[CV-04-034] Map Icon Design

Abstract

The use of map icons is an efficient way to condense a map object into a concise expression of geospatial data. Like all cartographic design, map icon design merges artistic and scientific elements into symbolic representations intended to be readily legible to map readers. This entry reviews the types of map icons and elements of icon design, including the ways in which the visual variables are used in map icon communication. As communicative devices, icons are imbued with cultural meanings and can oftentimes lead to the preservation of stereotypes. This review concludes with an examination of icons' perpetuation of – and challenge to – cultural stereotypes.

Keywords: cartography, design, feminist critique, map icon, visual variables

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Explanation

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1. Definitions

ANSI Standard Symbolization: a private not-for-profit organization administrating the creation and management of standards of conformance, which includes symbol standards

cultural negotiation: the process by which the meaning of a sign is formed through uneven social discourse

distractor: an object in a visual field that inhibits readers from identifying target objects during the visual search process

feminist cartographies: cartographic visualization that confronts current dominant power structures

iconicity: the degree to which the sign of the icon visually resembles its referent

- **associative:** a sign closely resembling an activity or object related to the referent, but does not resemble the referent itself
- **geometric:** a sign that bears little or no resemblance to their referent; these signs

are constructed with abstract geometric shapes, like a circle or a triangle
- **pictorial:** a sign that has been designed to directly resemble its referent

linguistic market: a social arena in which those with the most formal linguistic capital are viewed by most as those with the most credibility

map icon: symbols that incorporate a sign's associative elements with the overall map aesthetic.

map icon library: a set of icons with a similar aesthetic and design elements, so that they may be used in visual concert with each other

mimetic: a sign that imitates the appearance of a spatial feature or an object related to a spatial feature. This differs from pictorial in that mimetic signs do not directly represent the referent.

pre-attentive attributes: intentional characteristics of signs that are generally known by the intended reader without the requirement for further learning

selective visual variable: a variable within a set of objects that distinguishes them from the remaining visual field as part of a group

sign:

- **interpretant**: the conceptual meaning imbued in the sign
- **referent:** the activity or object that a sign denotes
- **sign vehicle**: the graphic form of a symbol that denotes a referent

typology: the study and classification of objects or characteristics of objects into a type or group

visual search process: the manner by which map readers find and identify map objects

2. Overview of Map Icon Design

To understand map icon design, it first must be conceptually situated in **semiotics,** which is the study of signs. **Map icons** are symbols that incorporate a sign's associative elements within the holistic map aesthetic A sign is comprised of three main components: the vehicle, the interpretant, and the referent. In his book A Theory of Semiotics, Umberto Eco defined signs as "everything which can be taken as significantly substituting for something else" (Eco, 1976). Considering Eco's definition, where a sign is "everything" that is substituted for something else, maps are themselves also signs – they are holistic amalgamations of several signs which substitute for phenomenon over geographic space. A map's green polygon is not the forest, but is rather a sign that can effectively communicate the location of a forest in relation to other geographical features, which are also substituted by signs. This inherent spatiality of maps means that unlike most other icons, map icons effectively communicate location.

Map icons also can simultaneously communicate complex activity, such as road closures, festivals, or animal breeding. To imbue such complex meaning into a map icon's relative

compactness, cartographers oftentimes leverage already-established signs into their icon design. While this practice may be expedient for legibility, it can result in perpetuation of stereotypical representations. Section 5 will further discuss this issue of map icon design.

Sign vehicles are the graphic form of a symbol that denotes a referent. When designed well, they are readily communicated to map readers as clear representations of the spatial **referent**, which is the activity or object that a sign or icon denotes. The conceptual meaning imbued in a map icon's sign is known as the **interpretant**.

The placement of map icons most commonly indicates the location of point data, however not all point data need to be symbolized by icons (see **Symbolization & the Visual Variables**). Point symbols represent spatial features that are typically at a scale too small to be symbolized as polygons or lines at the selected cartographic scale (see **Scale & Generalization**). Each icon should fit into its map's overall aesthetics and style (see **Design & Aesthetics**), and hierarchical categories also should be easily identifiable when grouping icons into subsets to encode additional information or improve organization of large icon libraries.

3. Types of Map Icons

Map icons can be either **pictorial, associative,** or **geometric** (MacEachren, 1995). The degree to which a sign vehicle represents its referent is defined as **iconicity** (Figure 1). Pictorial and associative signs both have a high level of iconicity, as they are recognized to have a relation to the referent. **Pictorial** signs directly resemble their referent, while **associative** signs closely resemble an activity or object related to the referent, but not the referent itself. **Geometric** signs are abstract shapes that bear little or no resemblance to the referent. The meanings of many icon signs, including those that are geometric, have become widely understood by the audiences that use them. However, as highlighted in Section 3.2, contemporary discussions on icon design now consider the problematic creation, use, and perpetuation of icons that have widely excluded many groups of people.

