

# COLOR | THE BASICS

Cartographic Design & Principles | Winter 2018

# Edward Tufte



*Graphical excellence is the well-designed presentation of interesting data – a matter of substance, of statistics, and of design.*

# Edward Tufte's Color Tufteisms

- Use color with an awareness that **adjacent colors perceptually modify** each other.
- Use **strong** color for **important data** in small areas against a muted background.
- Use **color redundancy** to reduce perceptual colors shifts and ambiguity
- Use color to **distinguish and differentiate** features on your map
- Use **muted** color for **less important** or background data
- Use color to distinguish **order in quantitative data**
- Use color to **mimic** the color of **phenomena**
- Use **muted** color over **large adjacent areas**
- Use color to **engage** your map viewer's
- Use color **palettes** found in **nature**



“The purpose of color on a map is to help a map viewer decipher the symbols in order to make meaningful inferences.”

“[Color] may be of secondary importance in communication, color is of primary importance when it comes to aesthetics.”

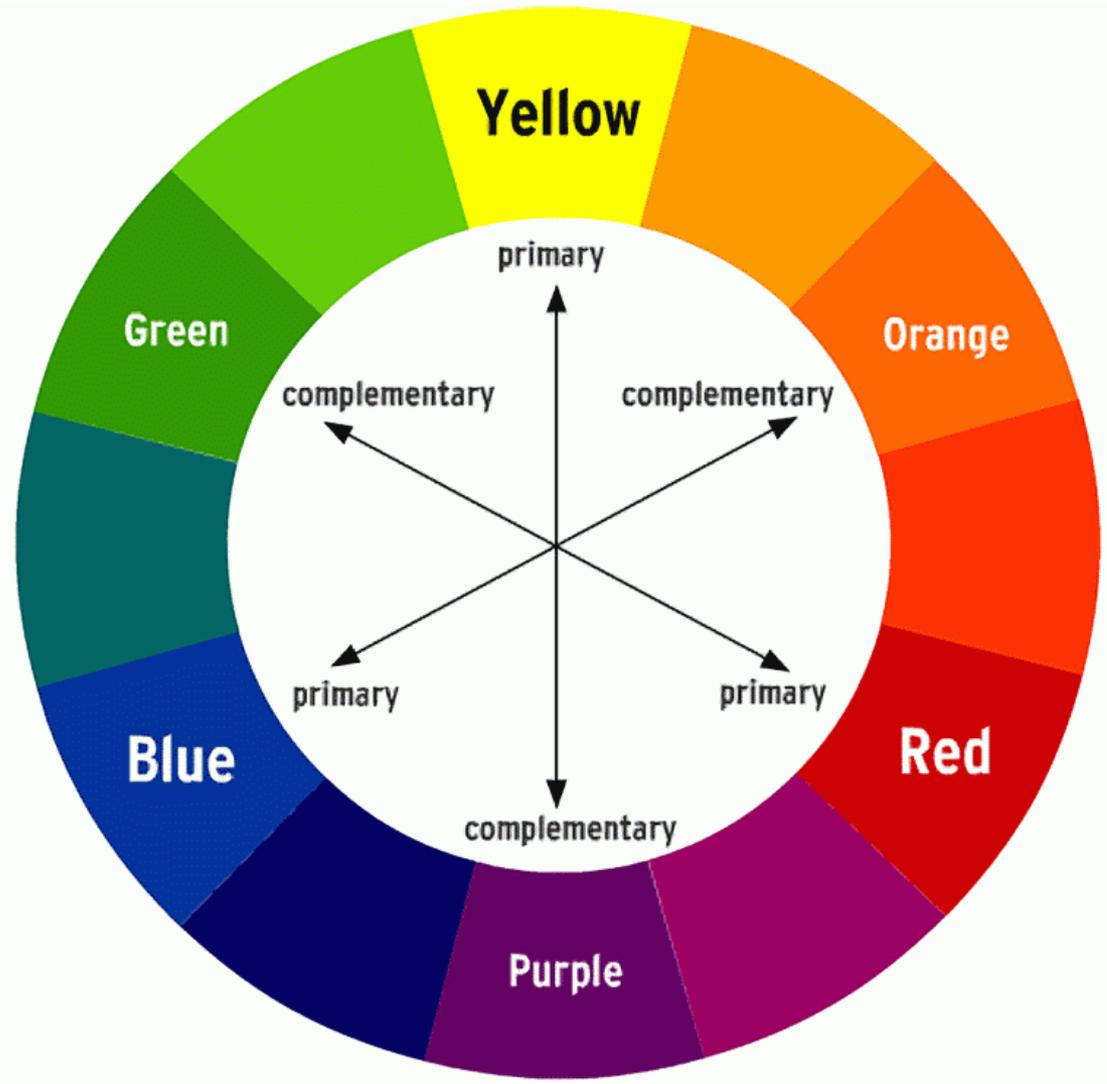
Gretchen Peterson, GIS cartography



# Color Theory

## Color Theory Basics

# Color Wheel



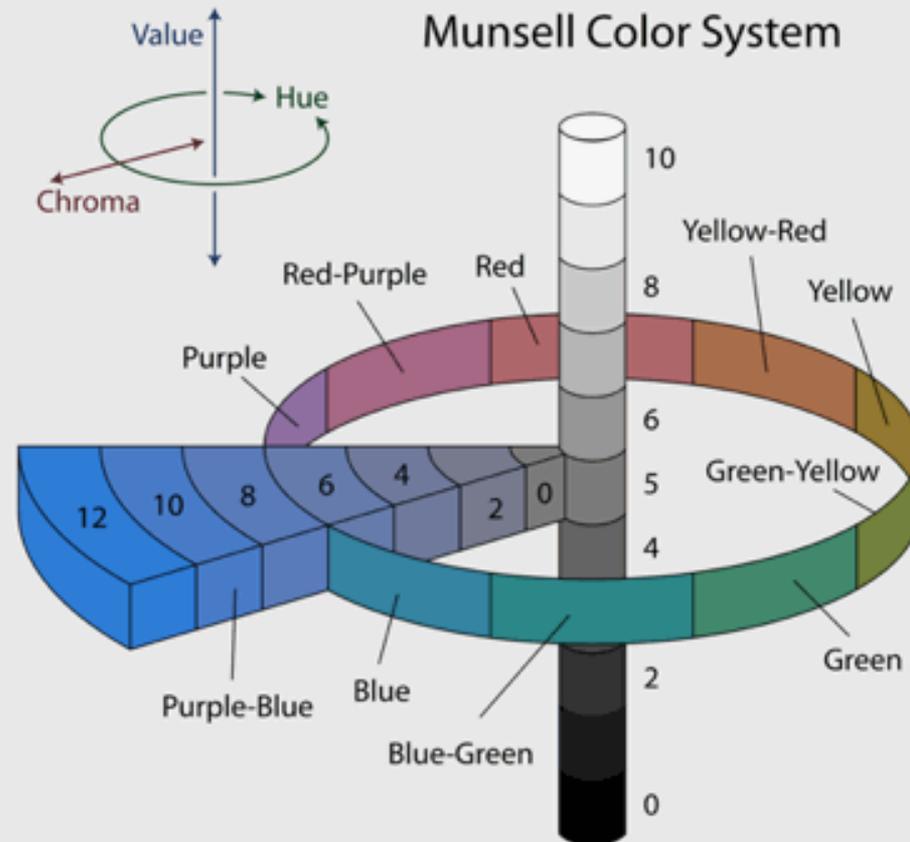
# Understanding Color



<https://www.youtube.com/watch?v=Qj1FK8n7WgY>

# Perceptual Dimensions

Every color has a combination of 3 perceptual dimensions



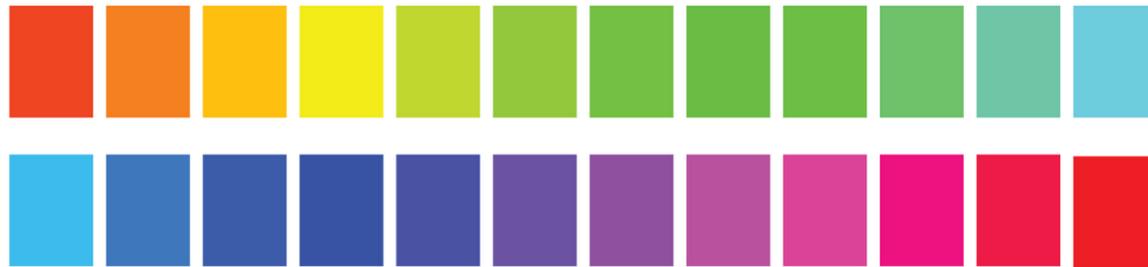
# HSV (Hue, Saturation, Value)

Helpful when you want to keep the basic hue, and tweak saturation & value

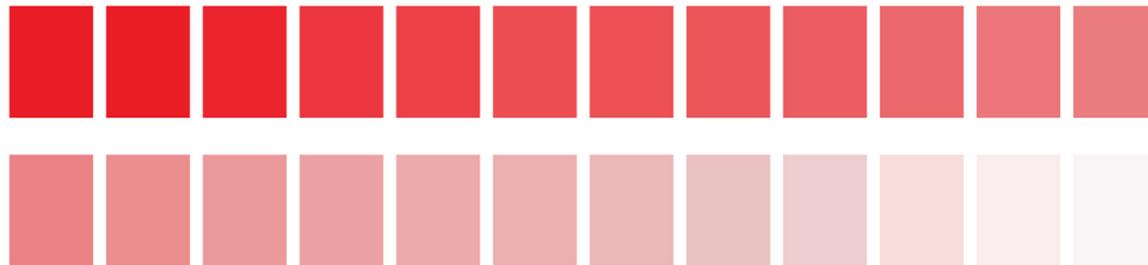
- Specify 3 sets of numbers:
  - ▣ Hue (color) 0-360
  - ▣ Saturation (amount of gray) 0-100
  - ▣ Value (amount of white in hue) 0 – 100
- Saturation & value are based on percent
  - ▣ Saturation: 100% = pure color, no gray
  - ▣ Value (brightness): 100% = white

# HSV

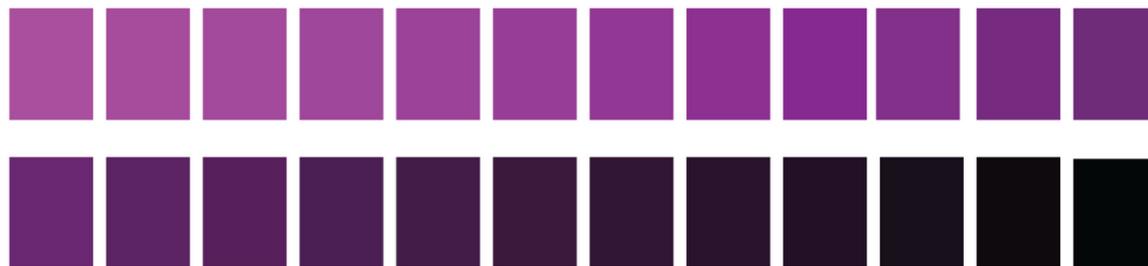
## HUE:



