

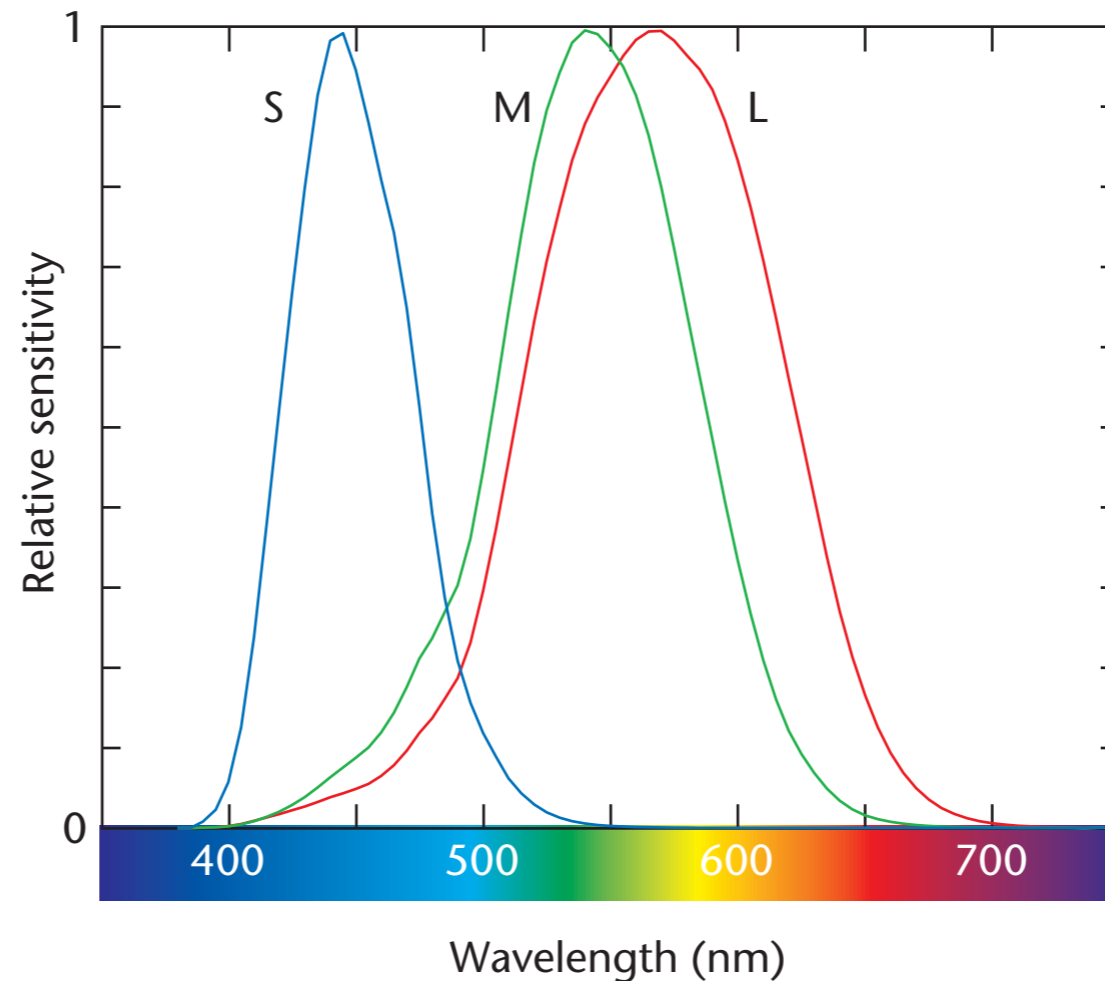
Topics in Data Visualization

Color

Jul 14 2014

How we see color

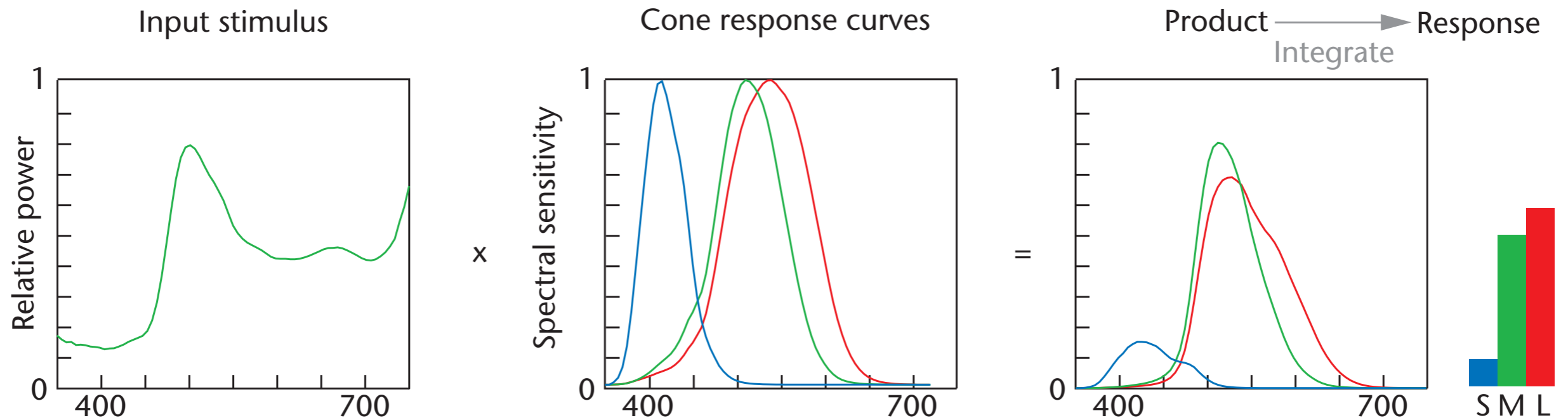
1 Spectral sensitivity curves for the short (blue), medium (green), and long (red) cones. The colored band shows approximate wavelength