Visualizing Spatial-temporal Interactions using Comparative Micromaps

Linda Williams Pickle

StatNet Consulting LLC

November 11, 2010

Outline

- Perception & cognition, impact on visualization design
- Data visualization design principles
- Comparative micromaps for time series data

Source: *Visualizing Data Patterns with Micromaps*, by Daniel B. Carr & Linda Williams Pickle, CRC Press, 2010

Visual Data Exploration

- Exploratory analysis is more interactive, less structured than classical statistical analysis
- Designer must offer interface options that satisfy needs of a range of users
- Today's computers can process massive amounts of data, but human mind has a greater ability to detect patterns
- Need to design considering our cognitive strengths & limitations to take advantage of this ability

A Model of Cognitive Processing

- Perceive information: most basic cognition, e.g., vision
- Comprehend, learn, store information in memory
- Integrate cognitive processes to reason, find solutions, make decision, or communicate

- Using a lower level process is faster, i.e., seeing is faster than thinking

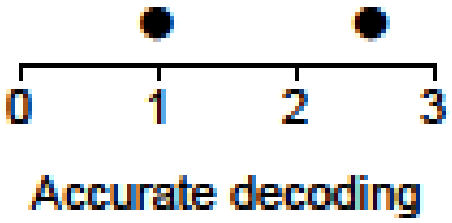
Perception & Cognition Impacting Visualization Design

- Sensation & perception
- Attention
- Color
- Memory

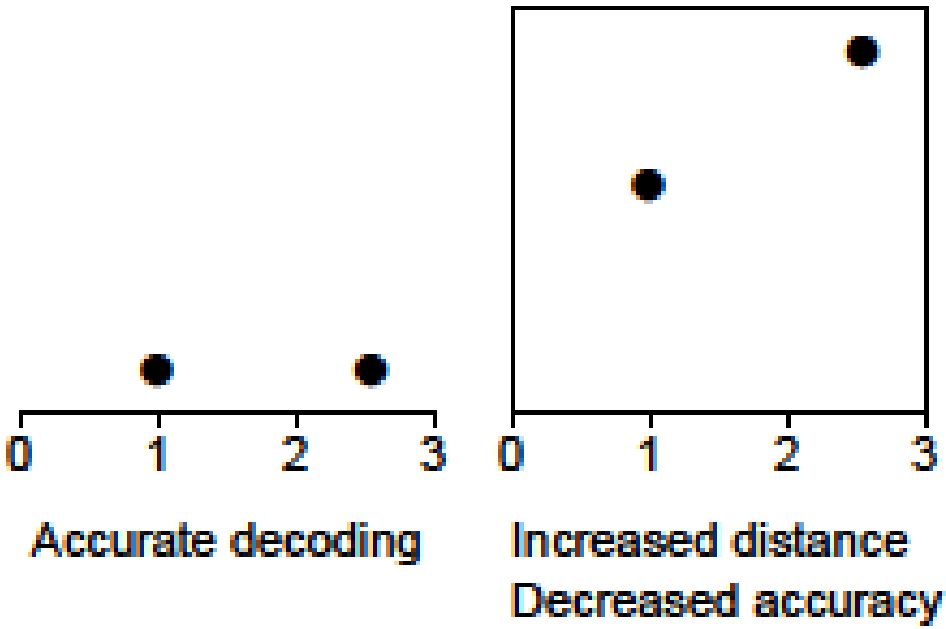
Sensation & Perception

- Sensation of characteristics of an item, e.g., color, texture, shape, in preattentive vision
  - Impacted by vision deficiencies, screen resolution
- Perception is translation of sensation to something meaningful, e.g., a quantity
- Lengths along a common scale are most accurately perceived, followed by lengths along nonaligned scales, angle, area, volume, curvature, color (Cleveland & McGill 1984)

