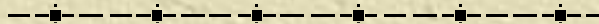


EnvSci 360 – Computer and Analytical Cartography

Lecture 6

Mapping with Color



Why Use **Color**?

- ✦ It is one of the available **visual variables** you can mix with other graphic elements to **improve communication**
 - Color allows greater number of features on a map
 - People easily recognize slight variations in color (hue, value, chroma)
- ✦ It is an aesthetic element that can **improve the appearance** and graphic quality of the map/poster

Using Color with Graphic Symbols

- ✦ In the color world, we have:
- **Hue** (or “color of the rainbow”)
 - **Value** (or lightness)
 - **Saturation** (or chroma, intensity)

Use “color models”
to “mix” colors on
a screen or paper

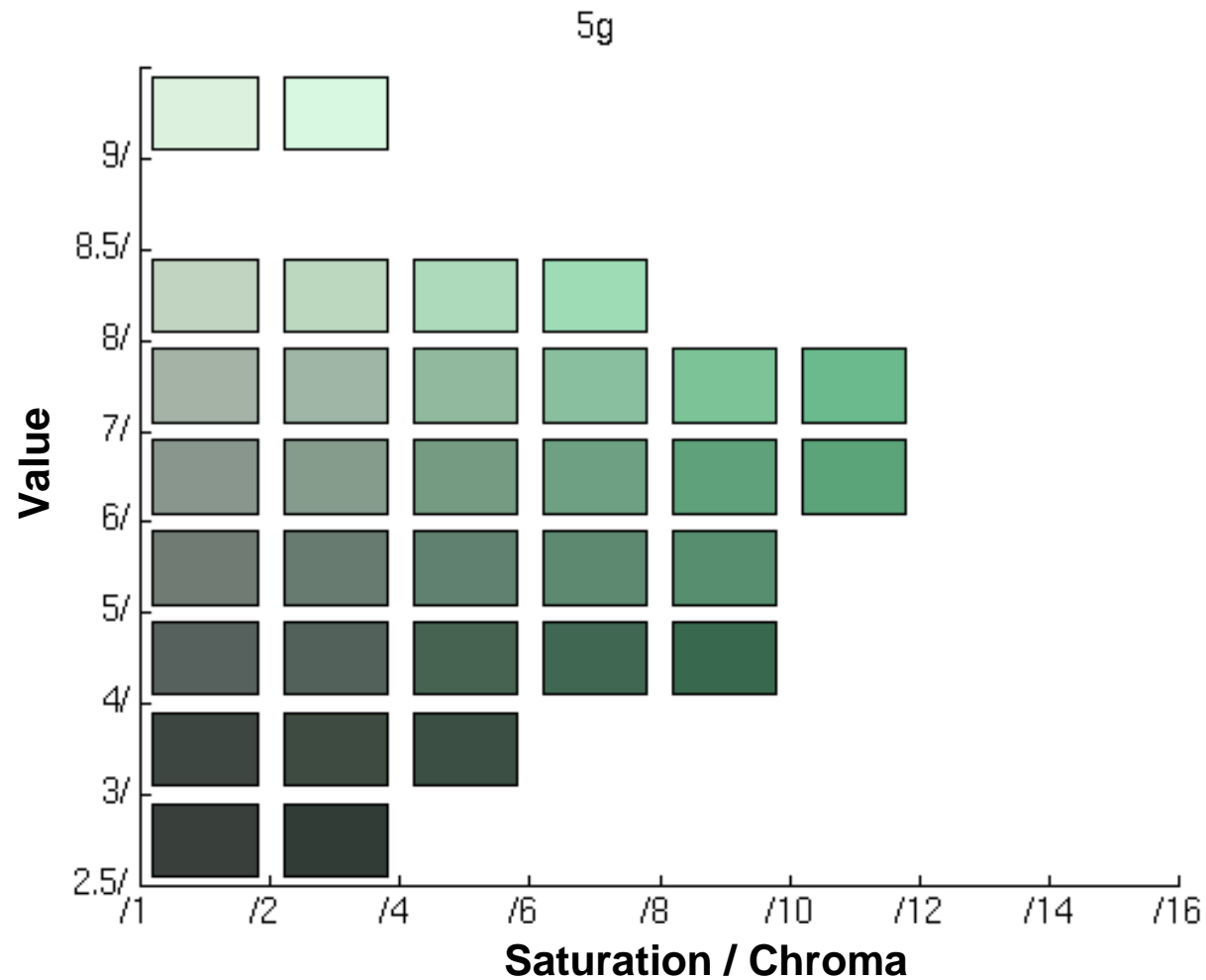
	Point	Linear	Areal	2½-D	3-D
Hue					
Lightness					
Saturation					

Color Dimensions

- ✦ **Hue** - focused on the wavelength of the color – the everyday “name” we give to colors
- ✦ **Saturation and Chroma** – how pure a hue is relative to a gray tone at the same value - the amount of “colorfulness”
- ✦ **Brightness/Value/Lightness** - how light or dark a hue appears, relative to a standard black to white range; refers to both grayscale and color



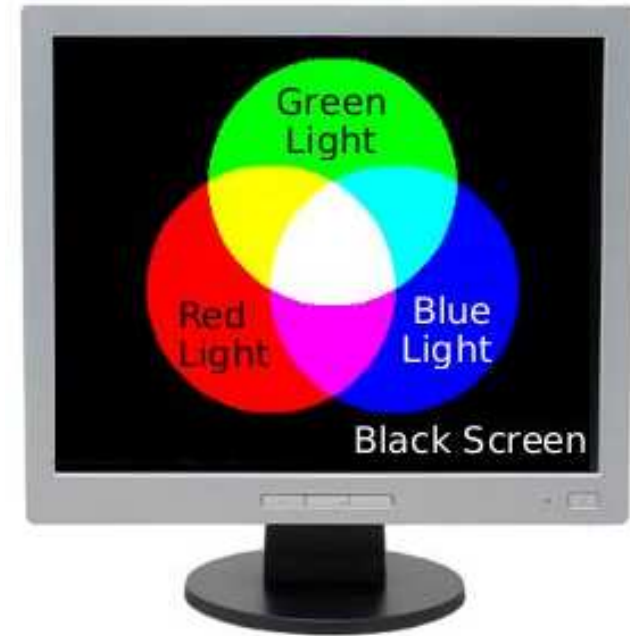
Color Dimensions



Color Models

✦ Additive Color Model

- “RGB” – **red (R), green (G), blue (B)** are the primary colors used on **computer screens**
- When combined in equal amounts, the additive primary colors produce white
- Measured from 0 to 255

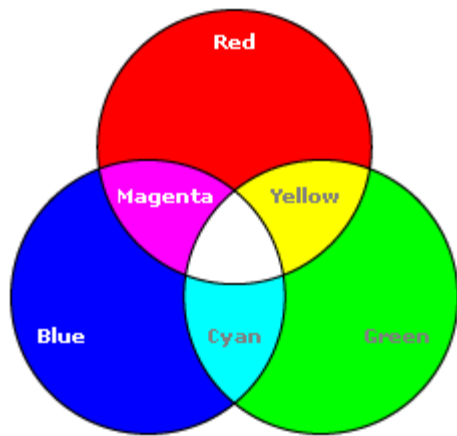


Color Models

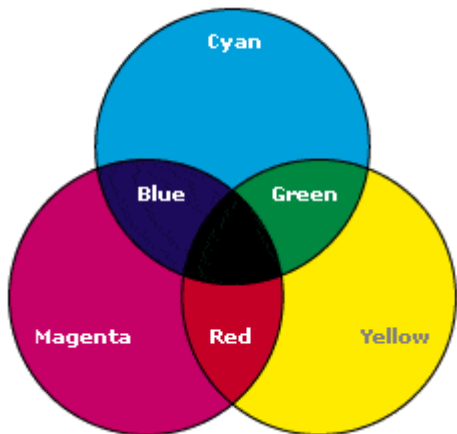
- ✦ Subtractive Color Model
 - “CMY” - Primary colors, used in **printing**, are **cyan (C)**, **magenta (M)**, and **yellow (Y)**
 - The mixing of the primary colors produces (in theory at least) **black (K)**
 - True black often added to model (“CMYK”)
 - Measured in percentages from 0 to 100



Comparing Color Models



RGB:
Light on
computer
displays



CMY(K):
Inks on
paper

How colors combine

$$\text{R} + \text{G} = \text{Y}$$

$$\text{R} + \text{B} = \text{M}$$

$$\text{G} + \text{B} = \text{C}$$

How pigments combine

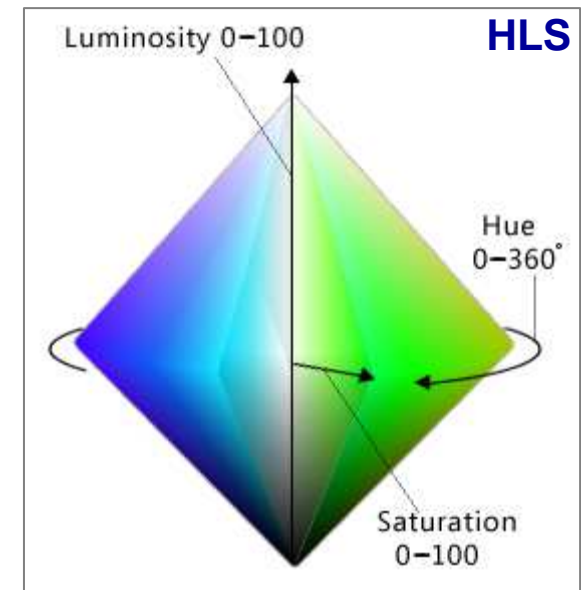
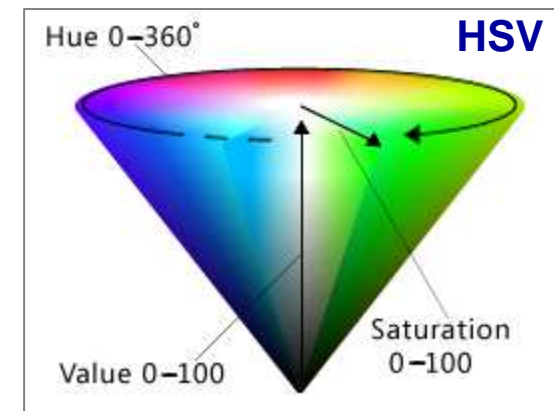
$$\text{C} + \text{M} = \text{B}$$

$$\text{C} + \text{Y} = \text{G}$$

$$\text{M} + \text{Y} = \text{R}$$

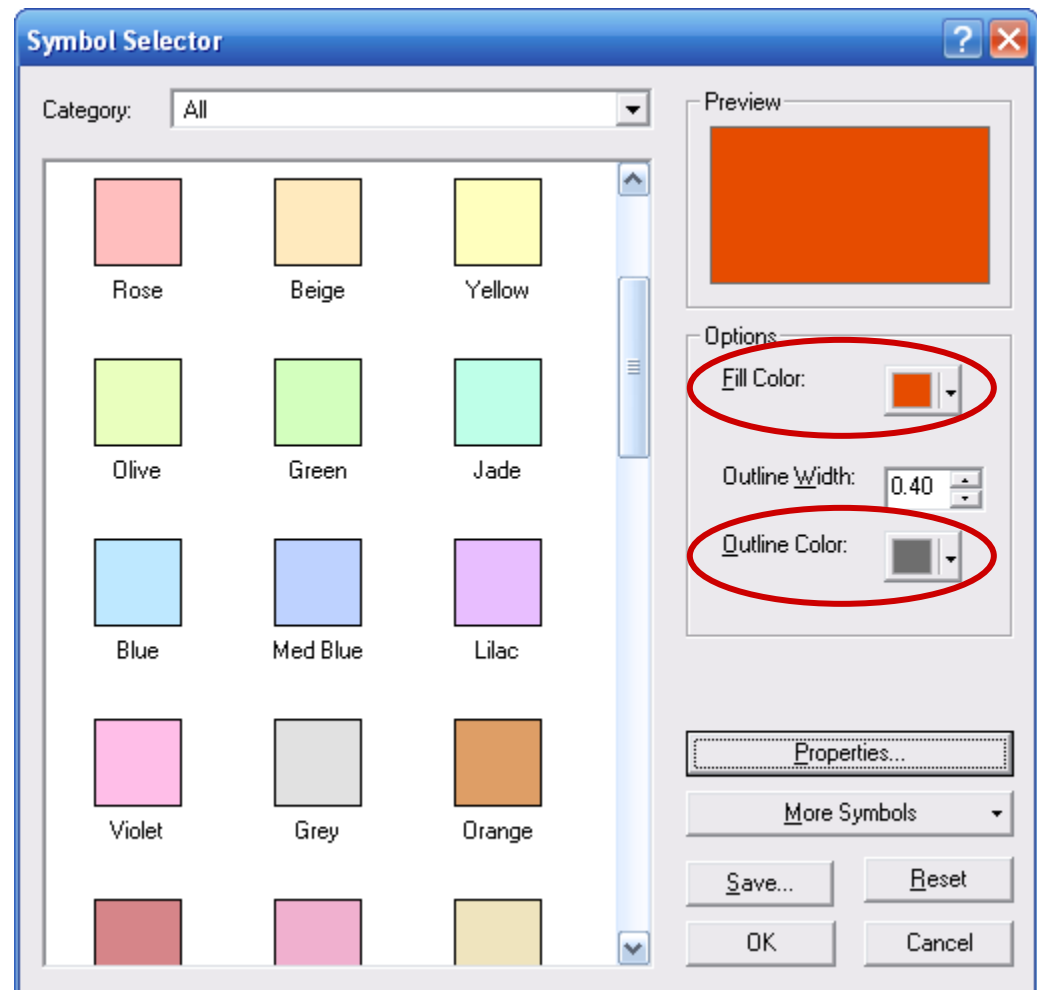
Perceptual Color Systems

- ✦ 3-D “color spaces” – representations of the RGB color model
 - **HSV** (Hue-Saturation-Value)
 - Hue is wavelength of color
 - Saturation is amount of pure color
 - 0% = none (white), 100% = pure
 - Value is brightness
 - 0% = dark (black), 100% = bright
 - **HLS** (Hue-Lightness/Luminance/Luminosity-Saturation)
 - White has lightness 1.0
 - Pure colors have lightness 0.5



