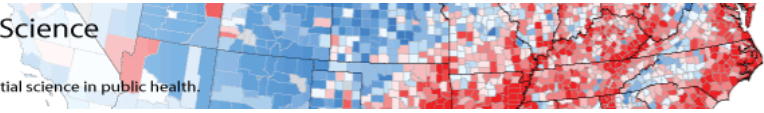




Geography and Geospatial Science
Working Group (GeoSWG)
Advancing applications of geography and geospatial science in public health.



Cartographic Guidelines for Public Health

August 2012
Centers for Disease Control and Prevention



Introduction

The Geography and Geospatial Science Working Group (GeoSWG) is an organization of geographers, epidemiologists, statisticians, and others who work with spatially-referenced data at the Centers for Disease Control and Prevention (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR). In May of 2011, the GeoSWG Executive Committee formed the Public Health and Cartography Ad Hoc Committee “to propose cartographic guidelines and best practices to produce high-quality, consistent map products for the public health community.” These Guidelines advance the application of geospatial concepts and methods within public health practice and research at CDC/ATSDR.

Public Health and Cartography Ad Hoc Committee

Chair

Elaine Hallisey, MA

Members

Dabo Brantley, MPH

Kim Elmore, PhD

Jim Holt, PhD, MPA

Ryan Lash, MA

Arthur Murphy, MS

Rand Young, MA

For more information on GeoSWG and these guidelines go to:

<http://app-v-atsd-web1/geoswgportal/default.aspx>*

* Some of the hyperlinks are internal to CDC only. CDC intranet links are indicated with an asterisk.

Cartographic Guidelines for Public Health

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Overview

The Geography and Geospatial Science Working Group (GeoSWG) has recognized the need for the development of cartographic best practices at CDC. With the audience and purpose of the map in mind, successful [cartographers](#) use map design conventions developed over time and supported by scientific research on human cognitive processes. In the design process, most cartographers will 1) define the map requirements, 2) prepare an outline based on the requirements and production considerations, 3) compile appropriate data, and 4) symbolize map data. Effective map design, or cartographic visualization, not only communicates spatial information, it also facilitates exploration and insight of geographic phenomena. These Cartographic Guidelines for Public Health outline thematic map design concepts, provide illustrated examples, offer links to definitions and relevant sites, and recommend further readings. The goal is to promote the production of high-quality, consistent map products to promote the mission of public health. With this end in mind, we expect the Guidelines will prove useful to CDC staffers involved in map design and production as well as to reviewers and journal editors.

Maps may fall into two broad categories, general-purpose or thematic. General-purpose, or reference maps, include [political maps](#), [road atlases](#), and [topographic or physical maps](#). The concentration here, on the other hand, is on thematic maps, which illustrate the geographic distribution of some phenomena, such as mortality rates or disease diffusion. Maps may also be classified by the physical form they take. Map designers must consider the format and final map size. Is the map product for an academic journal or a poster for the public at large? Is it on a printed page or online? Is the product best presented in static, interactive, or animated form? These factors affect design choices. Our emphasis here is on static maps, either printed or online. Nevertheless, we must note that although additional considerations apply to interactive or animated mapping, the basic visual treatment principles discussed here remain constant.

Map elements

Maps communicate using various visual devices. Along with balance, composition, and the effective use of white space, the following elements are often used to enhance map communication.

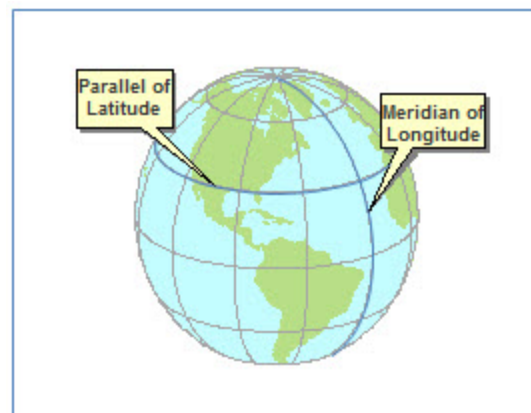
Borders or neatlines: A fine line often encloses a map, unless the map content itself provides a strong contrast with the page. Other lines may be necessary in the figure to emphasize hierarchy and focus.

Title: Include either on the map or in a figure caption. A subtitle is sometimes useful.

⚠ The word “Map” in the map title is unnecessary (it is obvious that it is a map).

North arrow: A [north arrow](#) is useful on maps that are oriented in some direction other than north or for very [large scale](#) maps.

Graticule: The [graticule](#) is a representation of meridians of [longitude](#) and parallels of [latitude](#) on a map. The graticule is useful for orientation and for visualizing the [projection](#) used on the map.



Scale: A [scale bar](#) or verbal/numeric [scale](#) may be included on maps. Map scale varies throughout a map depending on the projection used, particularly on small scale maps. A [variable scale bar](#) may be used on maps that have large scale variations, but omitting a graphic scale bar altogether may also be appropriate.

Inset maps: Inset maps are useful for providing broader context to the information on the main map. They can be at a smaller or larger scale than the main map.

Type: Type refers to the labels put on a map. Typography is the process of selecting and stylizing labels. Changes in [type family](#), type style, type size, lettering and word spacing, color, and orientation are used to create visual contrast between more important and less important typographical map content.

Legend: A legend explaining the map symbols should be included. The legend should be easy to understand, and self-explanatory. The following practices generally are applicable to legends for thematic data:

- Legend symbols should match their corresponding map symbols exactly.
- Items in the legend should be placed in a logical order based upon the data.
- Ranges of numbers can be separated by a dash or by the word “to,” which is useful for avoiding consecutively placed dashes when negative numbers are present.
- Numbers greater than 1,000 should include commas; numbers less than 1 should include a leading zero before the decimal point.

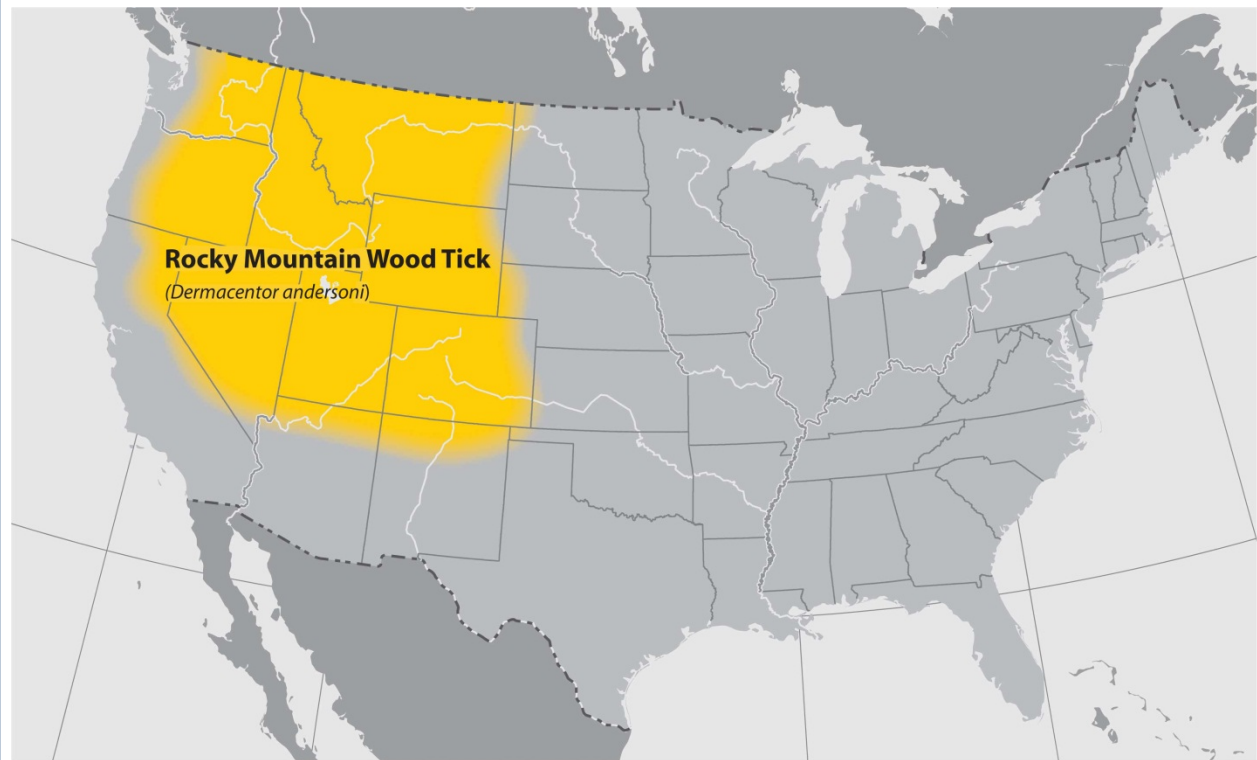
⚠ The word “Legend” as a legend heading is unnecessary (the legend is obvious).

⚠ Do not neglect to remove ArcGIS default legend headings (e.g., “mort_rate_cvh_09”). Use something that is intuitive to all map readers.

⚠ Using “Percent” in the map title and “Percentage” as a legend heading is not recommended. Instead, titles should use “Percentage” and legend headings should use “Percent.”

Other items: Data sources, dates, information about data processing, and, if required, map status (draft, final, etc.), should be indicated either in the legend or elsewhere. To achieve a unified look and instant recognition, CDC has developed a brand identity that requires the use of specific logos and other graphic elements. For more information, see [Brand Identity Standards](#).*

Example using Brand Identity Standards



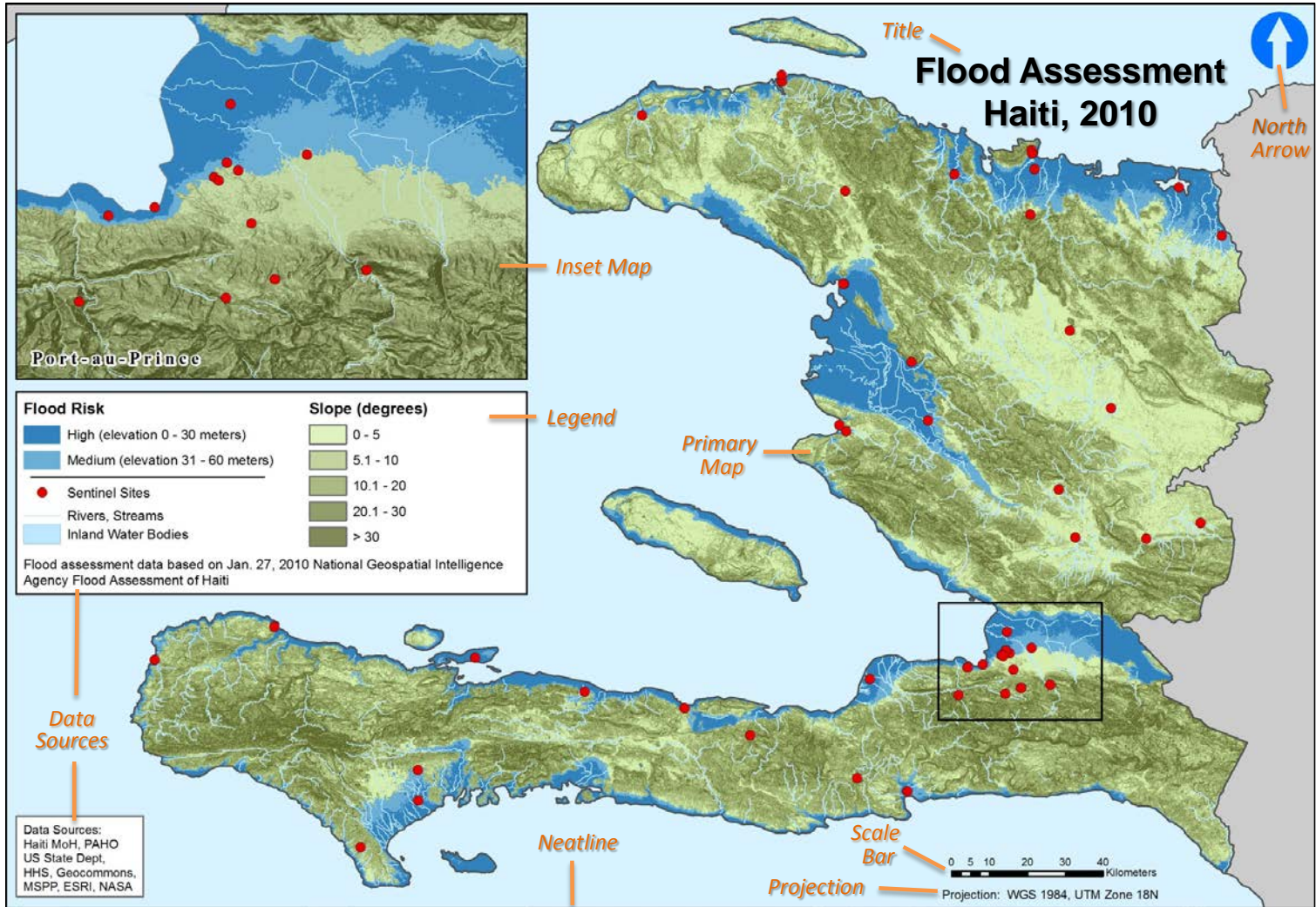
ABOUT THIS MAP: This map is not meant to represent risks for a specific tick-borne disease, because disease transmission is influenced by multiple factors beyond mere tick presence. This map has been designed to answer the question "What ticks should I be concerned about at a regional scale?" Please consult a local public health authority or USDA Agricultural Extension Office to determine more specific information at the state, county, or municipal level. Background data for this map is from the US National Atlas.