colors. (Reprinted by permission from A K Peters Ltd.)



We have three types of cones (color receptors) in our eyes.

They each have a different wavelength response function.

Trichromacy - we only need three numbers to accurately reflect how our eyes respond to visible light.



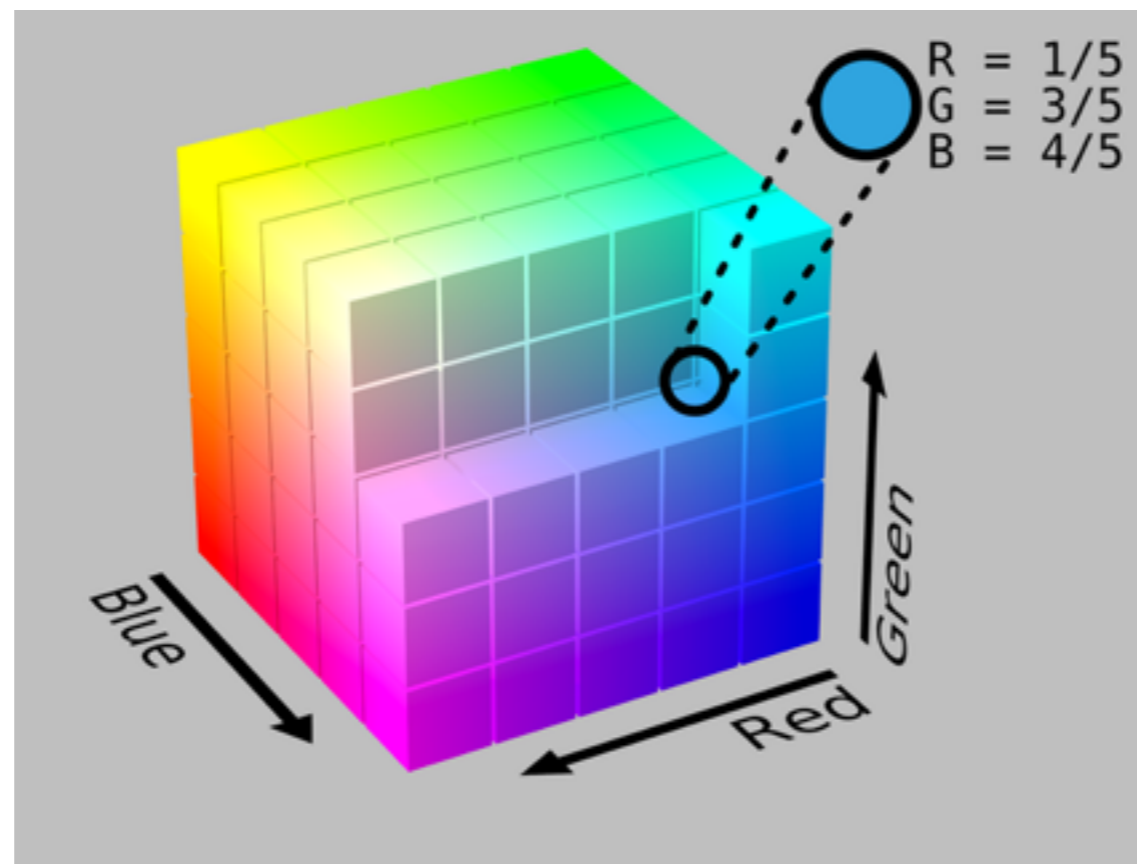
2 Multiplying a spectrum times the cone response curves and integrating the result creates the basic color signal to the brain. The height of the bars reflects the strength of the three signals. (Reprinted by permission from A K Peters Ltd.)

