Color in Visualization

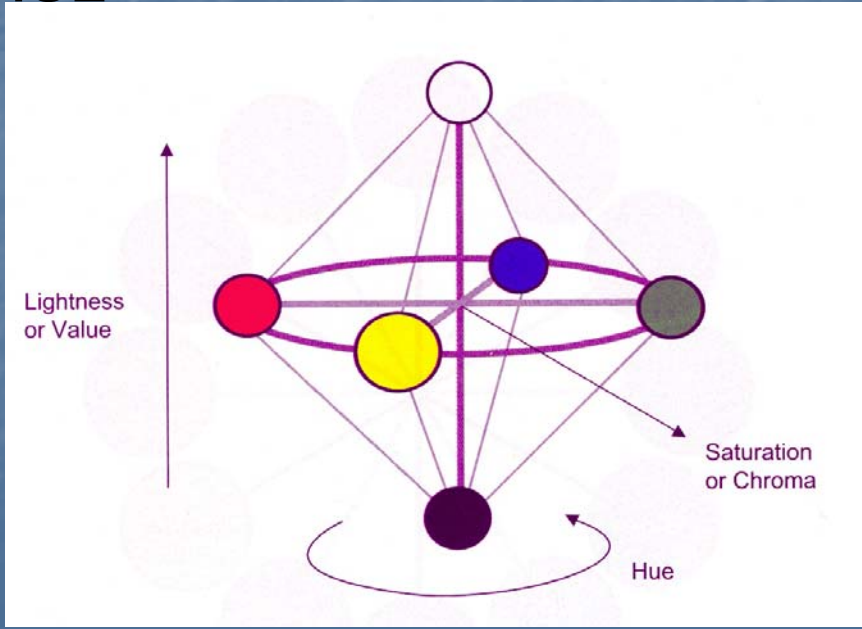
ICS 288: Visual Perception

Color selection and design

- Color harmony
- Constraint by practical and functional limits dictated by perception
  - Convention
  - Material cost

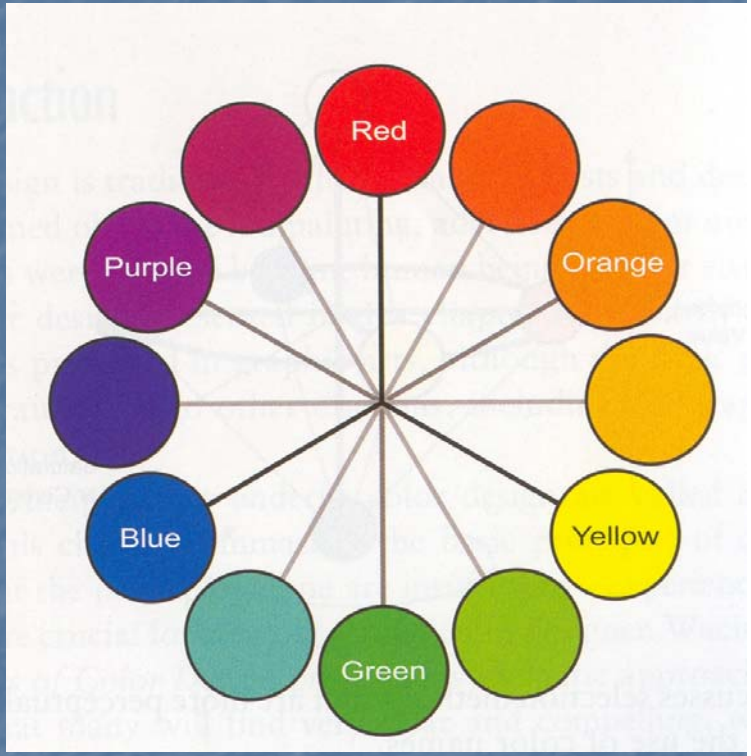
Principles

- Laid down in late 70s
- Changed little since then
- RGB, HSV or HSL



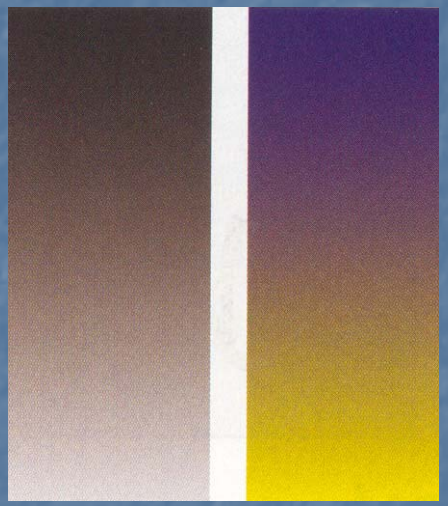
Principles

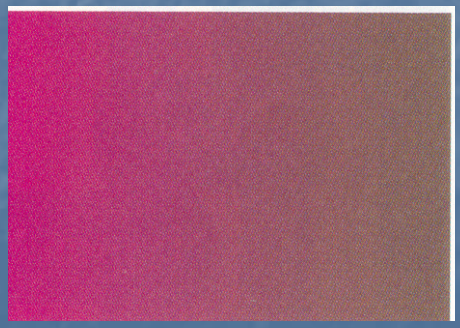
- Good design
  - Focus attention using contrast
  - Unifies using analogy
- Three primaries
  - Red, Blue and Yellow
- Three secondaries
  - Purple, Green and Orange
- Analogous together, contrasting opposite
  - Complement: highest contrast



Principles

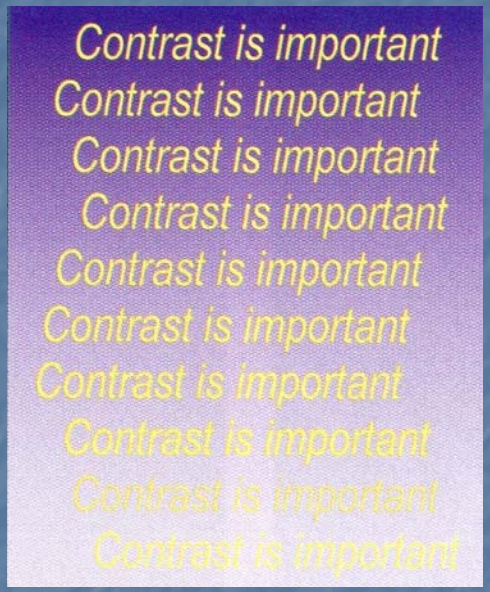
- Different types of color blend
- Chroma scale
  - Same value and hue, but different saturation
  - Very difficult to reproduce
- Should produce good gray scale