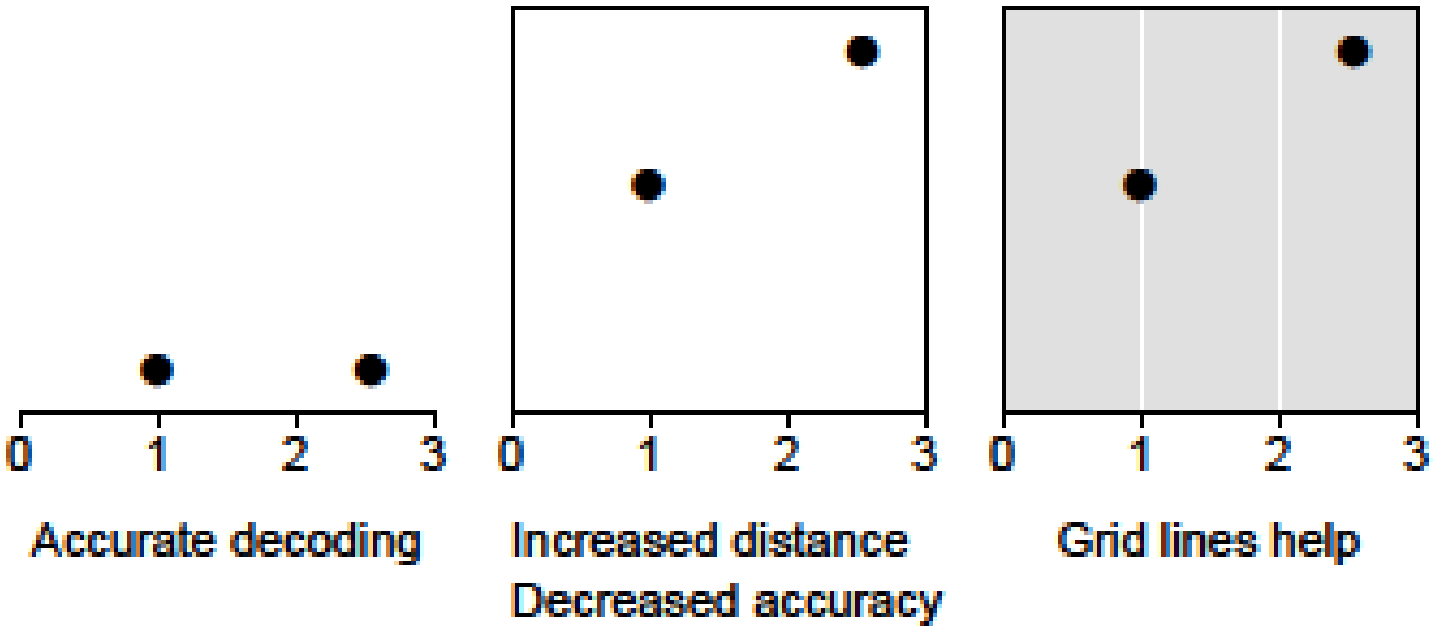
Helping the Reader Judge Line Lengths on an Aligned Scale



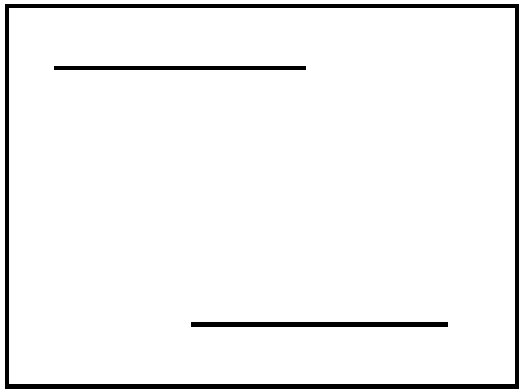
Helping the Reader Judge Line Lengths on an Aligned Scale



Helping the Reader Judge Line Lengths on an Aligned Scale

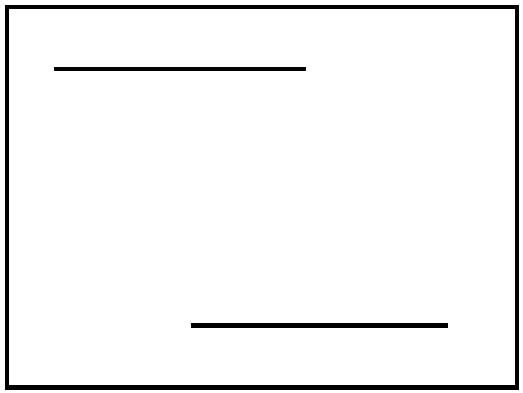


Helping the Reader Judge Line Lengths on a Non-aligned Scale

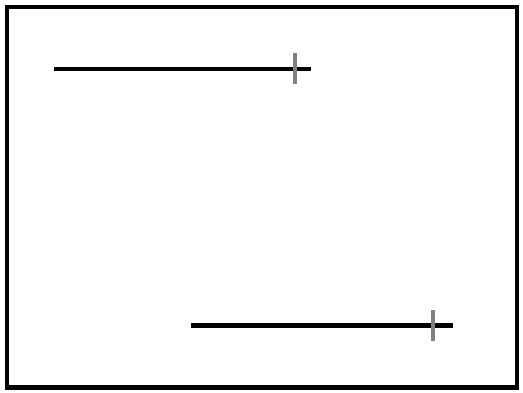


Is one line longer?

Helping the Reader Judge Line Lengths on a Non-aligned Scale



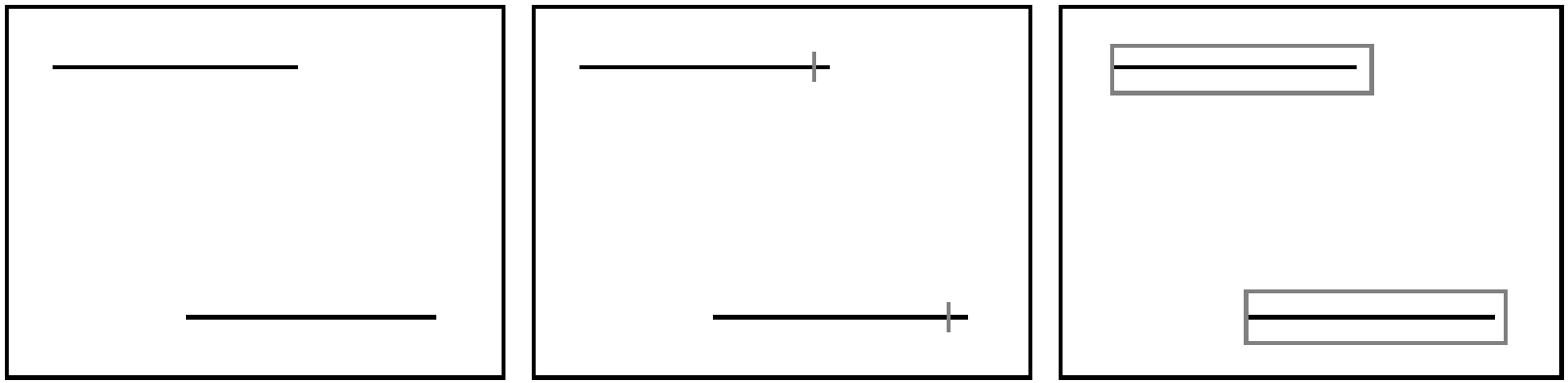
Is one line longer?