Since color is inherently three dimensional, we can match any color with three different colored lights, *primaries*.

How computers describe
color

Since color is inherently three dimensional, we can match any color with three different coloured lights, *primaries*.

This is how monitors work,



+ a definition of what color
R, G and B are

http://en.wikipedia.org/wiki/RGB_color_space

(R, G, B) - Scales differ, some use $[0, 1]$, some $[0, 255]$,
some $[0, 255]$ in hexadecimal

Colors in R

Colors for graphics devices are specified as hexadecimal sRGB color strings: "#E41A1C"

```
my_red <- "#E41A1C"
```

```
ggplot(diamonds) +  
  geom_point(aes(carat, price), color = my_red)
```

There are also a set of named colors:

```
colors()
```

```
ggplot(diamonds) +  
  geom_point(aes(carat, price), color = colors()[18])
```

How we perceive color

Other colorspaces

There are lot's of colorspaces (coordinate systems for describing color).

CIE XYZ - is the standard but not very intuitive

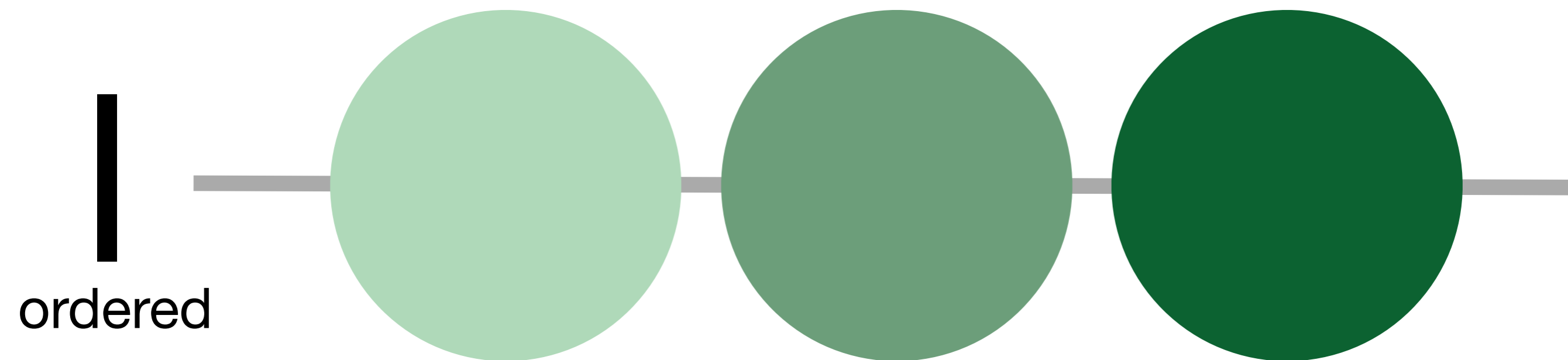
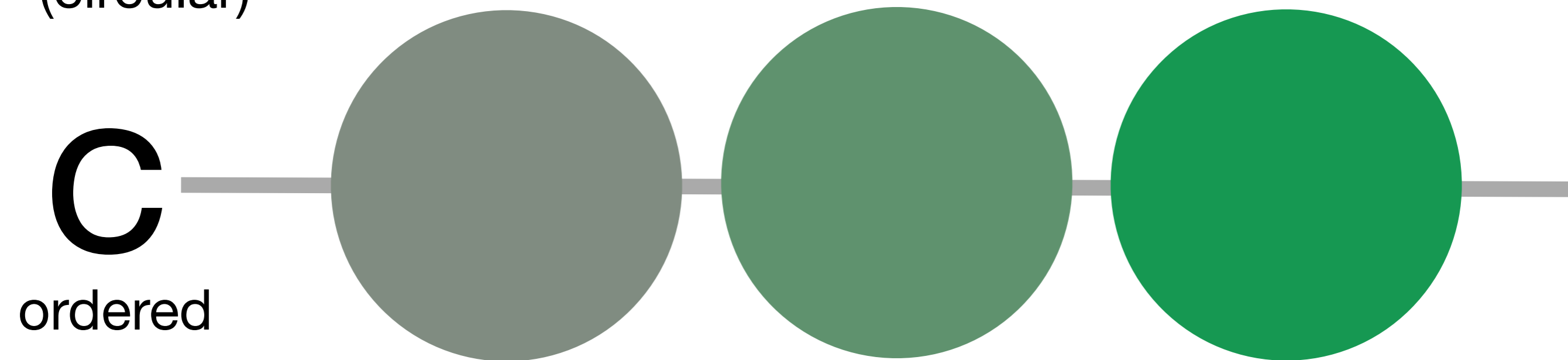
For graphics we want a colorspace that is:

- based on perceptual dimensions
- perceptually uniform (colors equidistant in the color space are perceptually equidistant)

Perception of color

We most naturally think about color in terms of three parameters.

- Hue – the property of color corresponding to wavelength (think colors of the rainbow)
- Chroma – is the color pure or dull
- Luminance/Lightness – think a scale from white to black



Match variable type to color scale

Continuous/ordered:

- vary chroma, luminance or both (ggplot2 default)
- sequential or diverging?
- hue as redundant coding

Discrete:

- equal impact, vary hue, hold chroma and luminance constant (ggplot default)

Experiment! What's the purpose? Is the purpose well served?

See also: <http://colorbrewer2.org/>

Other guidelines

Use saturated color when color coding small symbols, less saturated for larger areas.

Use luminance difference with background (and borders).

Avoid value and red together.

Beware colorblindness!