Color and ArcGIS

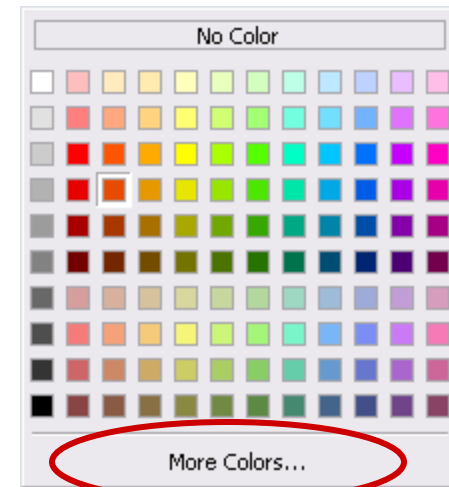
- ✦ Symbol Selector
 - Choose and edit color properties



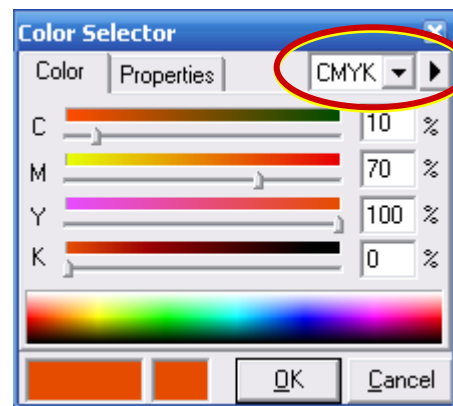
Color and ArcGIS

✦ Color Selector

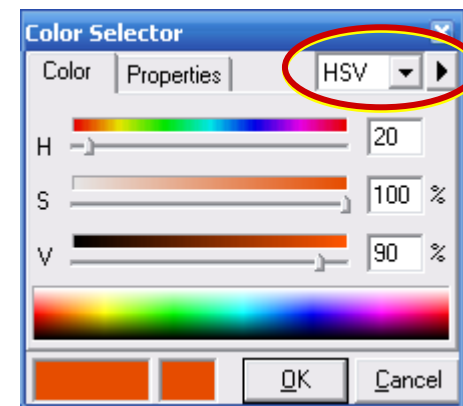
- Choose color model
 - Useful for code, matching colors



RGB



CMYK



HSV

Color and Pattern Use

✦ Dithering -
blending of colors
gradually



✦ Banding - stepped
change of colors;
(reduced bit-depth
without dithering)



Color Schemes

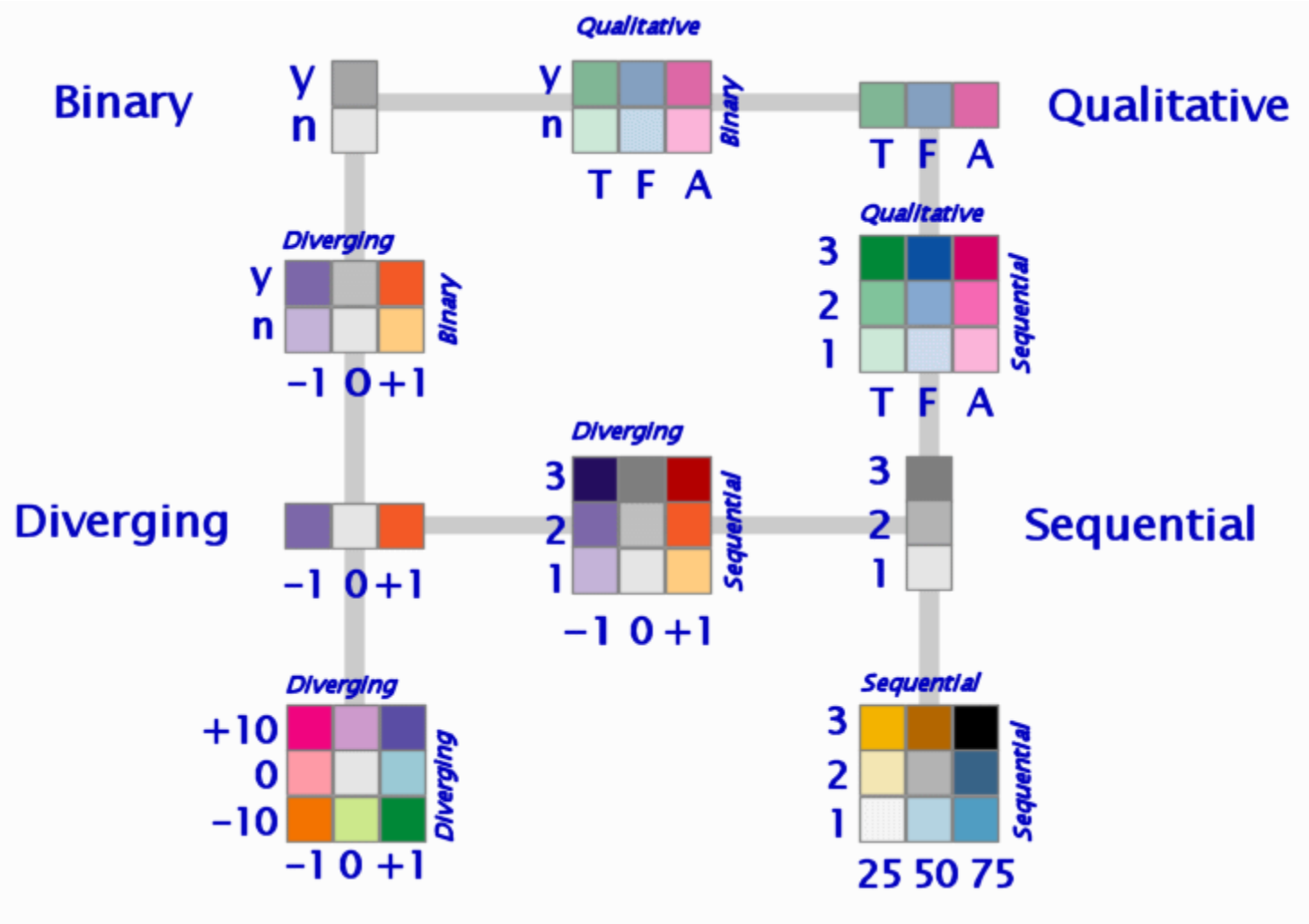
- ✦ Qualitative
 - ✦ Binary (also Qualitative, usually)
 - ✦ Diverging
 - ✦ Sequential
- } Quantitative

Resources:

<http://www.personal.psu.edu/cab38/ColorSch/SchHome.html>

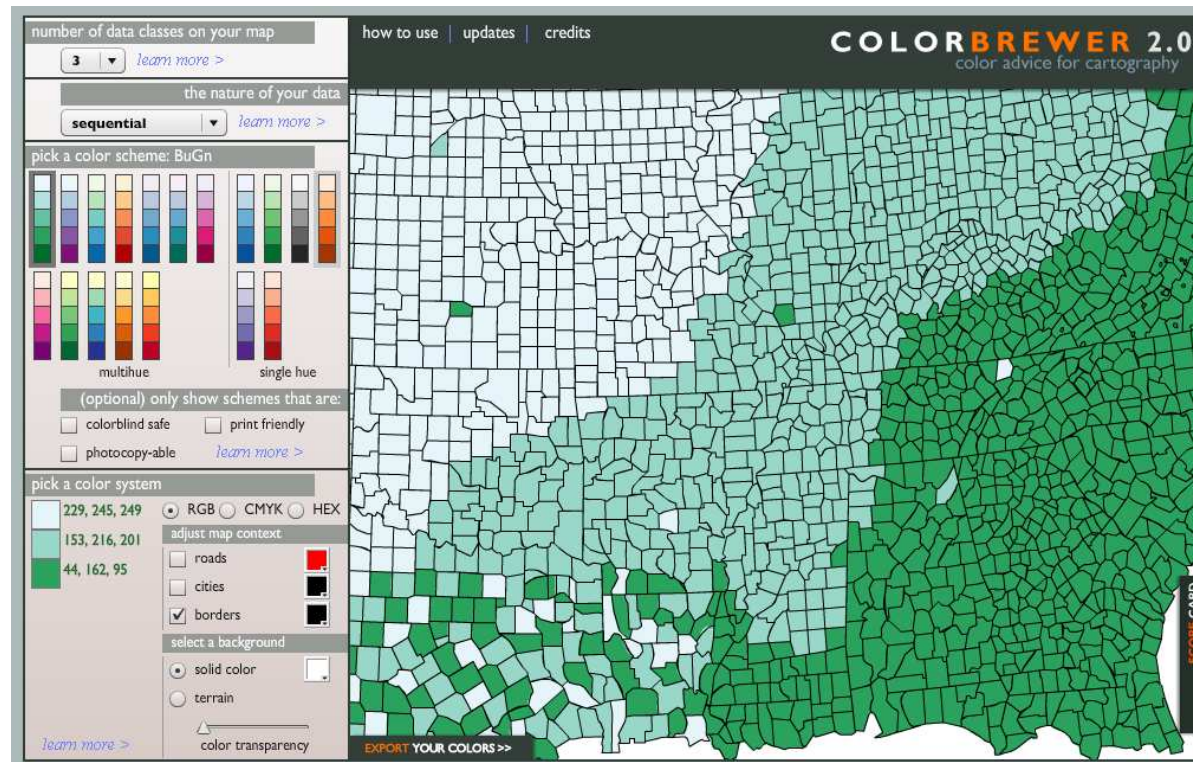
<http://www.personal.psu.edu/cab38/ColorSch/Schemes.html>

Color Schemes



Colorbrewer.org

- ✦ An Online Tool for Selecting Color Schemes for Maps (“color advice for cartography”)

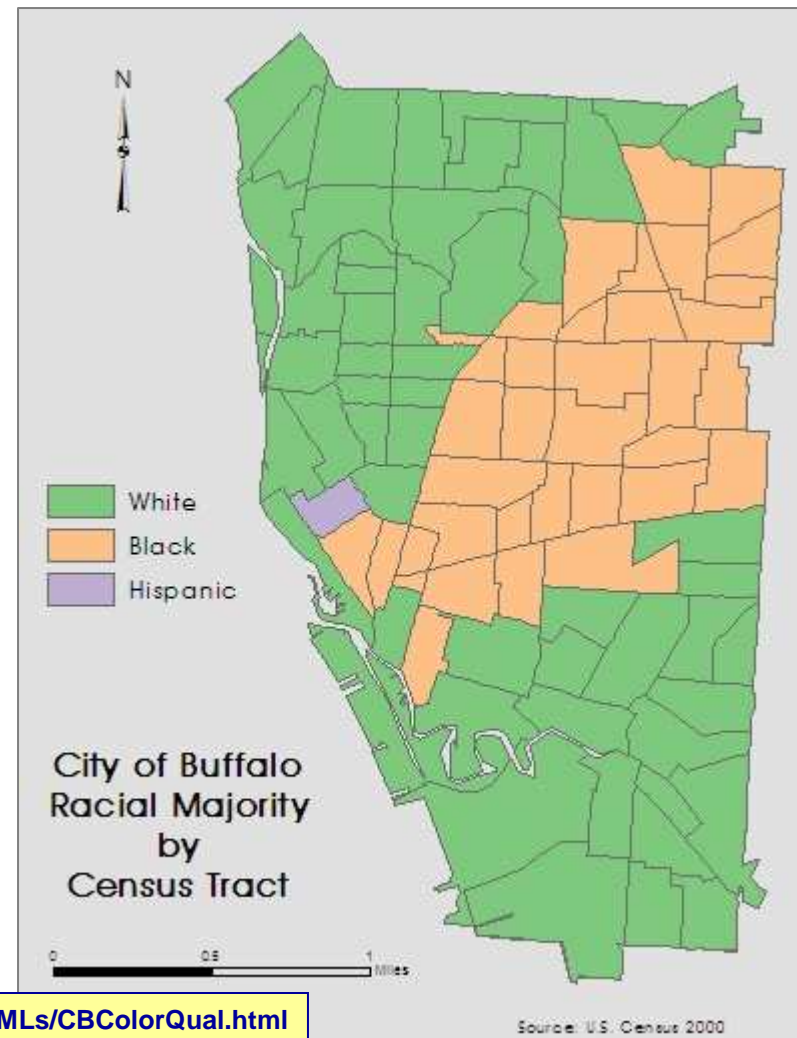


Also see: <http://www.albany.edu/faculty/fboscoe/papers/harrower2003.pdf>

Color and Qualitative Features

✦ Symbolizing Differences in hue

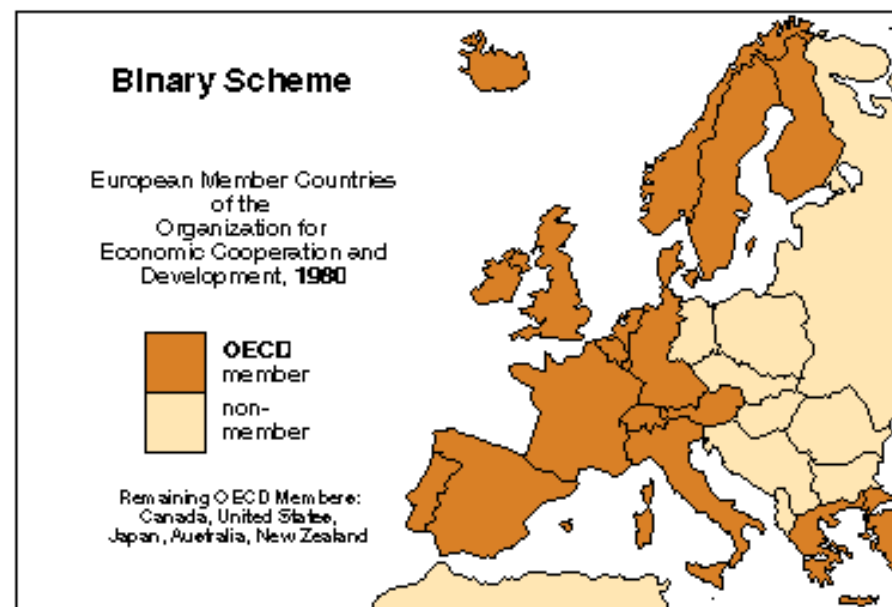
- Unique hues for nominally different features (i.e. kinds, types)
- Colors should be different without large magnitude changes
- Use common hues for similar types, combined hues for combined phenomena



Also see: <http://www.personal.psu.edu/cab38/ColorSch/SchHTMLs/CBCColorQual.html>

Binary Color Scheme

- ✦ Also used for **qualitative (nominal)** differences, but with only two categories, often “yes/no”-type classes.