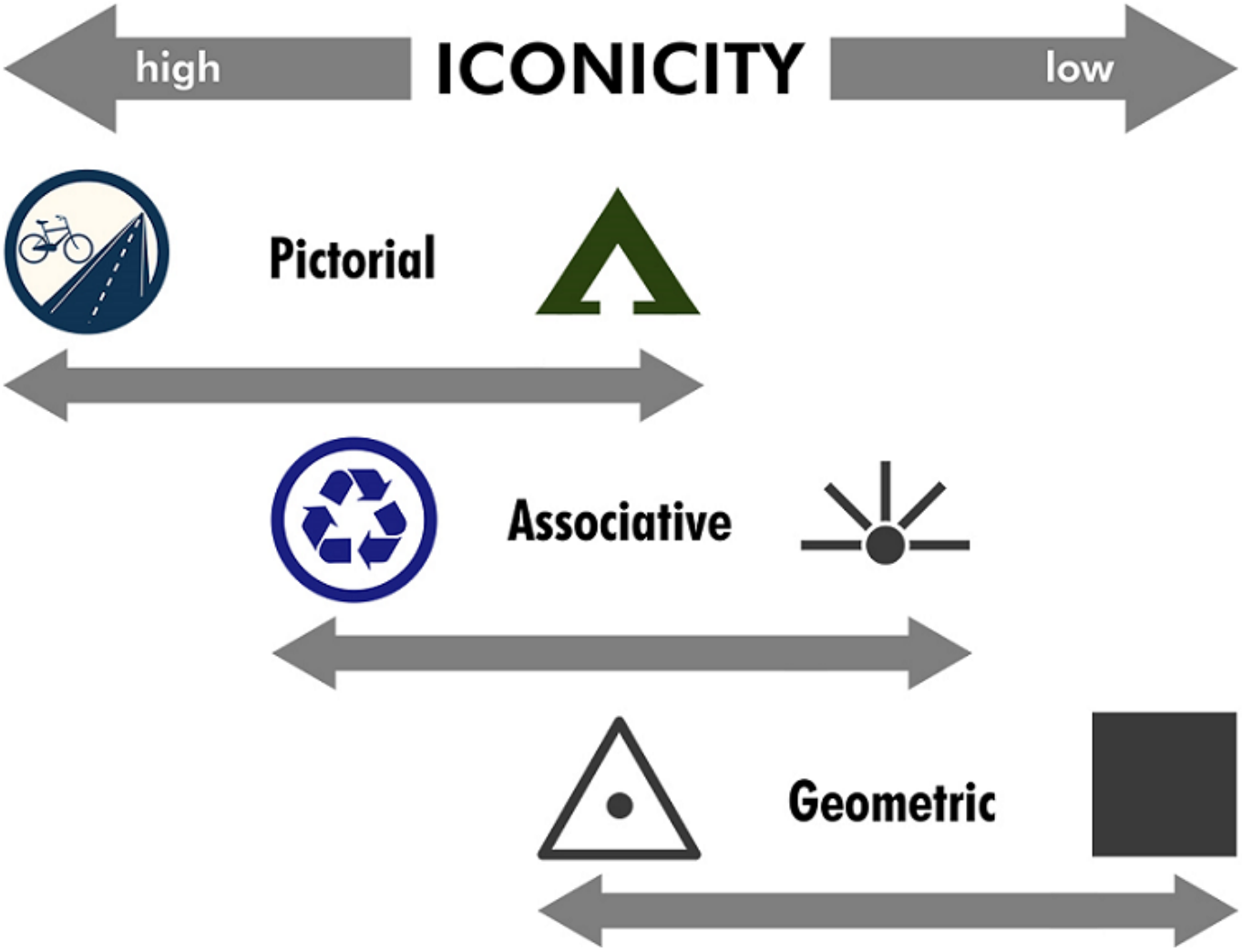


Figure 1. Map icons range in their level iconicity. The concept within this figure has been adapted from MacEachren, 1995. Source: author.

Because map icons expediently convey typological information into one concise symbol across a model of space that contains many symbols and **distractors** (objects in a visual field that distract readers from identifying the target objects), cartographers often use signs with **mimetic** characteristics to efficiently communicate the meaning of the icon's referent (Elias, et. al., 2005). In doing so, map icons use either pictorial or associative signs – the majority being associative – to communicate the interpretant (MacEachren, 1995). For instance, a map icon that consists of a depiction of a trail accompanied by a bicycle silhouette can easily be recognized as the location of a bike trail, in which case the sign's shape is pictorial, since it directly resembles the referent. Likewise, an icon containing a somewhat abstract silhouette of a person reading a book is considered an associative sign since the activity of book-reading is associated with a library (Figure 2).

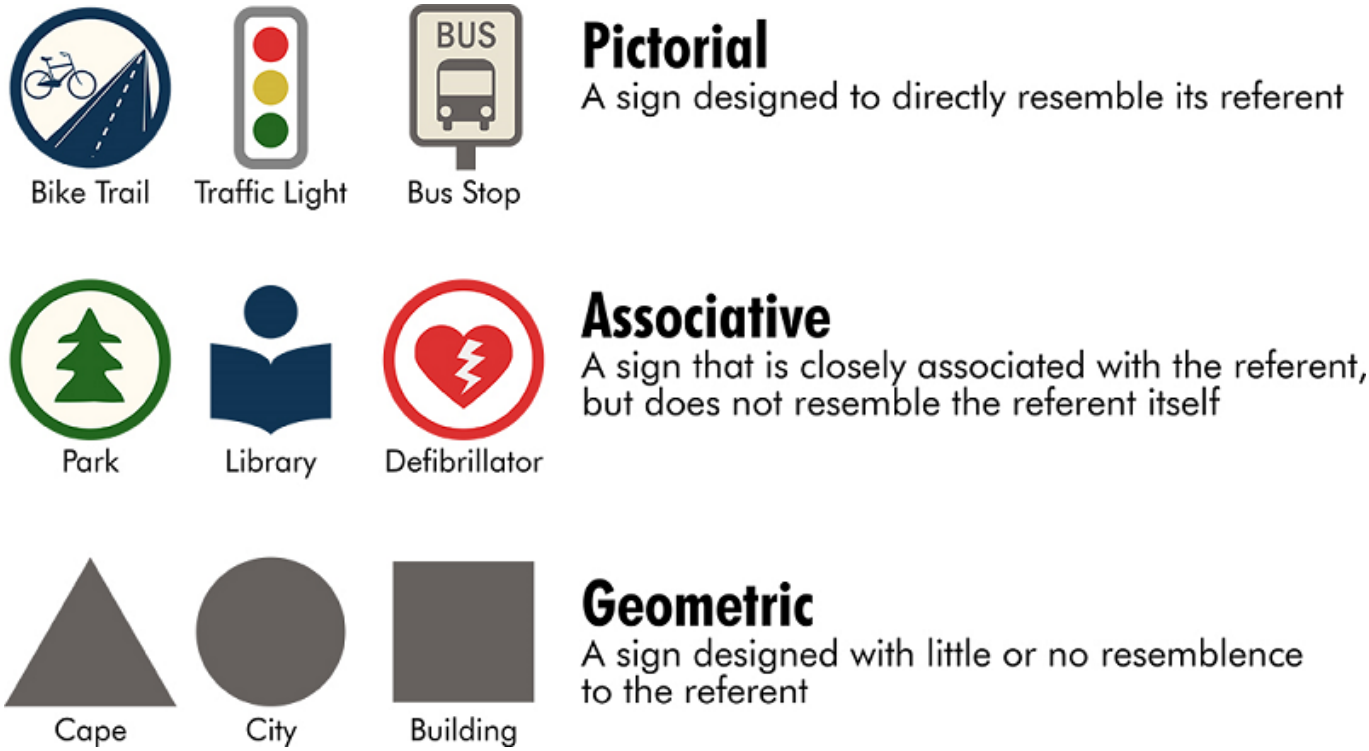


Figure 2. The three typological categories for signs, pictorial, associative, and geometric, adapted from MacEachren, 1995. Source: author.

Several examples of geometric signs that have acquired specific cartographic meanings for map readers can be found on the United States Geographical Survey's (USGS) topographic maps (Figures 3 & 4). Many of these abstract symbols have become ubiquitous in Western culture and are used widely by cartographers.