Mark a common length.

Compare right segments.

Helping the Reader Judge Line Lengths on a Non-aligned Scale

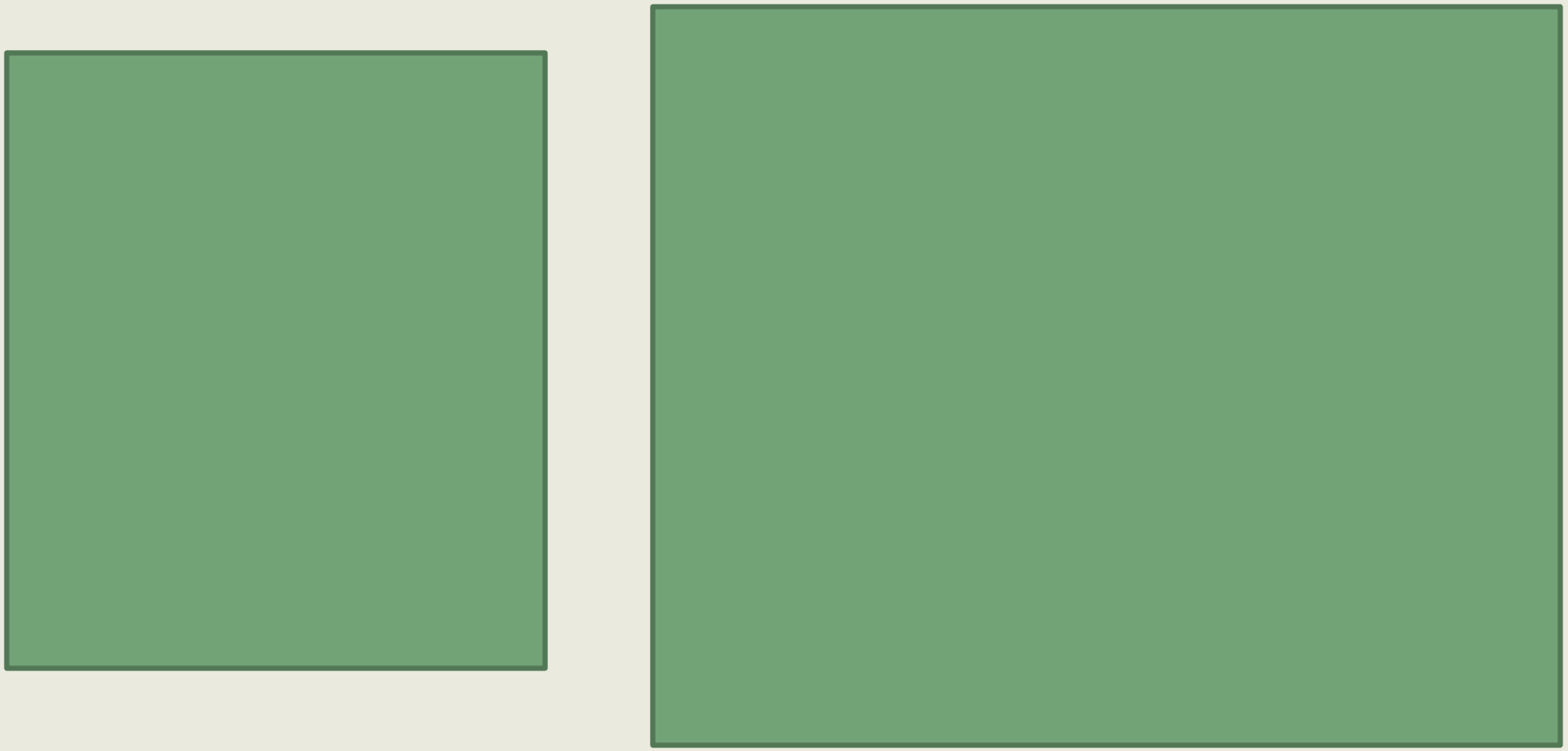


Is one line longer?

Mark a common length.
Compare right segments.

Add a common frame.
Compare right gaps.