Controlling color value

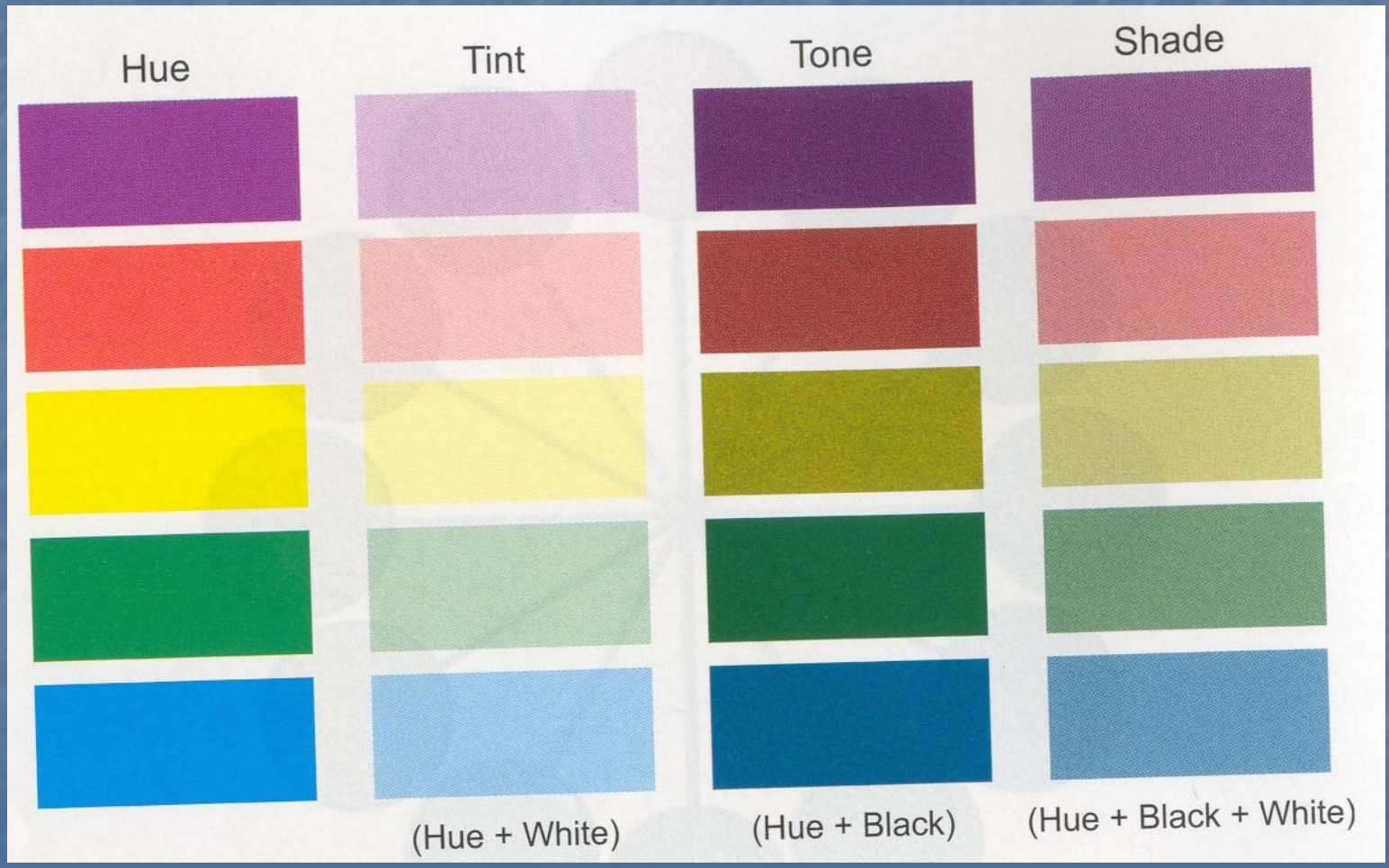
- Contrast in value critical for shapes and edges
  - Perceptually edges are more due to luminance contrast
  - Robust to grayscale conversion
- ISO standards specify 3-5:1 ratio
- Important for sharpness and legibility
- Different hue, same value for buttons, tabs
  - Denoting equally important entities



More commonly

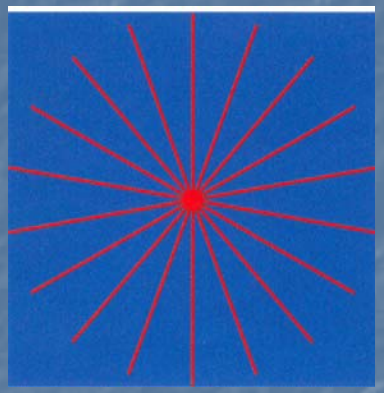
- Artists think about gradation and mixtures that may not lie precisely along the perceptual dimensions
  - Tint – lightened desaturated hue by adding white
  - Tone – darkened and grayed by adding black
  - Shade – mixed with both white and black