## SATURATION:

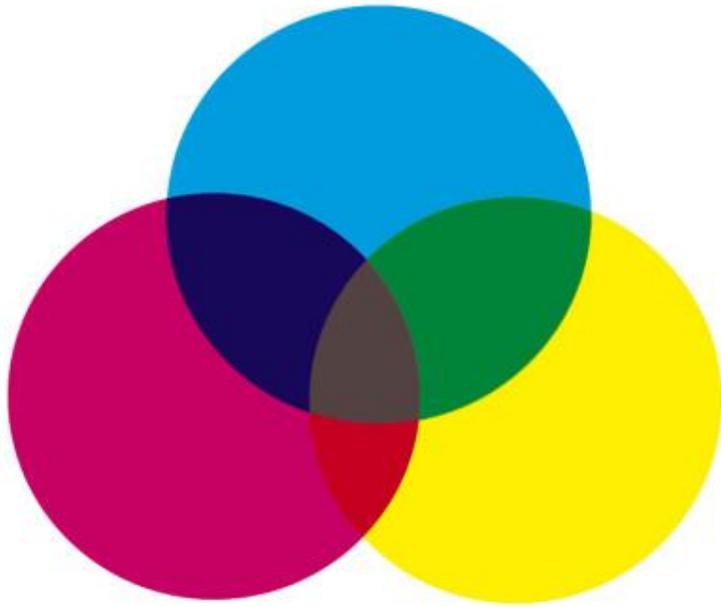


## BRIGHTNESS:

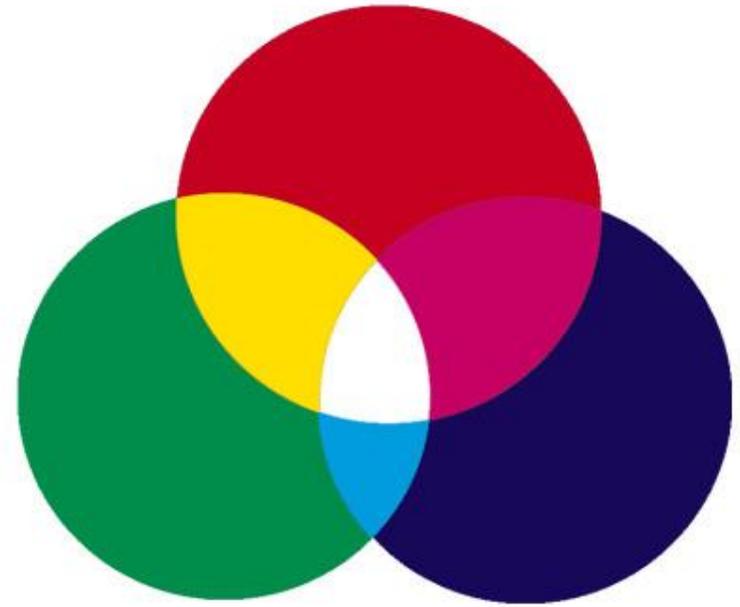


# CMYK (Cyan, Magenta, Yellow, Black)

- White sheet of paper that becomes a color once you add color to it
- Colors that can be combined on a page to produce all other colors are subtractive – some wavelengths are absorbed or subtracted by the paper
- Values in CMYK are percentages
  - 0,0,0,0 = white
  - 0,0,0,100 = black



**Subtractive color (CMYK)**



**Additive Color (RGB)**

# RGB (Red, Green Blue)

- Created for electronics like computer screens and TV's, where a monitor emits different amounts of red, blue, green to produce a desired color
- Describes a color in terms of the amount of each primary color you need to put on a black surface to produce the color (Additive)
- Initial surface is black, you are adding primary colors

# RGB

- Specify a number between 0 and 255 for each color
- To get full red the RGB is 255,0,0
- The brightness of the color decreases, as the number decreases 150, 0, 0 – still red

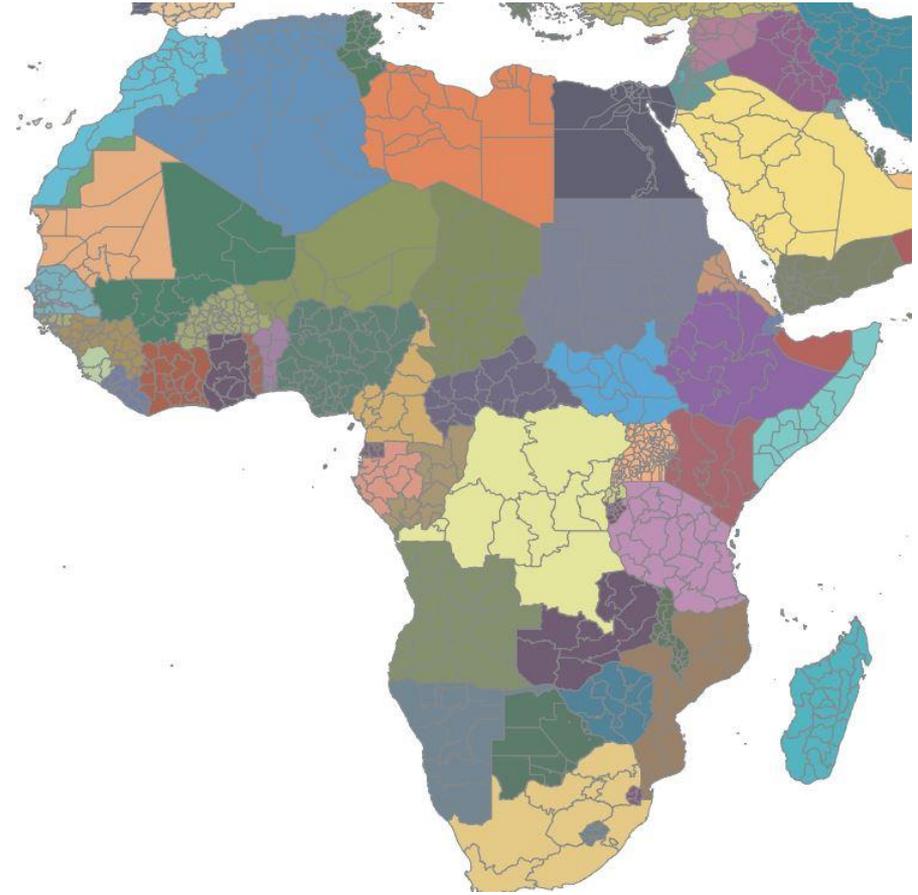
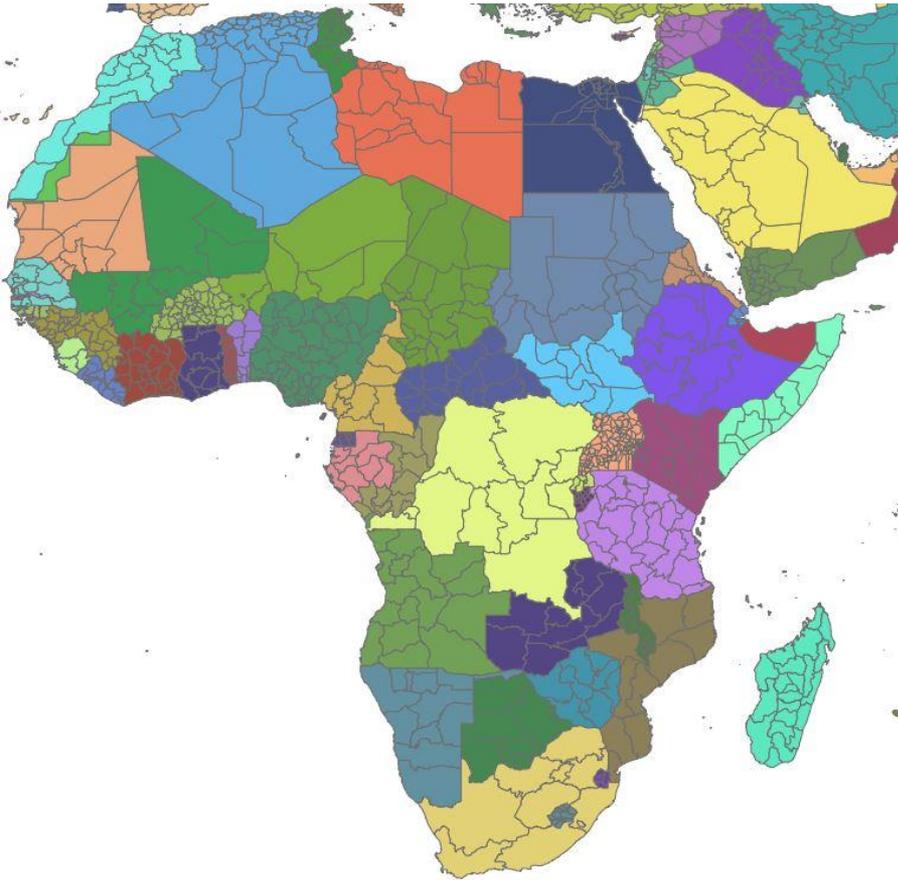
# RGB | Hexadecimal

- A derivative of RGB, hex is a numerical system used to display maps on the Web
- #83F52C – greenish
- 0 = no color value
- F = full color values
- Full green = #00FF00

# Colors & Printing

- GIS software uses RGB
- Printers use CMYK
- Most printers convert to CMYK prior to printing, which can change some colors
- Use CMYK in GIS to match the screen & print color (<http://support.esri.com/technical-article/000009120>)