National Center for Emerging and Zoonotic Infectious Diseases
Division of Vector-Borne Diseases



Finally, a variety of output file formats such as JPG, PDF, or TIF are used in production mapping. Choosing a file format is often guided by the intended audience. One resource for information on file formats is BioMed Central, a science, technology and medicine publisher with an extensive portfolio of journals. BioMed Central provides general guidelines on the preparation of illustrations and figures, including [file format descriptions](#). Cartographers should always consult the specific journal in which an article is to be published to determine the journal's specification.

Map elements

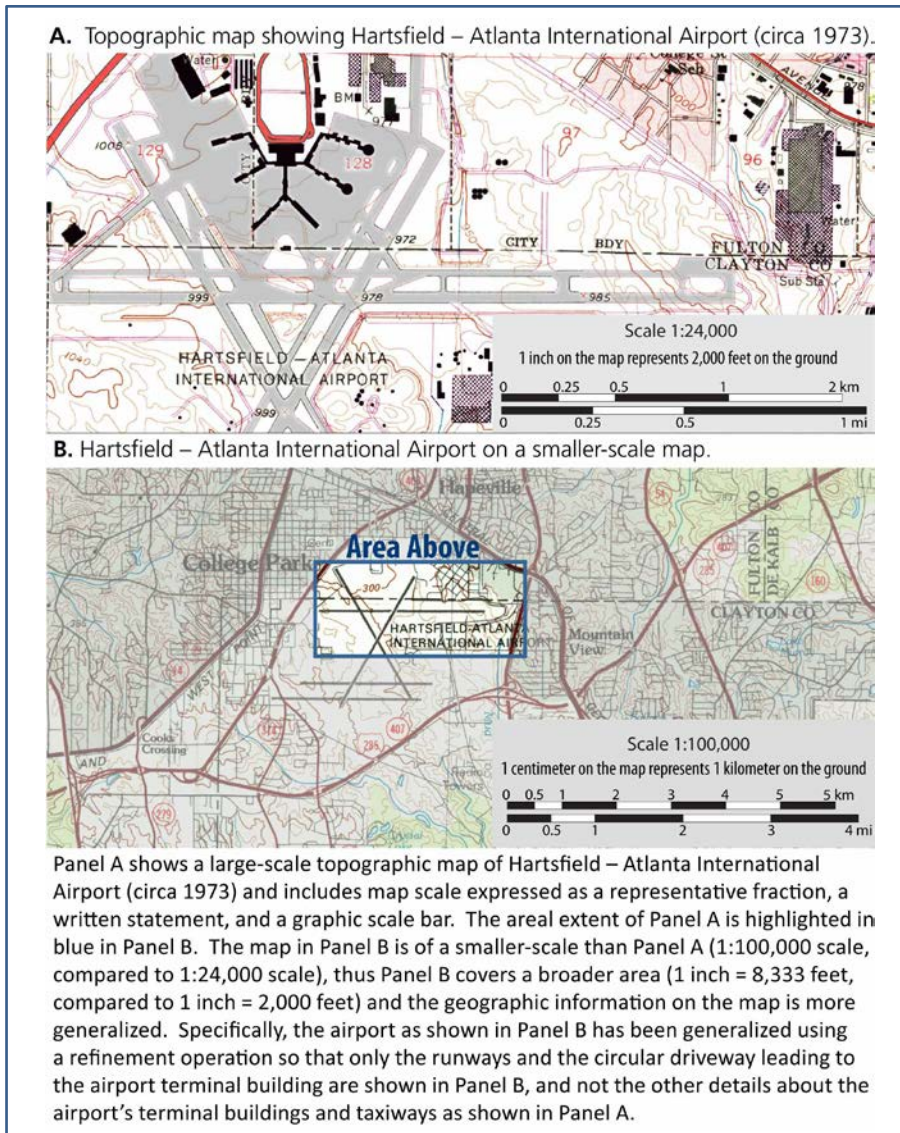


The illustration above shows various map elements arranged in a visually balanced manner. The primary map is the prominent element – the inset map provides a large scale view of a major city. The title is succinct, high in the visual hierarchy, and explains “what,” “where,” and “when.” On many public health maps the title also describes “who.” The legend describes the features or variables mapped. Data sources are important, as well. Other map elements often used on a map include a scale bar and north arrow.

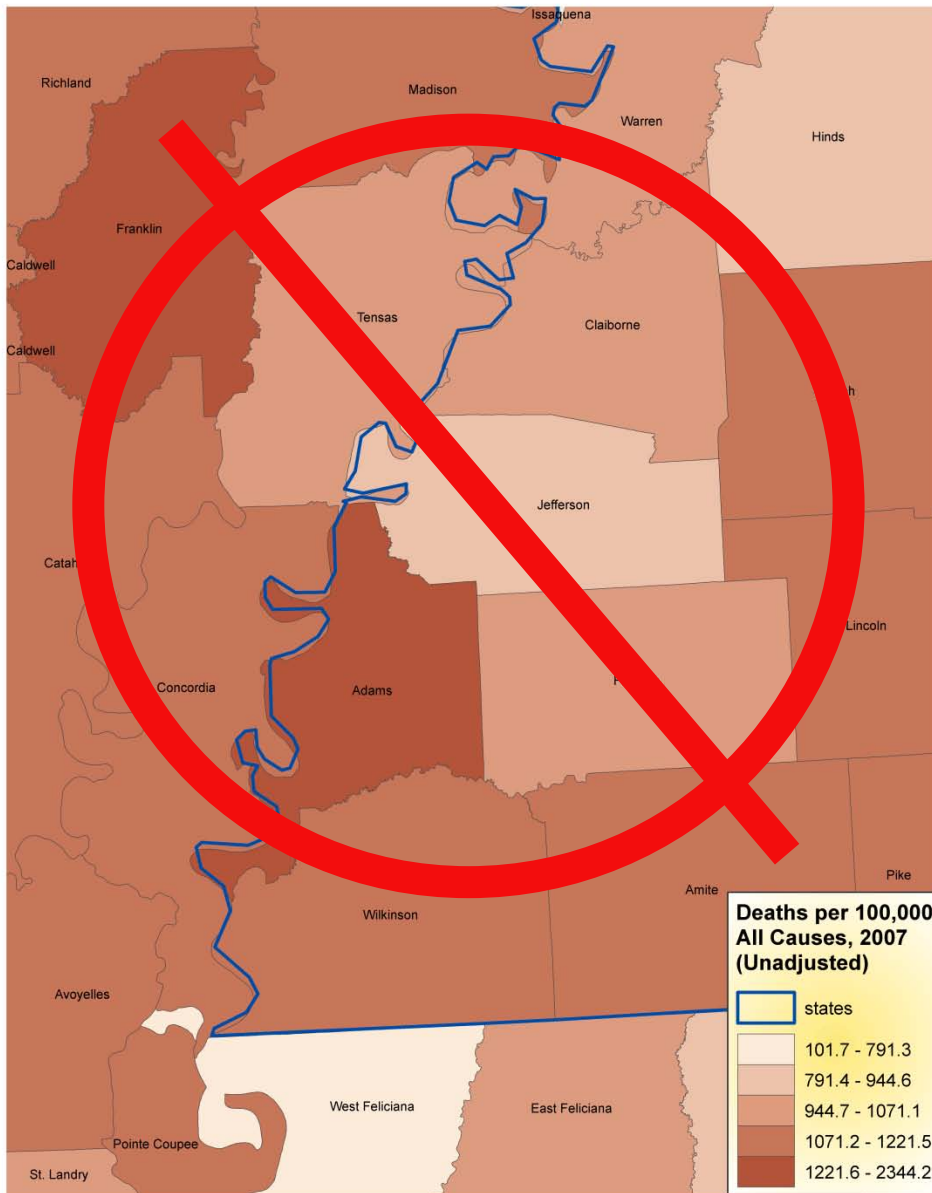
Map scale and generalization

"The earth is big. Maps are small. Map scale describes the difference [between the two], verbally, visually, and with numbers" (Krygier and Wood, 2011).

Map scale can be communicated as a written statement such as "one inch to the mile," a visual scale such as a scale bar on a map, or numerically as a representative fraction (e.g., 1/24,000 or 1:5,000,000) (See figure below). Map scale serves to convey to the map reader the way in which the data on the map relates to the real environment on the ground for the area shown. This is important information for a map reader who may be trying to navigate using the features shown on the map, measure the distance between two locations on a map, or describe how the map at hand compares to other maps. Likewise, it's important to remember that map scale will vary depending on the type of map projection chosen. As applied to maps, the terms "large-scale" and "small-scale" have different meanings than they do in everyday usage. A large-scale map shows an area with more detail, as if it were a close-up, whereas a small-scale map depicts an area as if from a distance, with less detail, i.e. more generalization. Generalization is a set of techniques used to reduce the amount of geographic information, or detail, to enhance map clarity. Since map data are not produced for every possible scale, the map author must make decisions about how much information to include on a map.



Inconsistent Generalization

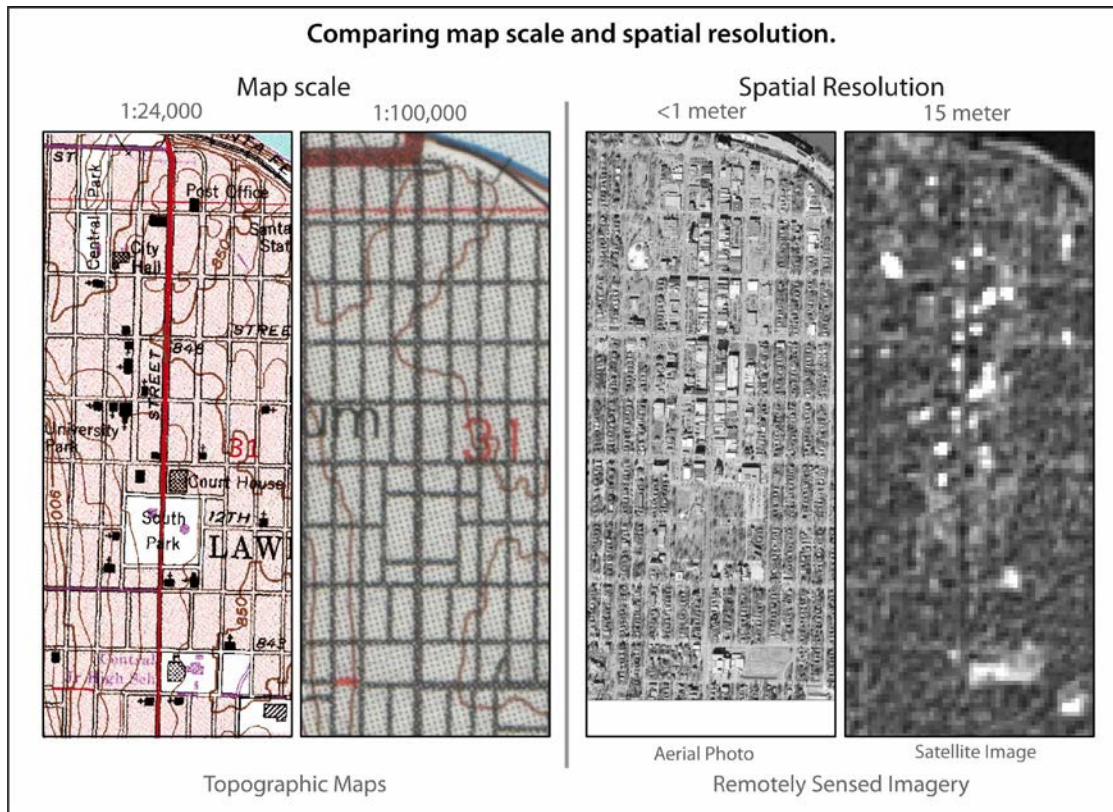


Knowing source data scale is important because scale can affect visualization and analysis results. These map layers do not work together because the state layer is more generalized than the county layer. Note the misalignment of the river boundaries.

Map scale is determined by the page size of the final map and the extent of the earth's surface to be shown on the map. It therefore serves as one of the foremost constraints to be determined at the outset of the map design process. Knowing the scale of the final map enables the map author to select data at an appropriate scale. Appropriate map data should be at either an equivalent scale to the final map, or from a more detailed larger-scale source. A very detailed vector dataset with a high level of precision can be made into a less detailed map through generalization. Every detail of the earth's surface may not be capable of being shown on the final map, or more importantly to thematic maps, may not be relevant to the problem which the map aims to answer. Different features on a map, such as county boundaries and roads, should use similar levels of generalization.

MapShaper is an online editor that lets the user simplify (generalize) uploaded polygon and polyline shapefiles.