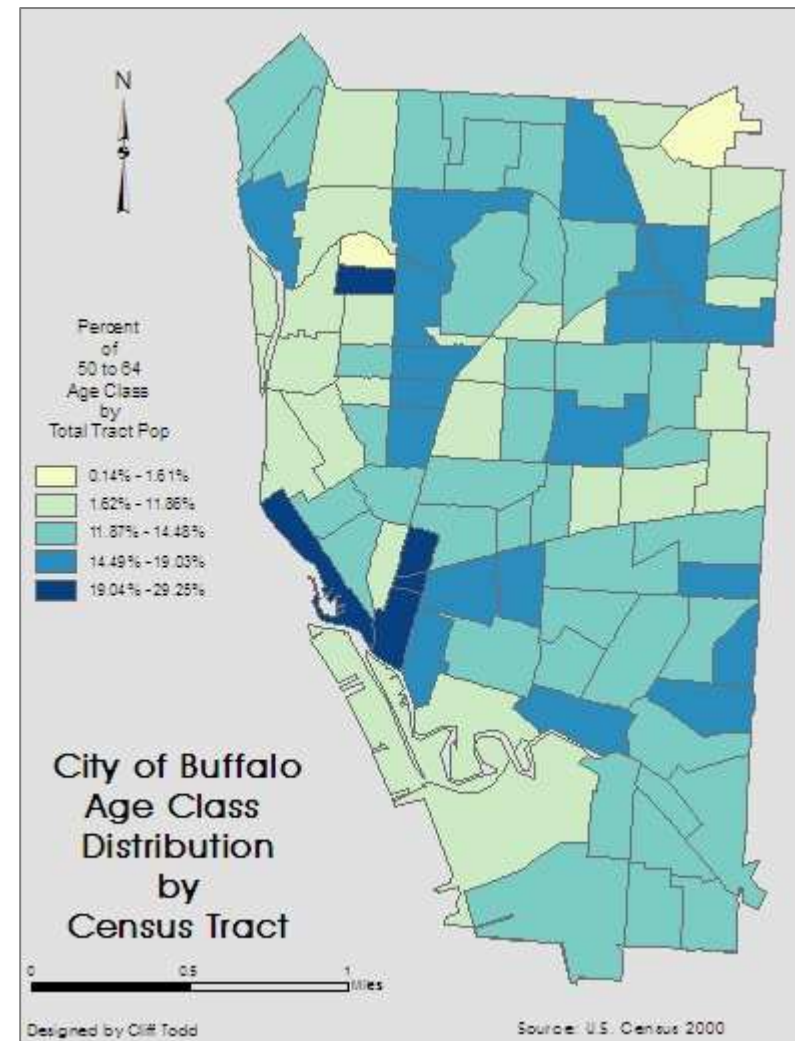
Also see: <http://www.personal.psu.edu/cab38/ColorSch/SchHTMLs/CBColorQual.html>

Color and Quantitative Features

✦ Convey how magnitude of features change **sequentially** (high to low)

- Do this by using:
 - a series of value and chroma combos for one hue
 - a sequence of colors between 2 hues
 - a progression of several hues (i.e. elevation)
 - a white to black progression

Also see: <http://www.personal.psu.edu/cab38/ColorSch/SchHTMLs/CBColorSeq.html>

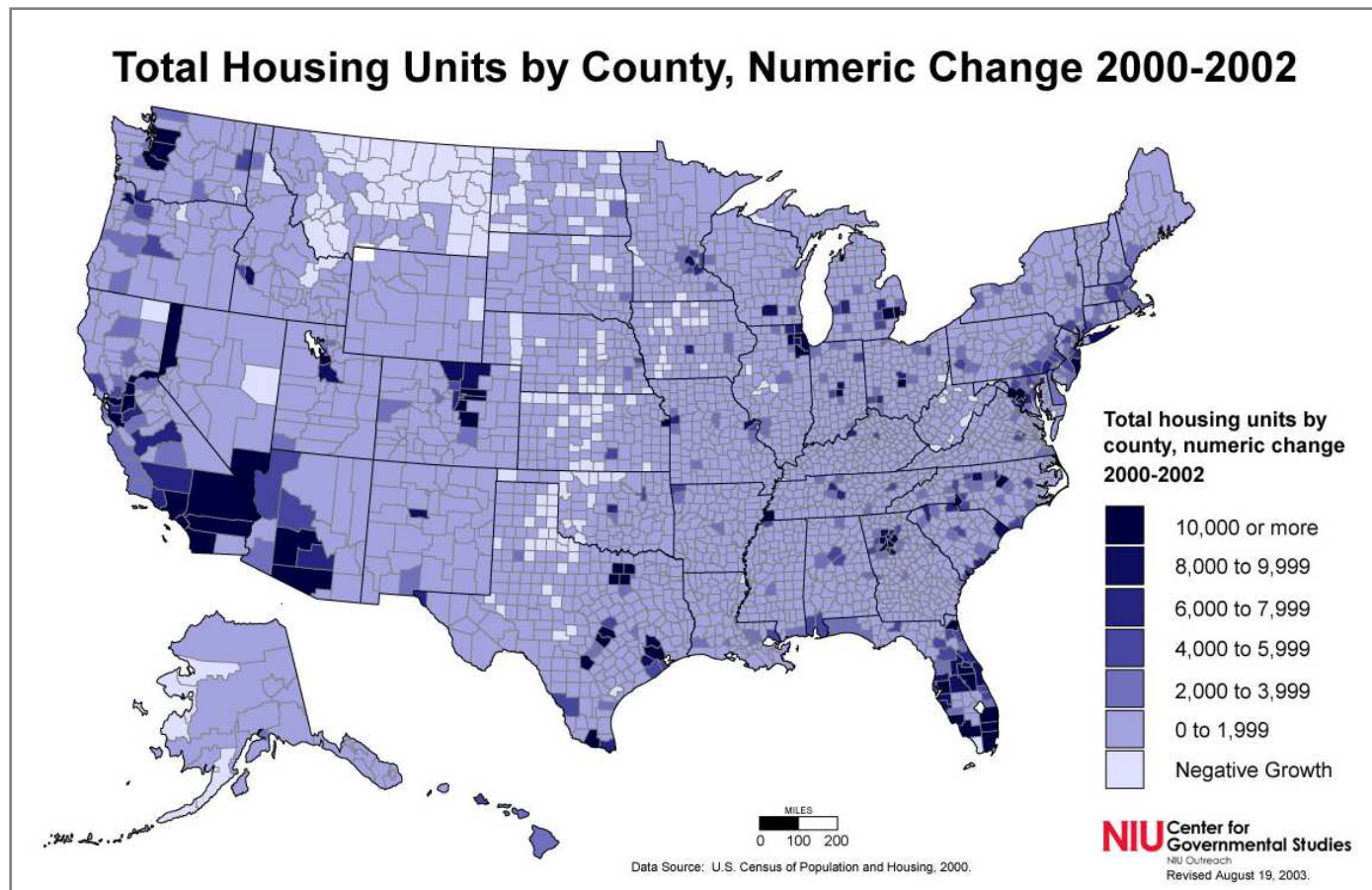


Color and Quantitative Features

- ✦ Hue guidelines in quantitative mapping:
 - Darker seen as more
 - Lighter seen as less
 - More saturation (intensity) seen as more
 - Less saturation or higher value seen as less

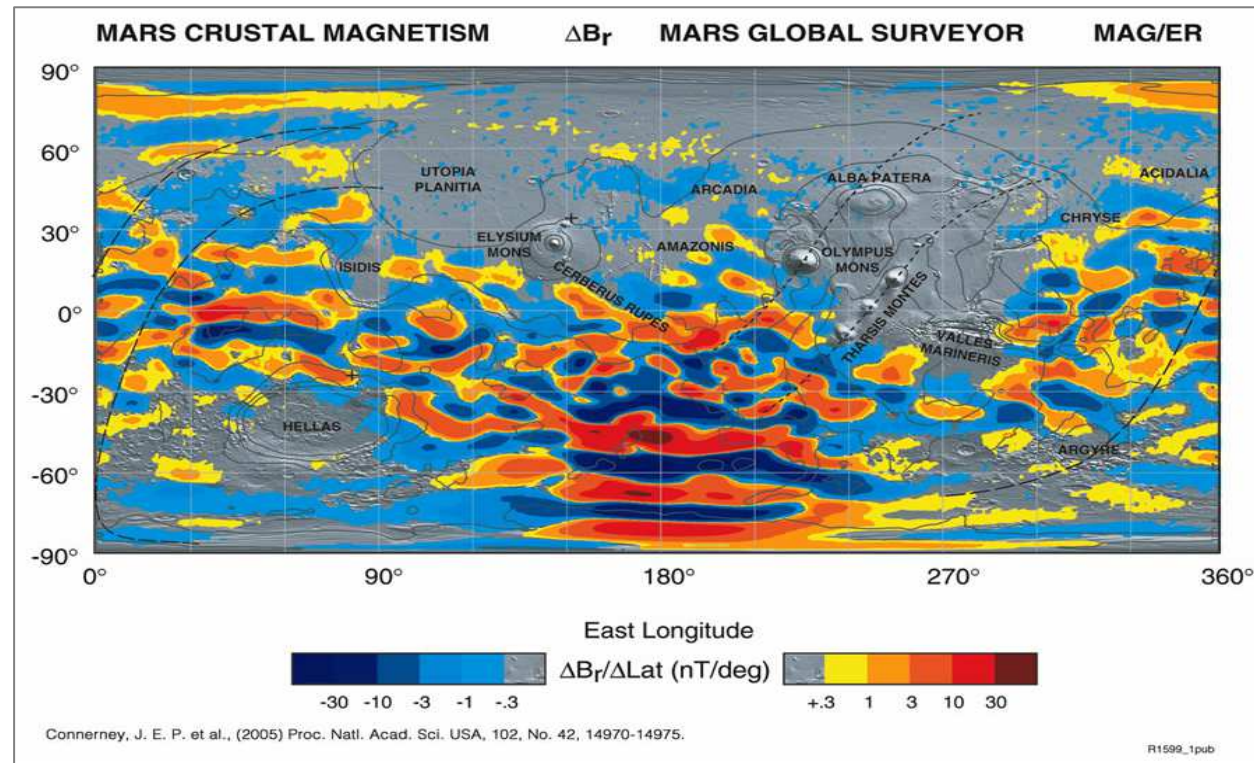
Sequential Color Scheme

- ✦ Use of single hue for values zero and above



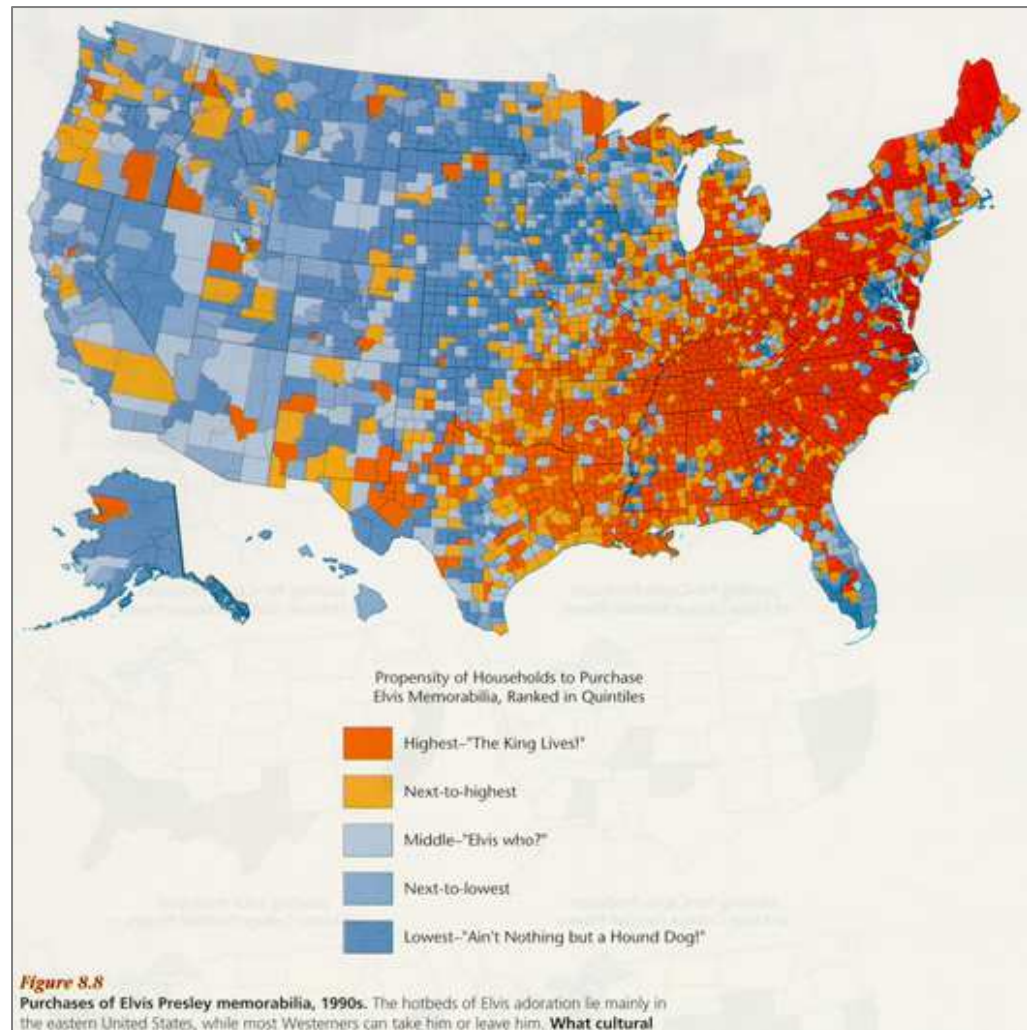
Diverging Color Scheme

- ✦ Best for negative to positive **quantitative** ranges, or mapping above and below a critical central value; use for standard deviation classification scheme