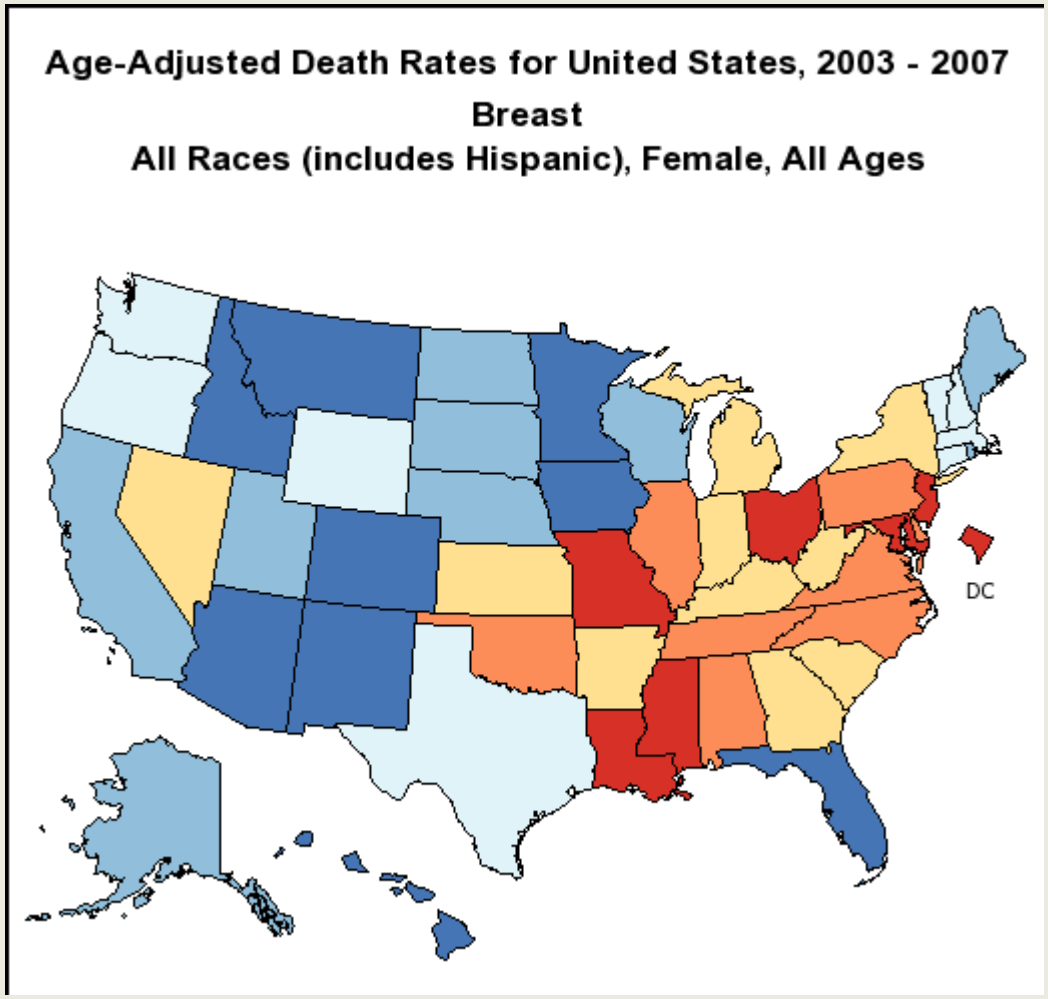
How much larger is right rectangle than the left one?