<http://colororacle.org/>

ggplot2

scale_colour_XXX & scale_fill_XXX

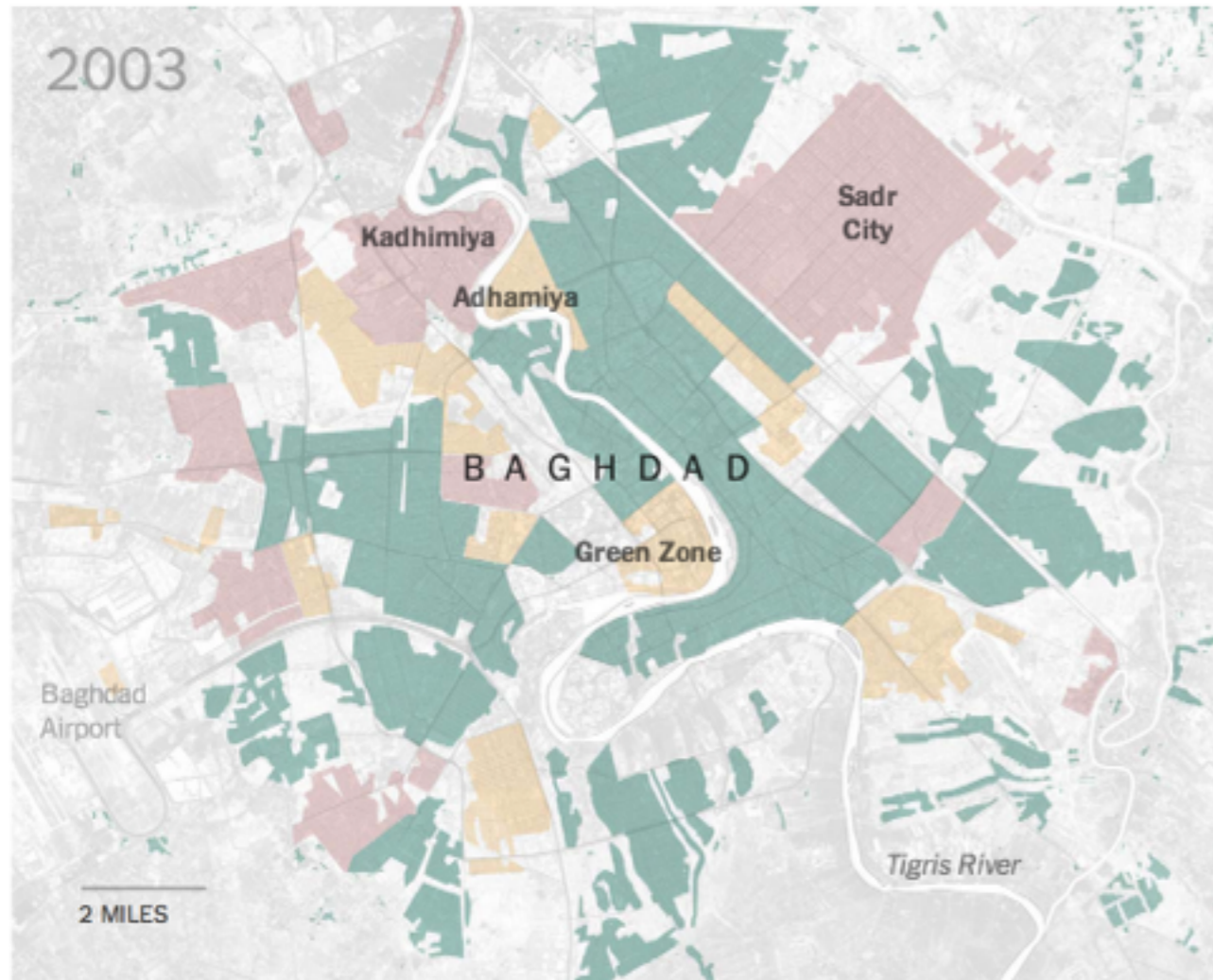
continuous

<u>gradient</u>	Sequential (2) color gradient
gradient2	Diverging (3) color gradient
gradientn	n color gradient
distiller	Gradient through brewer palette
grey	Grey gradient