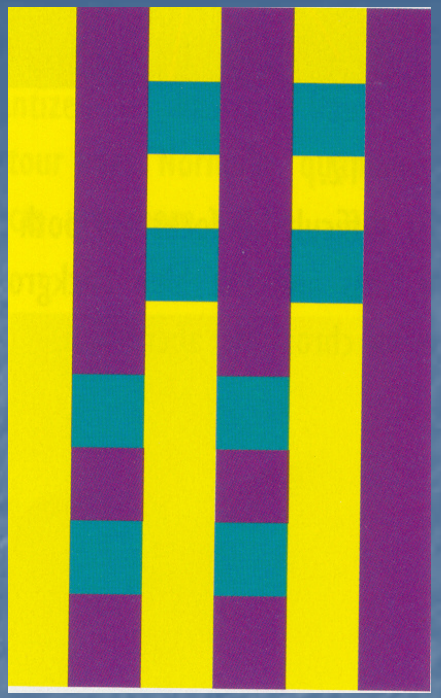
More Commonly

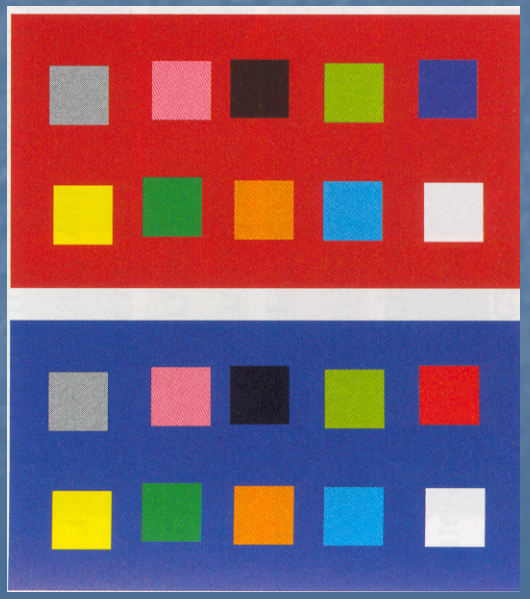


Avoid Color on Color

- Strengthen or Weaken
- Simultaneous contrast
- Depth of field varies with wavelength
  - Low intensity leads to vibrating edges
- Low density of S cones
  - Avoid blue edges
- Combined with variation in DOF
    - Especially on dark backgrounds like black







Color Blend

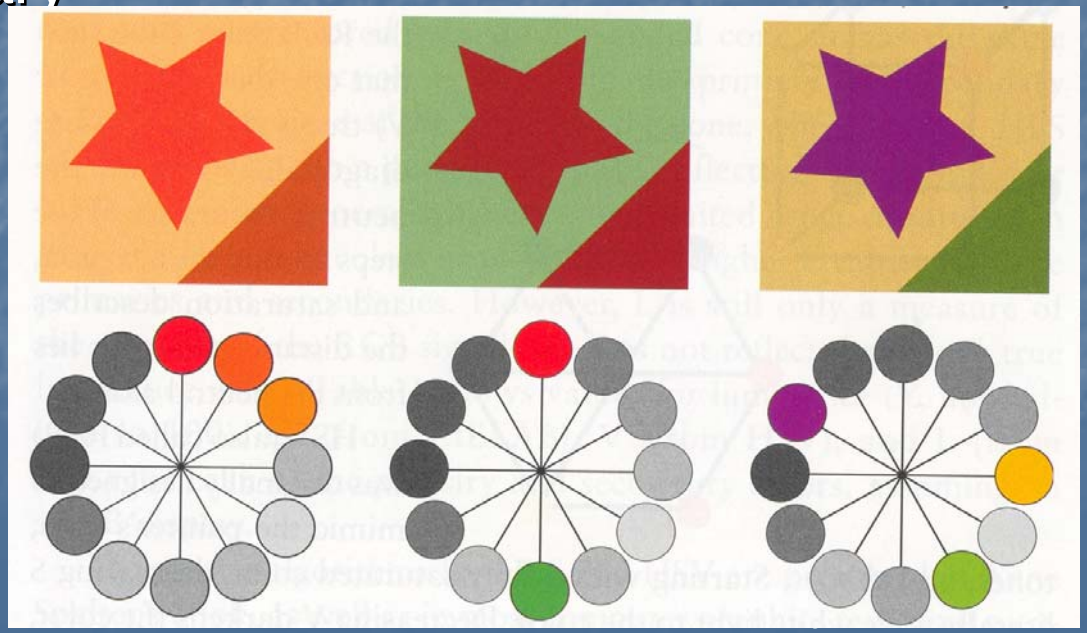
- Commonly is hue-white and hue-black
- Blend shows artifacts, is a stress case
  - Quantization, linearity
  - Leading to contours
- Interpolation path in some space
  - How it looks depends on the space
  - RGB for monitor, CMYK for print
  - Gamut mapping causes problems

Color Schemes

- Many books on series of schemes
- Important for conveying the mood of content
  - Warm red and yellow palette- Vibrant
  - Cool blue and green – Muted
  - Saturated – Youth
  - Subdued/Unsaturated– Sophistication/Maturity

Color Harmonious Schemes

- Monochromatic
- Analogous
- Complementary
- Split complementary



Color Selection Tools

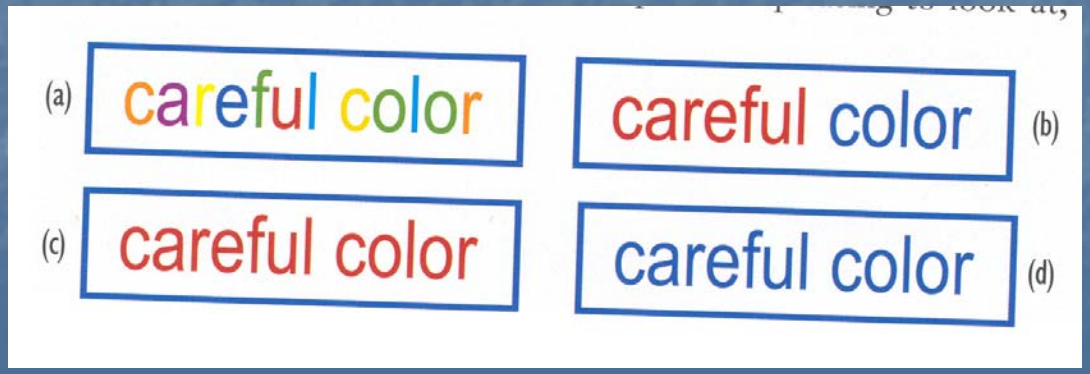
- 3D mapped to a set of 2D and/or 1D sliders
  - 3 slides each for a dimension (RGB, HSL)
    - Photoshop
- 2D chromaticity plane and 1D luminance slider
  - Powerpoint
- Some form of HSL or HSV

Information Visualization

- To label
  - As noun
- To measure
  - As quantity
- To imitate reality
  - As representation
- To decorate
  - As beauty