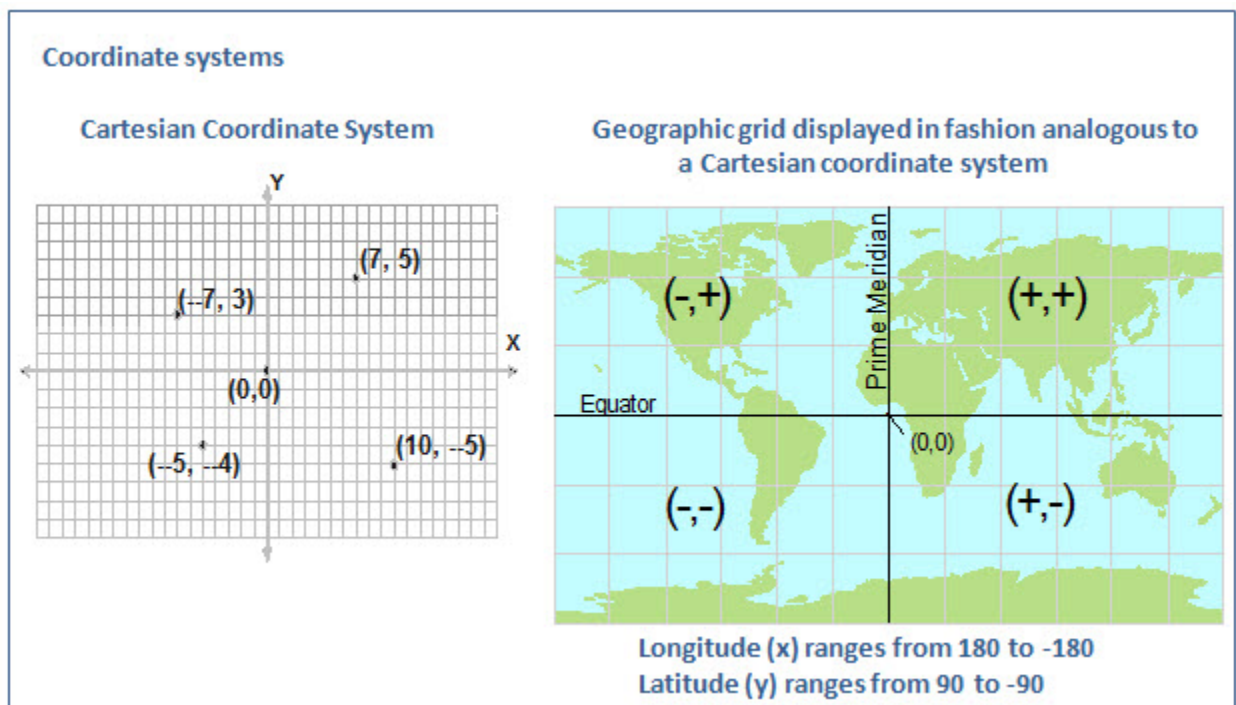
Spatial [resolution](#), a concept related to map scale, describes the amount of detail in a [raster](#) GIS data set. Spatial resolution expresses the area on the ground represented by an individual [pixel](#) (or cell) within an image or raster dataset. Numerically, spatial resolution is expressed as the width of a pixel area on the surface of the earth. For example, high resolution imagery found on web maps, such as GoogleEarth, may have a fine spatial resolution of 1 meter, meaning one pixel covers the area of 1 square meter on the ground. Other satellite imagery, or [digital elevation models](#) (DEMs) may have a coarser spatial resolution ranging from 5 meters to 8 kilometers, depending on the sensor platform and altitude above the earth's surface.



Map projection

Projections transform the curved, three-dimensional surface of the earth into a flat, two-dimensional plane. All map projections have distortions (distance, area, direction, and/or shape). The choice of projection depends on the intended use of the map. An equal-area map projection is a good selection for portraying geographic data distributions and is suitable for most other maps. However, if the map is attempting to show distance from patients to providers, for example, then an equidistant projection is appropriate because it preserves distance.

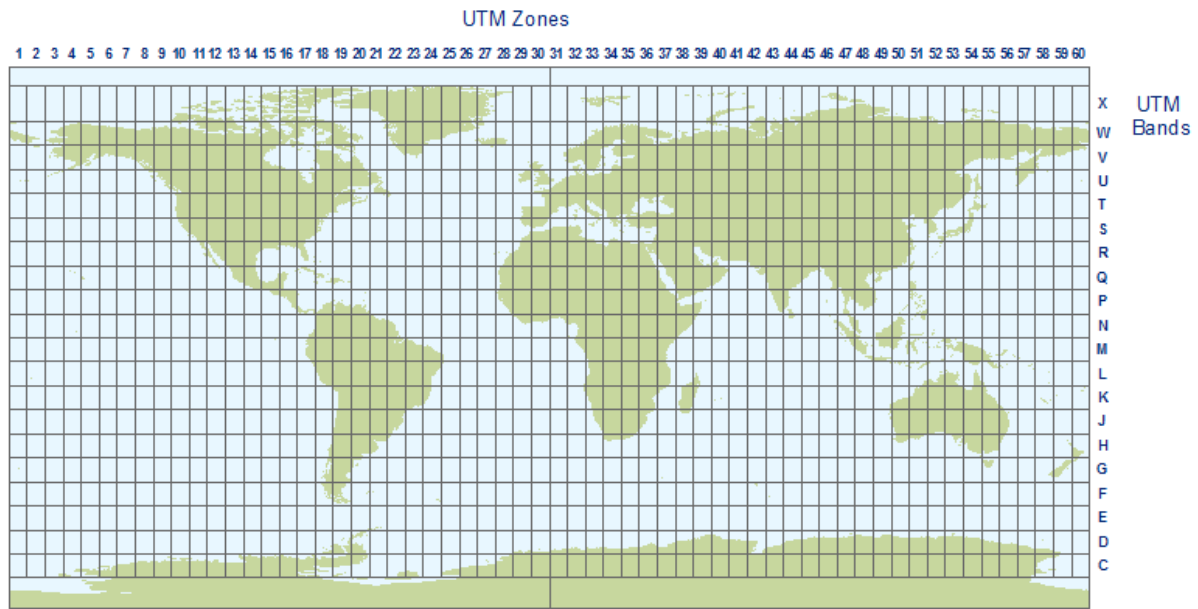
Cartographers sometimes refer to coordinate systems (or grid systems) and [datums](#) in context with map projections. Various coordinate systems and datums are used throughout the world. Most mapping starts with a projected map and a coordinate system overlay, which enables locational referencing. Datums, based upon different [ellipsoids](#) (idealized versions of the shape of the earth), define the origin and orientation of latitude and longitude lines. The most recently developed and widely used datum is [WGS 1984](#). Unlike earlier datums, WGS 1984 serves as a framework for locational measurement worldwide. Global positioning system ([GPS](#)) data are often collected in the WGS 1984 datum.



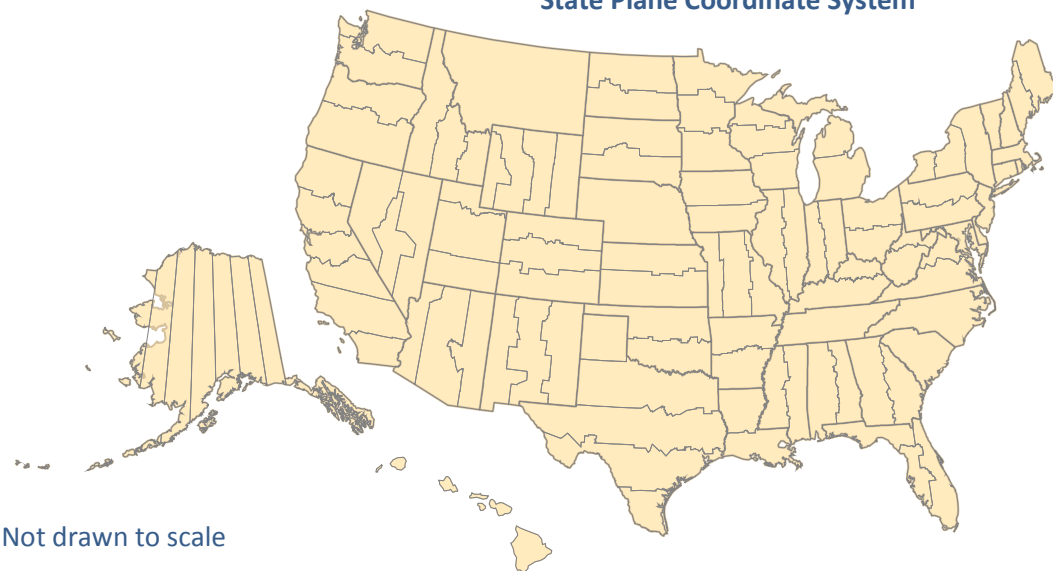
Two commonly used coordinate systems, of the thousands available, are Universal Transverse Mercator (UTM) and the State Plane Coordinate System (SPCS). UTM uses the transverse Mercator projection whereas most SPCS zones use either transverse Mercator or Lambert conformal conic projections. SPCS is only available in the United States and is the more accurate of the two. Mapping and analysis should only be done within a single UTM or SPCS zone, i.e. analysis should not cross zone boundaries.

UTM and SPCS Zones

Universal Transverse Mercator (UTM)




State Plane Coordinate System



SPCS and UTM are good choices for most maps of small areas. Because SPCS and UTM zones often split states however, many states developed standard systems to map the entire state with minimal error. For instance, Georgia uses a Georgia Statewide Lambert Conic or a Georgia Statewide Albers.

For thematic mapping of the US, Albers Equal Area Conic is a good choice. When mapping the world, any of the equal area projections, such as Mollweide or Eckert IV, are acceptable for thematic maps. Often, a map of a region of the world or a region of the US is required. In this case, an existing projection can be modified to orient the features more correctly by repositioning the central meridian, i.e. the imaginary vertical line down the center of the projection. For example, when mapping the northeastern US, an Albers Equal Area projection with a central meridian of -96 (positioned over Kansas) can have its central meridian shifted to -74, which runs through New York.

[USGS Map Projections](#) – *further explanation, examples, and suitability for various map purposes*

 Unprojected maps can give a false impression of geographic data distribution and density. This is particularly a problem for statistical maps, in which an equal-area projection should usually be used.

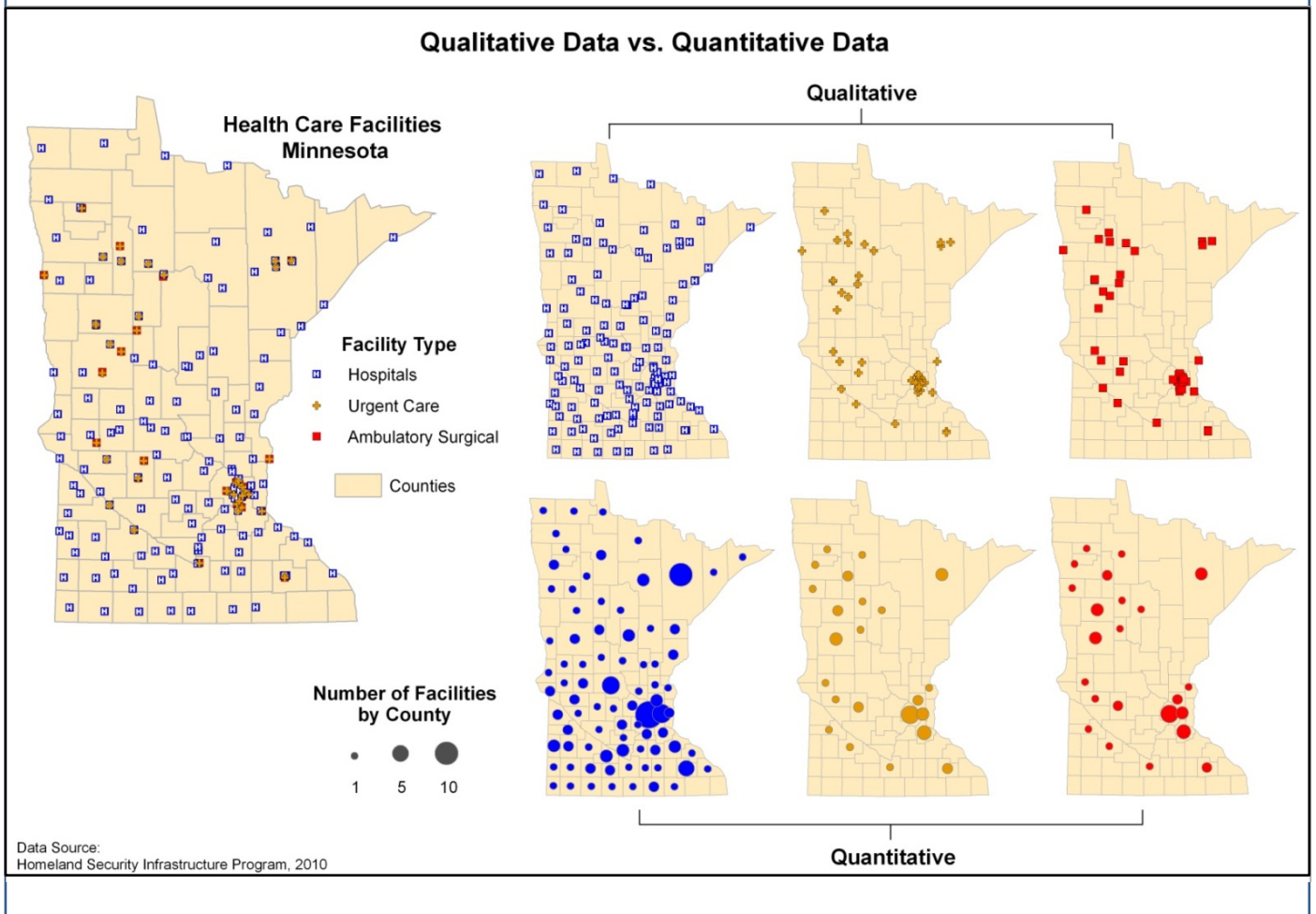
Data types and classification

Qualitative data show differences in kind (e.g., hospitals versus schools).

Quantitative data show differences in amount (e.g., [incidence](#), [prevalence](#) rates, or mortality rates). Quantitative data are often grouped into classes for mapping. To determine the type of classification method to use, consider the purpose of the map, the data distribution, and the knowledge level (i.e., mapping and statistical awareness) of the intended audience. Cartographers recommend no more than five to seven classes, due to the difficulty in distinguishing between the symbols representing each class (e.g., colors in area symbols on a choropleth map)

Qualitative Data vs. Quantitative Data

The top figures, which display qualitative data, show individual facilities by type. The symbols are different, but there is no implication of value. The bottom figures display quantitative data, numbers of facilities by county, as proportionally sized symbols. Symbol size represents value.



Selected quantitative data classification methods -

Equal Interval: Range of data is determined by subtracting the lowest value from the highest; then the range is divided by the desired number of classes to determine the beginning and end for each class. The major advantage of equal interval classification is that it is easy for many map users to interpret; it is best when applied to data ranges such as percentages and temperatures.