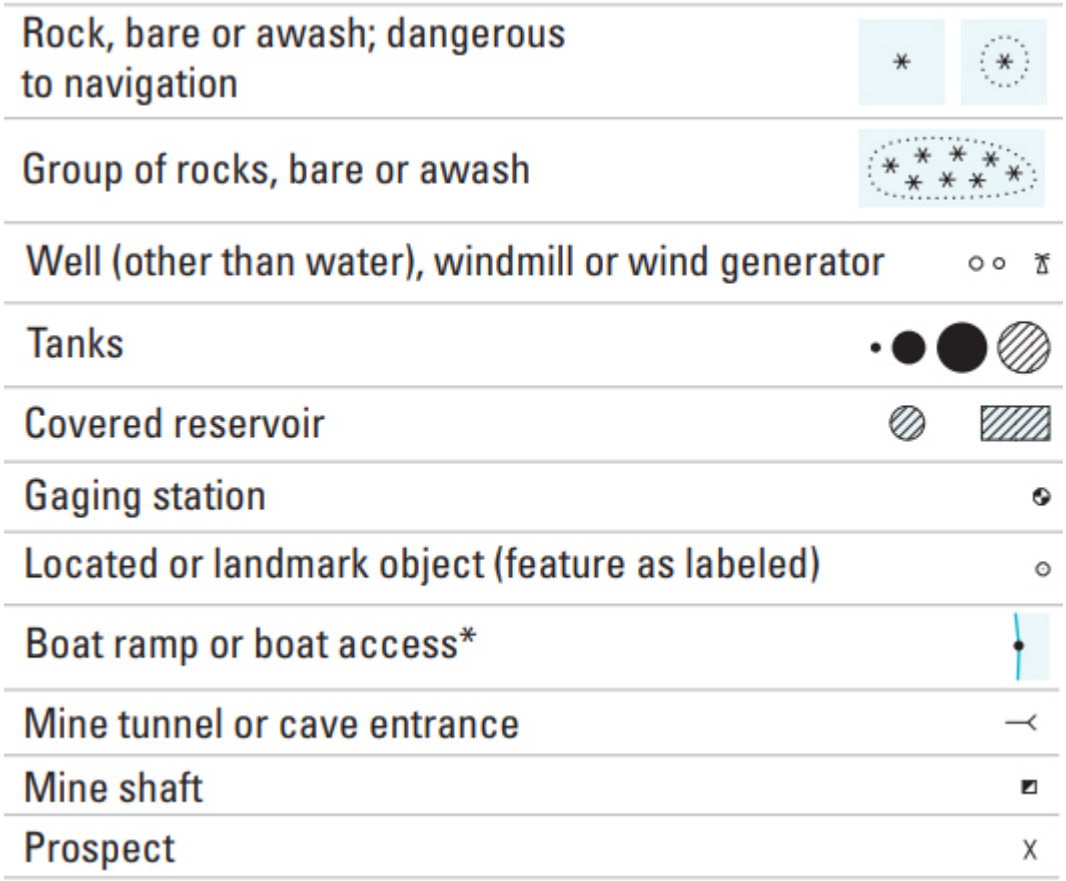


Figure 3. The USGS topographic map symbols consist of many geometric symbols, some pictured here. For example, the arrangement of three lines to form a six-pronged symbol has become a sign recognized by many map readers as a rock formation along a coastline. Source: Topographic Map Symbols, USGS (pdf).

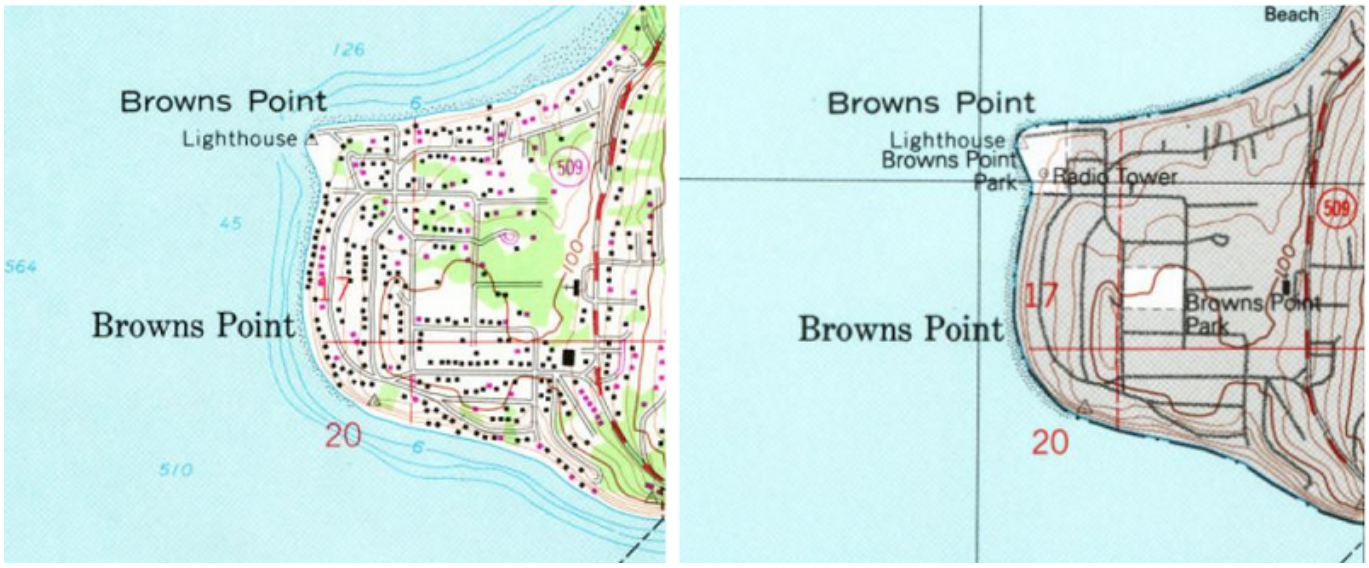


Figure 4. Brown's point in Tacoma, Washington from the 1968 USGS 'Tacoma North' topographic map (left) and its 1997 successor of the same name (right). The triangle symbol with a small dot in its center shown at the southern shoreline of this geographic feature has become widely recognized as a USGS monument by many map users. Source:

author.

3.1 Mimetic vs. Abstract Icons

While pictorial and associative signs with low iconicity are still clear enough to be visually related to a spatial referent, this is usually accomplished with a degree of abstractness. For example, in Figure 2, the bike trail is symbolized by an iconic detailed bicycle silhouette and trail, while the campsite symbol is a tent that has been abstracted to the basic triangle shape that tents had in decades past. Even though it is uncommon to find a triangle-shaped tent these days, when abstracted to this shape, this icon is nevertheless easily read by many map readers as a tent-camping location.