# RGB v CMYK





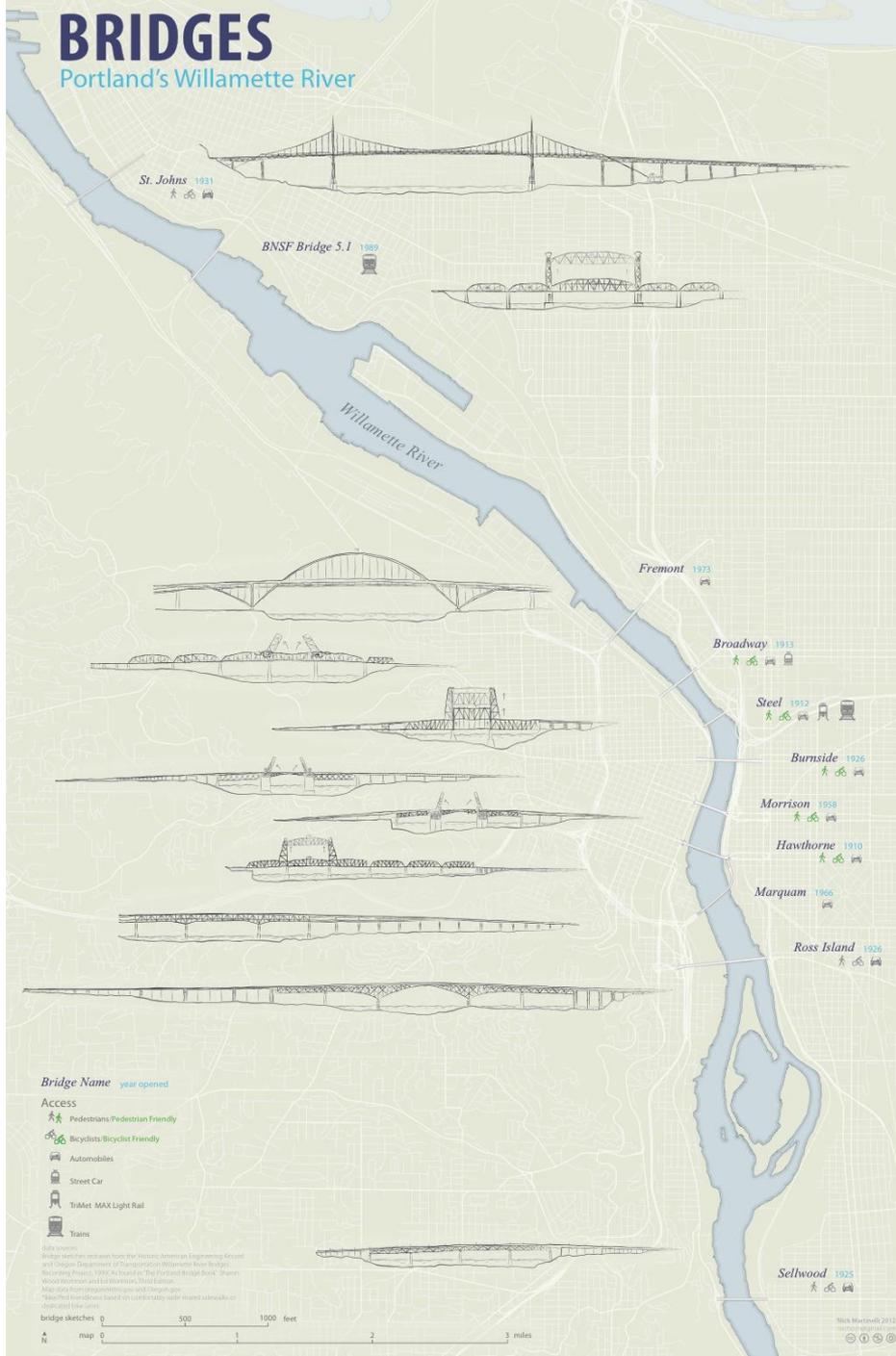
# Colors on Maps

# Colors on Maps

- ***Colors close to each other on the wheel = subdued, quiet effect***

# BRIDGES

## Portland's Willamette River



*St. Johns* 1931

*BNSF Bridge 5.1* 1989

*Fremont* 1973

*Broadway* 1913

*Steel* 1912

*Burnside* 1926

*Morrison* 1958

*Hawthorne* 1910

*Marquam* 1966

*Ross Island* 1926

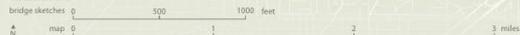
*Selwood* 1925

*Bridge Name* year opened

### Access

- Pedestrians/Pedestrian Friendly
- Bicyclists/Bicyclist Friendly
- Automobiles
- Street Car
- TriMet MAX Light Rail
- Trains

© 2012 Oregon  
 Bridge sketches not drawn from the Historic American Engineering Record  
 and Oregon Department of Transportation Willamette River Bridges  
 Recording Project, 1989. As found in The Portland Bridge Book: Short  
 Wood Structures and Full-Depth, Truss-Like.  
 Map data from OpenStreetMap contributors  
 \*Map data based on user-submitted information and  
 is not guaranteed.



# Colors on Maps

- Colors close to each other on the wheel = subdued, quiet effect
- ***Complementary colors (opposite on wheel) = vivid scheme that demands attention***



## THE MAGIC BEAN SHOP

A single cup of Starbucks coffee can depend upon as many as 19 different countries. Between the coffee beans, the milk, the sugar, and the paper cup, Starbucks coffee is a global hub that connects some of the poorest countries in the world with some of the wealthiest.



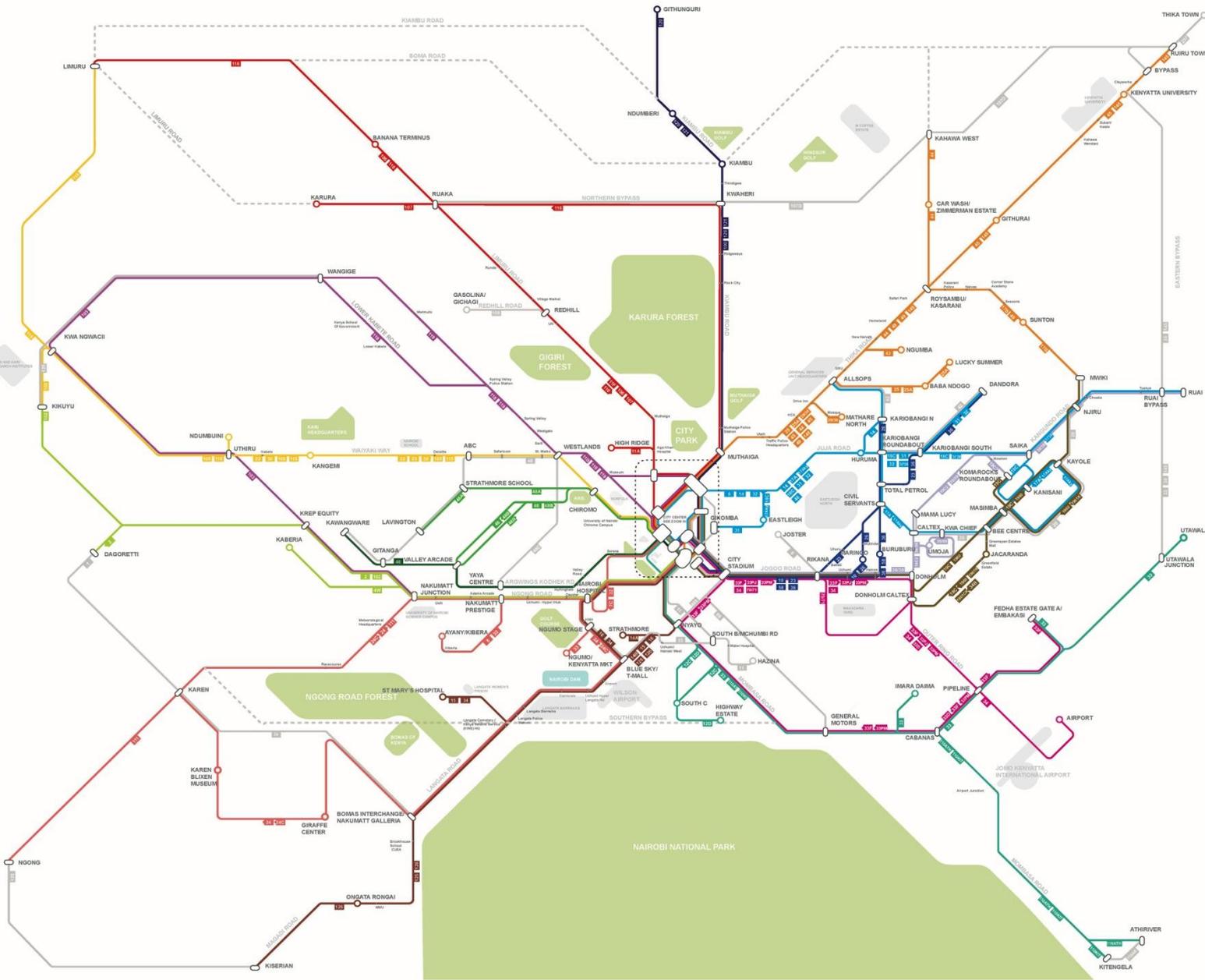
## THE FRIES THAT BIND US

Probably the single most visible symbol of American influence worldwide, McDonald's has over 31,000 restaurants in 118 countries, employing more than 1.3 million people. Despite its 13,000 restaurants in the USA, McDonald's is slipping at home. Its customer satisfaction is worse than any other fast food chain, and ranks lower than all major airlines and the IRS.



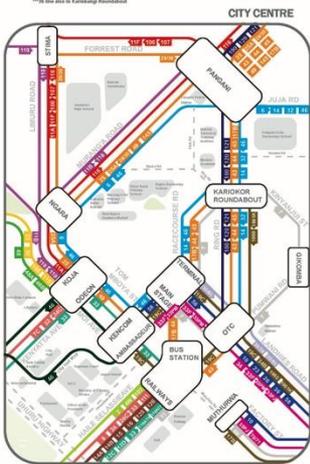
# Colors on Maps

- Colors close to each other on the wheel = subdued, quiet effect
- Complementary colors (opposite on wheel) = vivid scheme that demands attention
- ***Many colors from all over the wheel = carefully chosen so they do not clash***



# NAIROBI MATATU ROUTES

digitalmatatus



Data developed through a research collaboration between the Civic Data Design Lab, MIT Center for Sustainable Urban Development, Columbia University, School of Computing and Information, University of Nairobi, Kenyan Research Fund by the Roadside Foundation.

Data collected by:  
 University of Nairobi School of Computing and Information, CDDLab  
 Planet Labs, OpenStreetMap, Google Maps, Data Design Lab