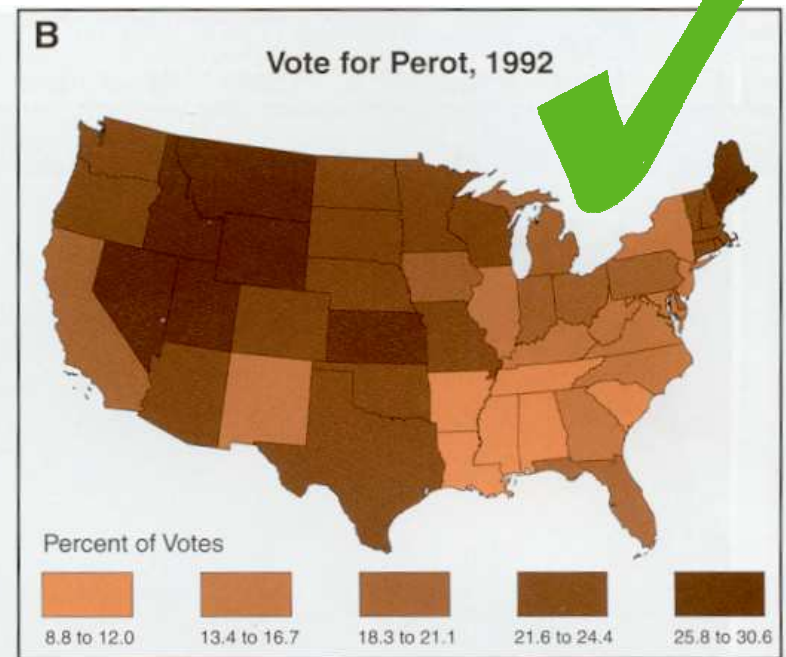
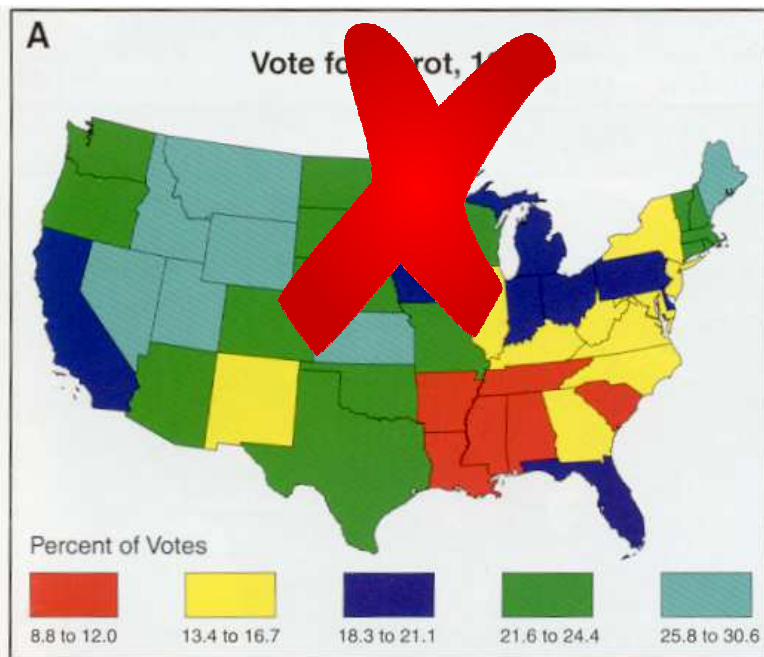
Diverging Color Scheme

- ✦ Two-hue diverging color scheme



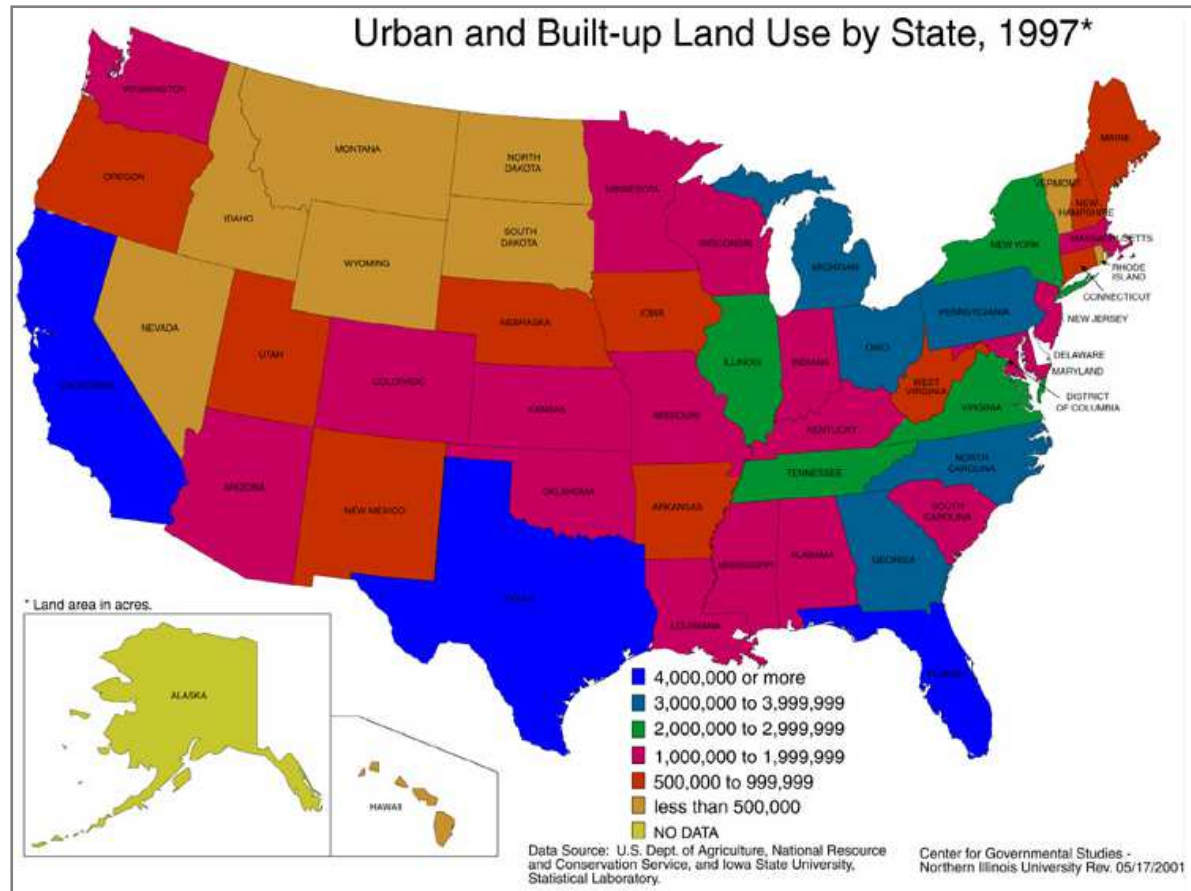
Color on Choropleth Maps

- ✦ Different hues would not work well in displaying differences in metric measurements, but different levels of lightness (or value) would



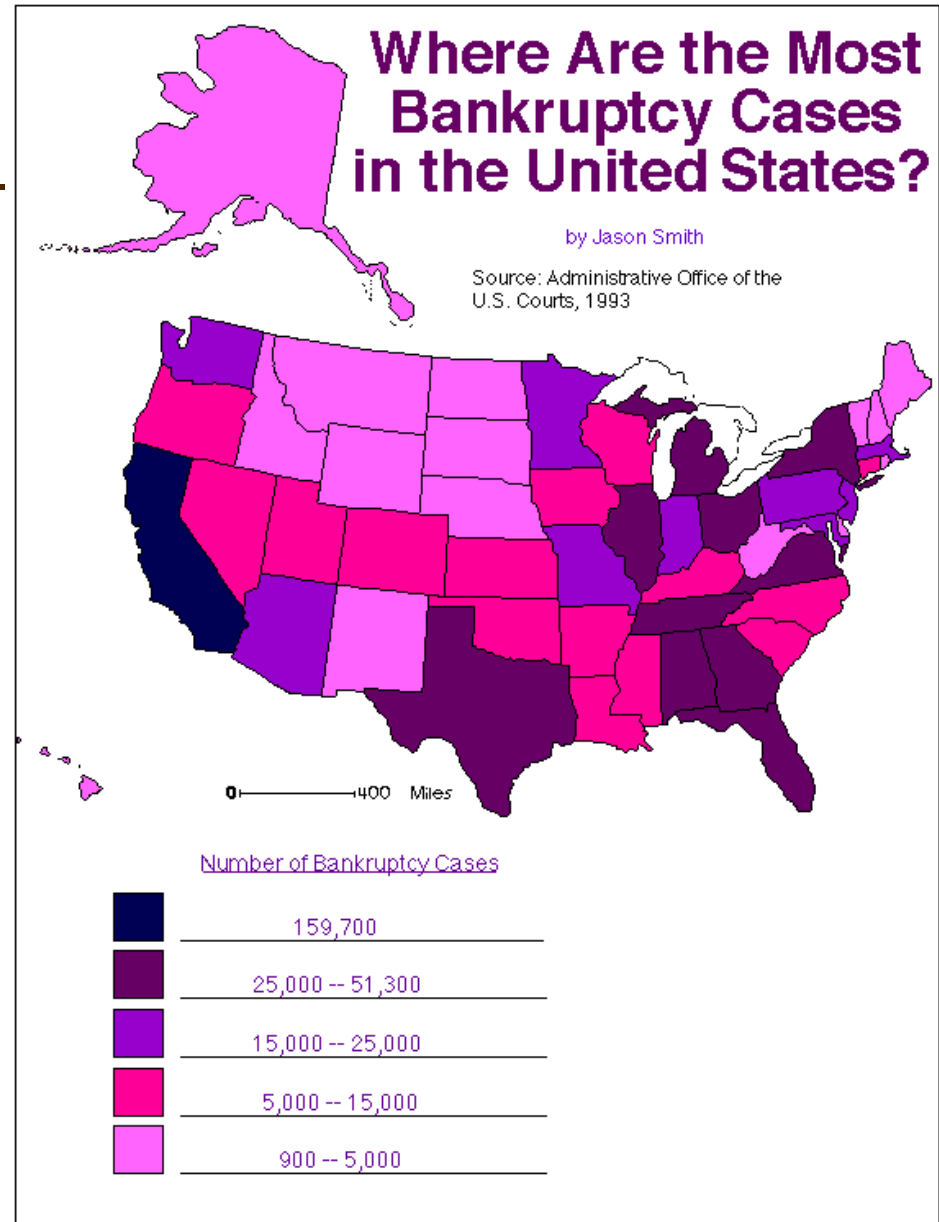
Color on Choropleth Maps

✦ Multi-hue color scheme – is this the right way to map this data?



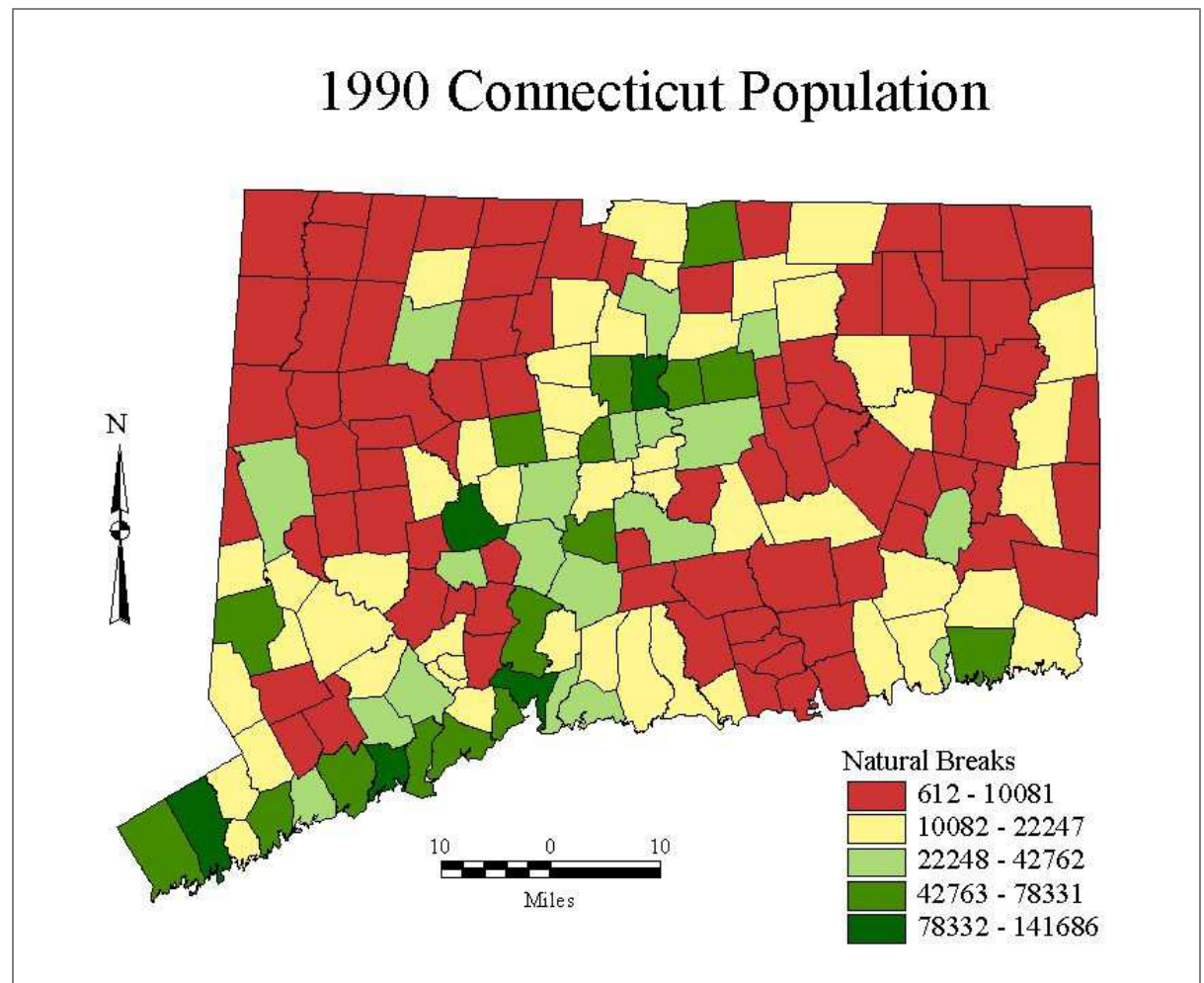
Color on Choropleth Maps

✦ Does this color scheme work?