In fact, all map icons are abstractions, just as all maps are abstractions (see **Scale & Generalization**). It is map icons' capacity to generalize a spatial occurrence into one succinct symbol that makes well-designed map icons so advantageous in overall map design.

3.2 Universal Icons

An effective method for creating legible map icons that are quickly associated with their referents is to incorporate signs, regardless of their mimetic nature, that are already commonly used to represent the spatial referent. However, identifying a sign with true universal understanding of its meaning is a challenge in cartography and data visualization.

Working toward universal standards in map icon libraries (see section 5.4), like the subset of icons in Figure 7, can improve communication efficiency across cultures (Bianchetti, et. al., 2012). Organizations like the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO) work to create symbol conventions with universal symbol-referent relationships for the purposes of safety and global legibility. However, it is important to note that these conventions and standards still must be learned by map users, and that no sign is truly universal given variable cultural context.

4. Map Icon Design and the Visual Variables

Because map icons typically communicate categorical differences, map icons commonly use the visual variables shape, color hue and color value, size, and orientation to communicate higher-level information. Size, while not frequently used as a visual variable in map icons, is sometimes employed to indicate the magnitude or amount of the referent(s). Other visual variables used less often may be evoked for representing uncertainty (e.g., transparency, crispness, resolution, etc.) about the map icon (see **Representing Uncertainty**), an additional recommendation from **feminist cartographies** (D'Ignazio, 2017; Kelly, 2018). See **Symbolization & the Visual Variables** for expanded discussion of the visual variables as they apply to point symbols.

5.1 Shape

Shape, or the form of the icon, is the most common visual variable that map icons use to

differentiate between referents (Michaelidou et. al., 2005). The silhouette of the icon itself is recognizable by its shape, with shapes incorporated into icons often on the mimetic side of the mimetic-arbitrary continuum (Figure 6). Shape is most frequently used to indicate nominal differences (e.g., a library versus a farmer's market). The outer frame of the icon also can vary by shape to communicate higher-level categories of icons (e.g., circles versus squares versus triangles) (Figure 5). Even with all other visual qualities kept constant, shape is very efficient for communicating meaning and variation of referents (Nelson et. al., 1997) (see Figure 7).

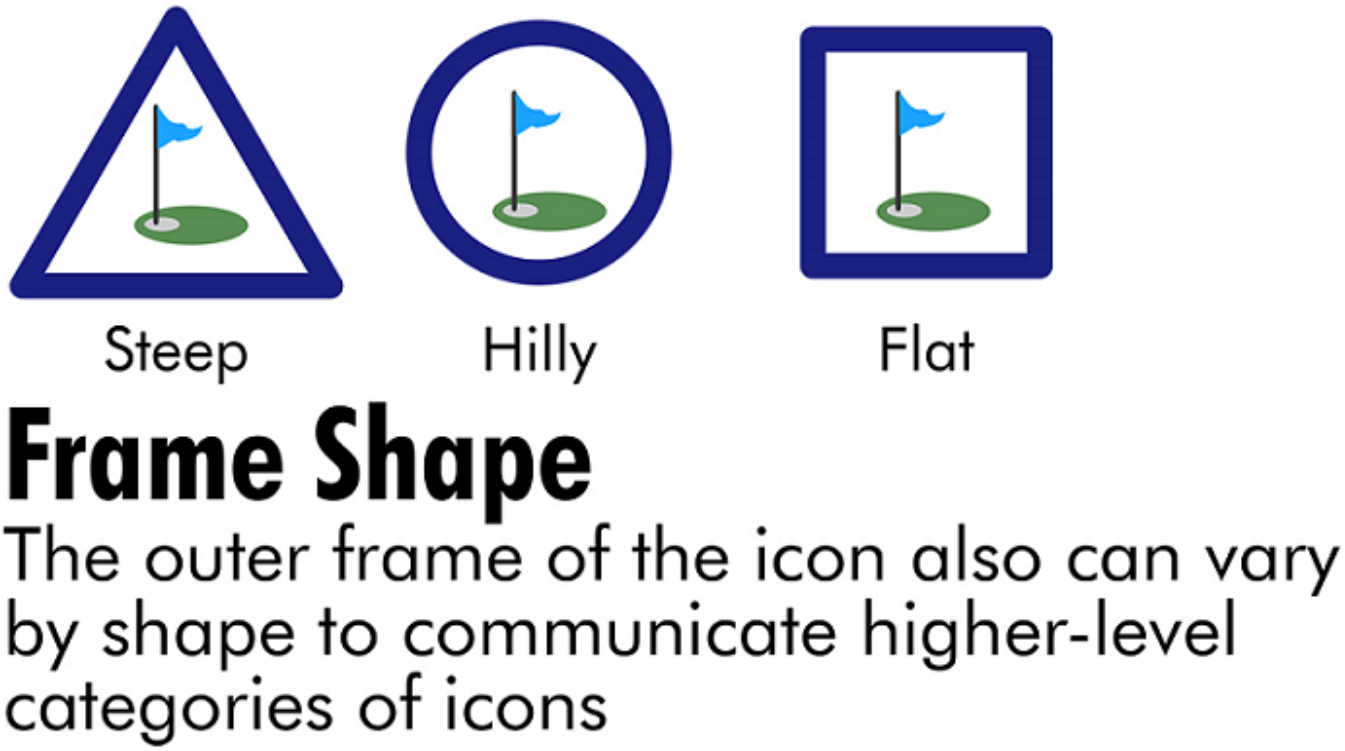


Figure 5. The outer frame of the icon also can vary by shape to communicate higher-level categories of icons. Source: author.