Map by:  
 FOR FERRACIA & MOORE ARCHITECTS  
<http://www.digitalmatatus.com>

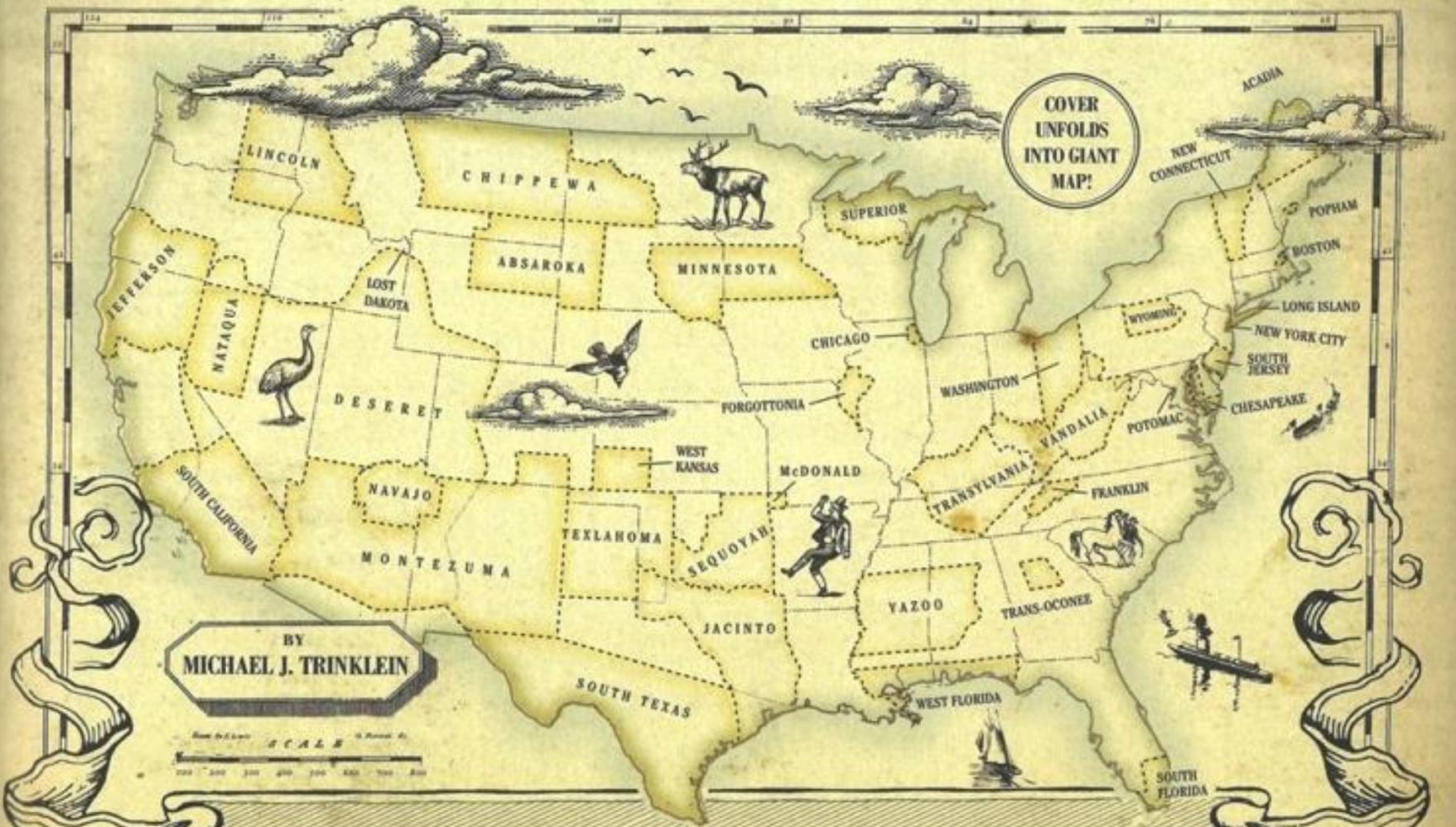
Created January 27, 2014

**CIVIC DESIGN DATA LAB**  
**CDDLAB**

# Colors on Maps

- Colors close to each other on the wheel = subdued, quiet effect
- Complementary colors (opposite on wheel) = vivid scheme that demands attention
- Many colors from all over the wheel = carefully chosen so they do not clash
- ***Neutral color scheme = black, white, gray***

COVER  
UNFOLDS  
INTO GIANT  
MAP!



BY  
**MICHAEL J. TRINKLEIN**

SCALE  
0 100 200 300 400 500 600 700 800

# LOST★STATES

★ TRUE STORIES OF TEXLAHOMA, TRANSYLVANIA, AND OTHER STATES THAT NEVER MADE IT ★



# Color. The Rules

# Color ‘Rules’

- Four Color Theorem
- Five Shade Rule
- Choropleth mapping
- Color Connotations
- Color Blending
- Contrast
- Colors around the map
- Color Blindness

# Four Color Theorem

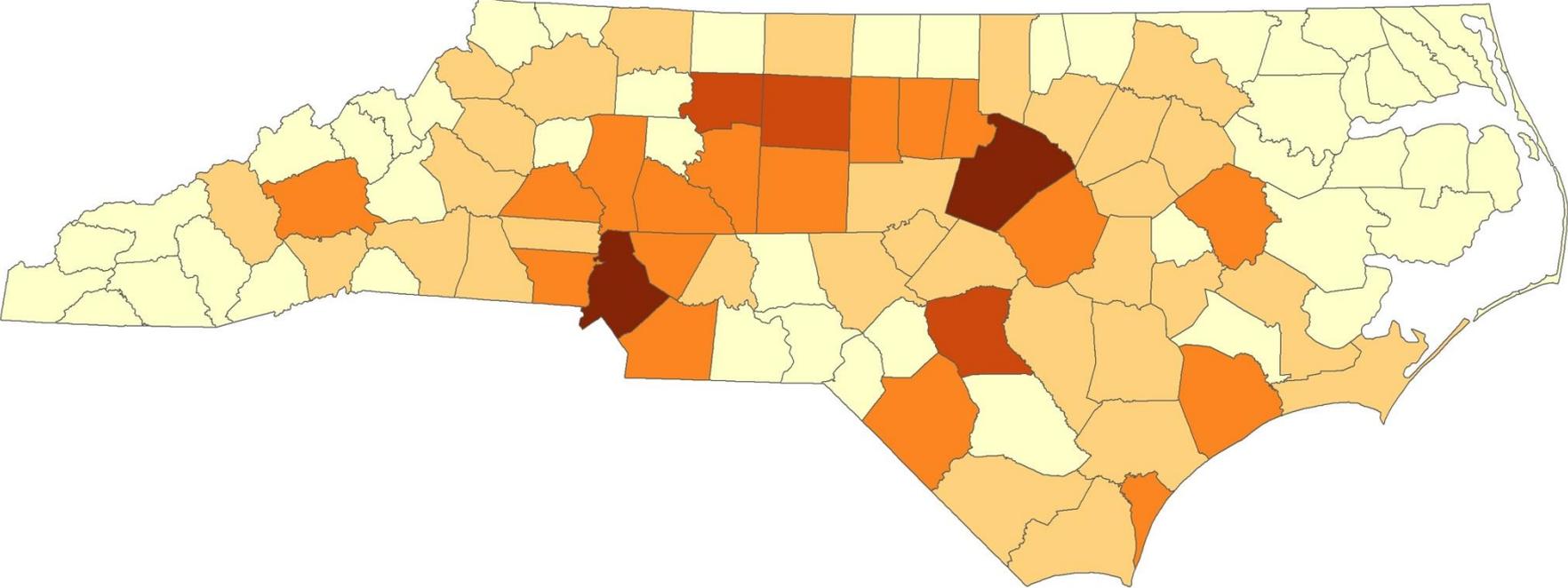
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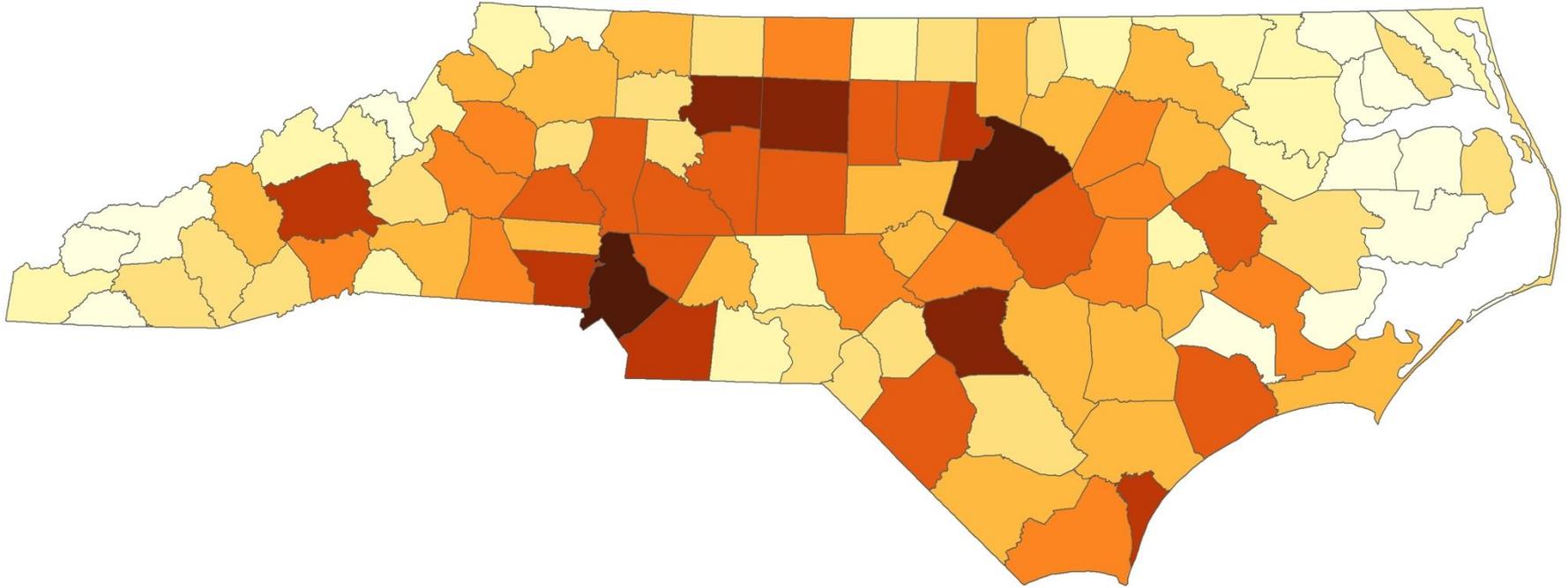
*No more than four colors are required to color regions of a map, so that no two adjacent regions have the same color*

<https://youtu.be/ANY7X-wpNs>

# Five Shade Rule

- Human eye can only distinguish between five shades of the same color (hue)
- Data represented on a Choropleth map should be broken into 5 or less classes
- Do not use any shade of that same color to denote any other features on the map
- Can use the same shades in map elements – title, border, etc.





# Choropleth Mapping

- Uses color lightness (value) to represent quantitative data values
  - ▣ Light colors = low data values
  - ▣ Dark colors = high data values
- What color is best?
  - ▣ Is there a literal or metaphorical color that represents the variable you are mapping?
  - ▣ i.e Mapping out household wealth using light to dark green

# Color Connotations

- Colors carry emotions or connotations
  - ▣ Important | Services
  - ▣ Elevation Lines | Terrain
  - ▣ Water
  - ▣ Snow | Ice
  - ▣ Green (environmental)

# Color Connotations



Low to high elevation



Poor to Good



Cold to hot

# Color Connotations

- Can go across cultures but, some are culturally specific
  - US:
    - Red = danger, poor conditions
    - Green = likeability, spring, environmental correctness
  - China:
    - Red = good luck, celebrations

# Symbolic Color Connotations

- Blue. Water, cool, positive, serenity, purity, depth
- Green. Vegetation, lowlands, forests, youth, spring, nature, peace
- Red. Warm, important, negative, numbers, action, anger, danger, power, warning
- Yellow/tan. Dry, lack of vegetation, intermediate elevation, heat
- Orange. Harvest, fall, abundance, fire, attention, action, warning

# Symbolic Color Connotations

- Brown. Landforms, contours, earthy, dirty, warm
- Purple. Dignity, royalty, sorrow, despair, richness, elegant
- White. Purity, clean, faith, illness, life, clarity, absence, light
- Black. Mystery, strength, heaviness, death, nighttime, presence
- Gray. Quiet, reserved, sophisticated, controlled, light, bland, dull