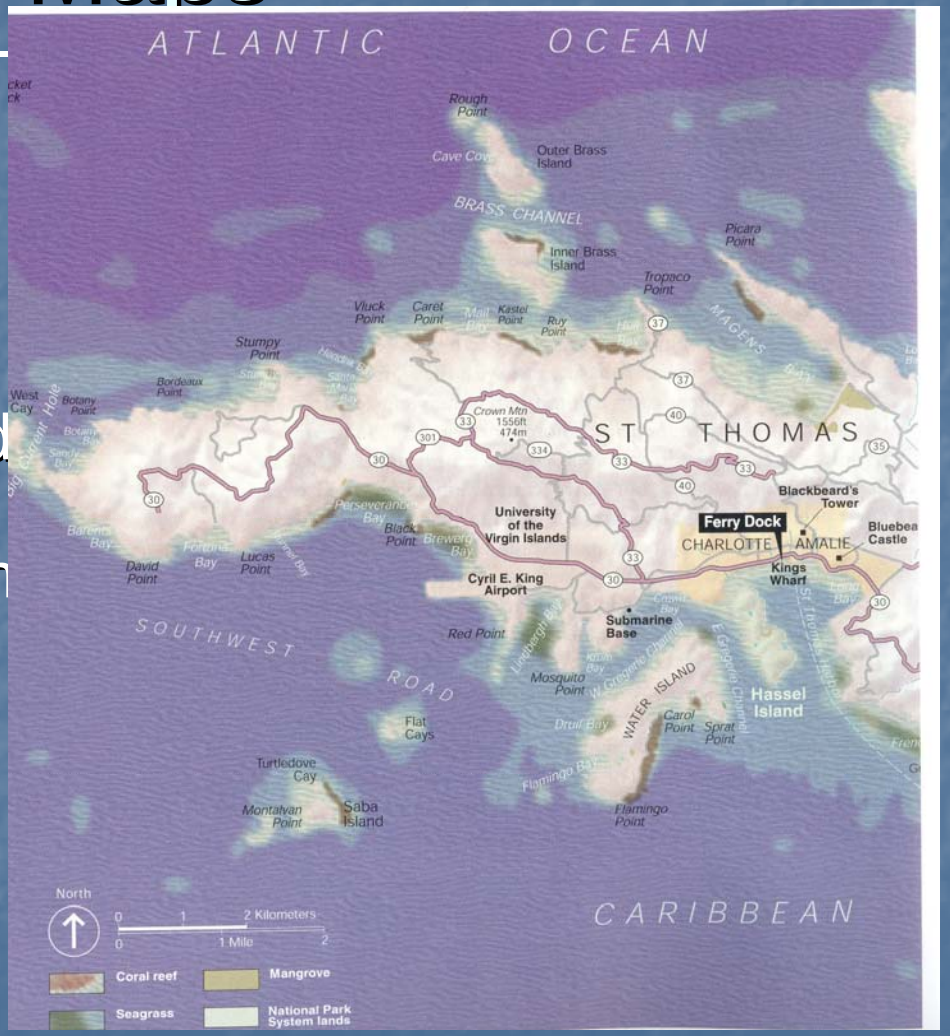
Good and Bad Uses

- Should be calrifying - Not confusing
- Should be tasteful - Not clumsy
- Should be robust
  - Across media, viewers and viewing conditions
- Do no harm policy



Maps

- Legend – label
- Shape and height of terrain by shading – quantity to measure
- Blue water and brown land accented by green mangrove – representation
- Pleasant to look at – harmonious as well as informative



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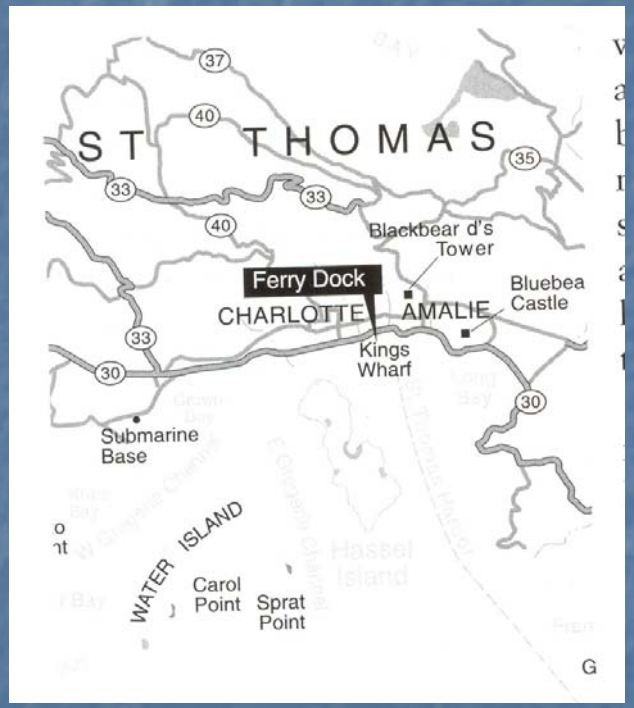
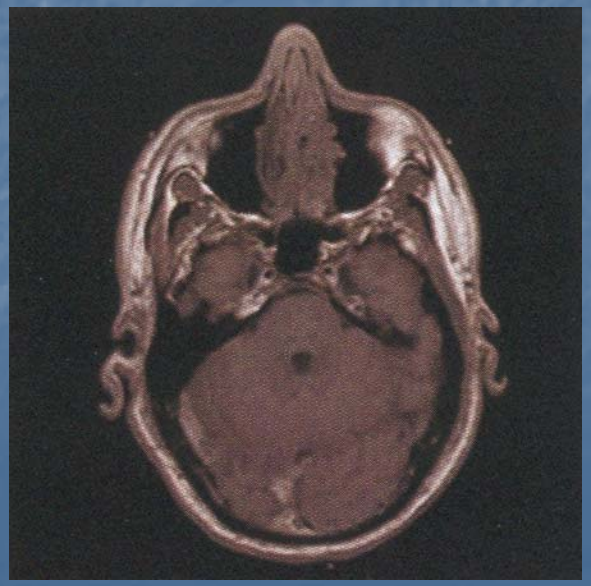
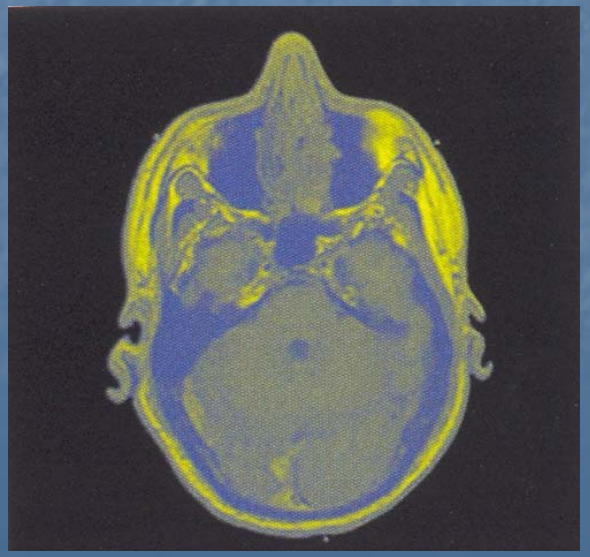
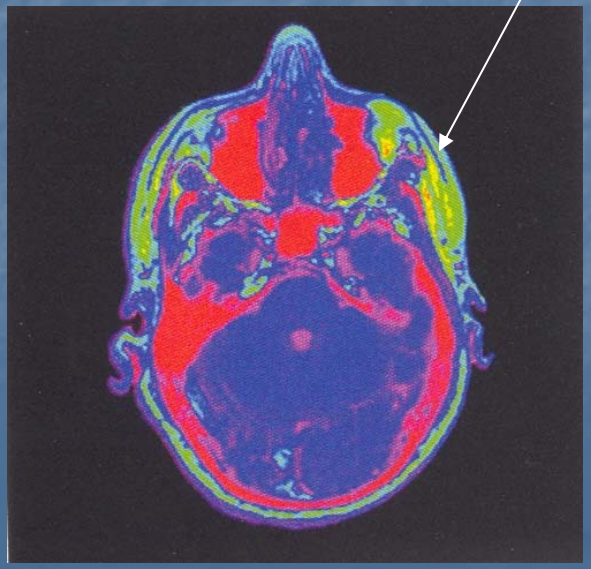