Quantiles: Each class contains the same number of observations (or geographic units); so with quintiles, one-fifth of the observations are in each group; with quartiles, 4 classes have the same number of observations in each. Quantiles classification shows top 20% (quintiles) or top 25% (quartiles) of population, regardless of break points. Quantiles work well when data are normally distributed. Quantiles are also a preferred method to use for maps in a series – a time series or race/ethnicity series, for example - where data are pooled and quantiles determined. Using a quantiles classification scheme applicable to all maps means the maps in the series are directly comparable.

Mean and Standard Deviation: Mean is computed and established as the center of the data distribution. Class intervals are determined by the standard deviation, a measure that indicates the spread of the data around the mean. Works best with a normal distribution (bell-shaped curve).

Natural Breaks: Class breaks occur where there are gaps in the distribution (i.e., few or no observations). The data distribution is explicitly considered; this is the major advantage. The major disadvantage is that the concept behind the classification may not be easily understood by all map users, and the legend values for the class breaks (e.g., the data ranges) may not be intuitive.

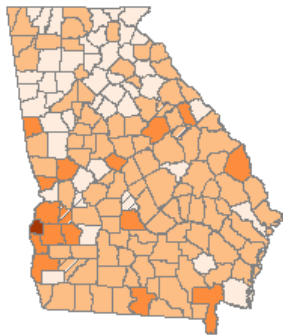
⚠ Class intervals should not overlap where a particular data value could conceivably belong to either of two classes. For example, the ranges for two classes should be 22 to 45, 46 to 77 and not 22 to 45, 45 to 77.

⚠ The number of class ranges should be no more than six or seven.

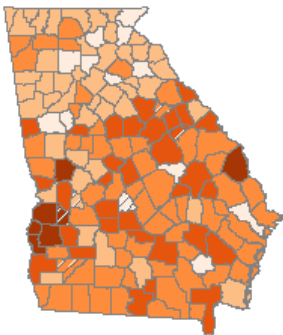
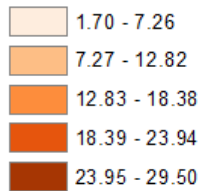
[Brewer and Pickle – Evaluation of Methods for Classifying Epidemiological Data on Choropleth Maps in a Series.](#)

Selected data classification schemes

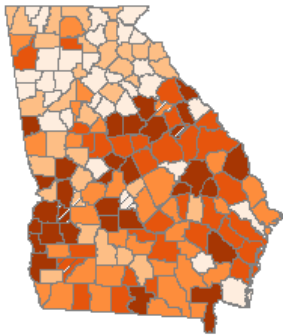
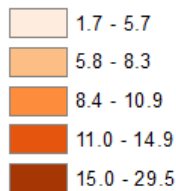
Selected Data Classification Schemes



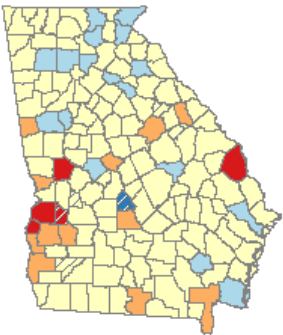
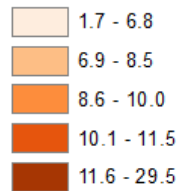
Equal Intervals



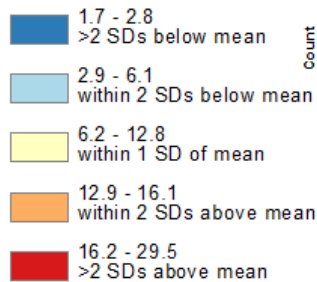
Natural Breaks



Quantiles



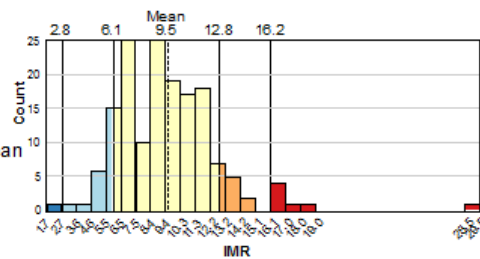
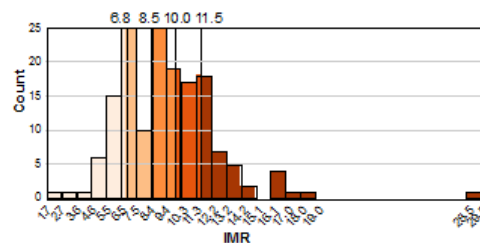
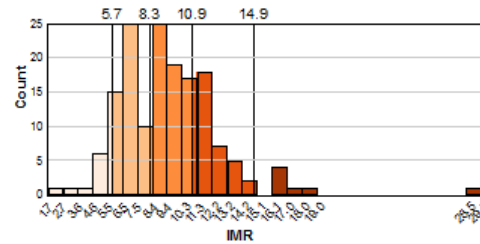
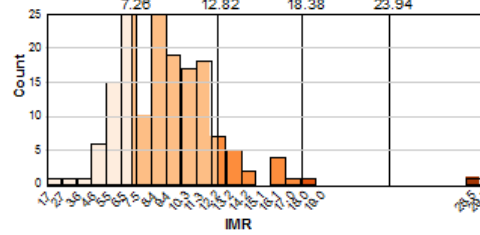
Standard Deviations



Infant Mortality Rates Georgia by County, 1999-2008

Deaths per 1,000 Births

For all maps, hatching represents small numbers/unstable rates.



Data source: Georgia Department of Public Health
<http://oasis.state.ga.us>
 Map compiled 8/2/2011

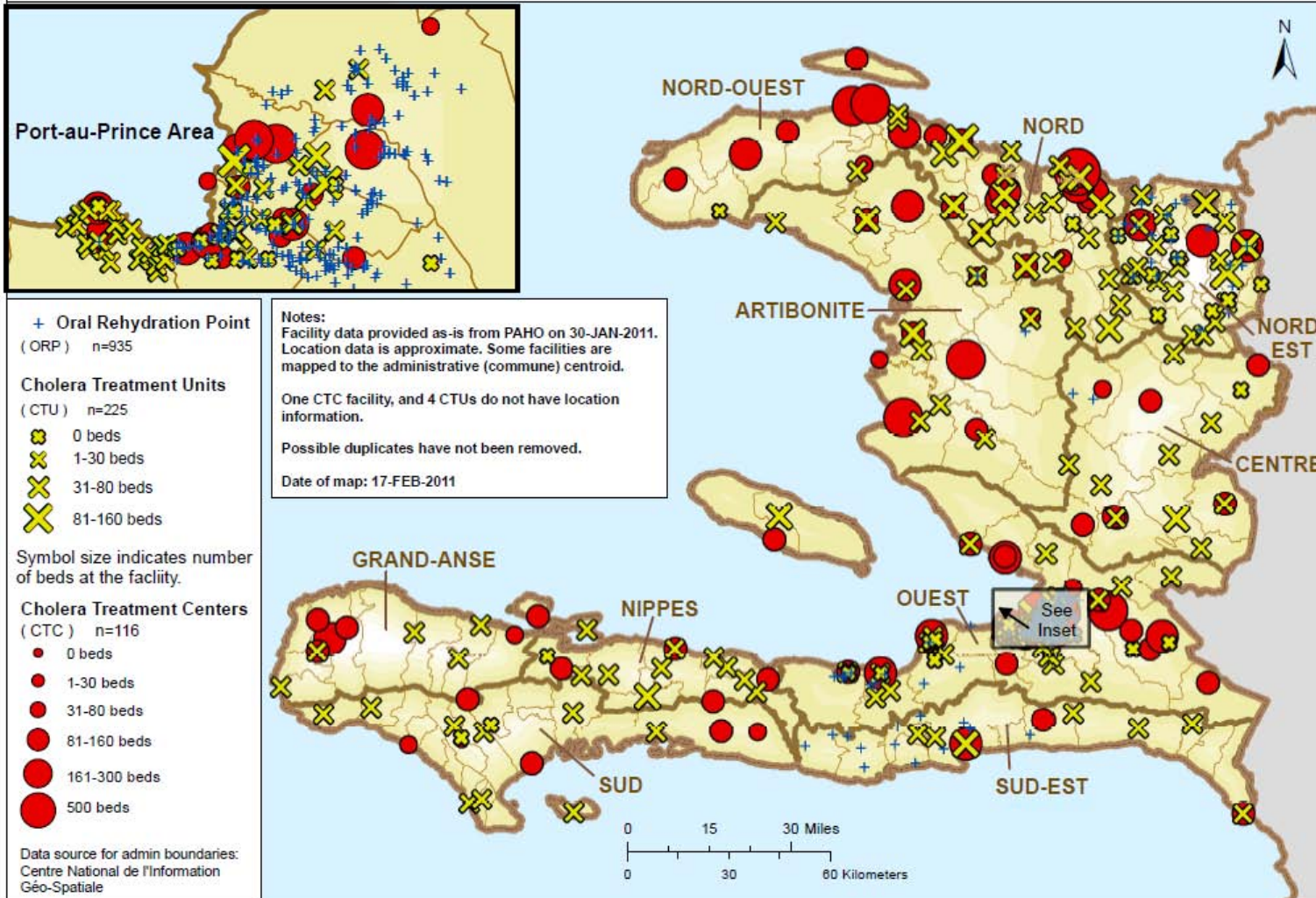
Data symbolization using visual variables

Size: Symbol size or line width can be used to represent quantitatively different data (either rank-ordered data or numerical amounts). For example, a larger square signifies a greater quantity than a smaller square.

Shape: Shape may be used to categorize features that are qualitatively different. A square is not more or less than a circle, but is different in kind.

Size and shape use

Cholera Treatment Facilities in Haiti



Color hue: Color hue (such as red, green, or blue) may be used to categorize features that are qualitatively different, such as a river and a road.

Color value: Color value (or lightness of hue) may be used to represent quantitatively different data (either rank-ordered data or numerical amounts), such as population density. Value is typically light for low numbers (e.g., light green) and dark for high numbers (e.g., dark green).

Color saturation: Color saturation (or intensity of hue, such as bright red compared with a dull, gray red) can be used for qualitative or quantitative data.

⚠️ Certain color combinations are difficult for color blind people to distinguish (red/green, blue/yellow).

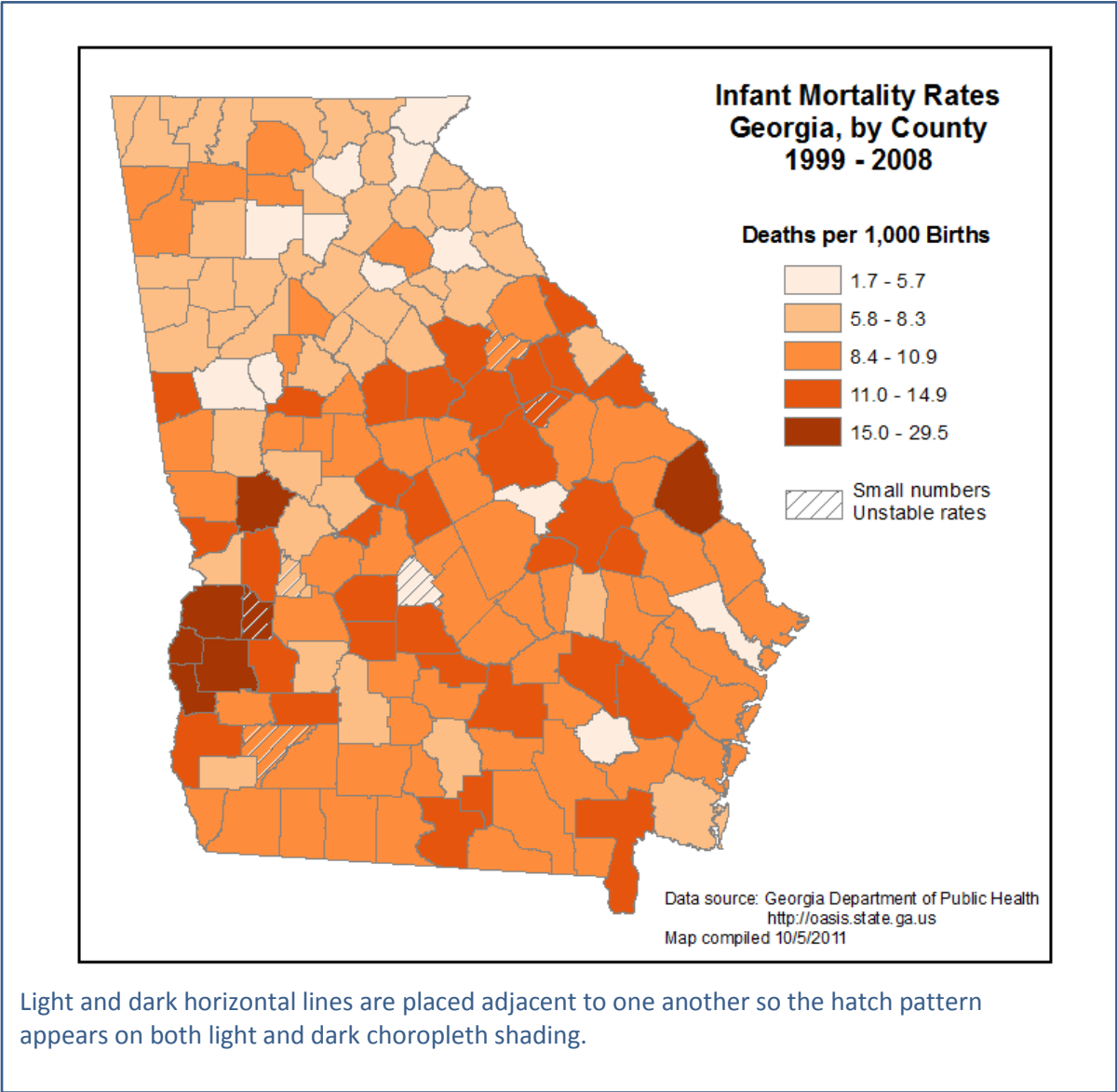
⚠️ Limit the use of colors that have connotations that are counterintuitive (e.g., red for “good” things, and green for “bad” things).