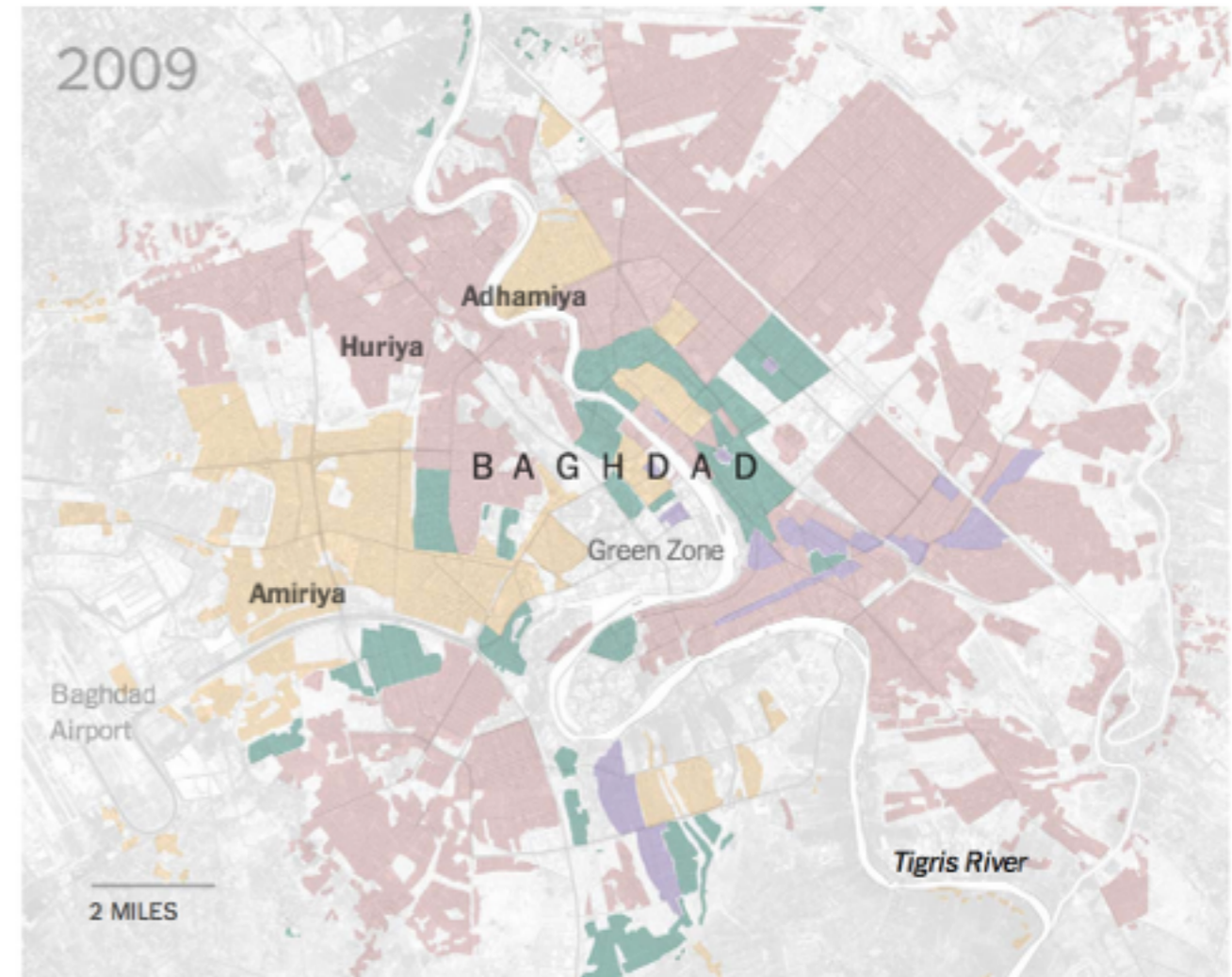
discrete

brewer	Brewer palette
<u>hue</u>	Hues with constant chroma and luminance
manual	Specify hex/named colors