Medical Visualization

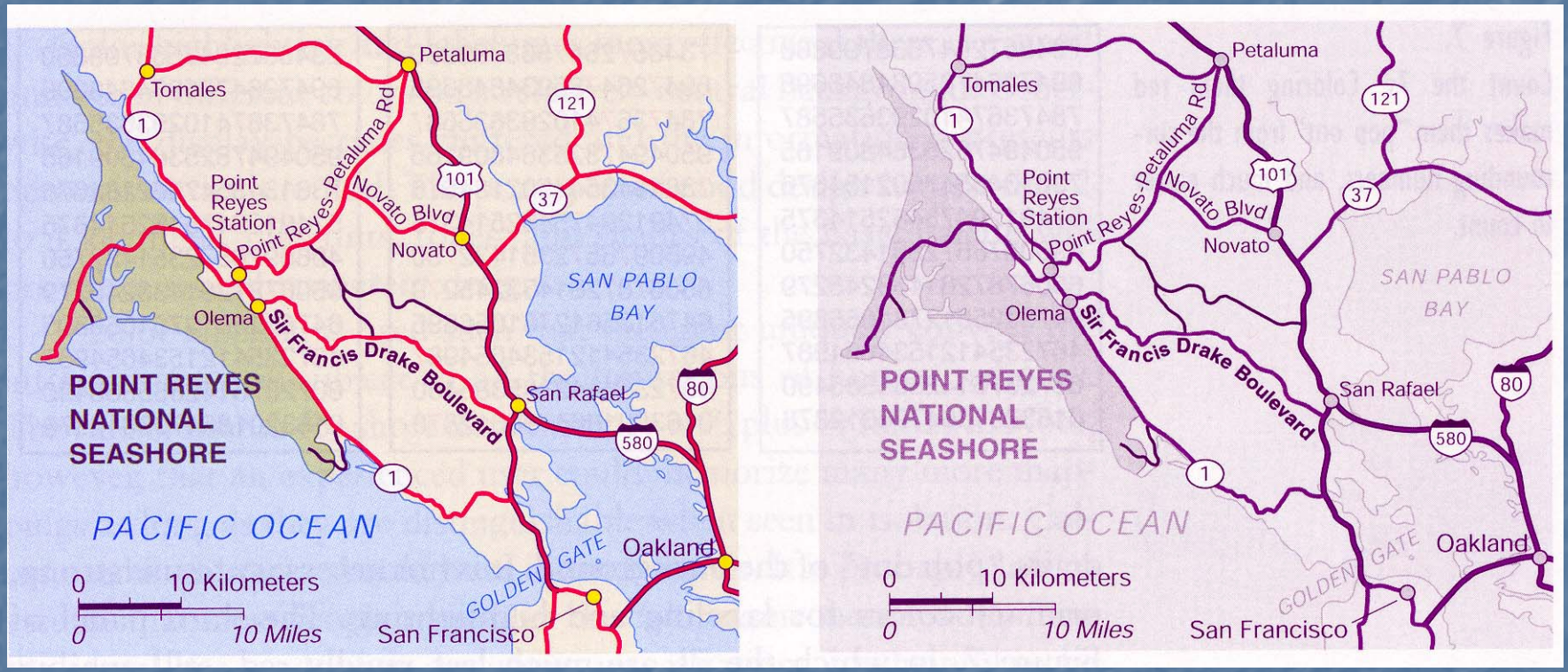
- No color in MRI
- Maps grayscales to densities
- Replacing grayscale with color
  - Pseudocolor