[ColorBrewer](#) provides color advice for cartography, including color schemes that are colorblind safe, print friendly, and photocopy-able.

Pattern: Pattern is the repetition of basic graphic elements, such as dots, lines, or other shapes. For example, in public health mapping, missing data values are sometimes shown with a white or gray solid fill whereas hatch patterns are often used to depict sparse data that has resulted in statistically unstable rates. Pattern as a visual variable should be used with caution to avoid maps that look “cluttered” or are visually distracting.

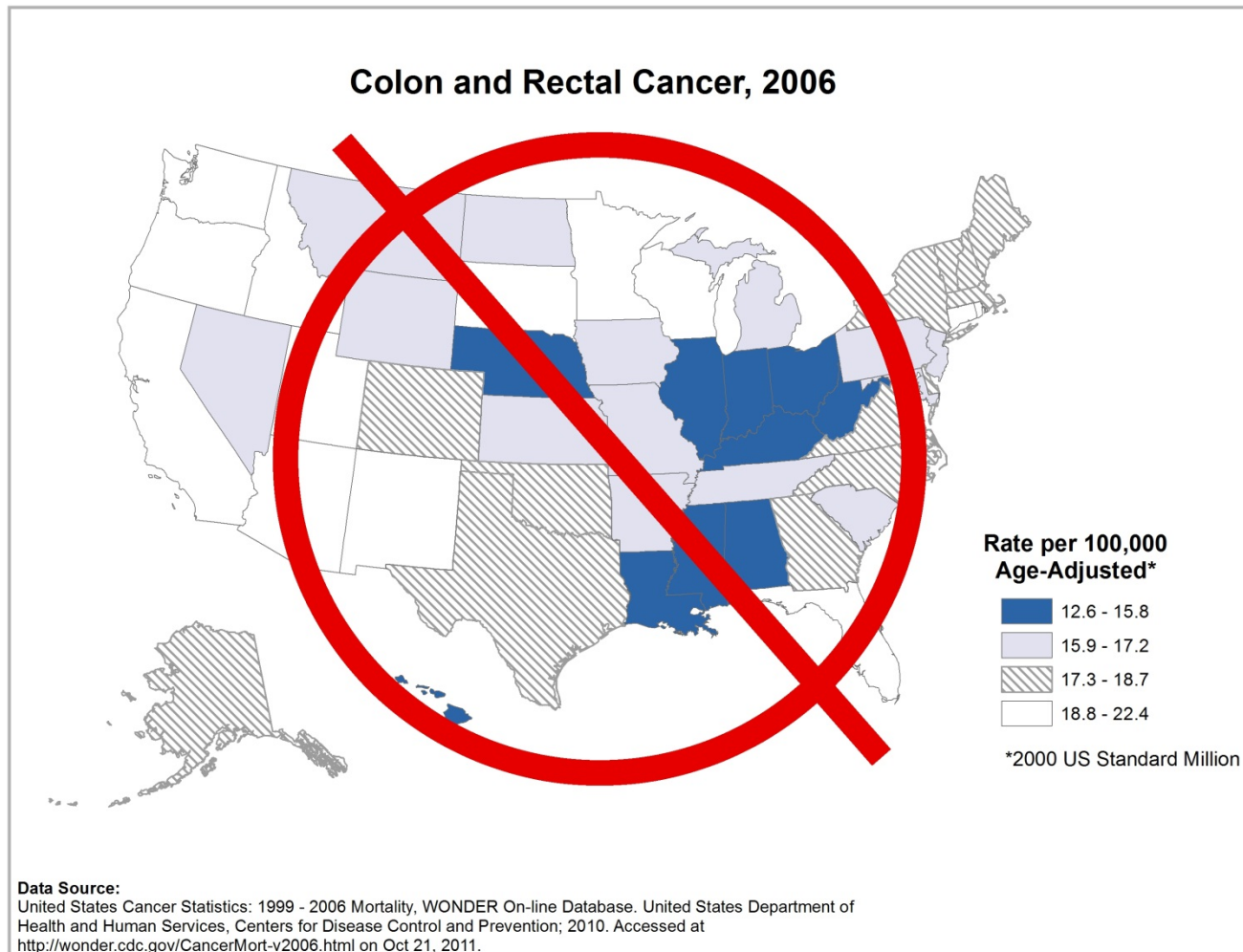
When limited to black-and-white, or grayscale reproduction, effective maps can be produced using combinations of size, shape, color value (i.e., grayscale), and pattern. Although color makes map design easier, it is not required to produce a good map.

Hatching to show unstable rates



⚠ Do not mix combinations of colors/shading and cross-hatching to represent data classes (e.g., black, blue, stippled, cross-hatched in the same map). **Cross-hatching patterns used in this way make it difficult to determine sequential value.**

Inappropriate use of hatching pattern




Type symbolization

A best practice is to use only one or two [type families](#) on the map, applying various combinations of type styles, sizes, and colors to achieve the desired [visual hierarchy](#). Similar features should be labeled with the same type characteristics; larger or more important features with larger type size. Type for data that represent the theme of the map should be more prominent than that of reference data, such as water bodies or political divisions. Care should be taken that type against background tints and lines is legible. A common convention is to use italics for natural features, such as water bodies, and Roman (normal) type style for political or artificial features. Word and letter spacing can be used to show variation in the areal extent of features.

[TypeBrewer](#) provides exploration of fonts for mapping.

- ⚠ For areal features, refrain from using labels that are at a variety of angles. Try to keep most area labels horizontal using techniques such as masking text so that boundaries “break” where the label crosses the boundary, splitting multi-word labels onto multiple lines, or by adding [leader lines](#).

Labeling areas



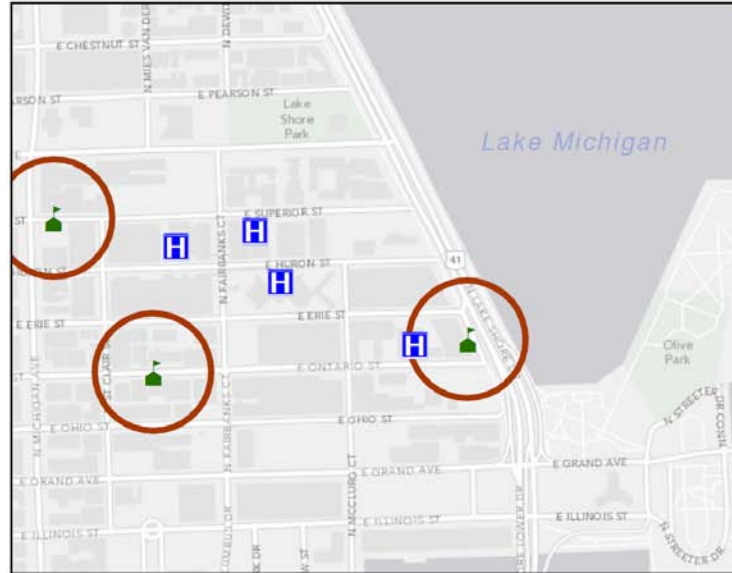
The map on the right uses masking to “break” boundaries of areas that are too small to completely contain a label. Secondly, it splits several labels onto two lines so that all features are clearly labeled. Unlike the map on the left where the multi-angled labels are visually distracting, the map on the right is more appealing to the eye.

Visual hierarchy

The map layout and design should clearly communicate the purpose of the map by emphasizing the most important map elements or features. Less important elements should be less noticeable. This can be accomplished with color, symbol and font size, line width, and other symbolization techniques.

Visual Hierarchy

The most important objects on the map should be shown with the greatest contrast to their surroundings. In the top figure, all objects are shown at the same level in the visual hierarchy. It's difficult to distinguish the important thematic objects from the base map. In the bottom figure, however, the base map is muted and the most important objects are symbolized to contrast strongly with their surroundings. Hospitals, schools, and school buffers are the visually prominent objects.



- ⚠ Using dark boundaries to show small areas, such as counties on a US map or census tracts on a state map, can result in visual clutter and confusing figure-ground relationships. Lighten the boundaries using lighter color shades or transparencies. Alternatively, do not show these boundaries.
- ⚠ Including map elements unnecessary for the purpose of the map introduces excess clutter and cognitive overload (e.g., hillshading on a statistical map).

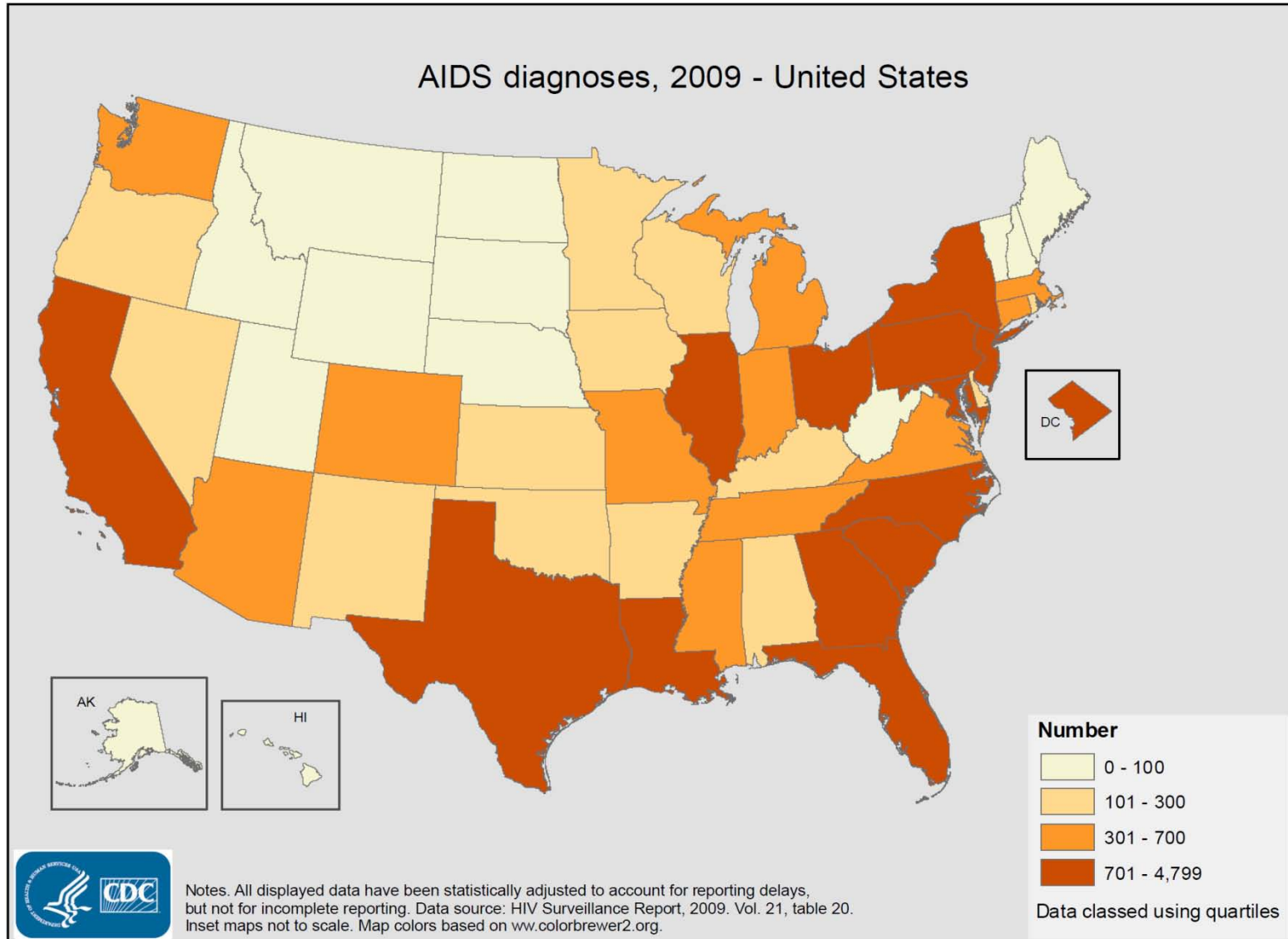
Selected thematic map types

As stated previously, the focus of the Cartographic Guidelines is to outline some of the best practices that go into making quality thematic maps, such maps being ideally suited to illustrate the geographic distribution of a wide variety of phenomena, such as mortality rates or disease diffusion. Listed below are a number of commonly-used thematic map types.

Choropleth map: These maps contain areas that are shaded relative to the statistical variable being displayed on the map. Data are aggregated to enumeration units (e.g, a politically defined or administrative area such as a state, county, or census tract). Choropleth maps are best used with phenomena that are evenly distributed within enumeration units and that exhibit abrupt changes at the boundaries of these enumeration units. These maps usually depict standardized data, for instance rates (i.e., risk) or proportions, but may also display raw numbers to indicate burden, a measure useful for planning and service delivery. The number of class ranges should be limited to between three and seven. Color scheme selection depends on the nature of the data. Mortality rates, for example, might be shown with a sequential scheme, whereas [standardized mortality ratios](#) would be better displayed with a diverging scheme (See [ColorBrewer](#) for examples).