Color on Choropleth Maps

✦ Does this color scheme work?



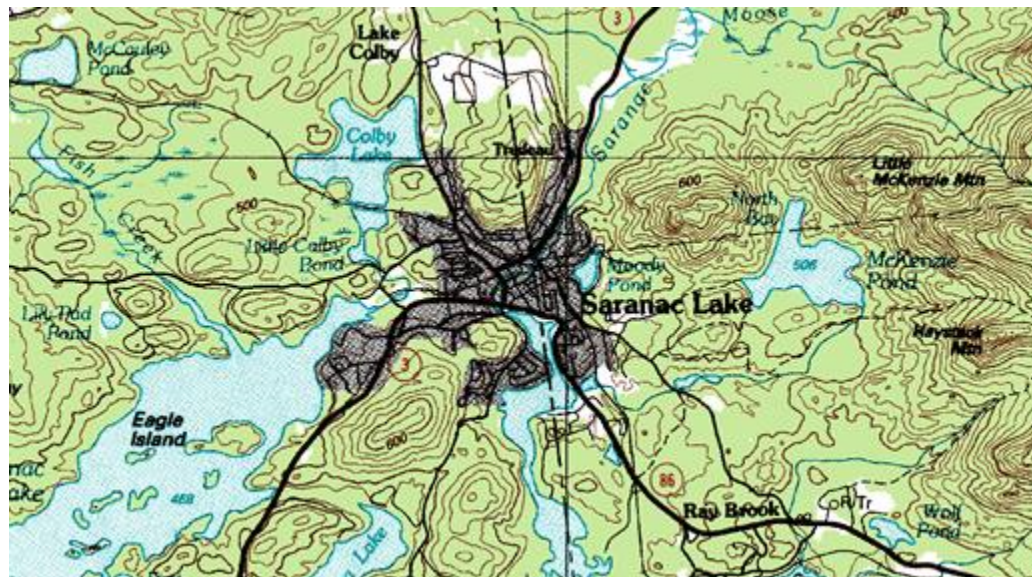
Color on Choropleth Maps

✦ Does this color scheme work?



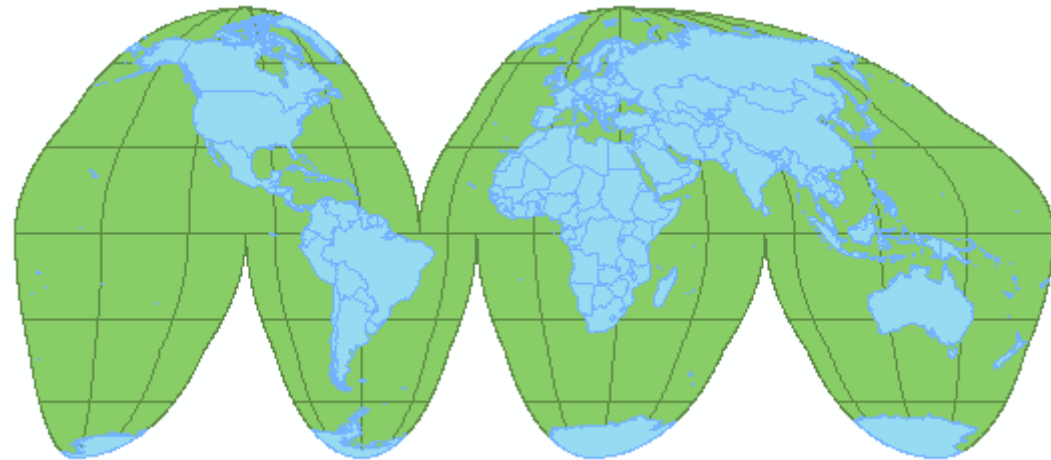
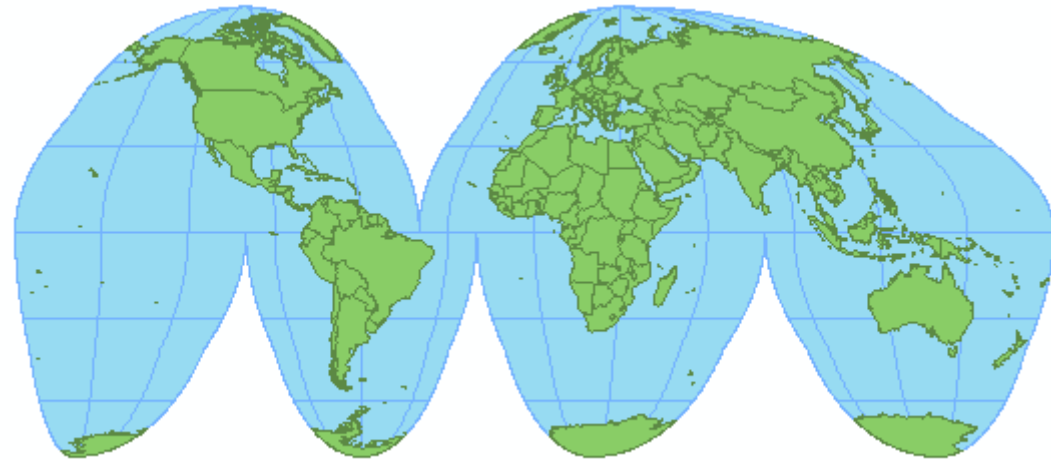
Hue Conventions

- ✦ Blue for water bodies and rivers
- ✦ Green for vegetated areas (forests, farms, parks)
- ✦ Brown for contours
- ✦ Yellow or tan for dry areas with little vegetation
- ✦ Agency-specific standards (i.e. USGS topo maps)



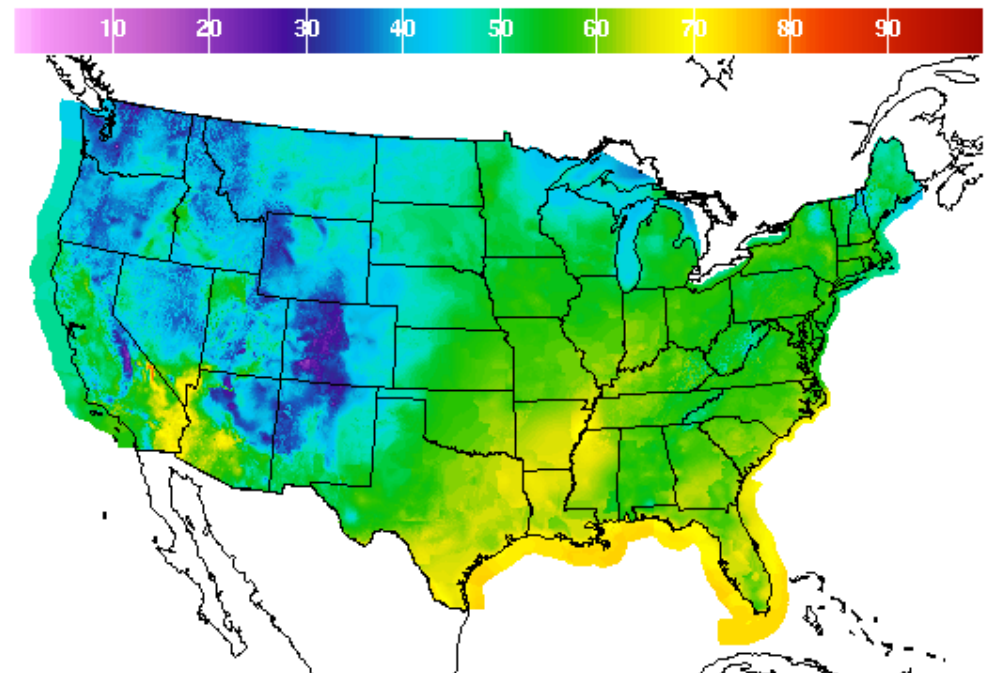
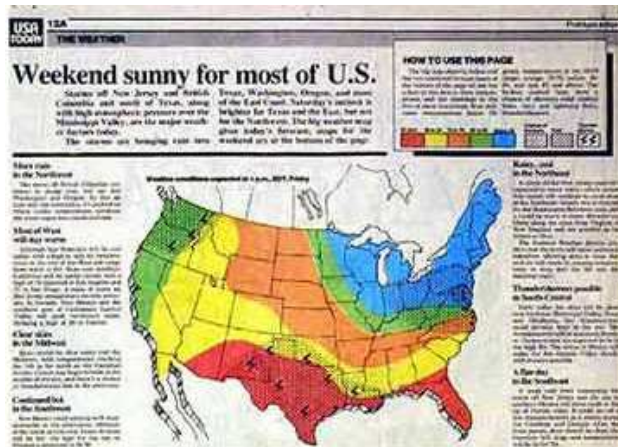
Hue Conventions

✦ Which one looks "right"?



Hue Conventions

- ☀ Symbolic connotations of hue - blue for cold, red for warm



National Digital Forecast Database
13z issuance Graphic created-May 09 9:05AM EDT

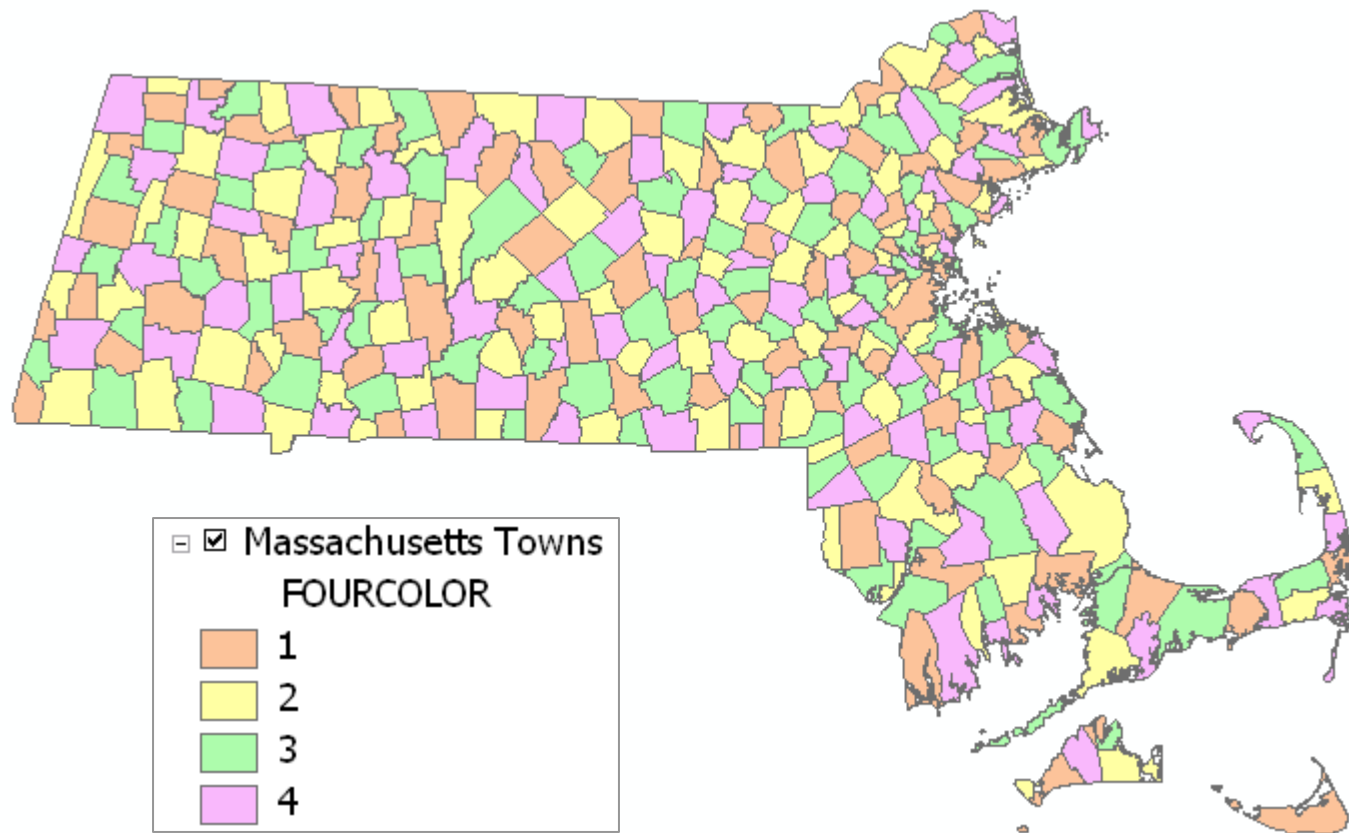


Hue Conventions

- ✦ Be aware of **emotional and cultural connotations** often attached to color
- ✦ In Western culture:
 - **Red**: danger, excitement, fire, passion, blood, fight or flight, some sexual connotation. (“good luck” in China)
 - **Purple**: Wealth, royalty, sophistication, intelligence.
 - **Blue**: Quietness, serenity, truth, dignity, constancy, reliability, power.
 - **Black**: Sophistication, elegance, power, rebellion, death.
 - **White**: Purity, cleanness, luminosity, vacuum.
 - **Yellow**: Warmth, the sun for many cultures, brightness, joy if little saturated.
 - **Green**: Nature, fresh, vegetation, health, green/blues are the favorites of consumers (“death” in China)
 - Cailin Boyle, [Color Harmony for the Web](#)

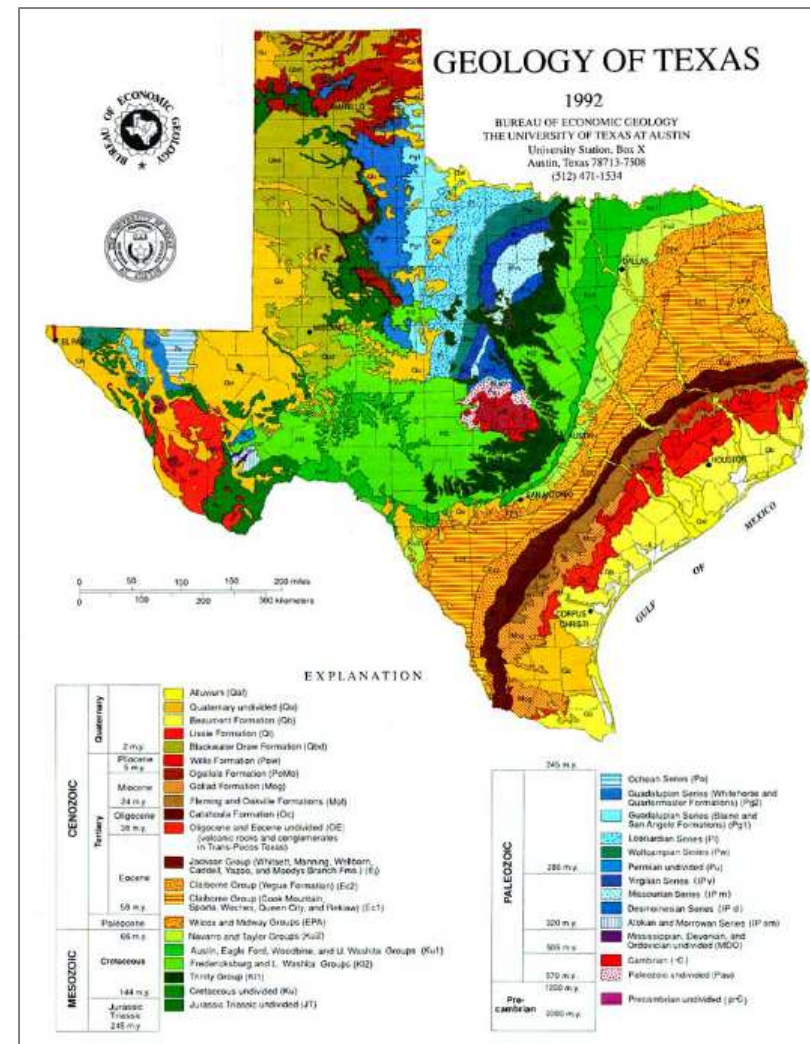
Four-color Theorem

✦ No two bordering polygons colored alike



Color Limitations

- ✦ Too many colors indistinguishable on map, even if they look different in a legend.
- ✦ Using patterns may help, but there are still a lot of similar hues on this map.