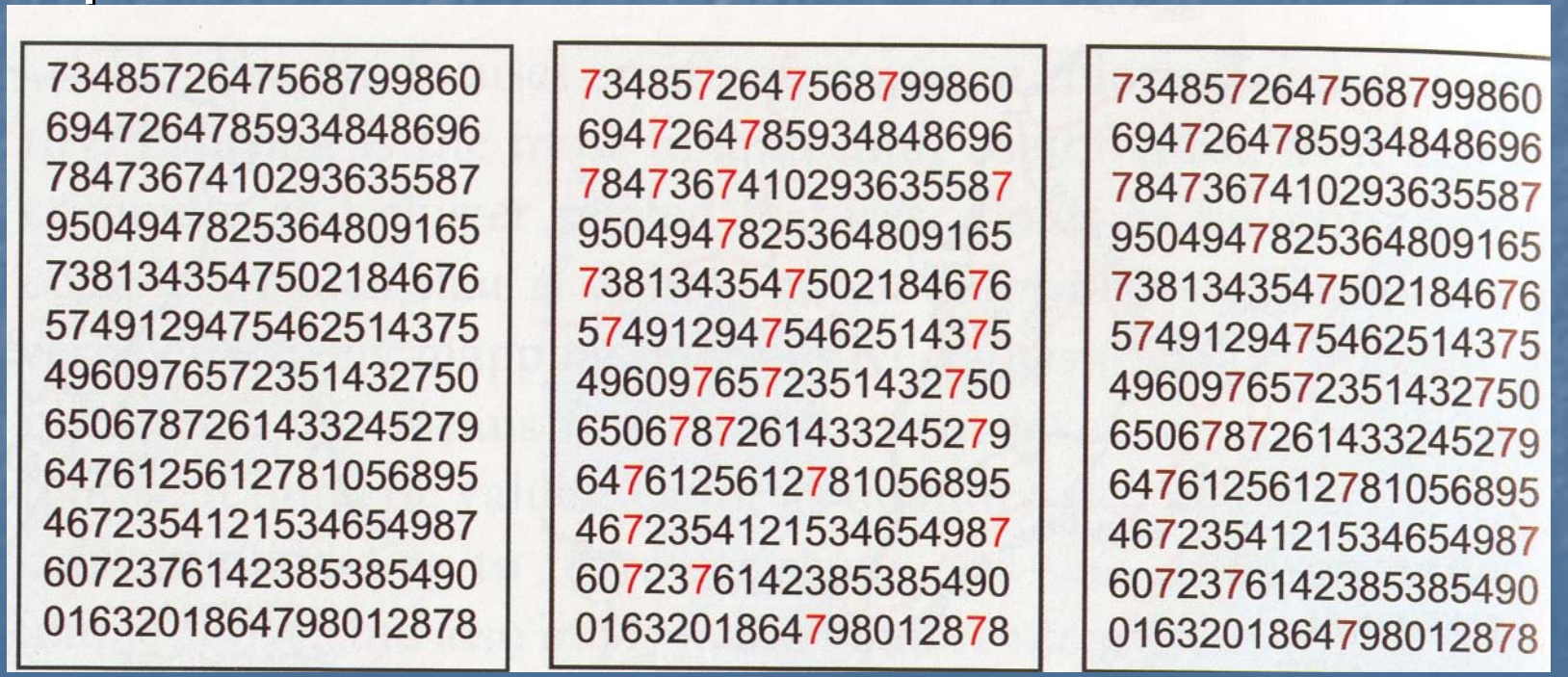


Color to Label



Color to Label

- Very low level perceptual phenomenon
- Pop out feature



Color to Label

- Can be used to group
- Again due to pop-out feature

	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
red	25.37	13.70	0.05	26.27	14.13	0.04	18.41	10.16	0.05	17.43	9.30	0.00
green	22.14	51.24	0.35	20.68	49.17	0.44	21.11	46.00	0.20	16.36	37.95	0.12
blue	13.17	3.71	74.89	15.38	5.20	86.83	11.55	3.37	65.53	9.96	3.44	56.14
gray	63.46	73.30	78.05	64.66	71.99	90.08	52.96	62.49	67.99	45.54	53.65	58.14
black	0.66	0.70	0.77	0.63	0.66	1.09	0.47	0.58	0.70	0.44	0.54	0.71

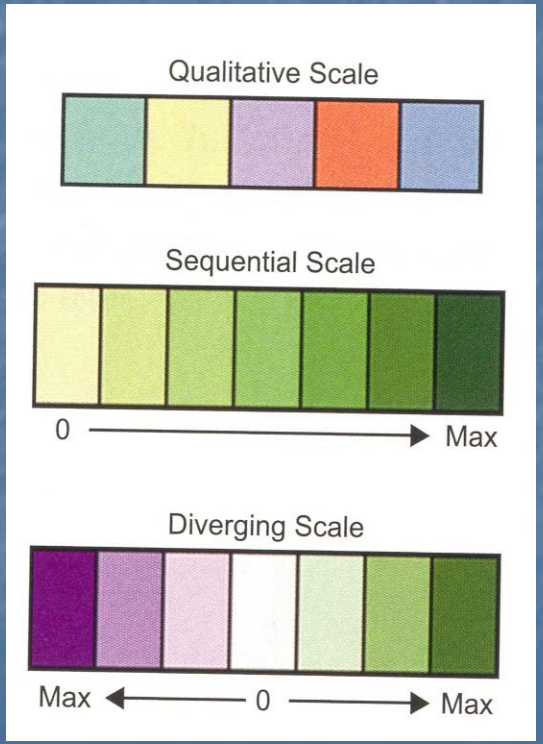
	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
red	25.37	13.70	0.05	26.27	14.13	0.04	18.41	10.16	0.05	17.43	9.30	0.00
green	22.14	51.24	0.35	20.68	49.17	0.44	21.11	46.00	0.20	16.36	37.95	0.12
blue	13.17	3.71	74.89	15.38	5.20	86.83	11.55	3.37	65.53	9.96	3.44	56.14
gray	63.46	73.30	78.05	64.66	71.99	90.08	52.96	62.49	67.99	45.54	53.65	58.14
black	0.66	0.70	0.77	0.63	0.66	1.09	0.47	0.58	0.70	0.44	0.54	0.71