# Cultural Color Connotation

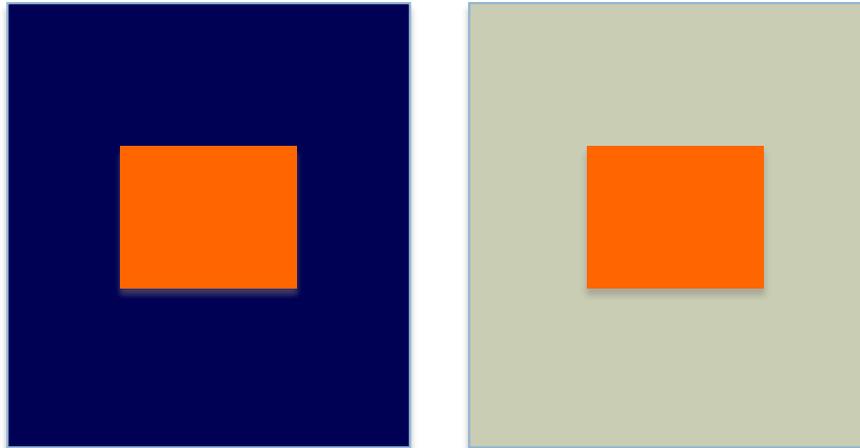
- Blue. Safe, cross-cultural color
- Green. Fertility and paganism in Europe, Sacred for Muslims, mourning and unhappiness in Asia
- Red. Bolsheviks, communists and other politically left organizations, purity in India
- Yellow/tan. Peaceful resistance, movement associated with Corason Aquino in Philippines
- Orange. Pro-Western activists in Ukraine, Protestants in Ireland, sacred Hindu color

# Cultural Color Connotations

- Brown. Mourning in India, Nazis in West, ceremonial for Australian Aboriginals
- Purple. Death and crucifixion in Europe, mysticism, prostitution in the Middle East
- White. Unhappiness in India, mourning in China, royalists & traditionalists in Western
- Black. Fascists, anarchists, and other extremists in Western world, death and mourning in India
- Gray. Corporate culture in the West (also blue), dead and dull in Feng Shui

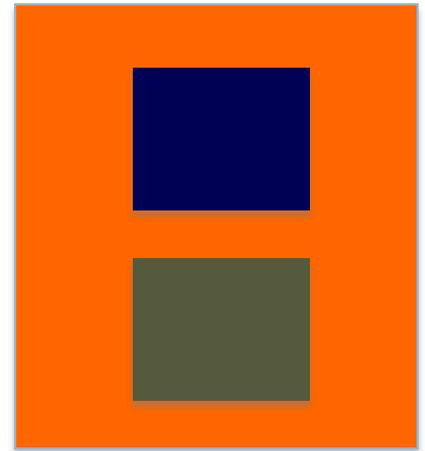
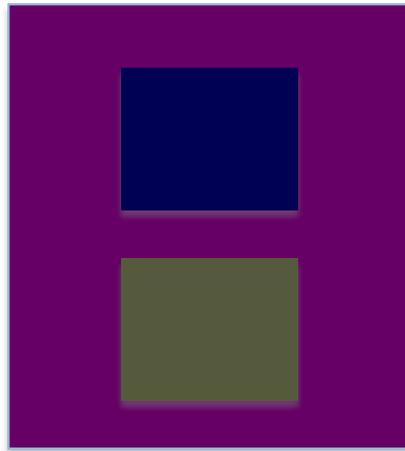
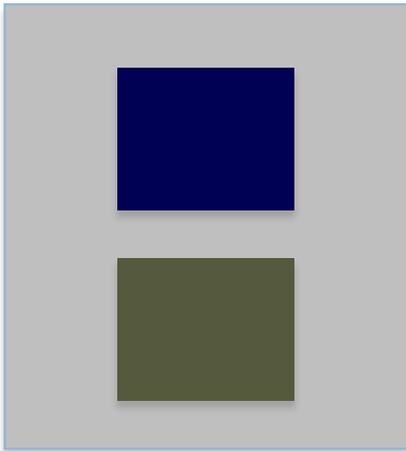
# Color Blending

- Colors look different when they are combined with other colors



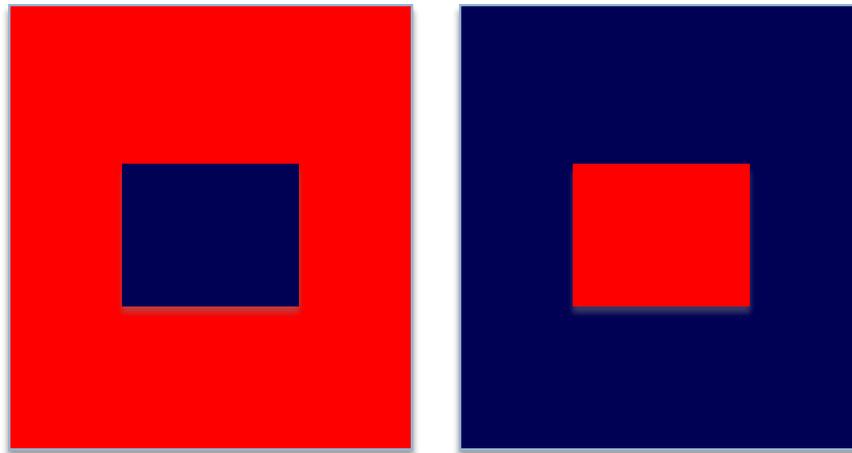
# Color Blending

- Create swatches of color combinations to serve as a guide for your map, or general reference
- Change colors within your map to examine the combinations



# Color Blending

- Some color combinations play eye tricks on you



# Color Contrast

- Distinguish features from one another and from the background
- Dark background with lighter features OR light background with darker features

# New York City Subway Diagram



## Stations and connections

- always stops, except for rush hours, peak direction
- weekdays only
- weekdays, peak direction only
- rush hours only
- nights and weekends only
- service in one direction only
- no regular service
- transfer
- out-of-station transfer
- regional rail connection
- wheelchair access

## Subway Services

- 7 Avenue Local
- 7 Avenue Express
- 7 Avenue Express
- Lexington Avenue Express
- Lexington Avenue Express
- Lexington Avenue Local
- 42 Street-Flushing Local
- 8 Avenue Express
- 8 Avenue Local
- 8 Avenue Local
- 6 Avenue Express
- 6 Avenue Express
- 6 Avenue Local
- 6 Avenue Local
- Crosstown Local
- Nassau Street Local
- Nassau Street Express
- 14 Street-Canarsie Local
- Broadway Local
- Broadway Express
- Broadway Local
- Shuttle
- SIR Staten Island Railway



# Colors Around the Map

- Can grab attention away from the map if too colorful
- Colors should be used *meaningfully*, not arbitrarily or gratuitously
- Color ‘echoing’
  - ▣ Borrow a color used in the map for the title, scale bar, north arrow, border, etc.
  - ▣ Meant to complement, not compete

# МЕТРОПОЛИТЕН И ТРАМВАЙ

## Общественный транспорт Самары



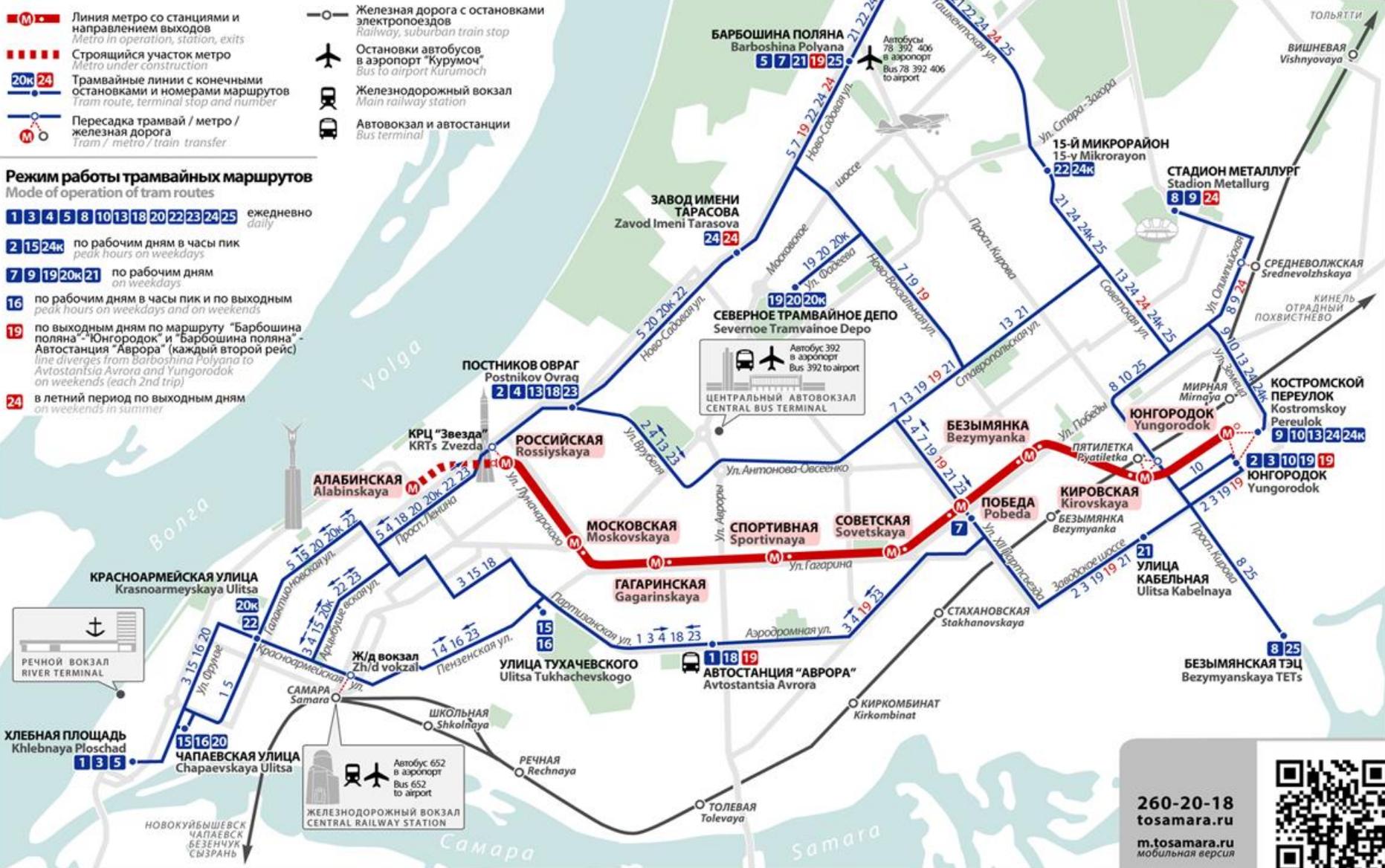
- Линия метро со станциями и направлением выходов  
Metro in operation, station, exits
- Строящийся участок метро  
Metro under construction
- Трамвайные линии с конечными остановками и номерами маршрутов  
Tram route, terminal stop and number
- Пересадка трамвай / метро / железная дорога  
Tram / metro / train transfer

- Железная дорога с остановками электропоездов  
Railway, suburban train stop
- Остановки автобусов в аэропорт "Курумоч"  
Bus to airport Kurumoch
- Железнодорожный вокзал  
Main railway station
- Автовокзал и автостанции  
Bus terminal

### Режим работы трамвайных маршрутов

Mode of operation of tram routes

- 1 3 4 5 8 10 13 18 20 22 23 24 25** ежедневно  
daily
- 2 15 24к** по рабочим дням в часы пик  
peak hours on weekdays
- 7 9 19 20к 21** по рабочим дням  
on weekdays
- 16** по рабочим дням в часы пик и по выходным  
peak hours on weekdays and on weekends
- 19** по выходным дням по маршруту "Барбошина поляна - Юнгородок" и "Барбошина поляна" - Автостанция "Аврора" (каждый второй рейс)  
line diverges from Barboшина Polyana to Yungorodok and Yungorodok to Avtostantsia Avrora and Yungorodok on weekends (each 2nd trip)
- 24** в летний период по выходным дням  
on weekends in summer