Maps and Color Blindness

- ✦ “To design maps that are readable by the color-vision impaired but are also appealing to those with normal color vision successfully, cartographers need to know how the color-vision impaired person perceives color and which color combinations become confused.”
 - Color Design for the Color Vision Impaired
by Bernhard Jenny and Nathaniel Vaughn Kelso



Figure 1 The visible spectrum as perceived by the normal viewer (top) and by those with red-green vision impairment (bottom)

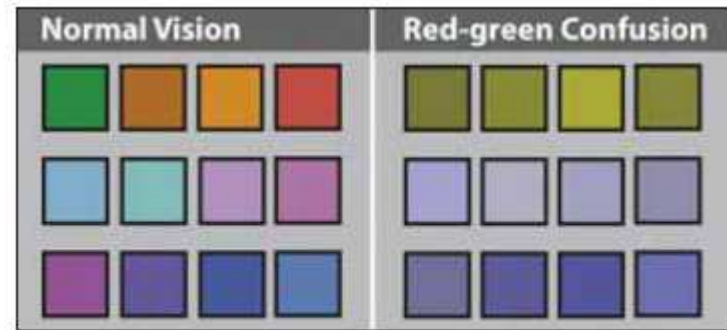


Figure 2 Colours as they appear to readers with normal vision and to those with red-green vision impairment

See http://colororacle.org/resources/2007_JennyKelso_ColorDesign_lores.pdf

Maps and Color Blindness

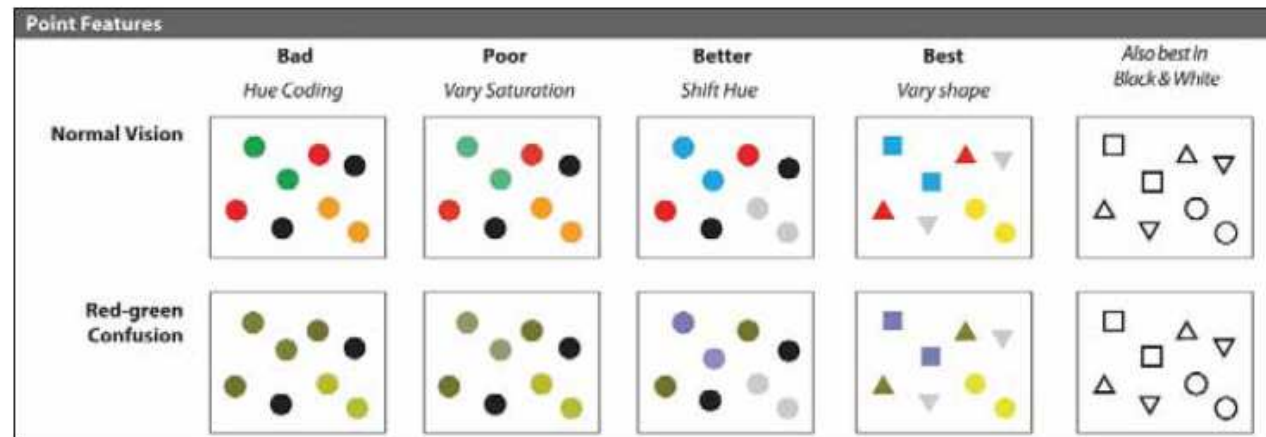


Figure 4 Point classes typical of a dot map distinguished by saturation, hue, and shape

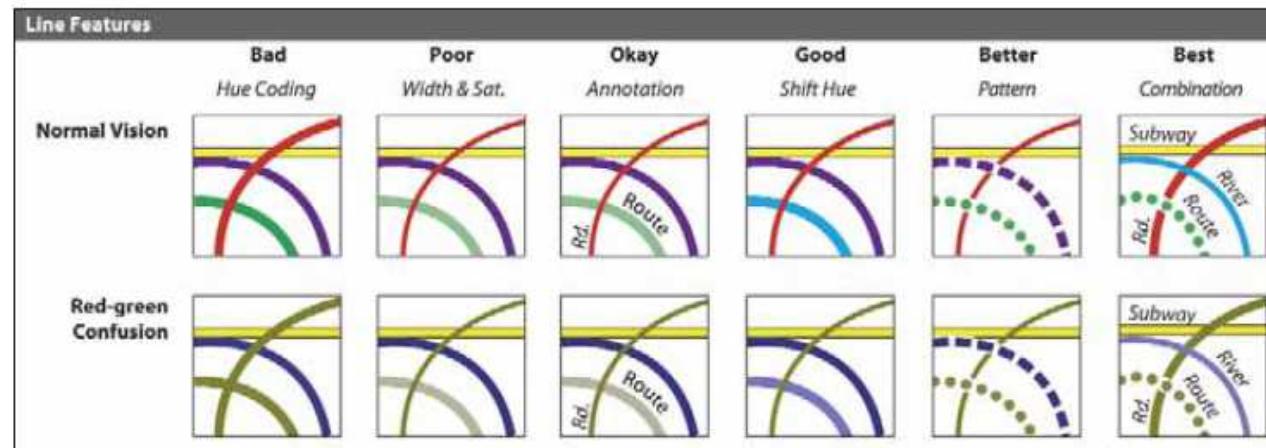


Figure 5 Line classes distinguished by width and saturation, annotation, hue, and line pattern

Maps and Color Blindness

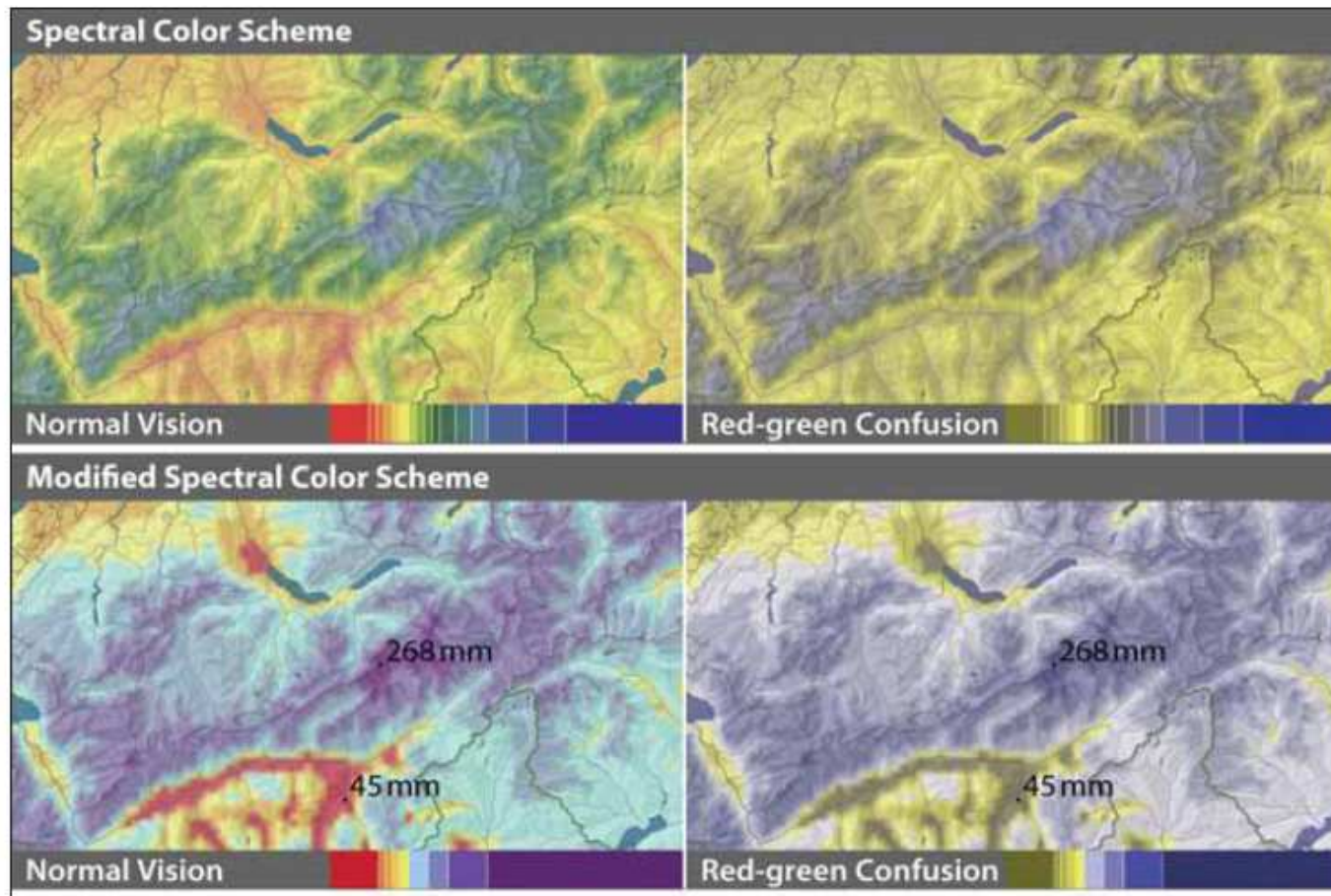
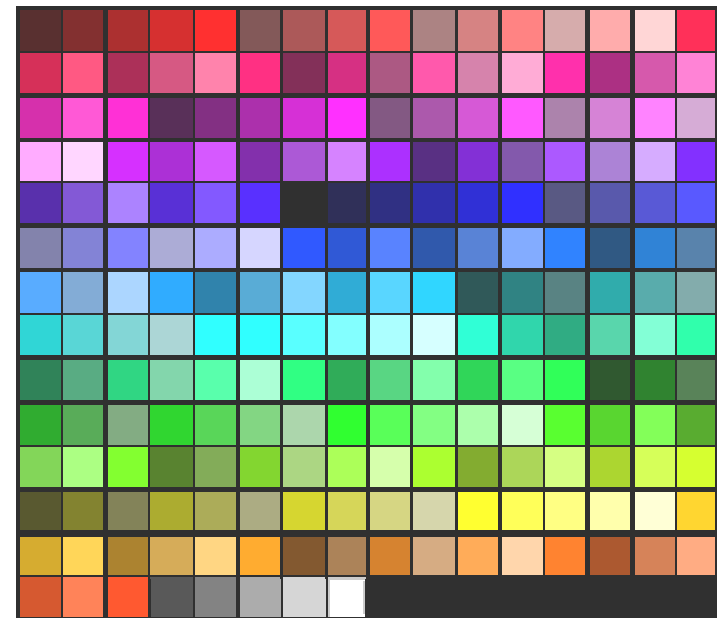


Figure 6 Spectral colour schemes for precipitation maps, with rainbow colours (top row) and with an improved spectral scheme (bottom row). Colour ramps are depicted below the maps ('Mean monthly precipitation in January', ©Atlas of Switzerland 2, 2004)

Beware – Screen vs. Print

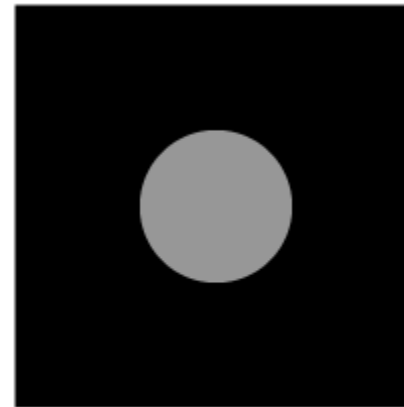
- ✦ Often, the colors you see on screen will not look the same when printed
 - You can use “shadesets” to match screen colors to how they will print
 - Shadesets should be printed on the printer or plotter you will use for mapping



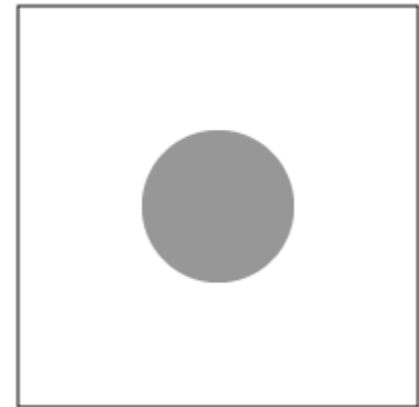
Beware – More...