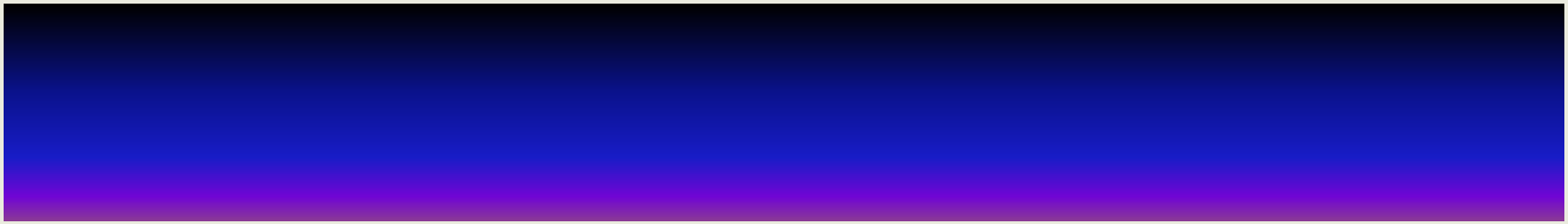


Attention

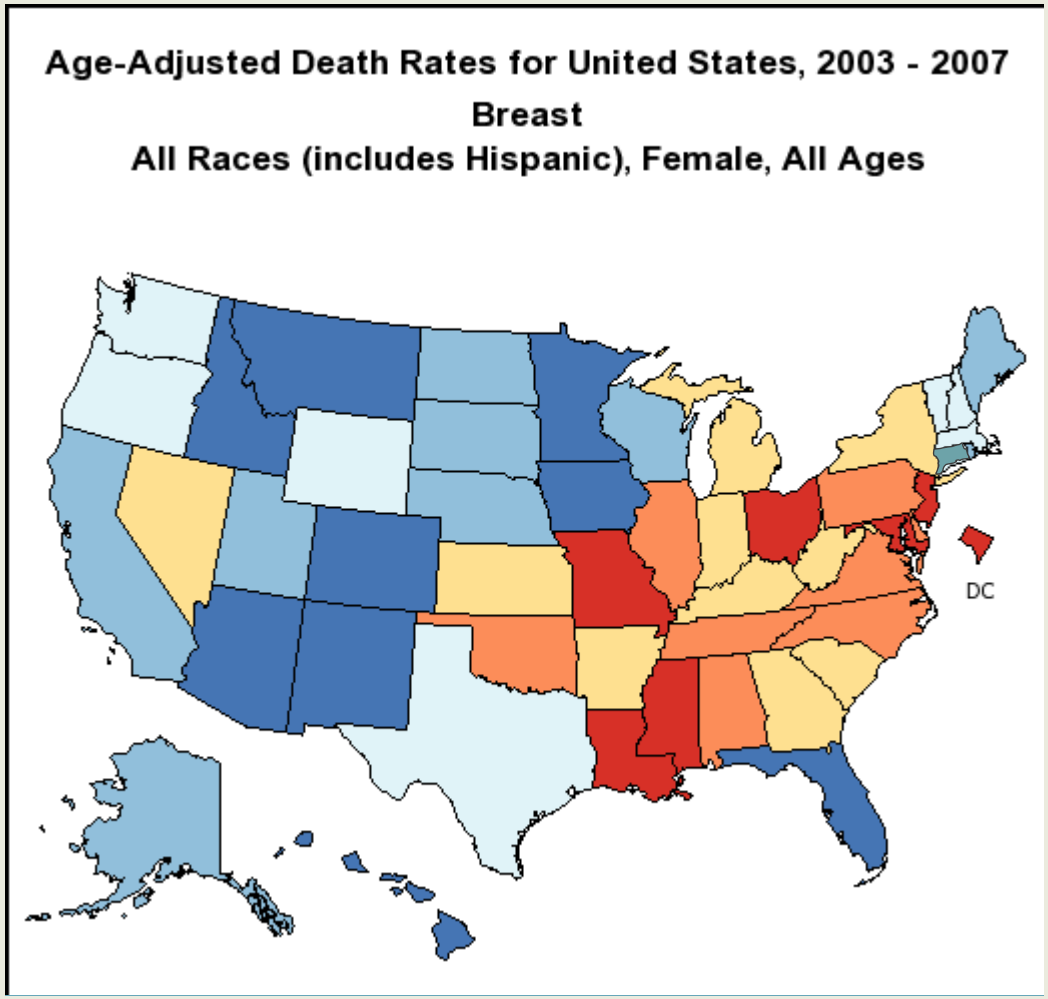
- In order to perceive visual stimulus, we must focus our attention on relevant part of image
- Types of blindness relevant to animation:
  - Inattentional blindness: looking at wrong part of image, e.g., attention drawn away by movement, saturated colors or large objects
  - Change blindness: 1st image mentally erased before 2nd image is seen, so differences not seen
  - Attentional blink: inability to see 2nd change in image if it occurs 200-500 msec after 1st change
- Span of attention: can attend to only 3 or 4 items at once