KEY  Sunni majority  Shiite majority  Christian majority  Mixed areas

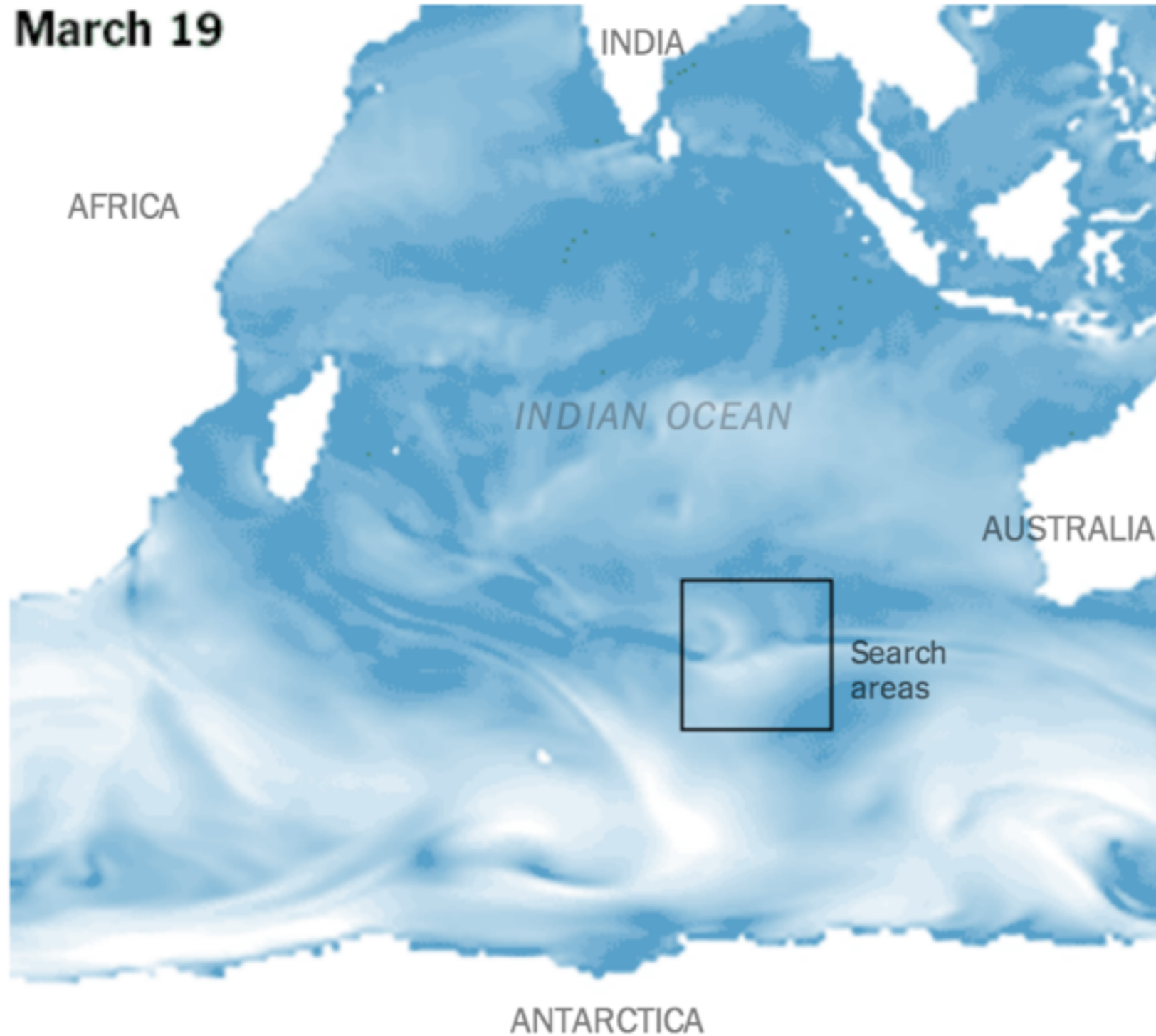


2003: Before the Invasion



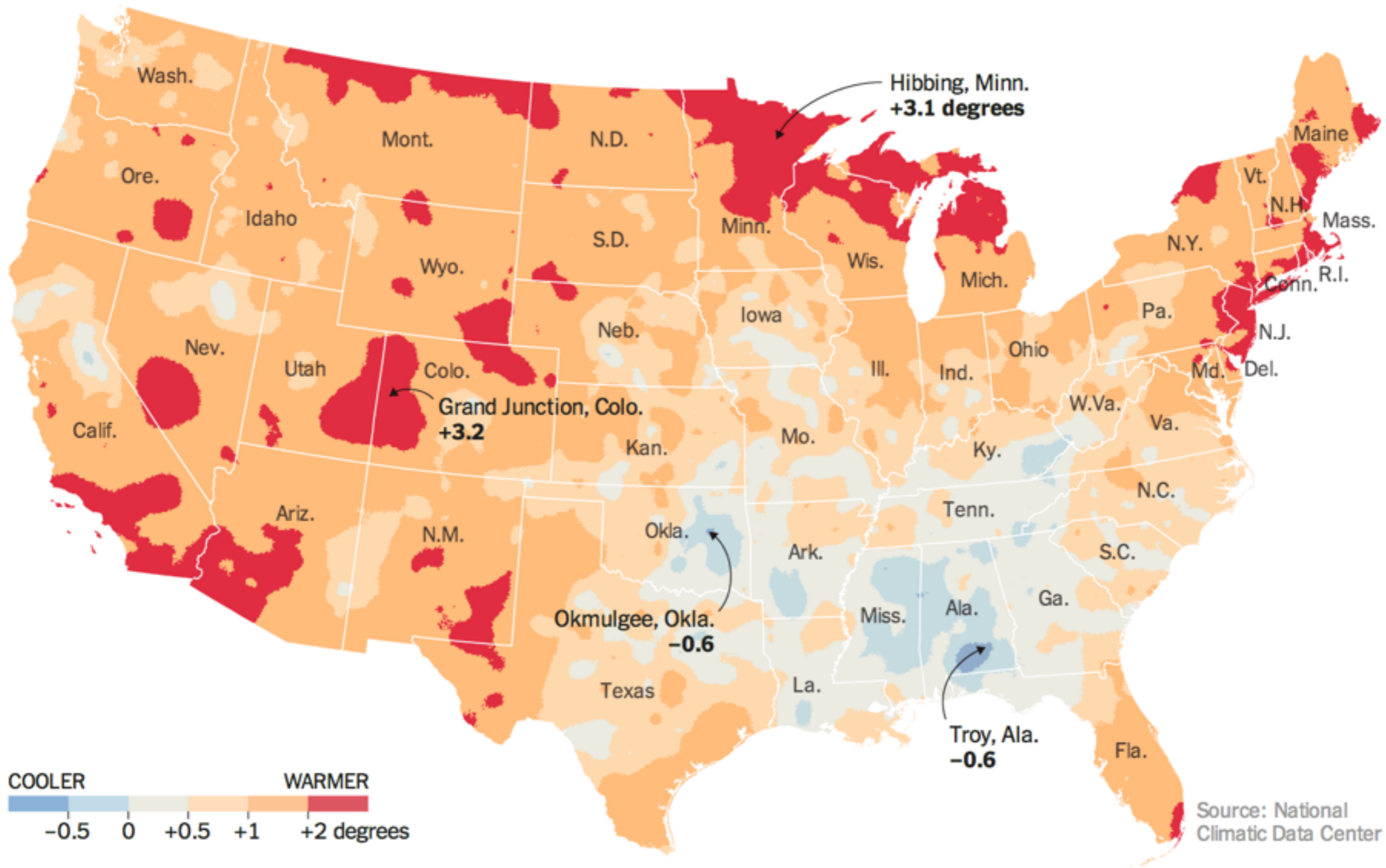
2009: Violence Fuels Segregation

<http://www.nytimes.com/interactive/2014/06/12/world/middleeast/the-iraq-isis-conflict-in-maps-photos-and-video.html#baghdad-sect-map>



Wind Speed LOW HIGH

Wind conditions differ dramatically within the search zone. In the southern part of the search area, wind speeds average around 20 miles per hour and, at times, exceed 100 m.p.h. In the northern sections of the search area, wind speeds average about 30 m.p.h.



Rising Temperatures

1991-2012 average temperature compared with 1901-1960 average

