Cartographic Guidelines for Designing Effective Maps

1. **Size**: The figure should be designed with an eye towards where it will appear. Journal articles, reports, proposals, etc. have different requirements and constraints than maps for websites or presentation. Figures reused from other formats will often need some elements redesigned.

2. **Generalization**: Small-scale maps should show more area, less detail, and more generalization of features. Large-scale maps should show less area, more detail, and less generalization of features. A coastline on a large-scale map is symbolized by a line with more detailed curves than the same coastline on a small-scale map.

3. **Map projection**: Maps should be projected. An equal-area projection is required for mapping data distributions and is a good choice for most other maps. The projection parameters should be appropriate for the area portrayed – e.g., don’t use a “lower 48” projection for a map of just Washington state. Mercator and “geographic” projections are never appropriate.

4. **Data classification**
   a. **Qualitative data** show differences in kind (e.g., forest versus urban land cover). Qualitative data should be grouped so that features in the same group are more similar than dissimilar and features in different groups are more dissimilar than similar.
   b. **Quantitative data** show differences in amount (e.g., population density). Quantitative data should be grouped by specific external criteria (e.g., equal interval) or by the characteristics of the data (e.g., natural breaks, quantiles).

5. **Data symbolization, using visual variables**
   a. **Size**: Size should be used to represent quantitatively different data (either rank-ordered data or numerical amounts). A larger square signifies a greater quantity than a smaller square.
   b. **Shape**: Shape should be used to categorize features that are qualitatively different. A square is not more or less than a circle, but is different in kind.
   c. **Color hue**: Color hue (such as red, green, blue) should be used to categorize features that are qualitatively different, such as a river and a road. “Rainbow” color schemes are not appropriate for numerical or ordered data as there is no natural ordering of colors in the human eye-brain system.
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d. **Color value:** Color value (or lightness of hue) should be used to represent quantitatively different data (either rank-ordered data or numerical amounts), such as precipitation. Value is typically light for low numbers (e.g., light green) and dark for high numbers (e.g., dark green) in sequential datasets, such as a dataset of population change from 0% to 100%. For diverging data sets with an important midpoint (between negative and positive values), such as population change from −50% to +50%, hue and value can vary to show the two directions in the data set. The midpoint from 0% to −50% can be symbolized using a light to dark color hue. The midpoint from 0% to +50% can be symbolized using a different, complementary light to dark color hue. Mnemonic colors should be used when possible, such as green/brown for wet/dry. ColorBrewer.org is a good resource for choosing color schemes.

e. **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. Saturation is difficult to use on its own to symbolize data. Saturation is typically used to reinforce changes in value for quantitative data or to reinforce changes in hue for small areas on a map that are qualitatively different.

6. **Visual hierarchy:** Visual hierarchy should emphasize the most important map elements. Less important elements should be less noticeable. Visual hierarchy should clearly communicate the intellectual hierarchy and purpose(s) of the map. Study areas, countries, and political subdivisions should not appear as “islands”. Use “figure-ground” symbolization to de-emphasize surrounding areas instead.

7. **Map elements**
   a. **Borders and neatlines:** A border should enclose each map to provide visual stability and closure. Other lines may be necessary in the figure to emphasize hierarchy and focus.
   
b. **Title:** For journal articles and reports, no title should be included in the map; the title should be in the figure caption. Otherwise include a descriptive and succinct title. A subtitle and some explanatory text may also be useful, but should not be overwhelming.
   
c. **North arrow:** A north arrow should be included on large scale maps (usually scales less than 1:200,000), where north is in the same direction across the entire map – i.e., meridians do not visually begin to converge. Complex compass roses are distracting and should be avoided in favor of a simple arrow.
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d. **Graticule**: On smaller scale maps without a north arrow, a graticule (i.e., a grid of parallels and meridians) helps the map reader place the study area on the globe. The graticule should be low in the visual hierarchy, and only a few graticule lines are necessary. On maps of the USA and Canada, a graticule is not necessary as state and provincial borders are a good substitute. Elsewhere, hiding the graticule behind land masses so that it only shows over the ocean helps keep the graticule low in the visual hierarchy.

e. **Scale bar**: A scale bar should be included on most maps, except for projections where distance varies with latitude. Complex, multi-division scale bars are distracting and should be avoided in favor of a single division scale bar (no one will be using your map for navigation). The distance portrayed should be a round number.

f. **Location maps**: One or two nested inset maps showing the continental and country location of the study area are often useful. Alternatively, the first map in the article or presentation may set the larger context and subsequent maps show just the study area. The size of the region shown is dictated by the venue: a local conference needs only a small region but an international journal should have a continental context.

g. **Legend**: A legend should be included that explains and interprets the symbolization of the main thematic content of your map. This is not required for reference maps. Use descriptive terms as well as (or instead of) numerical values to aid interpretation. Numbers should be in round numbers, and include units. If the symbolization can be explained with labels on the map itself, this is often preferred to a legend. The legend need not have a description for every item on the map: properly symbolized, many features such as boundaries and water bodies are self-evident. The title ‘Legend’ or ‘Key’ is usually unnecessary.

h. **Labels**: Labels for data that represent the theme of the map (when used) should be more prominent than labels used for reference (such as water bodies or political divisions). Care should be taken that lettering against background tints and lines is legible. Place labels judiciously to avoid overwhelming the map.

i. **Lettering**: Use only one or at most two font “families” on the map. Similar features should be labeled with the same font characteristics; larger or more important features with larger type size.

j. Use these elements to provide **visual balance** for your map. Most of them (title and thematic labels being the main exceptions) should be low in the **visual hierarchy** of the map.