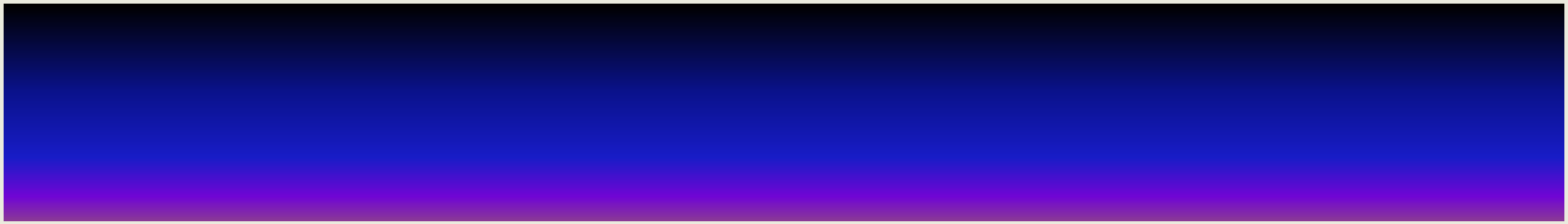
1st map



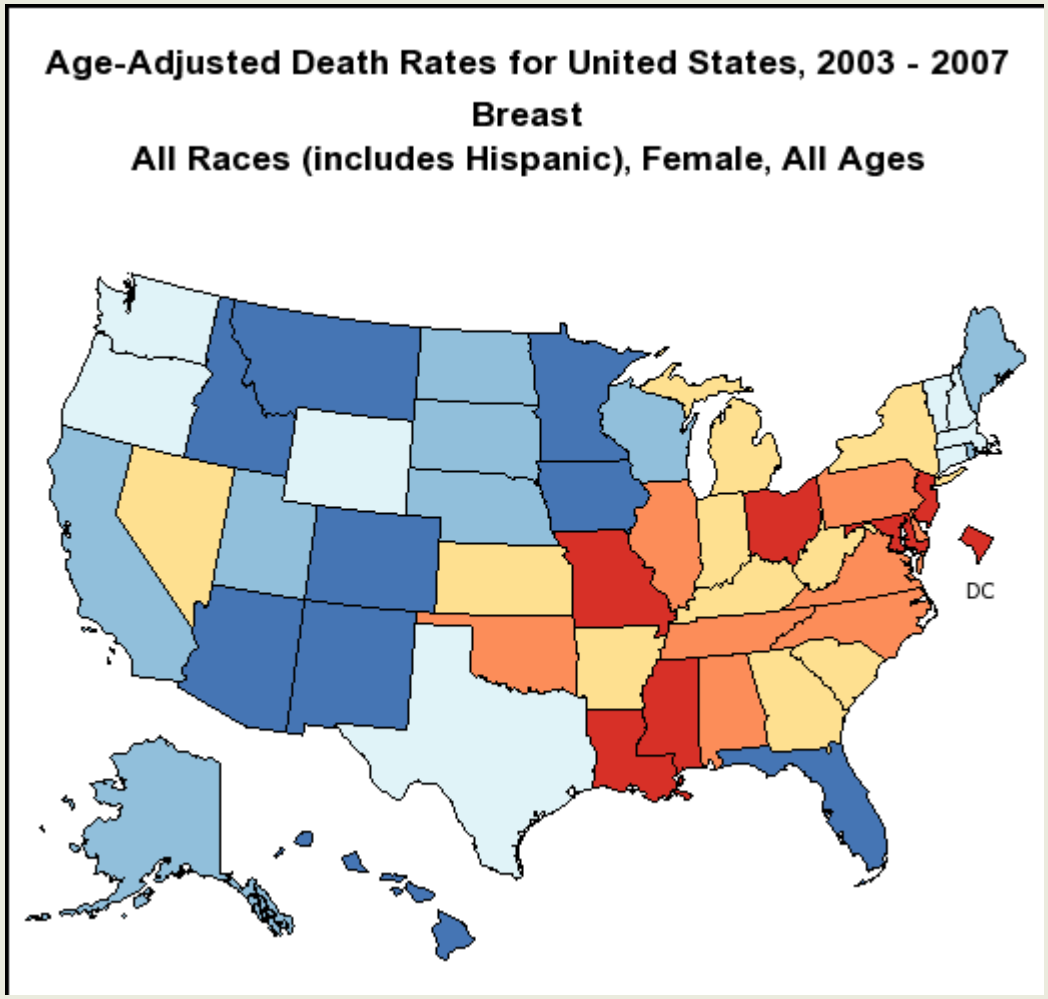


2nd map

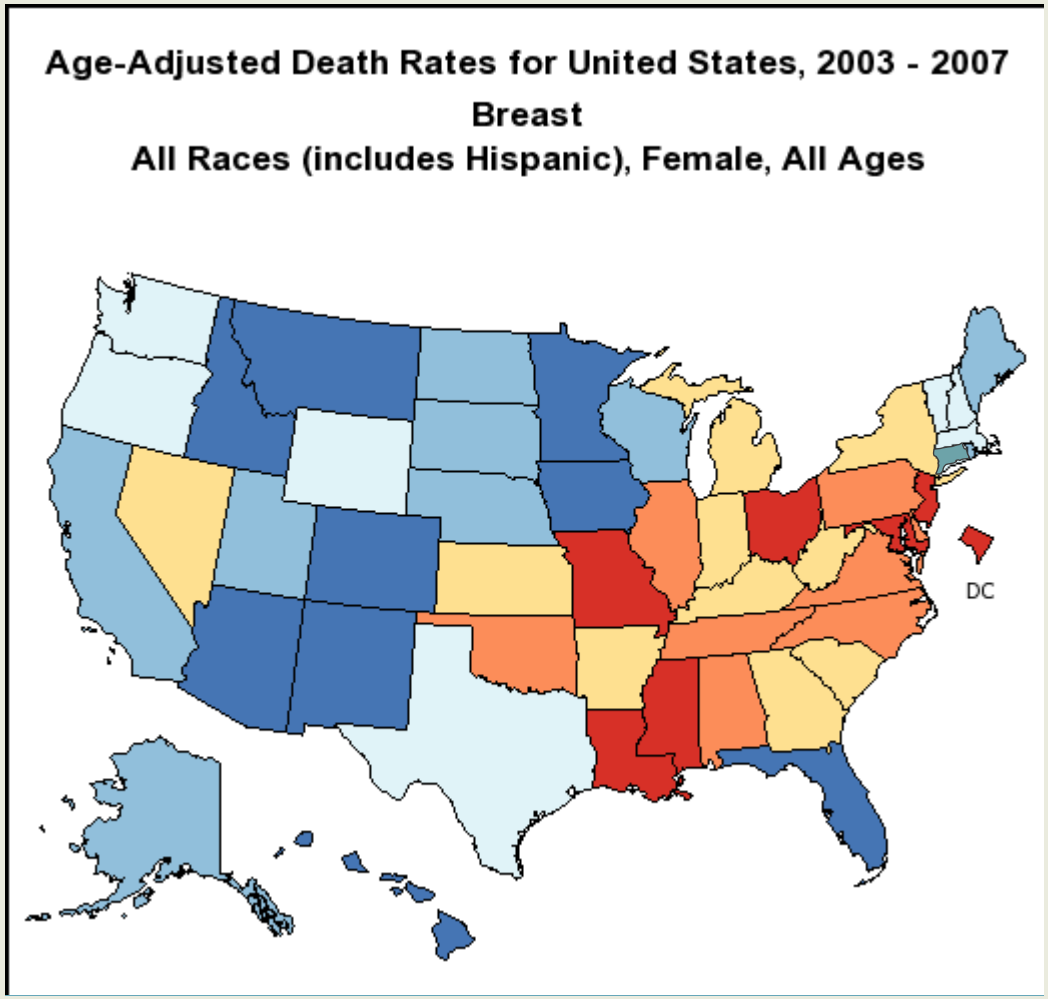




1st map



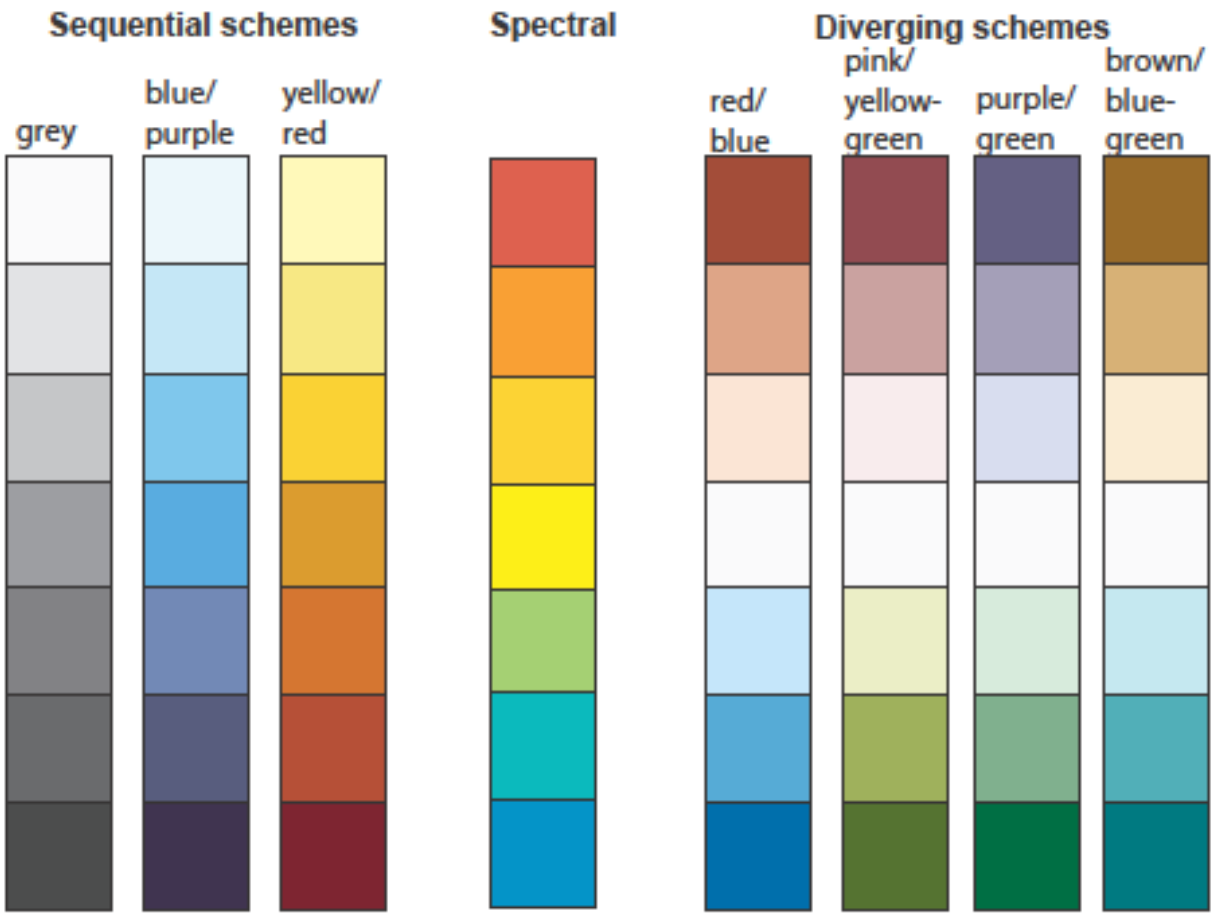
2nd map



Color

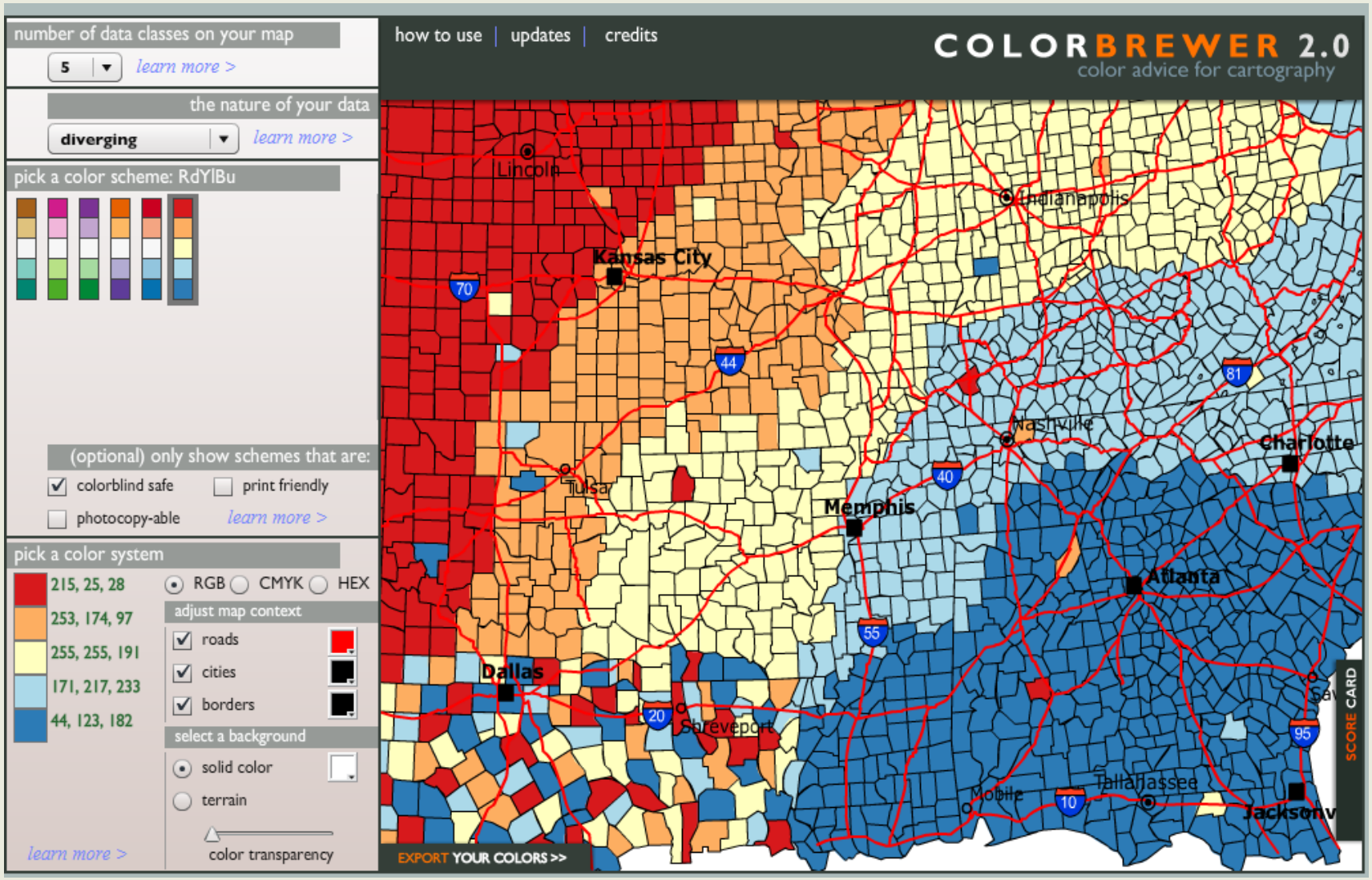
- Defined in 3D, e.g., Hue/Saturation/Value, RGB
- Hue differences best for encoding different attributes, e.g., in qualitative graph
- Varying saturation alone not perceived well, so encoding quantitative variables by both saturation & value (lightness) is best
- Perception affected by surrounding colors