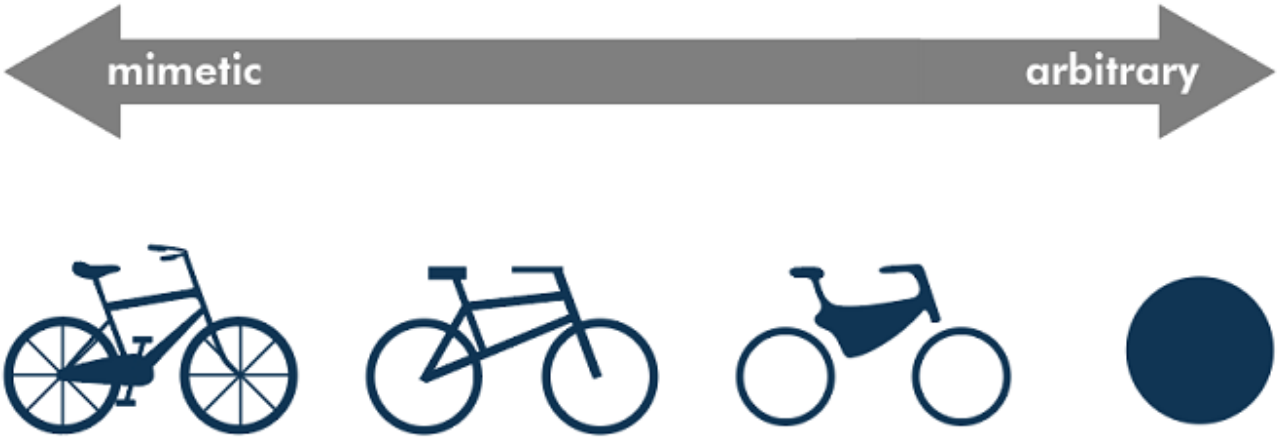


Figure 6. An example of the mimetic-arbitrary continuum in bicycle icon design. Adapted

from MacEachren, 1995. Source: author.

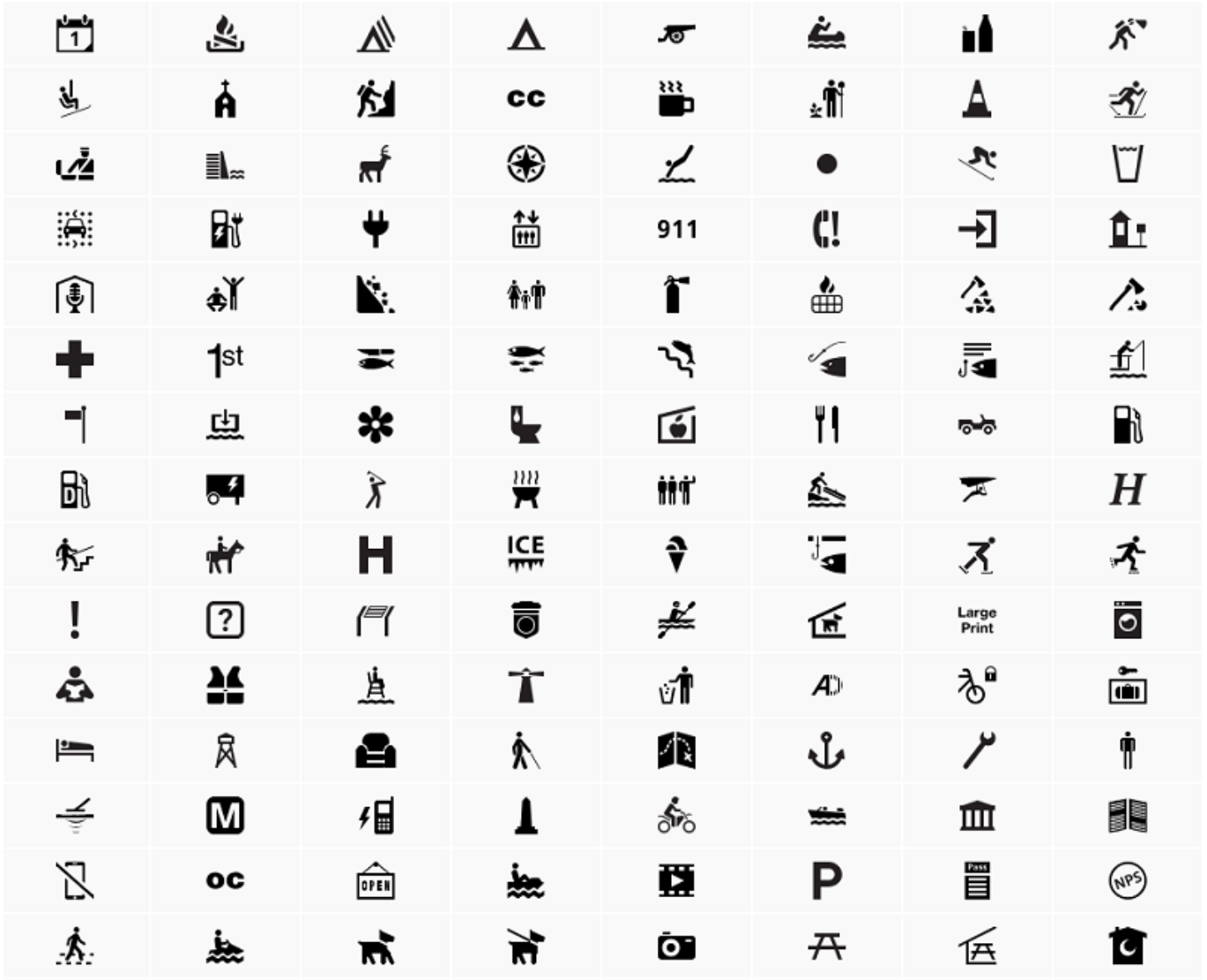


Figure 7. A subset of the National Park Service's NPMap Symbol Library, version 2.5.0, released April 26, 2018. These NPS icons have been designed to employ pictorial and associative shapes, while keeping all other visual variables constant (size, hue, crispness, color value, etc.) Source: National Park Service.

5.2 Color Hue and Color Value

Map icons often vary by color hue (the dominant wavelength) or color value (variations of light to dark) to communicate additional information. Both hue and value are more effective than shape during the **visual search process** (Nelson, 1997; Michaelidou et. al., 2005), which is the manner by which map readers find and identify map objects. Thus, as users visually scan maps they first look at differential colors and then inspect the icon shape once a symbol of interest is identified. Color hue is used to encode categorical differences among features (Figures 9 & 10) and color value is used to encode ordinal differences (Figure 10). One appropriate application of color to map icons is to show different conditions within each

feature (e.g., open versus closed), rather than different categories of symbols (Figure 9). Often, map icons are designed by using color hue and value simultaneously to indicate ordinal information (Figure 11).

Color hue and value can be applied to the background frame of an icon (Figure 9) or to the silhouette of the icon (Figure 10). Rarely are two or more colors used in a single map icon, given their typical small size on the map page and need to maintain legibility. Color should be used judiciously in map icon design, as the number of unique colors on the map can increase quickly, again decreasing its legibility.