✦ Simultaneous contrast

- The appearance of a color can change depending on the surrounding color



Value Contrast A



Value Contrast B



G4 on Y4

Hue Contrast C



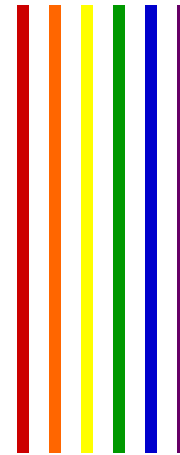
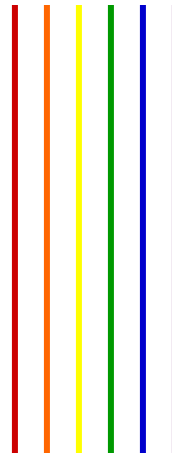
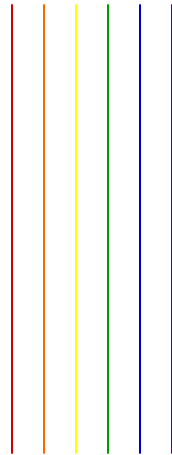
G4 on C4

Hue Contrast D

Beware – More...

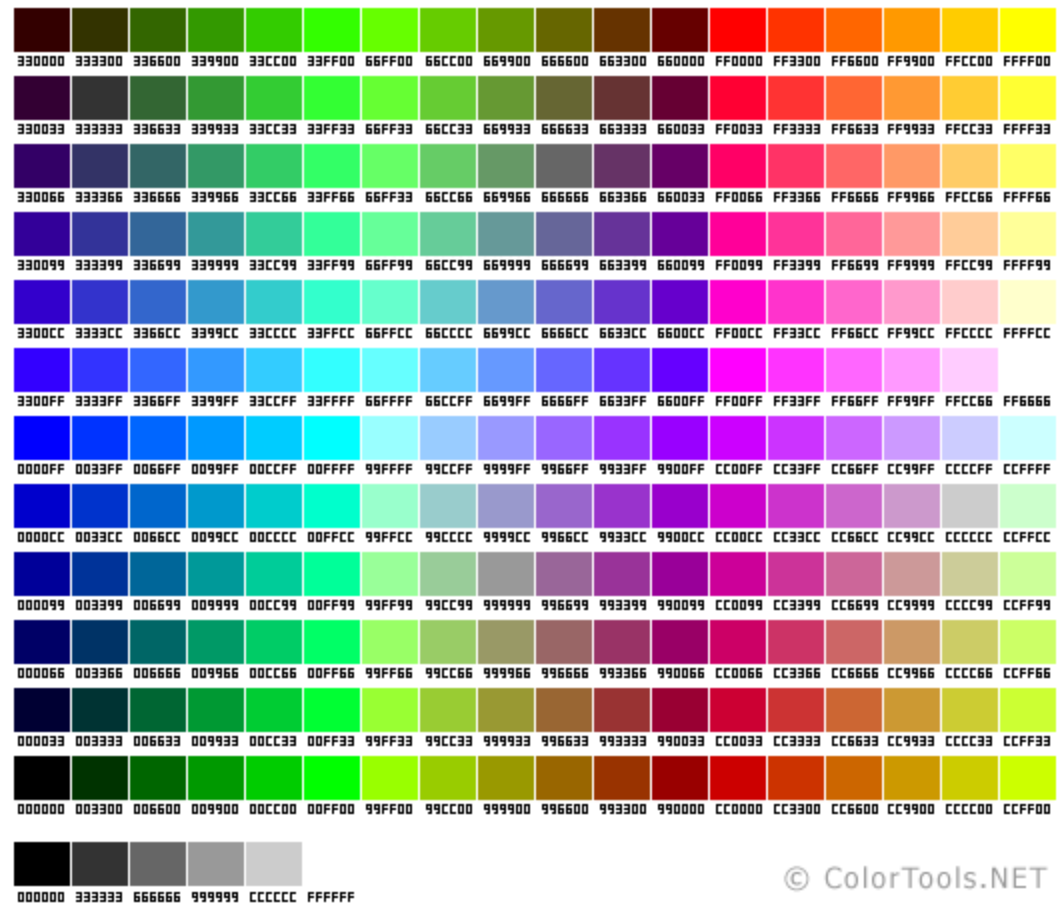
✦ Line width and hue

- The thinner the line, the harder it is to distinguish its color



"Web-safe" Colors

- ✦ Colors that will not be altered (dithered) when shown on browsers running on a 256-color monitor
- ✦ 216 unique colors, usually specified as a 6-digit hexadecimal number/ character code
- ✦ Used in HTML/CSS – and WEB MAPPING
- ✦ Almost no need for this anymore



See <http://www.permadi.com/tutorial/websafecolor/> and <http://websafecolors.info/>

Mapping in Black & White

- ✦ Patterns come to the rescue
 - Often used for bedrock/geology type, climate, soils, land use
 - General categories:
 - Coarse line - parallel or wavy (cross-hatching uses perpendicular lines)
 - Dot patterns - round dots in regular or irregular arrays
 - Pictographic - resemble feature (I.e. wetlands, swamps)
 - Reversed - above 3 but light on dark background
 - Shades of gray for choropleth mapping

Mapping in Black & White

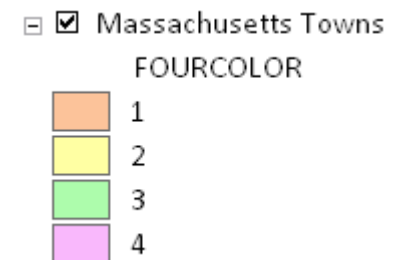
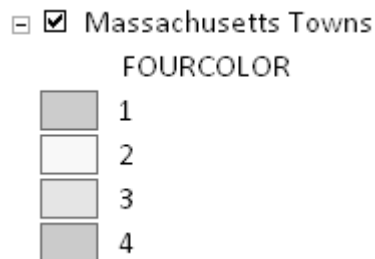
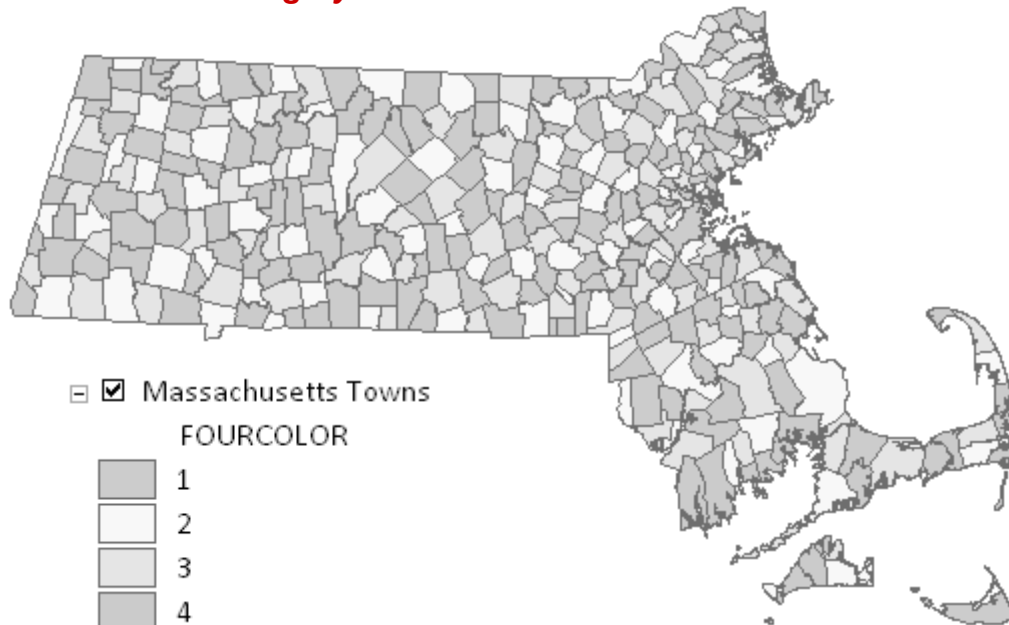
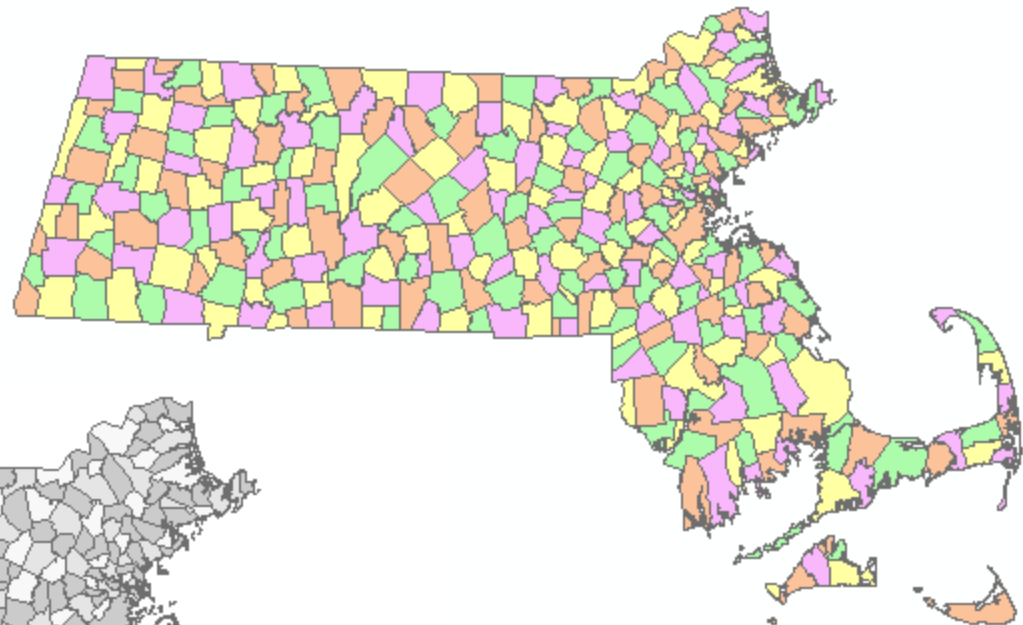
This works



Mapping in Black & White

Simply changing a color image to grayscale doesn't always work

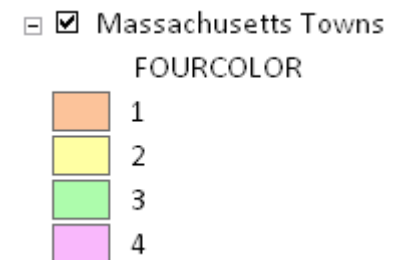
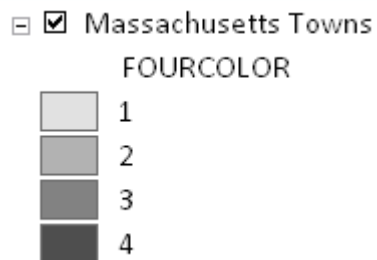
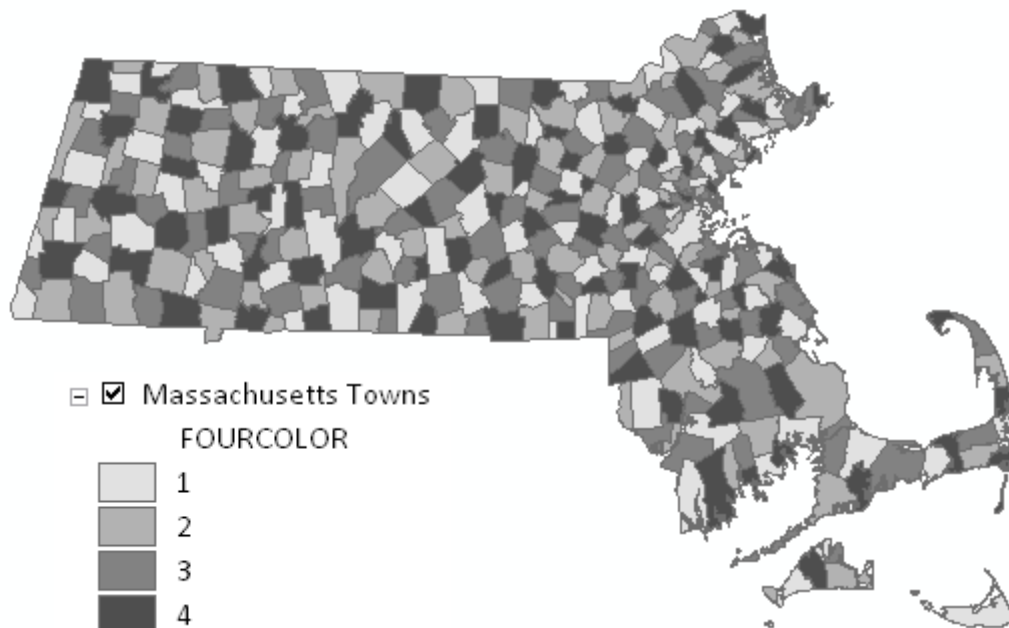
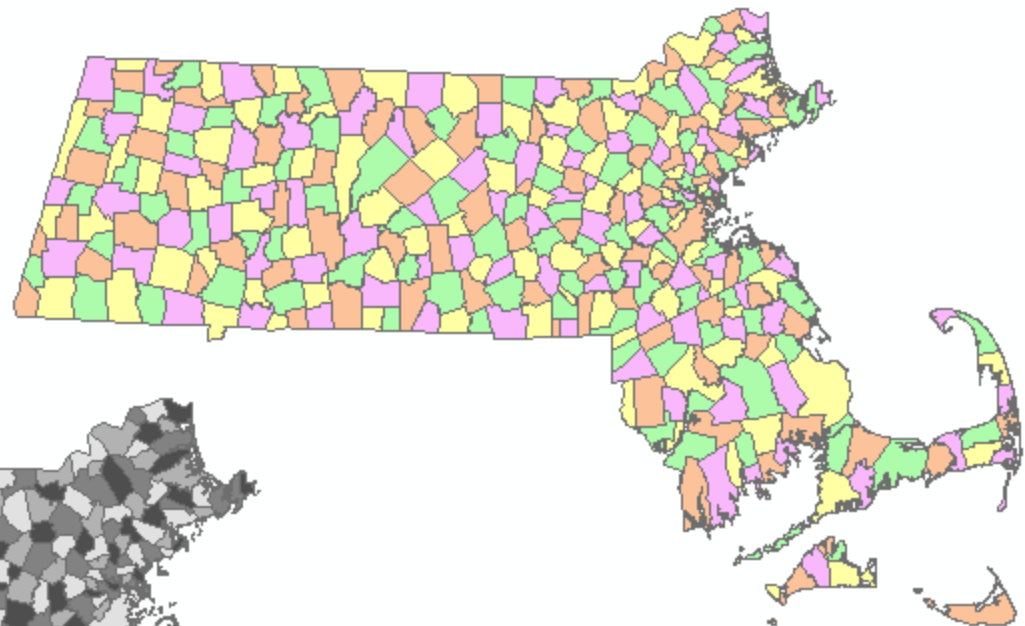
Categories 1 and 4 are virtually indistinguishable when the map image is converted to grayscale