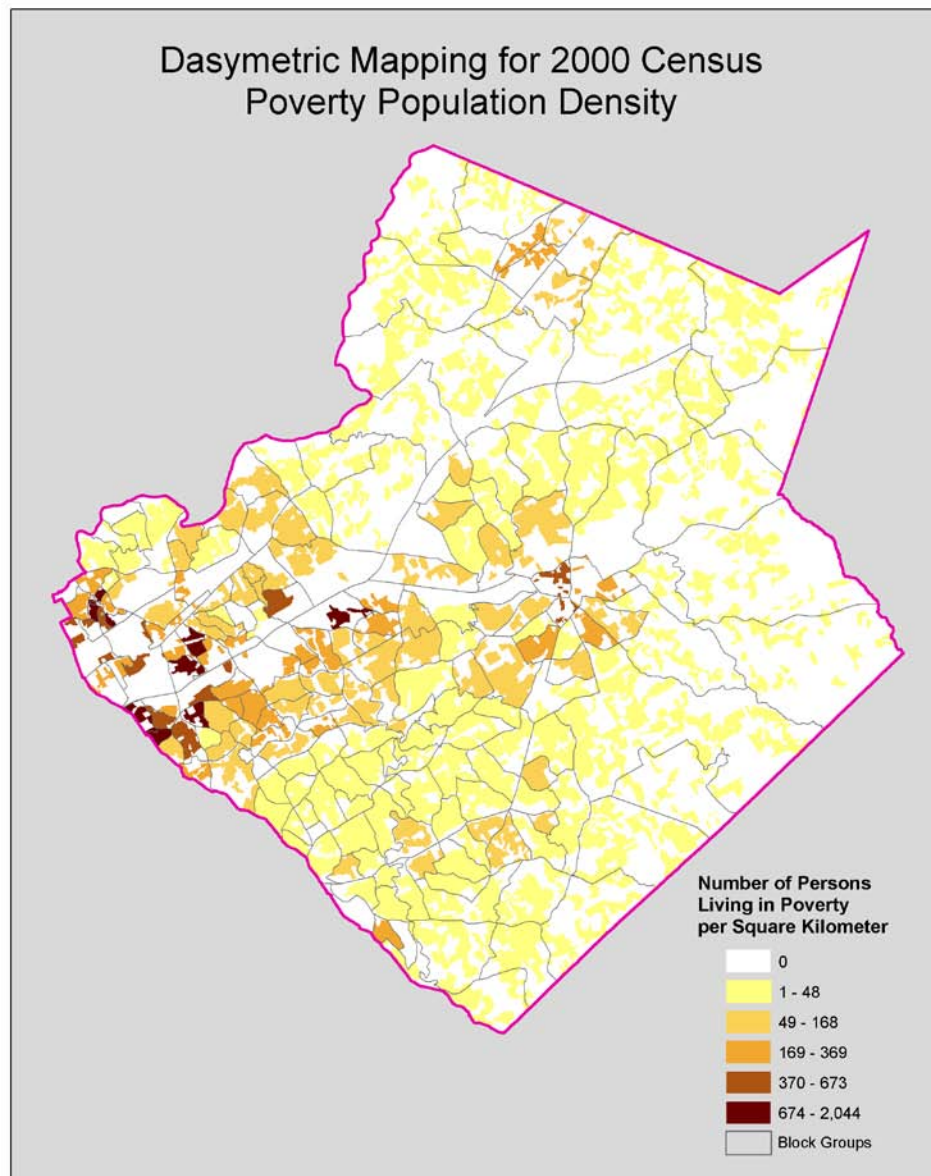
Choropleth map

AIDS diagnoses, 2009 - United States



Dasymetric map: Similar to the choropleth map in that standardized area data are mapped. However, the zone boundaries are based on ancillary (i.e., supplementary) variables and do not necessarily match the boundaries of enumeration units, such as counties.

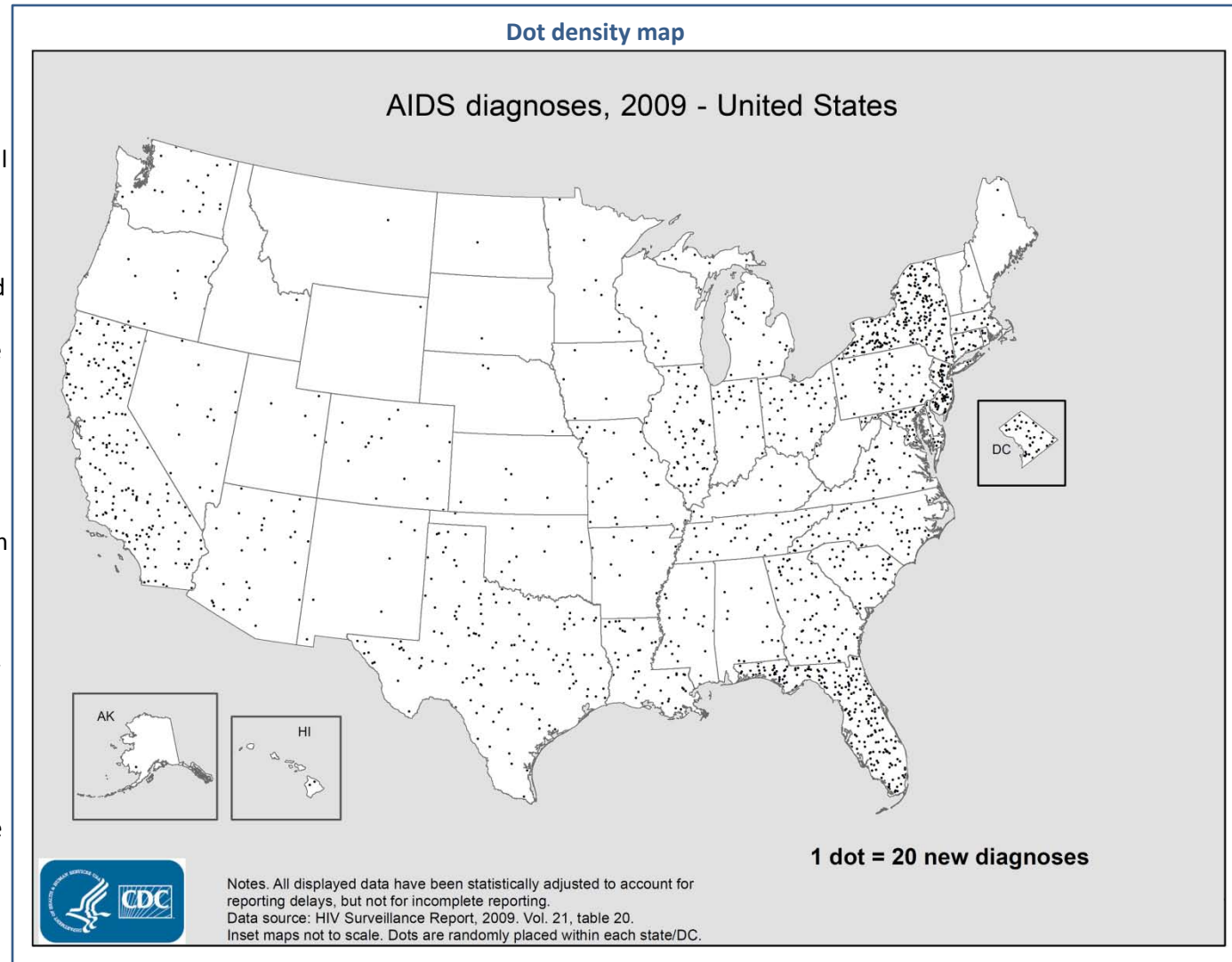
Dasymetric map



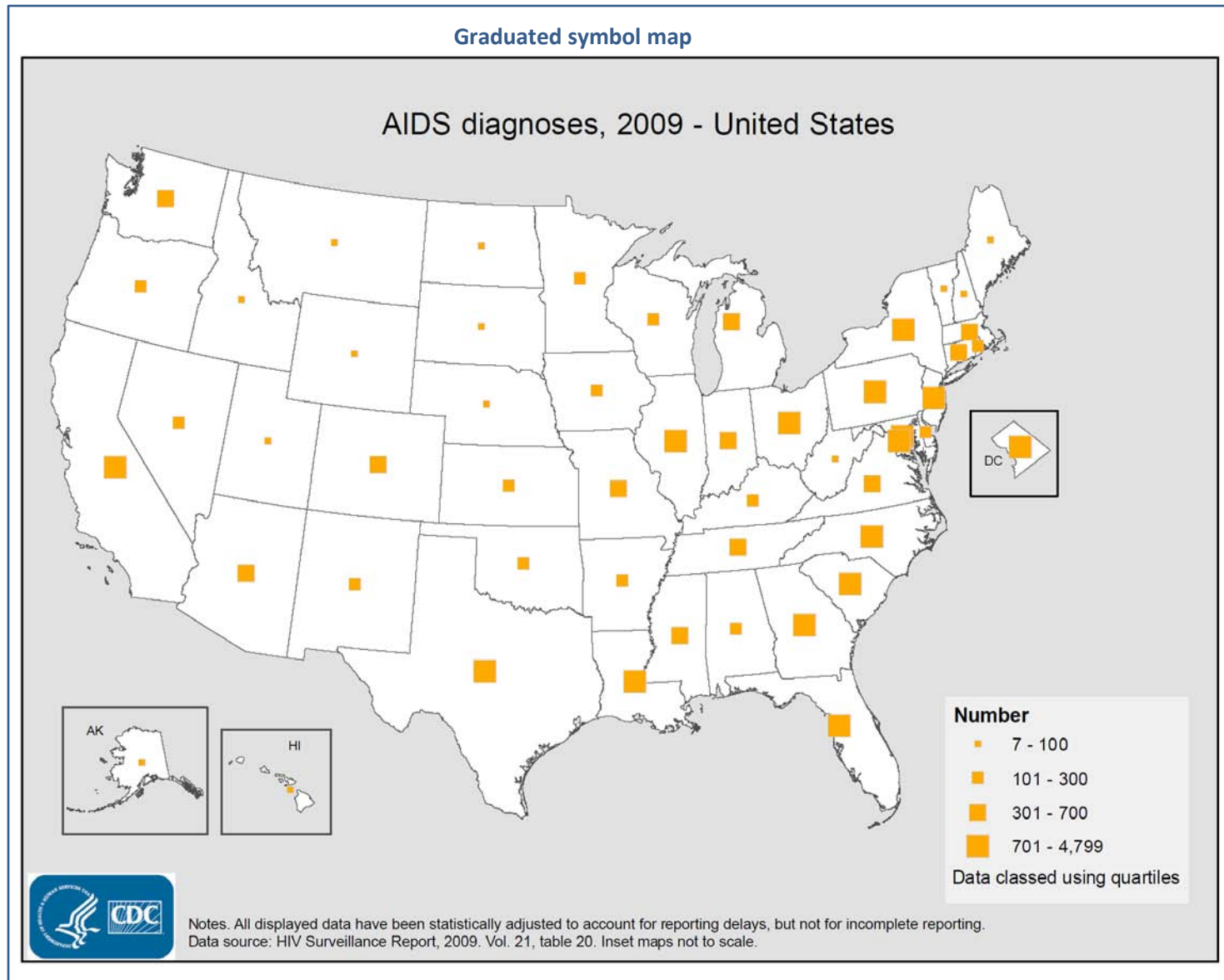
Data used for the dasymetric map included: 1) LandPro2001 (1 meter resolution land-use/landcover data), obtained from the Atlanta Regional Commission, used to delineate residential areas, and 2) Census data from 2000, used to obtain population counts and estimates of the number of persons living in poverty at the block group level. White areas in the map indicate non-residential areas – areas with no population, and by definition, zero population living in poverty.

Dot or dot density map:

Dots indicate the presence of a feature or event thereby illustrating a spatial pattern and relative density. Individual dots might represent a single event, with each dot placed to represent the true location. If it is not possible to map every event, dots may represent multiple events and are placed randomly within an area. Dot density maps are best used for count data and can show multiple data sets by using different symbols or colors. Interpretation of these maps can be strongly influenced by design decisions made about dot size, value, and arrangement. Dot density maps should include a note indicating that dots have been placed randomly within an area.