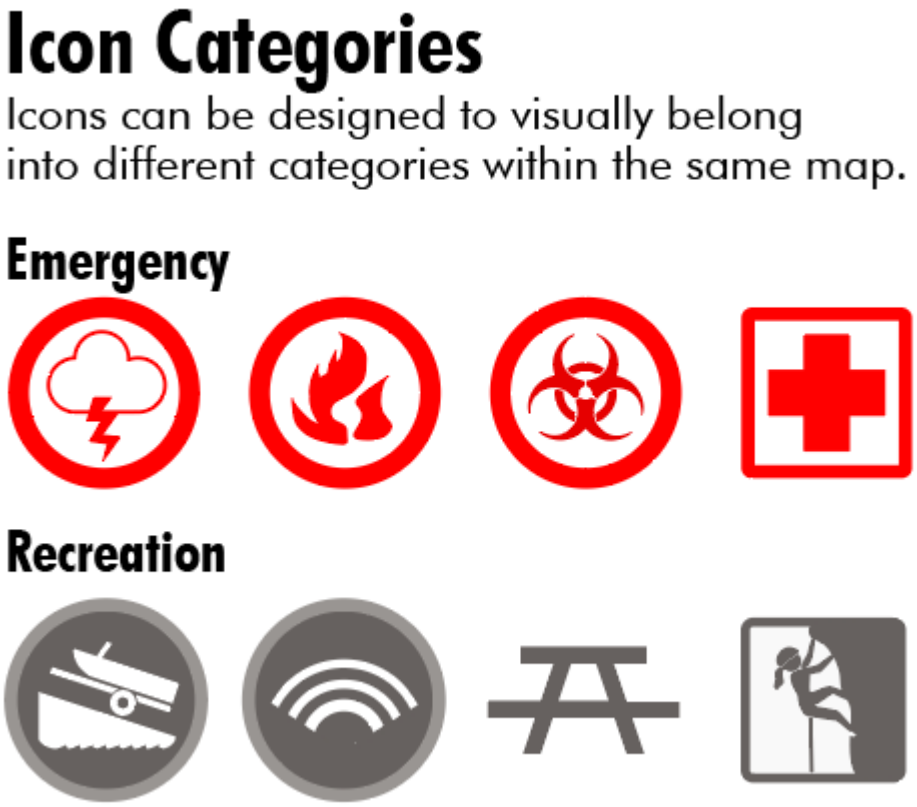


Figure 8. Icons can be designed to use hue as a visual variable differentiating the icons by category. Source: author.



Figure 9. The two icons above were designed for locations of the same type. The two icons are visually identical except for hue, which distinguishes the qualitative difference (seasonal access) in locations of the same type (recreation area). Source: author.



Figure 10. Color value used to indicate the heat index's ordinal value. As the heat index increases in danger, the value of the symbol's sign increases. Source: author.

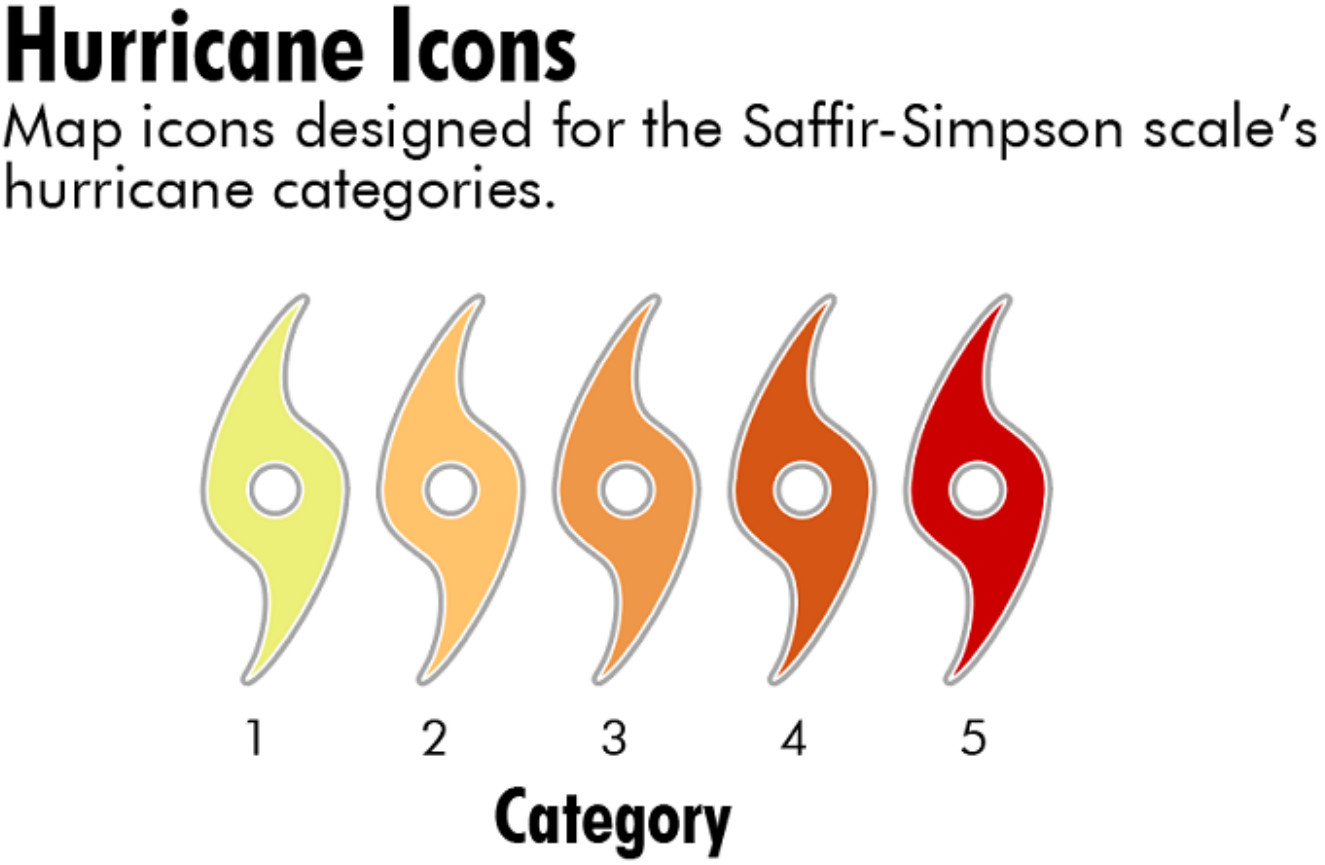


Figure 11. The shape in the above series of icons is commonly used to symbolize hurricanes. In the Saffir-Simpson scale, hurricanes are categories by their wind speed, with category as the lowest range of windspeed, and increasing with each subsequent category. Sequential color schemes that use color hue and color value are appropriately applied, communicating the hurricane's intensity at the location of the icon. Source: author.