Color to Label

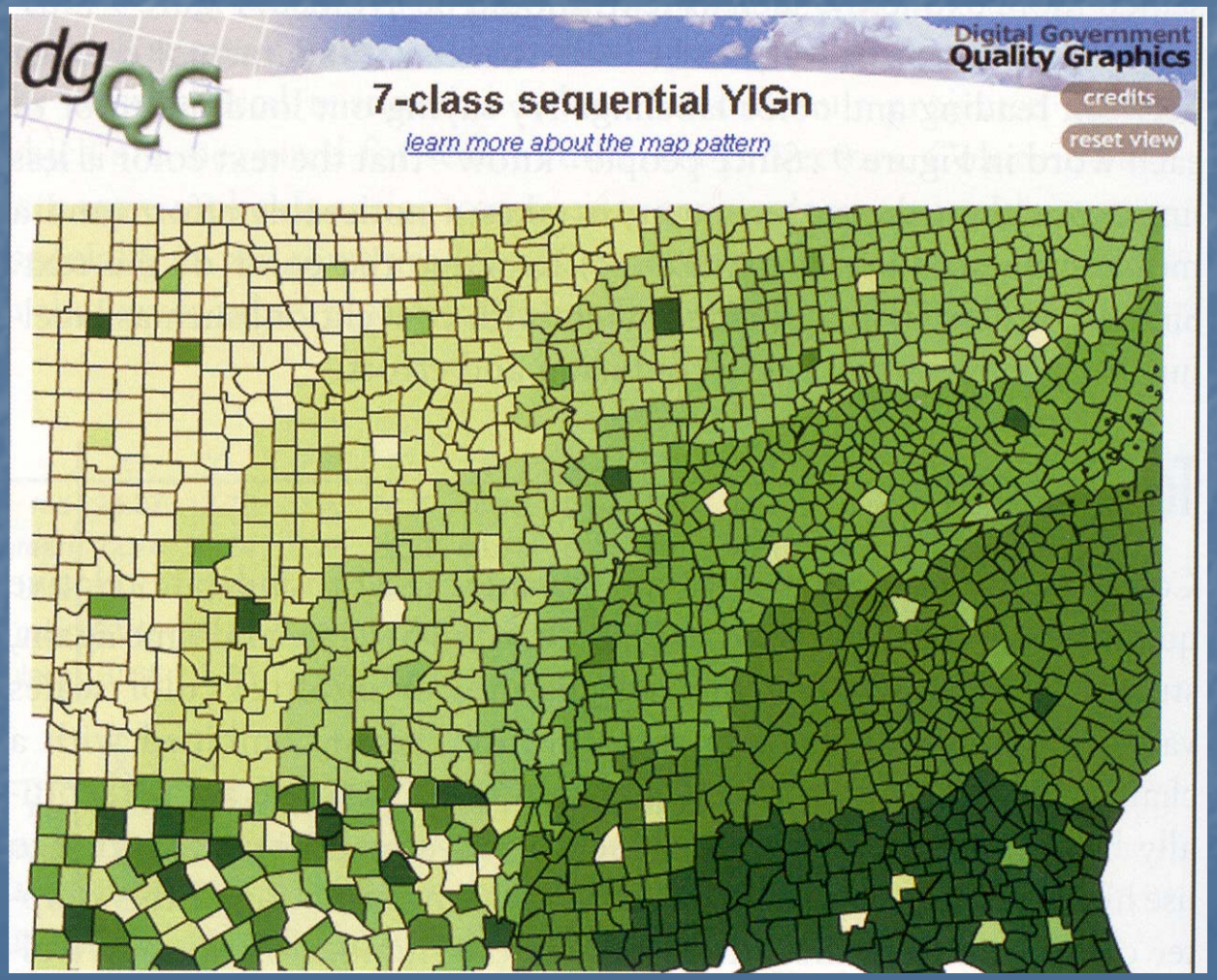
- Effective when a small number of colors are used against neutral background
  - Remember names instead of hues
- Information should not conflict with color names – e.g. green stop sign
- Cognitive influence

Color to Quantify

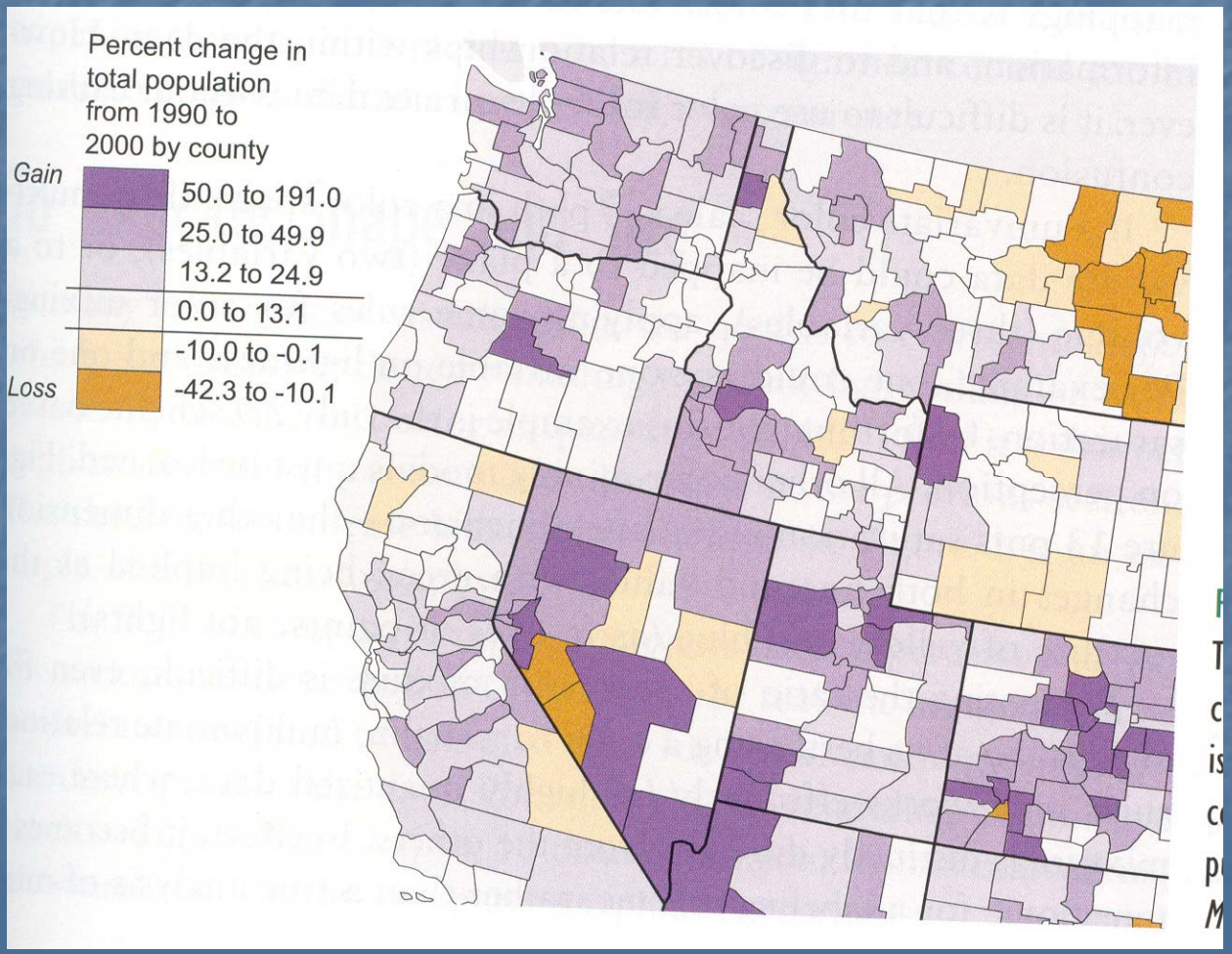
- Most natural
  - Scale that varies in value or saturation
  - Used in Cartography
  - Perceptually no hue scale
- Qualitative
  - Same value, different hue
- Sequential
  - Scale in value/saturation
- Diverging
  - Cross fade through neutral