Mapping in Black & White

The color map may need to be redesigned to be effective as grayscale

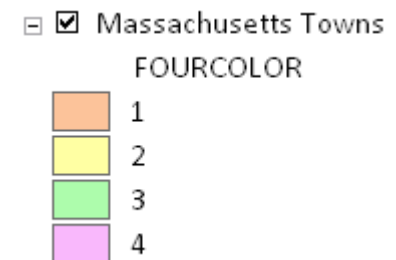
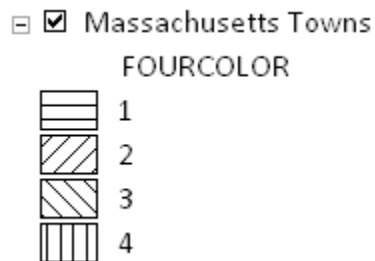
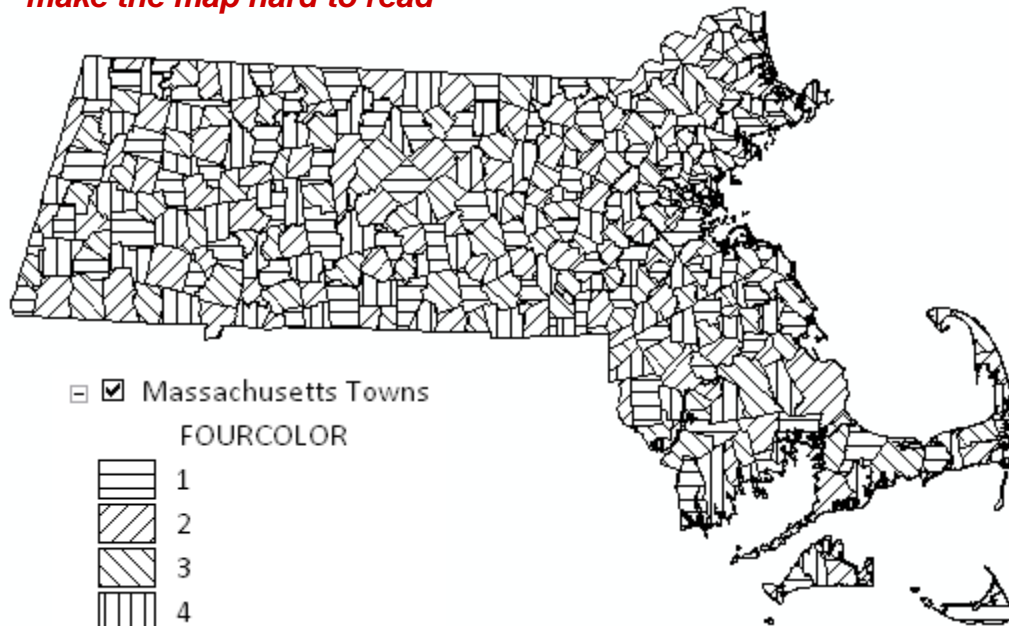
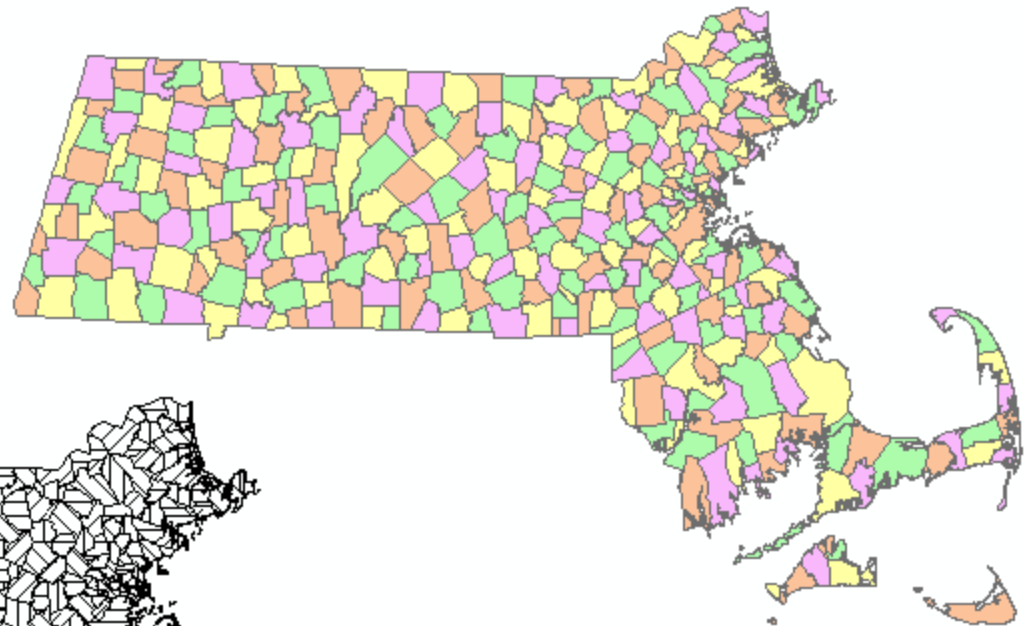
But beware of turning a qualitative scheme into one that looks quantitative



Mapping in Black & White

Black and white patterns may be a better choice, but they must be readable

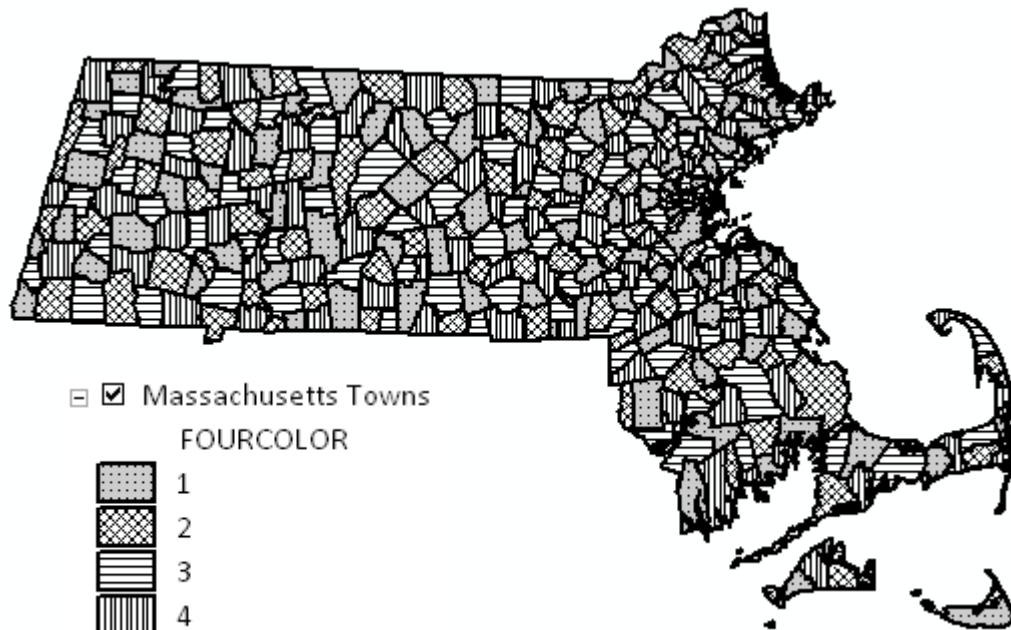
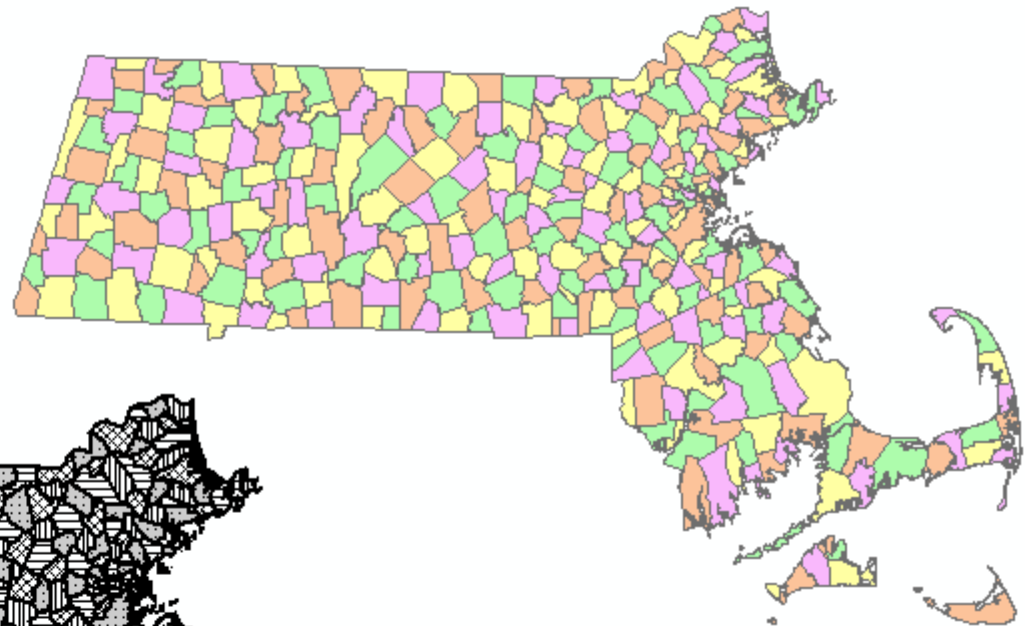
Here, the legend symbols look different, but the differences make the map hard to read



Mapping in Black & White

Black and white patterns may be a better choice, but they must be readable

Getting a little better...



Massachusetts Towns

FOURCOLOR



1

2

3

4

Massachusetts Towns

FOURCOLOR



1

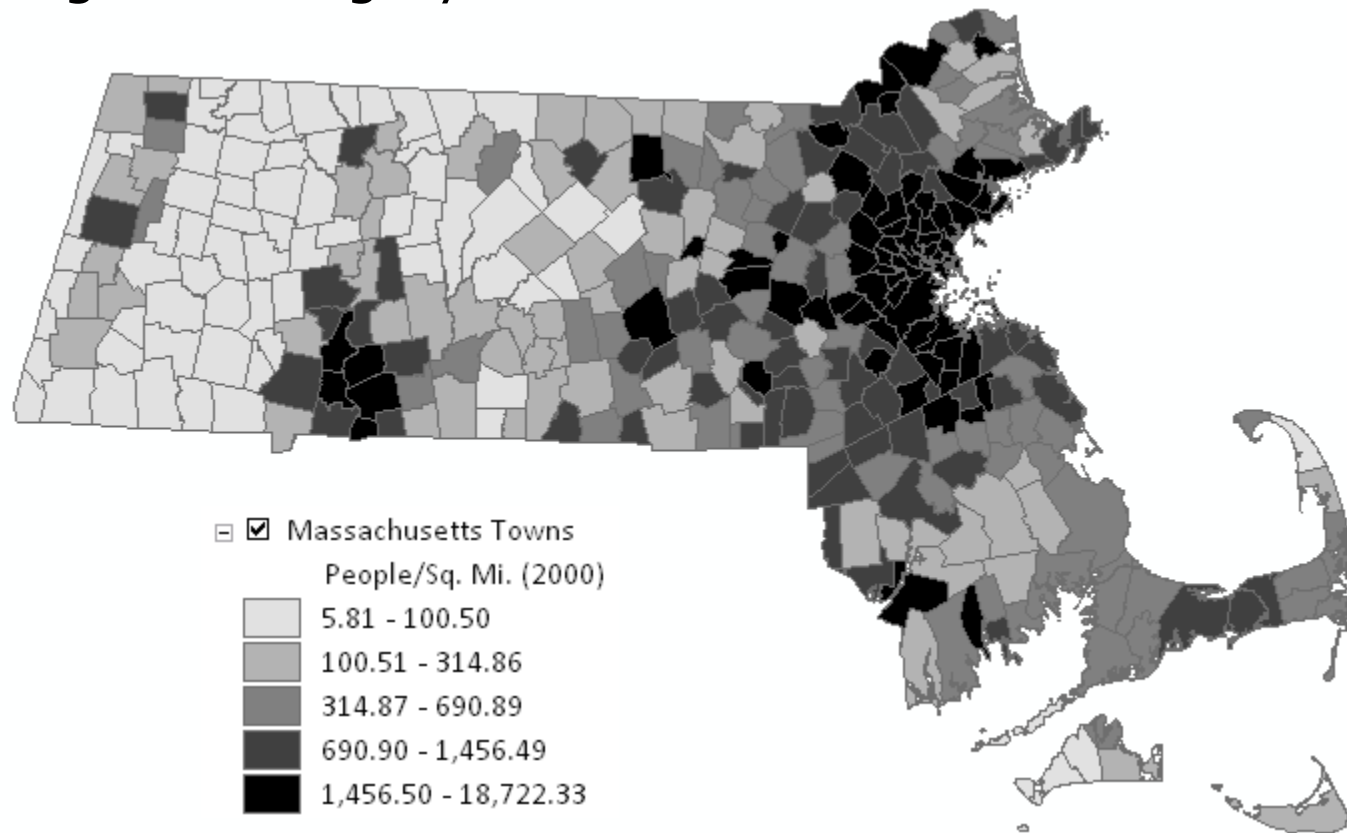
2

3

4

Mapping in Black & White

- ✦ Shades of gray for choropleth mapping – this map was designed with grayscale in mind



Resources

- ✦ Chapters 7, 8, and Appendix in Designing Better Maps
- ✦ Chapter 12 in Making Maps, 3rd Edition
- ✦ <http://colorbrewer2.org>
- ✦ <http://colororacle.org/>
- ✦ <http://makingmaps.net/2007/07/16/map-color-resources/>
- ✦ <https://makingmaps.net/category/11-color-on-maps/>
- ✦ Book: Colour Basics for GIS Users