Since map icons are designed to fit appropriately within a map's overall aesthetic, color should always be considered, even if all symbols are monochromatic. While hue consideration for a monochromatic set of icons influences the map's aesthetic, in these circumstances, hue is not a variable by which data can be visually differentiated (Figure 7).

4.3 Orientation

Finally, orientation, or the the direction or angle of rotation, can be used to encode spatial information about the map icon. As a selective visual variable, orientation can be used to highlight variance in map icons that are otherwise constant in all other aspects of design. Typically in these cases, orientation is used to indicate a directional aspect of the referent or to emphasize the alignment of referents in relation to its surroundings or other referents (Roth et. al., 2011). Orientation is a pre-attentively processed attribute, which means the orientation of map icons can clearly communicate the spatial referents' direction or alignment without the requirement for map readers to learn additional information.

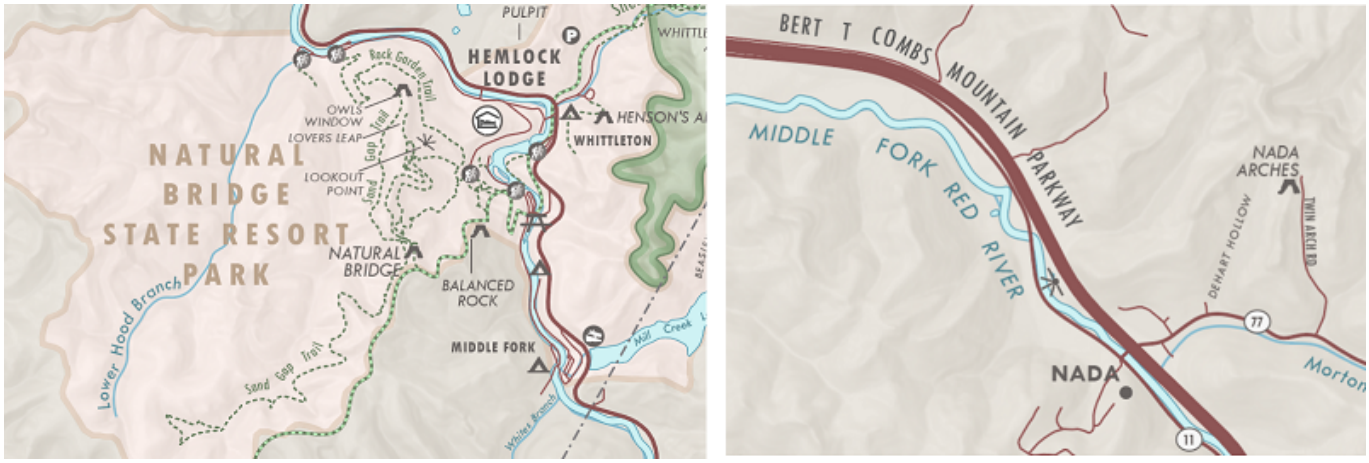


Figure 12. In both images, the scenic view icon is identical in all visual characteristics except orientation. The orientation indicates the direction of the scenic view. Source: author.

4.4 Map Icon Libraries

A group of map icons used across a single map are best incorporated into the overall design when they come from a single map icon library. Map icon libraries (Figure 7) consist of icons with a similar aesthetic and design elements, so that they may be used in visual concert with each other. When using a single well-designed map library, adding a new icon to a map from that library will not jolt the map's appearance. That is to say, while map icons themselves should be recognizably different from one another, when they are used together in map, they should visually coalesce as part of the greater design that contributes to the map's message.

To accomplish this visual coalescence when designing map icon libraries, cartographers follow intentional consistency in the ways the icons are similar and different from each other. A good practice when designing a set of icons for a single library is to have a reason for the icons' differences, where the utilized visual variables are be employed with purpose, avoiding too many superfluous design elements. The groups of map icons in Figures 3, 5, & 7-12 share elements that are common to map libraries. Each group contains map icons where the signs have the same or similar levels of abstractness. Each group's icons also use shape, color, and size to describe their connections and differences.

5. Map Icons and Cultural Meaning

A map's set of icons can communicate a large portion of the spatial story within the map, indicating what the map creators want readers to learn about a certain space. Consider the set of icons for a city's recreation map: it would include trailhead, bicycle activity, and park icons. Perhaps this map also would contain sports facility icons like tennis courts and soccer fields. The symbol set would likely include any beach, swimming, boating, and other water-related icons pertaining to the water recreation in the mapped area. Such a symbol set has the potential to make a city appear as a recreational wonderland. Now imagine that same map extent, this time with the purpose of showing the location of the city's toxic waste

sites. Even if this second map included one single icon used multiple times to show multiple toxic waste sites, this one reoccurring icon can communicate a convincing message that toxic waste afflicts the city.

5.1 Signs and Cultural Negotiation

Because map icons assist map makers in telling these powerful spatial stories, icon design also can assist in maintaining a socio-spatial message, perpetuating the notion that mapped phenomenon are independent of the cartographer; that the map icon's depiction and accuracy is directly in line with ground truth (Harley 1989; Edney 2005). Map icons' capacity to aid in the map's political maintenance of power structures and struggles exists not just in the map's gestalt message, but also within messages conveyed by individual icons.

Therefore, the meanings of signs should not be considered static. Rather, they are **culturally negotiated** through societal discourse, and can change over time. Further, the entire practice of cartography historically has been a mode of knowledge production controlled by an elite few (Harley, 1989; Crampton & Krygier 2006) (see **Cartography & Power**). As such, the cultural negotiation behind the meaning of many signs used in map icons largely has been restricted to a privileged class, oftentimes in the interest of maintaining exclusive power structures. Map icons, as signs with culturally negotiated meanings, are part of the **linguistic market** (Bourdieu, 2002). Markets in this sense, are socio-spatial arenas where linguistic knowledge can be utilized to communicate, or even gain social or real capital. As linguistic markets increase in formality, society tends to require more formalized and structured behavior to be considered "legitimate." Likewise, although map icons are space-maintaining and space-creating vehicles that are read by many, historically there is an imbalanced access to this spatial debate in terms of creating and disseminating icons and their meanings. Therefore, an understanding of the process and perpetuation of map icons is imperative for understanding and improving map readership and representation.

Some map icons perpetuate stereotypes that preserve a restrictive and negative prototypical representation of what or whom – or for whom – the sign represents, or conversely for whom the sign does not represent. When choosing an icon that has a readily interpreted meaning, or when creating an original sign for an icon, avoiding the use of signs that capture negative or exclusive prototypical assumptions can assist in the icon's inclusive broader legibility and representation (D'Ignazio & Klein, 2016; Kelly, M. 2018).