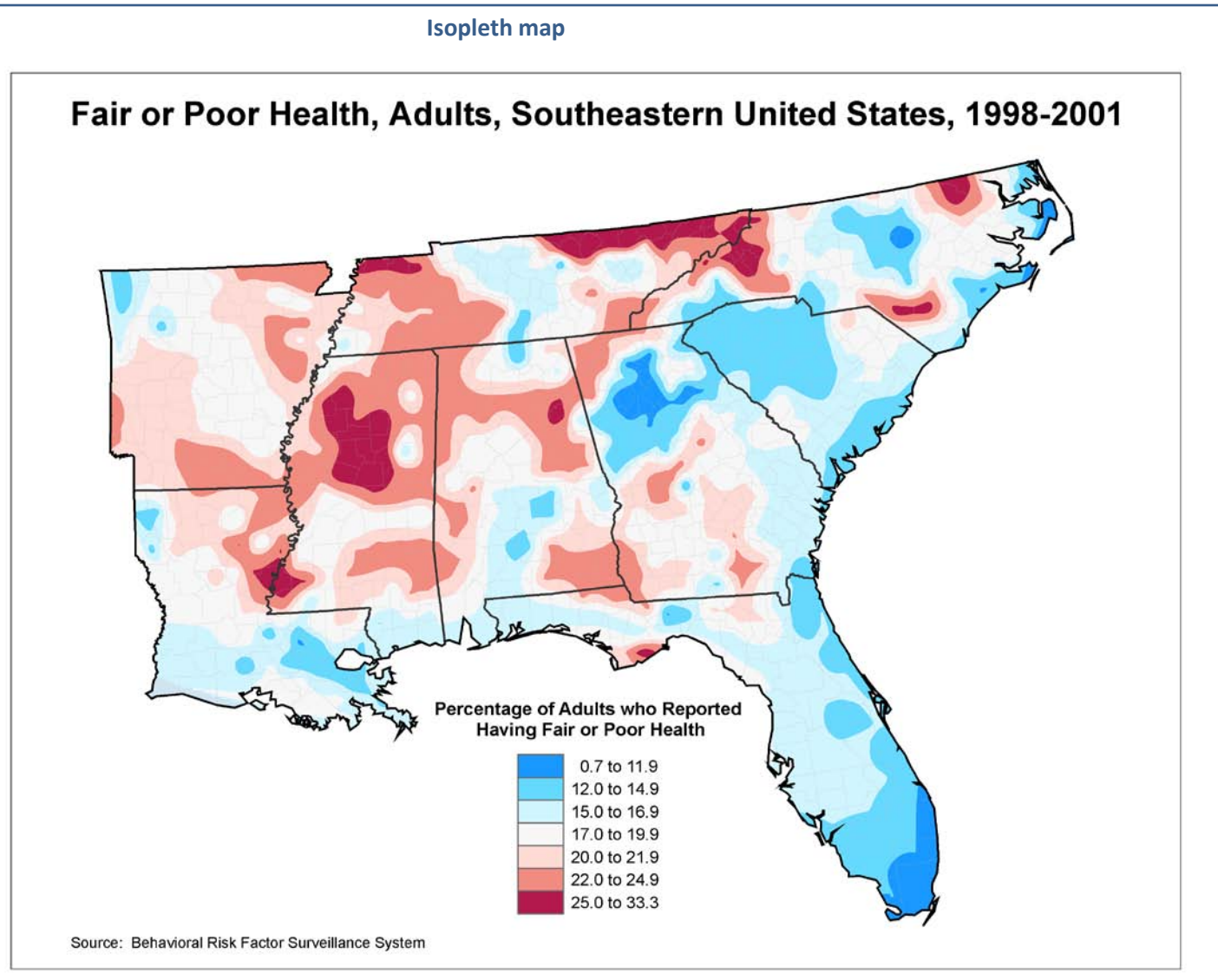


Graduated symbol map: Symbols vary in size to show their relative quantitative values. Graduated symbol maps are best used when there is variation and range in the data. The goal is to show relative magnitudes of phenomena, such as disease burden. This map type is a good choice for count data and should not be used for derived data such as rates.



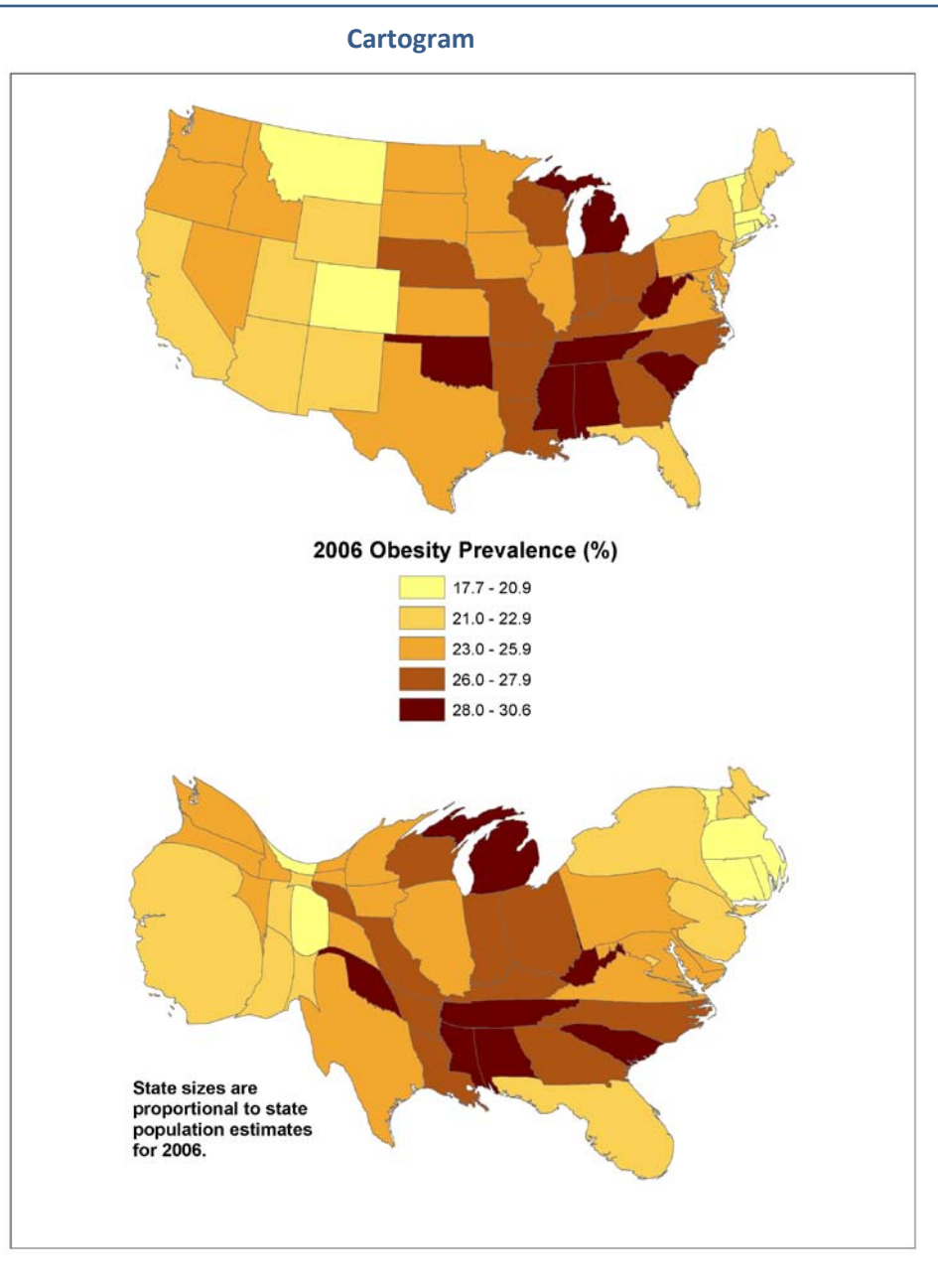
Isopleth map: Depicts smooth, continuous phenomena, such as weather or pollution, using lines that connect points of equal numerical value. Isopleth maps are effective for highlighting spatial patterns in the data, as opposed to depicting abrupt changes between enumeration areas.

To create this map, 1998-2001 [BRFSS](#) county-level estimates were assigned to each county's geometric [centroid](#) in ArcGIS. A [raster](#) layer was then [interpolated](#) using an [inverse distance weighted](#) technique (many interpolation options are available) and the output displayed using a seven-class diverging color scheme.



Cartogram (or density equalizing map projection): The geometry of each mapped area is distorted to symbolize an attribute other than land area (e.g., population or income). Construction methods are complex and interpretation can be difficult so cartograms should be accompanied by a description of the mapping technique. Cartograms are often constructed manually, but there are some digital algorithms available.

The bottom bivariate (i.e., two-variable) map shows state population as a value-by-area cartogram in conjunction with obesity prevalence in choropleth form.

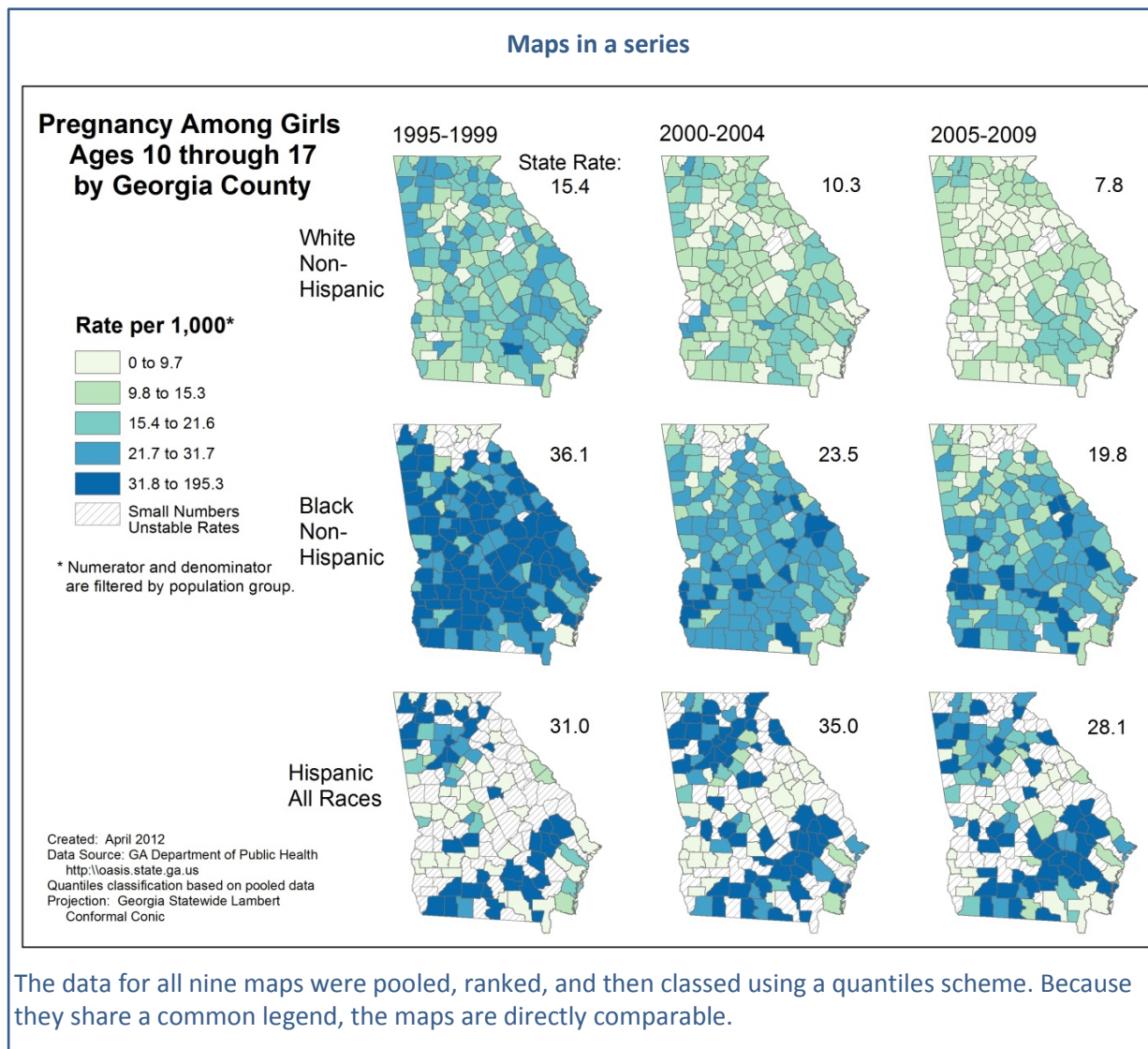


- ⚠ Spectral color schemes (red, orange, yellow, green, blue) do not work well on maps that show abruptly changing phenomena, such as choropleth maps. Spectral color schemes are better suited for depicting smooth phenomena that vary continuously, such as weather, on maps suited for smooth, continuous data, such as isopleth maps.

Maps in a Series -

Map types can be overlaid to show multiple variables. For example, the cartographer can depict a choropleth map of lung cancer prevalence rates with a proportional symbol map overlay of lung cancer counts to visualize risk and burden on one map. Likewise, the cartographer could show a variable along with the underlying topography, such as an isopleth overlay of weather data on a relief map. However, presenting multiple variables (or time-slices) on a single map is sometimes ineffective. A series of small maps, or small multiples, presented side-by-side enables efficient geographic comparison across variables or through time. Small multiples untangle the variables of interest, and allow the reader to scan the maps for trends or differences. A series of small multiples will generally be most effective if the designer follows these guidelines:

- The individual maps should be of the same size and at the same scale.
- If classifying data values, the classification scheme should be the same for all maps so they are directly comparable. Although it is preferable to avoid “empty classes,” it may not be possible when creating a classification scheme for maps in a series.
- Individual maps should be simple, and should include only one or two thematic layers.
- Maps should be sequenced or grouped in a logical or meaningful way.



The data for all nine maps were pooled, ranked, and then classed using a quantiles scheme. Because they share a common legend, the maps are directly comparable.

Confidentiality Issues

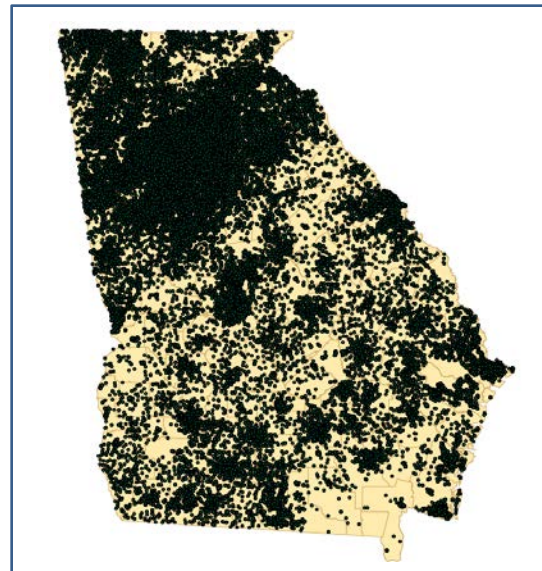
Maintaining the confidentiality of individuals is an important consideration in mapping health data. Although health data mapping is not addressed explicitly in the [HIPAA Privacy Rule](#), pinpointing a location can enable “ambitious de-identifiers” to determine an individual’s identity, thereby violating the Privacy Rule. In this section we focus on ways to comply with the Privacy Rule specifically when mapping point data.