260-20-18  
tosamara.ru  
m.tosamara.ru  
мобильная версия

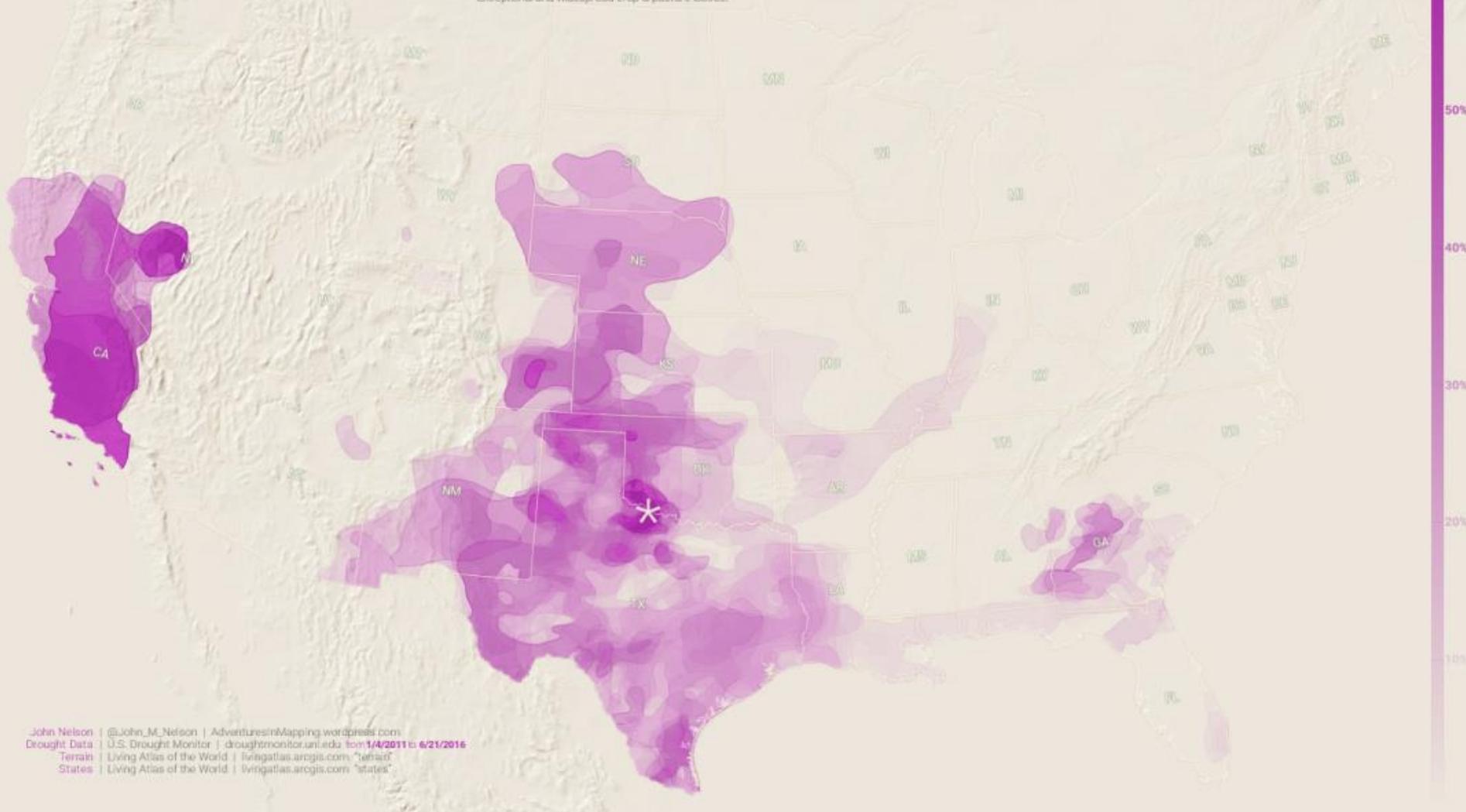
# % of Past Five Years at Exceptional Drought

Shortages of water in reservoirs, streams, and wells creating water emergencies.  
Exceptional and widespread crop & pasture losses.

★  
Electra, TX

175 of the past 285 weeks (61.4%)

from 1/4/2011 to 6/21/2016



John Nelson | @John\_M\_Nelson | AdventuresInMapping.wordpress.com  
Drought Data | U.S. Drought Monitor | droughtmonitor.unl.edu from 1/4/2011 to 6/21/2016  
Terrain | Living Atlas of the World | livingatlas.arcgis.com "terrain"  
States | Living Atlas of the World | livingatlas.arcgis.com "states"

# Color Blindness

- Approximately 8% of the general population sees color differently than the rest of the population
- Red-green color confusion
  - ▣ Deuteranopia (5% of all males)
  - ▣ Protanopia (2.5% of all males)
- Blue-yellow color confusion
  - ▣ Tritanopia (<0.3% women and men)

<https://www.youtube.com/watch?v=7Apx-mTeLQE&feature=youtu.be>

# Color Blindness

Poppies and cyclamen.



Protanope.

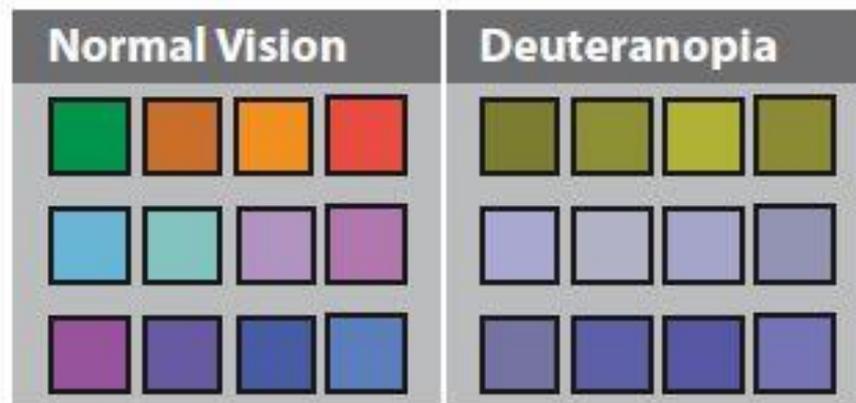


Tritanope.



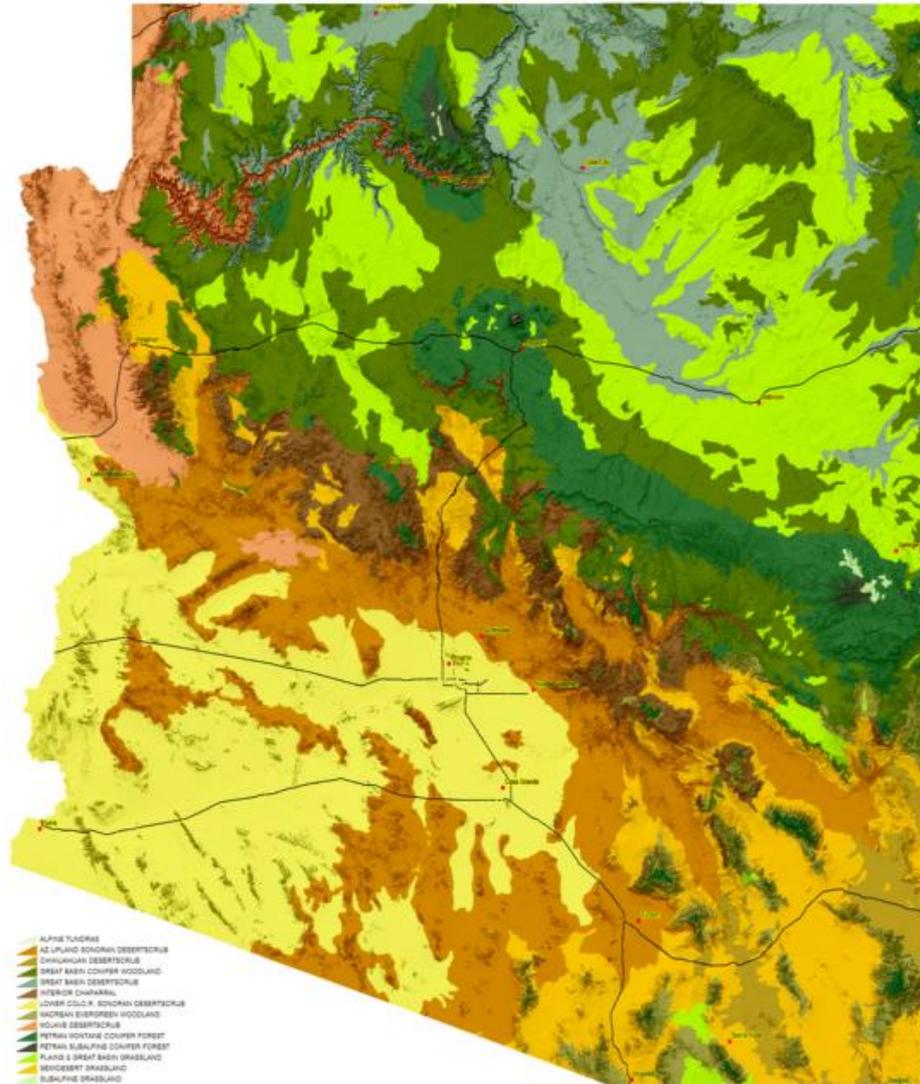
# Color Blindness

Do you try to account for this in your cartography?