D'Ignazio & Klein provide a useful framework for interpreting meanings in map icon design by introducing six principles of feminist data visualization (Figure 13). These principles highlight core approaches for including multiple views and representations within artifacts designed in the digital humanities (see **Feminist Critiques of GIS**). Consider the following questions proposed by D'Ignazio and Klein:

Can the artifact communicate the subject positions of the researcher(s) and designer(s) in a transparent way? Whose view of the world does the visualization represent? Can the visualization communicate whose voices are missing? Could perspective-taking be a useful strategy to consider for multiple views on the data? (D'Ignazio & Klein, 2016).

As succinct representations of spatial data, map icons certainly fall within the category of the data visual, and as such, the utility of the six principles of feminist data visualization

can apply (Kelly, 2018).

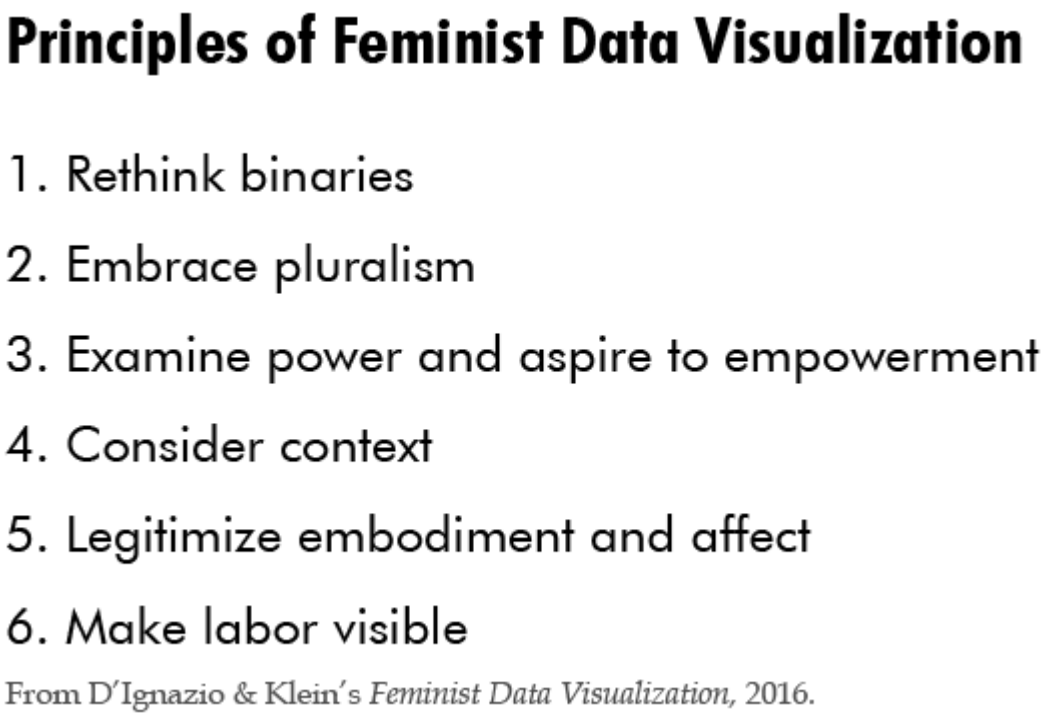


Figure 13. The principles of feminist data visualization by D'Ignazio & Klein, 2016.

6. Conclusion

Like all sign systems, map icons communicate meaning beyond their actual form. Further, as data-visual representations, map icons' particular sign system makes use of many of the visual variables. This capacity to convey complex data visual stories – and the location of those stories – into a compact cartographic element is the reason that map icons are so expediently utilized by cartographers. Well-designed map icons can assist in the map's aesthetic and legibility, and to expedite this legibility, already-established signs are oftentimes leveraged by cartographers and icon designers. Yet with each utilization of a sign, a meaning is further reified. When using or creating a map icon's sign, map readership and legibility can be increased when practicing intentional design by avoiding signs that perpetuate socio-cultural exclusion.

References

Bertin, J. (1967). Sémiologie Graphique. Les diagrammes, les réseaux, les cartes. With Marc Barbut [et al.]. Paris : Gauthier-Villars. (Translation 1983. Semiology of Graphics by William J. Berg.; University of Wisconsin Press).

Bianchetti, R.A., Wallgrun, J.O., Yang, J., Blanford, J., Robinson, R., Klippel, A. (2012). Free Classification of Canadian and American Emergency Map Symbol Standards. The

Cartographic Journal, 49(4), 350-360.

Bourdieu, P. (1991). Language and Symbolic Power. Cambridge, Massachusetts: Harvard University Press.

Crampton, J. W. & Krygier, J. (2006). An Introduction to Critical Cartography. ACME: An International E-Journal for Critical Geographies, 4(1), 11-33.

D'Ignazio, C. (2017, January 23). What would feminist data visualization look like? [blog post]. Visionscarto.

D'Ignazio, C. & Klein, L. (2016). Feminist Data Visualization. Workshop on Visualization for the Digital Humanities. Baltimore.

Eco, U. (1976). A Theory of Semiotics. Indiana University Press.

Edney, M. H. (2005). Putting “Cartography” into the History of Cartography: Arthur H. Robinson, David Woodward, and the Creation of a Discipline. Cartographic Perspectives, (51), 14-29.

Harley, J. B. (1989). Deconstructing the Map. Cartographica 26(2), 1-20.

Kelly, M. (2018, October). Feminist Cartographies. North American Cartographic Information Society (NACIS) Annual Conference, Norfolk.

Lloyd, R. (1997). Visual Search Processes Used in Map Reading. Cartographica, 34(1), 11-32.

MacEachren, A. M. (1995, 2004). How Maps Work: Representation, Visualization, and Design. New York, New York: Guilford Press. Paperback edition (2004).

Michaelidou, E., Filippakopoulou, V., Nakos, B. Petropoulou, A. (2005, July 16). Designing Point Map Symbols: The effect of preattentive attributes of shape. International Cartographic Conference (ICC 2005), A Coruña, Spain.

Nelson, E., Dow, D., Lukinbeal, C., & Farley, R. (1997). Visual Search Processes and the Multivariate Point Symbol. Cartographica 34(4), 19-33.

Roth, R. E., Brewer, C. A., & Stryker, M. S. (2011). A typology of operators for maintaining legible map designs at multiple scales. Cartographic Perspectives, 2011(68), 29-64.

Tufte, E. R. (1983). The Visual Display of Quantitative Information. Cheshire, CT: Graphics Press.

White, T. (2017). Symbolization and the Visual Variables. The Geographic Information Science & Technology Body of Knowledge (2nd Quarter 2017 Edition), John P. Wilson (ed.).