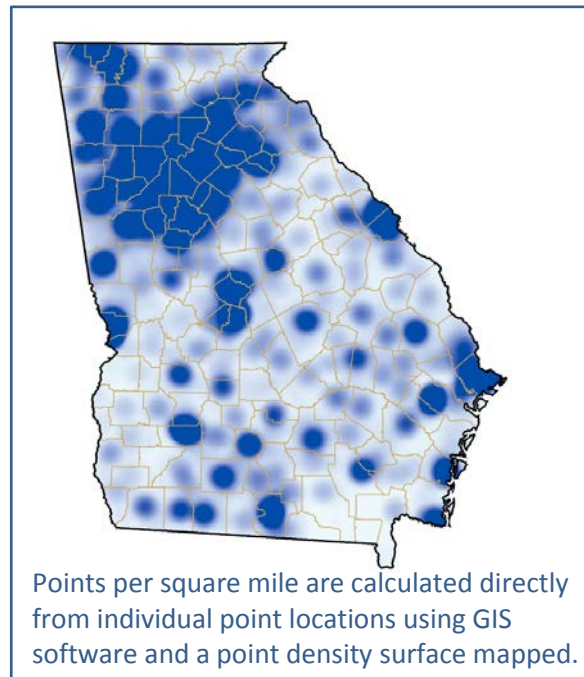
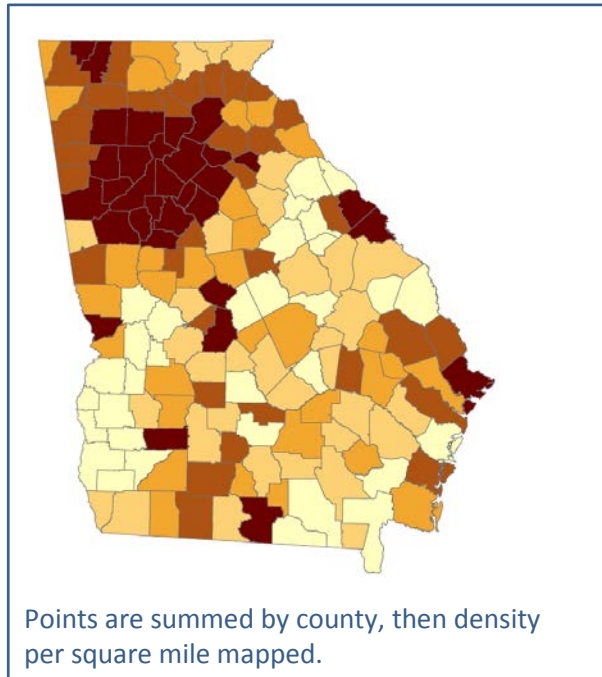
At large scales point data may be mapped without locational reference, such as streets, boundaries, or landmarks. Existing point distributions are still apparent, but confidentiality is more likely to be ensured.



At smaller scales, mapping points can give a general idea of the geographic distribution of a variable without enabling identification of an individual. In the illustration to the right, point patterns are visible, but individual points are imperceptible. In cases such as this, geomasking techniques may be preferable.

Geomasking refers to additional techniques that preserve the confidentiality of individual health records. Examples of geomasking include data aggregation, i.e. summing points within enumeration units such as counties or census tracts, and surface generation, i.e. calculating point densities with GIS software.





Shifting point locations is another way to geomask data. Random perturbation is random point shifting, either within an enumeration unit or within a buffer sized to reflect local population density. A quick method is to randomly shift each point in the enumeration unit within which it is located. A better method is to shift each point randomly within a donut-shaped buffer sized to reflect the local population density. This method offers more control in balancing the masking of locations with preserving the geographic distribution. All of these methods involve some subjectivity with the ultimate goal of the cartographer to preserve confidentiality.

508 Compliance

Section 508 of the Rehabilitation Act was enacted to eliminate barriers that might interfere with the ability of individuals with disabilities to fully access electronic information or use electronic tools and services. Section 508 requirements apply to web sites, including all forms of information and posted content, as well as any associated applications including web or media. Content providers for all federal web information and applications are expected to apply due diligence with regards to the provisions. Similar requirements apply to other government entities (e.g., state, local, international) and even to some private entities.

CDC web applications and documents should meet specific acceptance criteria. These criteria include requirements for keyboard navigation, text equivalents, and labeling of form controls among others. [Checklists*](#) provide guidance for content providers. For mapping, text and/or tabular data that explain the content, using either [alternative text](#) (“alt text”) or by writing text on the page, should be included. End users may then employ screen readers or other assistive technologies to identify and interpret what is displayed on the screen.

A common challenge in Section 508 compliance relates to graphics in PDF format, a frequently used map format. Alternative text is most efficiently added to all content images in the source document before the document is converted to PDF. Alternate tag text should be brief and descriptive with text dependent on the context of the page. [Creating a Compliant PDF*](#) explains the process. Another provision, such as alternative text for multilayer GIS presentations, is not available in current technology. CDC, like most organizations, has a formal process for approving exceptions to Section 508. Contact the [CDC Section 508 Helpdesk*](#) for more information or to apply for an exception.

References and recommended resources

- Armstrong, M.; G. Rushton; D. Zimmerman. 1999. Geographically masking health data to preserve confidentiality. *Statistics in Medicine* 18: 497-525.
- BioMed Central. Illustrations and Figures. 2011.
<<http://www.biomedcentral.com/info/ifora/figurefileformats>>. Accessed 9/14/2011.
- Brewer C.; L. Pickle. 2002. Evaluation of Methods for Classifying Epidemiological Data on Choropleth Maps in Series. *Annals of the Association of American Geographers* 92(4):662-681.
- Brewer, C. TypeBrewer. 2006. <<http://TypeBrewer.org>>. Accessed 7/20/2011.
- Brewer, C. ColorBrewer. 2009. <<http://ColorBrewer2.org>>. Accessed 7/18/2011.
- Brewer, C. 2005. *Designing Better Maps: A Guide for GIS Users*. Redlands, Esri Press.
- Buckley, A; K. Field. Making a Meaningful Map: A checklist for compiling more effective maps. Esri. 2011. <<http://www.esri.com/news/arcuser/0911/files/mapchecklist.pdf>>. Accessed 10/20/2011.
- Centers for Disease Control and Prevention, Division for Heart Disease and Stroke Prevention. 2011. Tips for Creating Maps for Public Health.
<<http://www.cdc.gov/DHDSP/maps/GISX/resources/maps1.html>>. Accessed 7/18/2011.
- Centers for Disease Control and Prevention. Epi Info. 2011. <<http://wwwn.cdc.gov/epiinfo/index.htm>>. Accessed 7/18/2011.
- Centers for Disease Control and Prevention, Office of the Associate Director for Communication. 2011. Working with OADC: Web site Guidance and Resources.
<<http://intranet.cdc.gov/od/oc/subTopic/web/508.htm>>.* Accessed 8/2/2011.
- Centers for Disease Control and Prevention. 2011. Section 508 for Web.
<<http://intranet.cdc.gov/cdcweb/usability/508/checklists.html>>.* Accessed 8/2/2011.
- Centers for Disease Control and Prevention. 2011. Creating a Compliant PDF.
<<http://intranet.cdc.gov/od/oc/includes/documents/pdf/508-PDF-How-To-Guide.pdf>>.* Accessed 8/2/2011.

- Centers for Disease Control and Prevention. 2011. Maps Based on Data from 2009 HIV Surveillance Report.
<http://wwwdev.cdc.gov/hiv/topics/surveillance/resources/slides/2009report_tables/index.htm>.
Accessed 8/4/2011.
- Centers for Disease Control and Prevention. 2011. Level III Software Product Security.
<<http://intranet.cdc.gov/ociso/LevelIII>>.* Accessed 8/19/2011.
- Centers for Disease Control and Prevention. 2011. Brand Identity Standards.
<http://brandidentitystandards.cdc.gov/CDC's_New_Brand_Identity/>.* Accessed 9/30/2011.
- Dent B. 1999. Cartography: Thematic Map Design. Boston: WCB/McGraw Hill.
- Esri. 2011. <GIS Dictionary. <<http://support.esri.com/en/knowledgebase/Gisdictionary/browse>>.
Accessed 10/25/2011.
- Harrower M.; M. Bloch. 2006. MapShaper.org: A Map Generalization Web Service.
<http://maps.grammata.com/cga2006_paper.pdf>. Accessed 8/16/2012.
- Koch T. 2005. Cartographies of Disease: Maps, Mapping, and Medicine. Redlands: ESRI Press.
- Krygier J.; D. Wood. 2011. Making Maps: A Visual Guide to Map Design for GIS. New York: The Guilford Press.
- National Geographic. 2005. Mapmaking Guide.
<<http://www.nationalgeographic.com/xpeditions/lessons/09/g68/cartographyguidestudent.pdf>> .
Accessed 10/25/2011.
- NIH. 2004. Research Repositories, Databases, and the HIPAA Privacy Rule. Publication Number 04-5489.
<http://privacyruleandresearch.nih.gov/research_repositories.asp>. Accessed 11/3/2011.
- McKendry, J.; G. Machlis. 2009. Cartographic Design and the Quality of Climate Change Maps. Climatic Change 95(1)219-230.
- Monmonier M. 1996. How to Lie with Maps. Chicago: University of Chicago Press.
- Norheim, R. 2011. Cartographic Standards and Practice in Academic Journals. Presentation at the 2011 annual meeting of the Association of American Geographers.
- Pickle L.; M. Mungiole; G. Jones; A. White. 1996. Atlas of United States Mortality. Hyattsville: U.S. Department of Health and Human Services.
- Robinson A.; J. Morrison; P. Muehrcke P; A. Kimerling; S. Guptill. 1995. Elements of Cartography. New York: John Wiley & Sons.
- Slocum, T.; R. McMaster; F. Kessler; H. Howard. 2009. Thematic Cartography and Geovisualization Upper Saddle River: Prentice Hall.

Stinchcomb, David. 2004. Procedures for Geomasking to Protect Patient Confidentiality. Esri International Health GIS Conference. Washington, DC.

Tufte, E. 1990. *Envisioning Information*. Cheshire: Graphics Press.

Tufte, E. 2001. *The Visual Display of Quantitative Information*. Cheshire: Graphics Press.

Tufte, E. 2002. *Visual Explanations*. Cheshire: Graphics Press.

Software resources for cartographic production

The type of software needed to make professional map products varies depending on the type and form of the data and the map requirements. If your data are already in a digital format accessible to common desktop GIS software, such as Esri's ArcGIS Desktop, your workflow will be different than if your data exist only in an analog format, such as a printed map or data table. The following table, which is certainly not exhaustive, lists some useful software packages.

Current as of 4/5/2012.

Name	Source	Free and Open Source	Level III Approved	Common cartographic use
Acrobat Pro	Adobe	No	Yes	Acrobat Pro generates PDF files for a variety of content. For map production, it provides author controls to manage content and set password protections to limit printing, copying, or opening files.
ArcGIS Desktop	Esri	No	Yes	Integrate cartographic data from different sources in different formats, generate new digital data, and visualize data by varying map scale, projection, page layout, and data symbology. Final map products can be a static JPG, GIF, AI, or PDF/GeoPDF, KML/KMZ file.
Epi Map	CDC	Yes	Yes	Epi Map is a module of Epi Info, a suite of lightweight software tools. Epi Map provides simple GIS and mapping capabilities.
GeoDa	ASU GeoDa Data Center	Yes	Yes	GeoDa is designed for exploratory spatial data analysis, and as such provides extensive visualization tools. Tools for cartographic output are also available.
Geographic Imager	Avenza	No	No	This is a suite of plug-in tools for Adobe Photoshop, permitting the direct import and export of raster GIS data. Additional data symbolization features include color ramps tailored for DEM data.
GNU Image Manipulation Program (GIMP)	GIMP.org	Yes	Yes	For cartographic production, GIMP provides a free alternative to Adobe Photoshop, for cropping, resizing, converting file types, and performing contrast enhancements on image files.
GoogleEarth	Google	Yes	Yes	Data visualization tool, for displaying GPS data, vector data (KML or KMZ format), and rudimentary georeferencing of raster data. Limited data symbolization functionalities exist for vectors.

IDRISI	Clark Labs	No	No	Although the primary focus of IDRISI is image processing and GIS analysis, the software provides a variety of display and map composition utilities for visualization.
Illustrator	Adobe	No	Yes	A tool for working with vector line-work as well as raster data. Line-work can be manipulated to generalize data, or refine data symbolization and page layout. It can also integrate raster data in some file types. Images can be manually stretch or scaled, but data cannot be digitally reprojected. Useful for putting finishing touches on a printed map, such as managing text layout, inserting text, and managing overall print layout.
IMAGINE	ERDAS	No	Yes	IMAGINE performs advanced remote sensing analysis and spatial modeling. It offers the ability to produce cartographic quality map compositions.
InstantAtlas	InstantAtlas	No	Yes	InstantAtlas is “data presentation software for location-based statistical data.” It includes map production capabilities.
Maptitude	Caliper	No	No	Maptitude is desktop GIS software that includes high quality cartographic production.
MAPublisher	Avenza	No	Yes	MAPublisher is a suite of plug-in tools for Adobe Illustrator that enables a user to import SHP files and other digital GIS formats directly into Adobe Illustrator. It can also handle some data reprojections.
Photoshop	Adobe	No	Yes	Useful for preparing JPG, GIF, or other images from scanned maps for integration and georeferencing in other software. Notable tools include Crop and Resize, and image contrast enhancement. Also useful for preparing final map images for distribution.
Quantum GIS (QGIS)	QGIS.org	Yes	No	Similar functionalities as Esri’s ArcGIS Desktop for integrating, and generating data, but limited in the data symbolization. Map data cannot currently be exported as vector line work (AI or EPS file types)