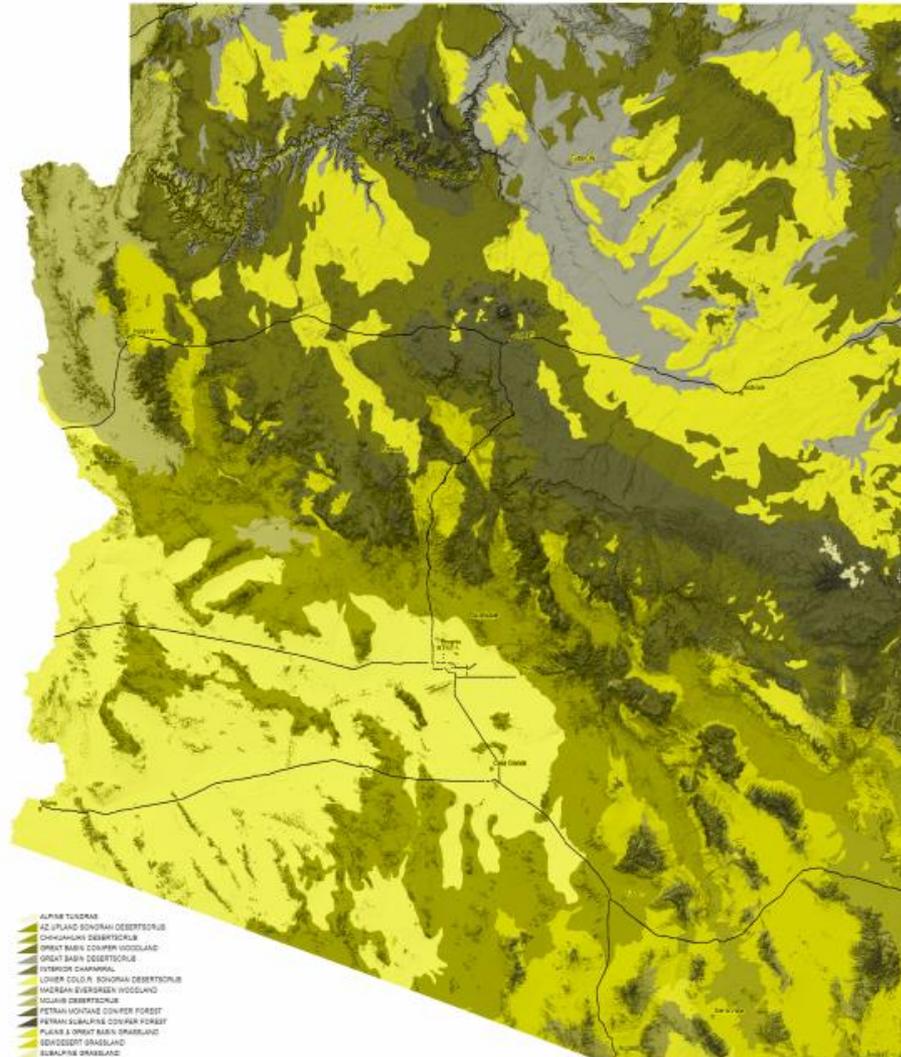


*Figure 3. Colors as they appear to readers with normal vision and deuteranopia.*

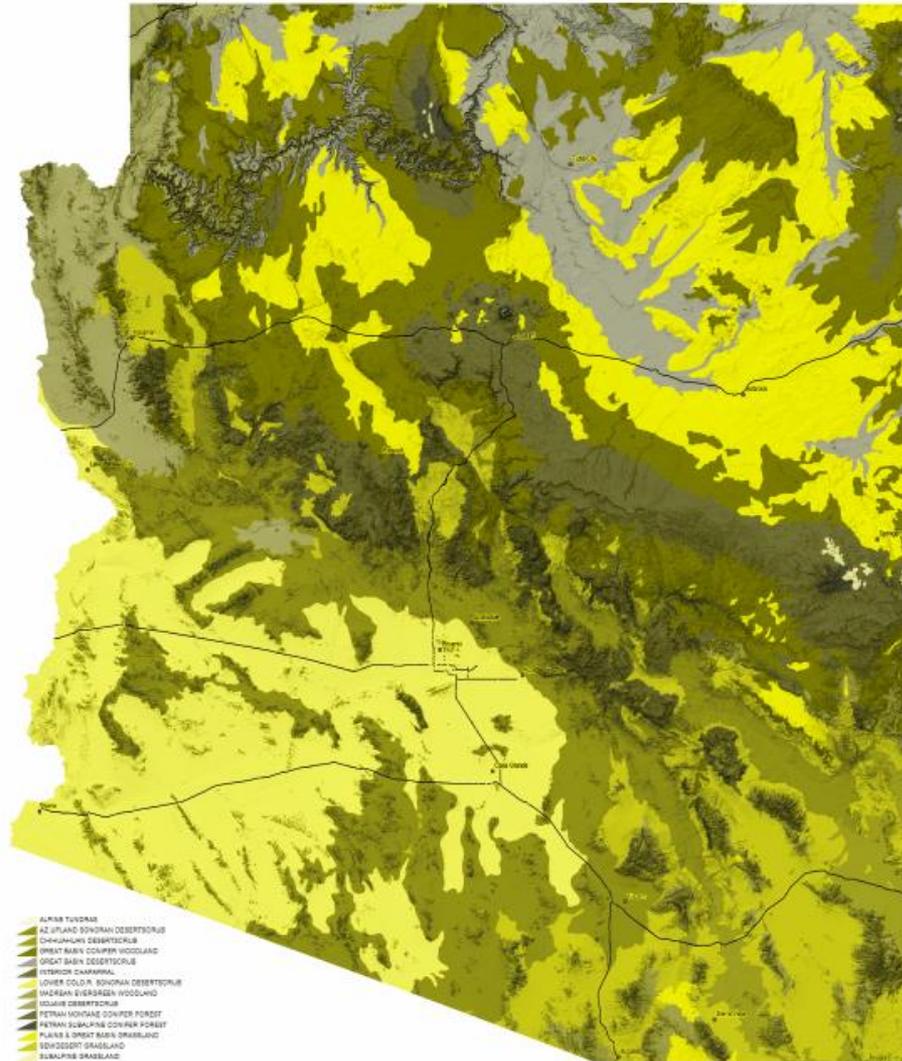
# Original Map



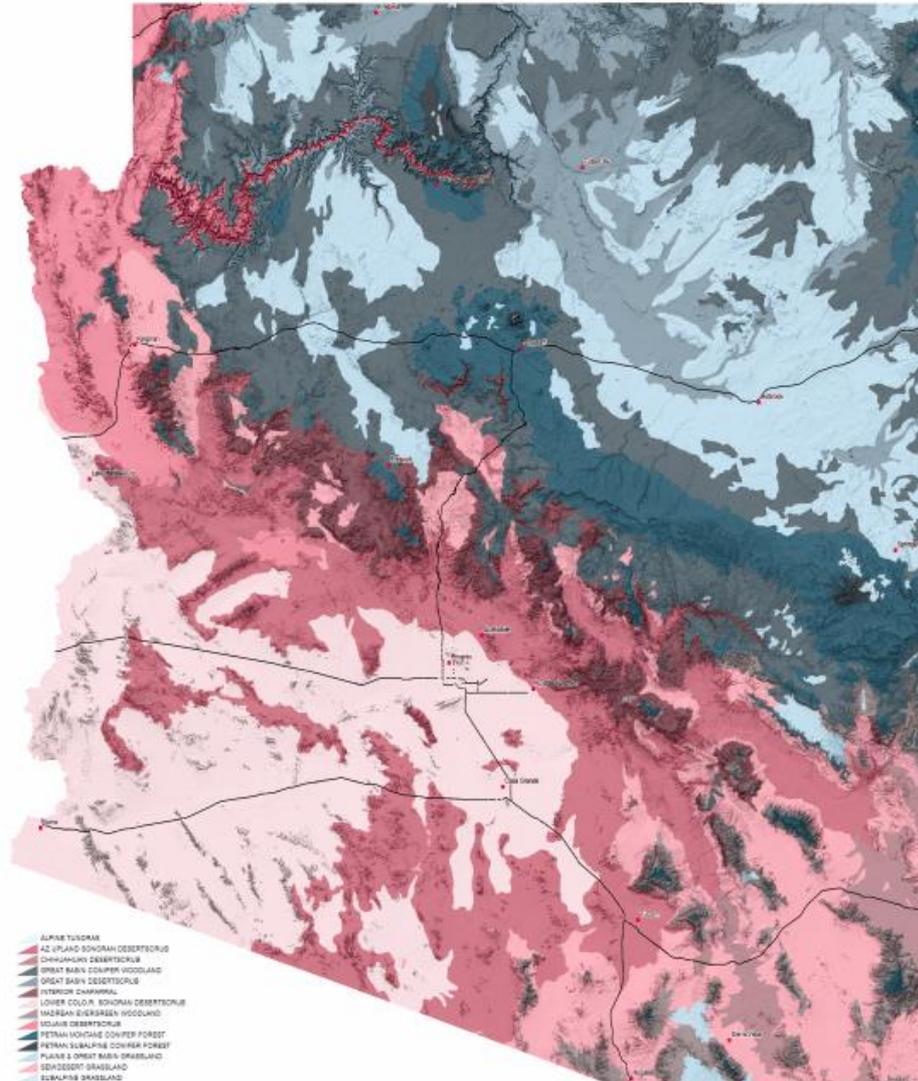
# Deuteranopia



# Protanopia



# Tritanopia



# Color Blindness – Point symbols

- Combine shapes with varied hue and saturation

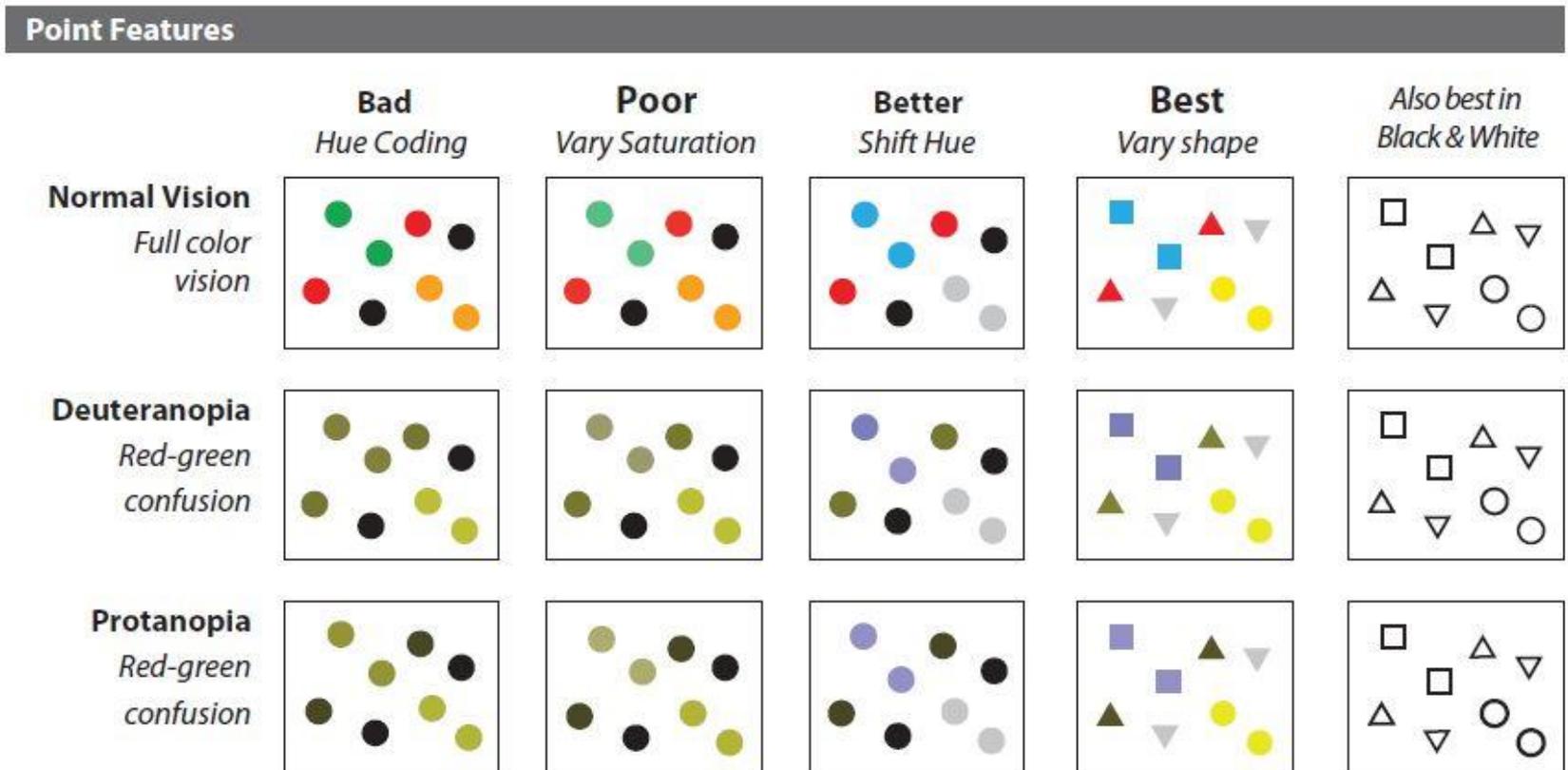


Figure 5. Point classes typical of a dot map distinguished by saturation, hue and shape.

