector image manipulation.

A popular resource for color schemes specifically designed for cartographic use is the online palette generator Colorbrewer. This web-based resource has options for class number,

diverging or converging themes, and single hue palettes. The palette selected can then be copied directly into map software or saved in xcel, csv or css format. (Fig. R1)

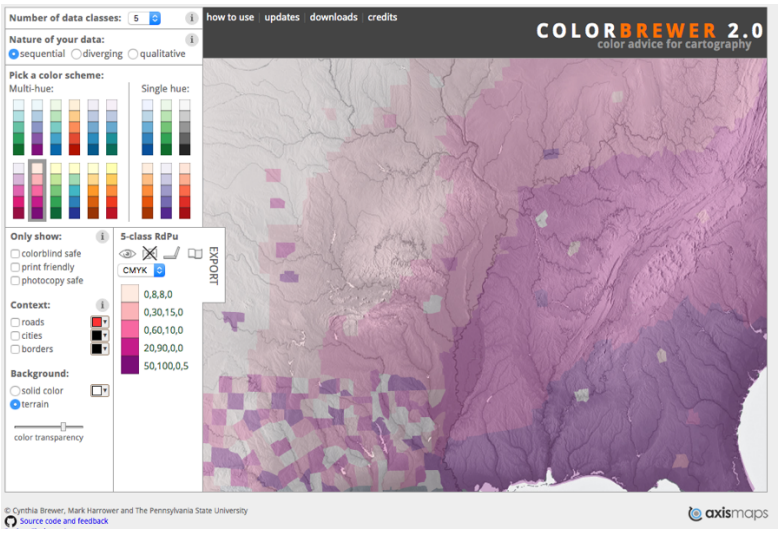

Figure R1. Colorbrewer online color palette generator by Cynthia Brewer

Another online resource for cartography can be found at carto.com/carto-colors. These data-driven color schemes are offered in sequential, diverging and qualitative ramps that are easily copied as HEX# into a map template.

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