Examples

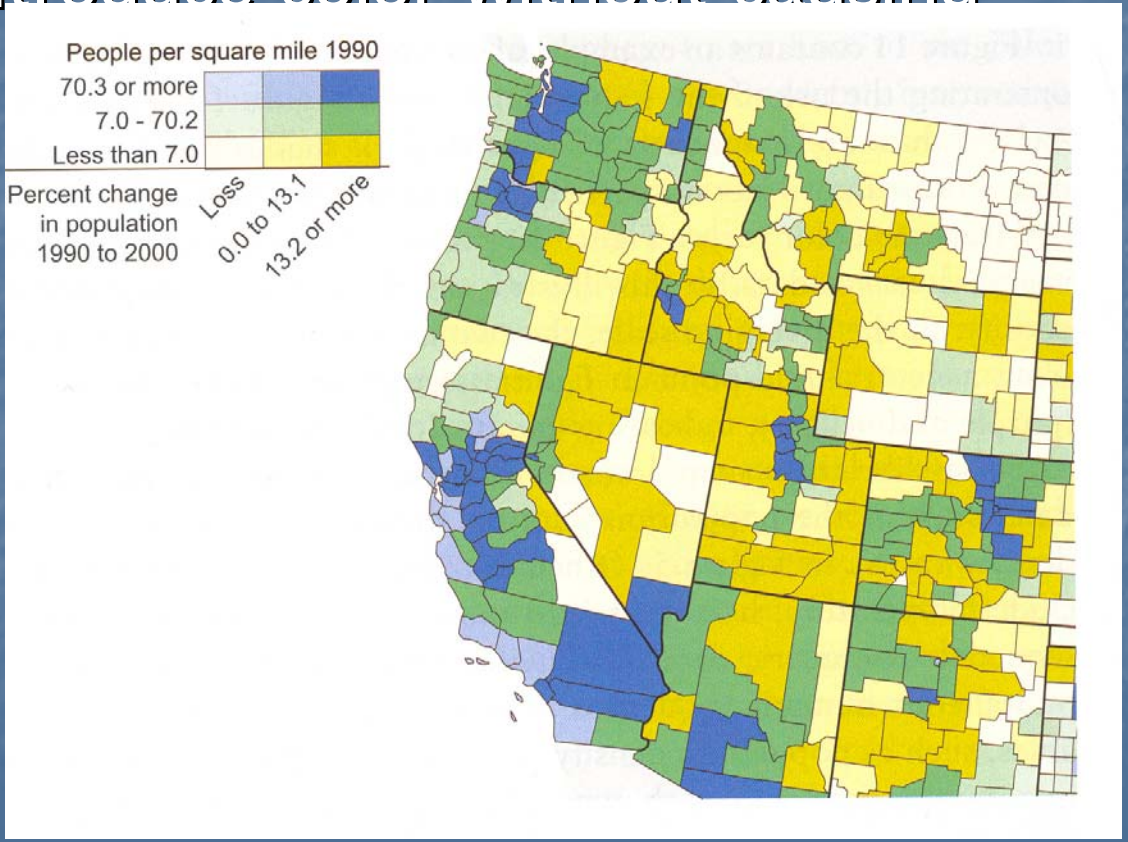

dgQG
Digital Government
Quality Graphics
7-class sequential YlGn
learn more about the map pattern
credits
reset view

Examples


Percent change in total population from 1990 to 2000 by county
Gain
50.0 to 191.0
25.0 to 49.9
13.2 to 24.9
0.0 to 13.1
-10.0 to -0.1
Loss
-42.3 to -10.1

Multivariate Data

- Difficult to introduce color without causing confusion



Multivariate Data

- Univariate – Map to a line
- Bivariate – Map to a plane
- 3 variables – Map to a volume
- 2D – one dimension on value, another on saturation
  - Only one that is perceptually intuitive
  - Everything else has to be learned
- Using patterns with colors often help
  - Especially if it exploits the relationship across variables

Making color robust

- Accommodating viewers with anomalous vision
  - Good contrast in values
  - Reinforce with encoding in shape and size
    - Stop sign is hexagonal in addition to being red

Making color robust

- Accommodating different media
  - Gamut Mapping – lightening or darkening, hue shifts
  - Scales – Uniform and non-uniform
- Usually map a few key colors
  - Define some robust way to move between them in a consistent fashion