# Color Blindness – Line symbols

- Vary the width, pattern, hue and/or saturation

## Line Features

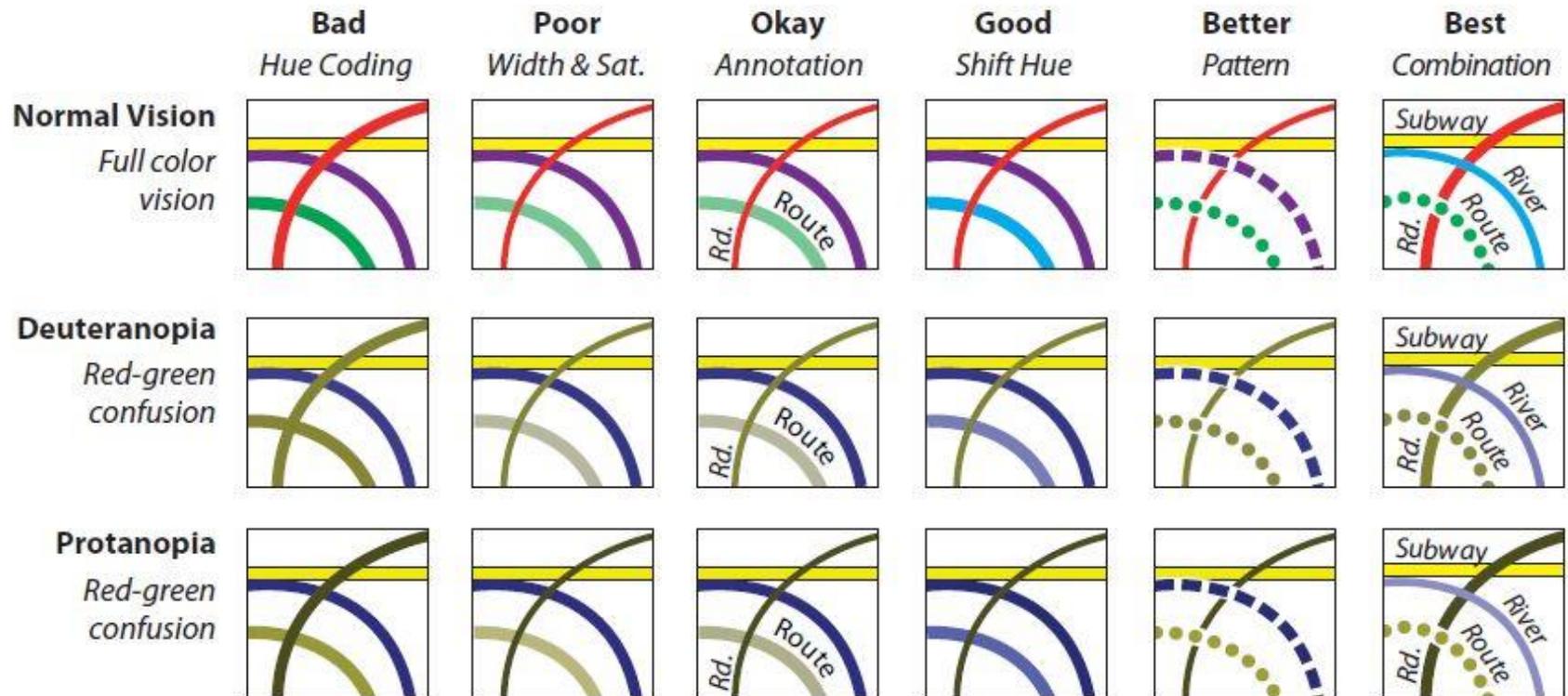
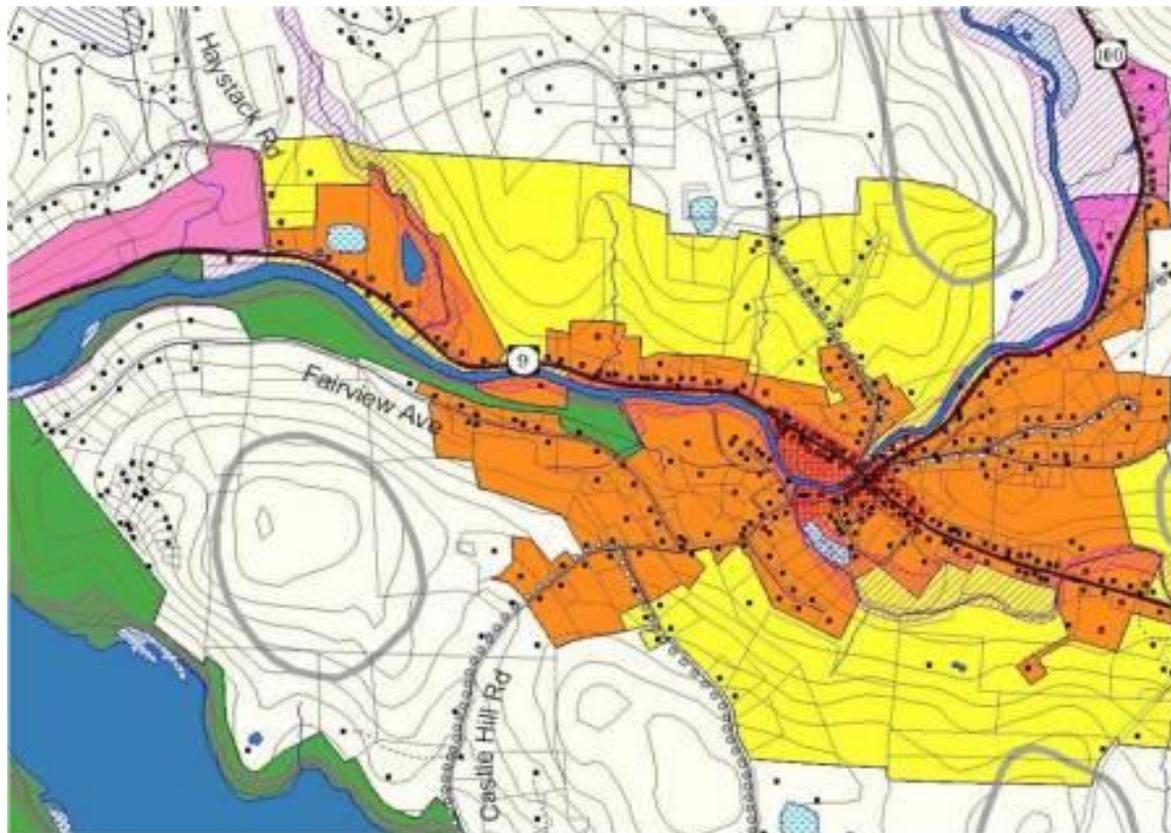


Figure 6. Line classes distinguished by width and saturation, annotation, hue and line pattern.

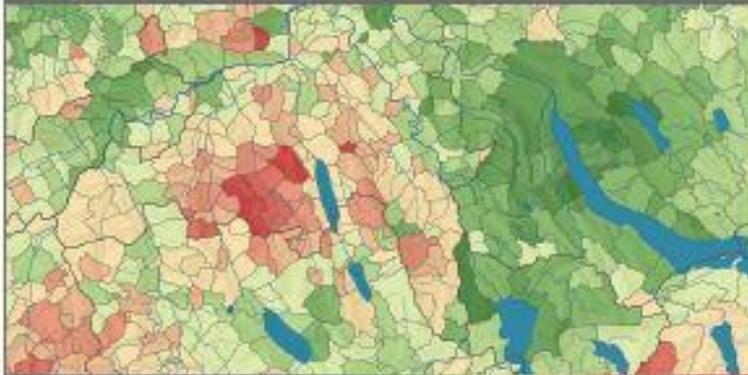
# Color Blindness – Area symbols

- Vary color hue and saturation, include pattern
- Limit color classes to 5 or less

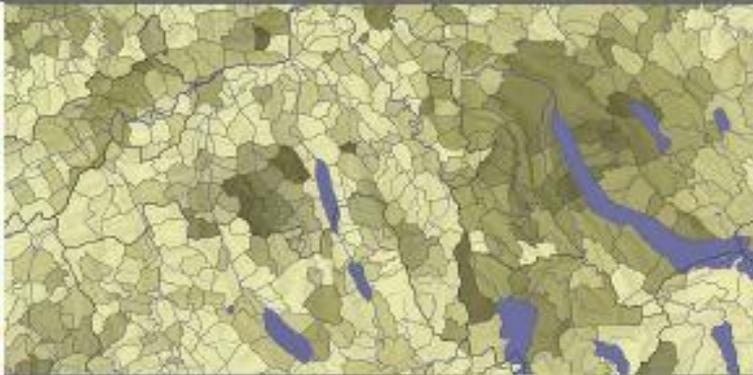


# Color Blindness – Area symbols

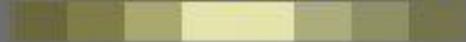
**Diverging Red-Green Color Scheme**



**Normal Vision**



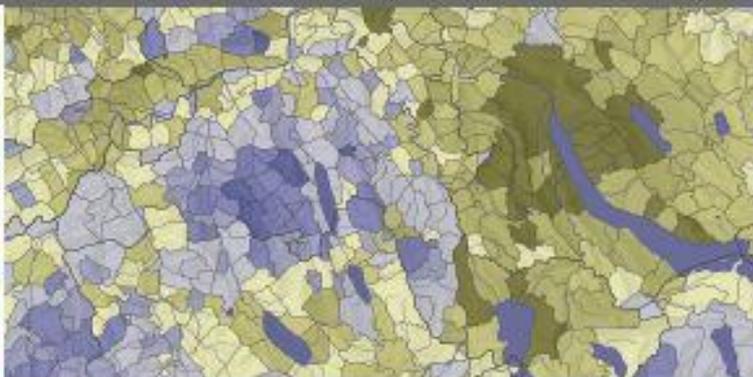
**Deuteranopia**



**Diverging Purple-Green Color Scheme**



**Normal Vision**



**Deuteranopia**



# Color Blindness – Label features



Figure 7. Annotation of metro lines and stations in the transportation diagram of Madrid.

# Tools for Cartographers

- <http://www.vischeck.com/>
- <http://colorbrewer2.org/>
- <http://colororacle.org/index.html>