- Color conventions matter: warmer or darker color for higher quantities

Good Map Color Schemes



Brewer, MacEachren, Pickle 1997

www.ColorBrewer.org
Color Advice for Cartography

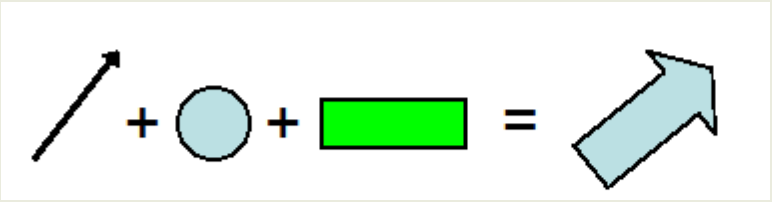


Memory

- Very short-term (iconic) memory: stores visual images for up to 0.5 seconds
- Working memory controls flow of information
  - Receives images from iconic memory, saves for up to 20-30 seconds
  - Stores info into long-term memory after new info is integrated with prior knowledge
  - Retrieves images from long-term memory as needed

How to Extend Working Memory

- Integrate multiple data attributes into 1 glyph; we can examine each attribute separately (encoding is separable)



- Perceptual grouping of objects (n = 3 to 5) so each chunk is more easily remembered
  - Can group by proximity, color, lines, etc.

Improving Long-term Memory

- Retention & remembering = storage & retrieval to/from long-term memory
- Add visual cues, e.g., color legends on maps
- Visualize an image of encoded values, e.g., can remember pattern on map but not all #s on it
- Embed information within something familiar, e.g., song or story (“stickiness”)

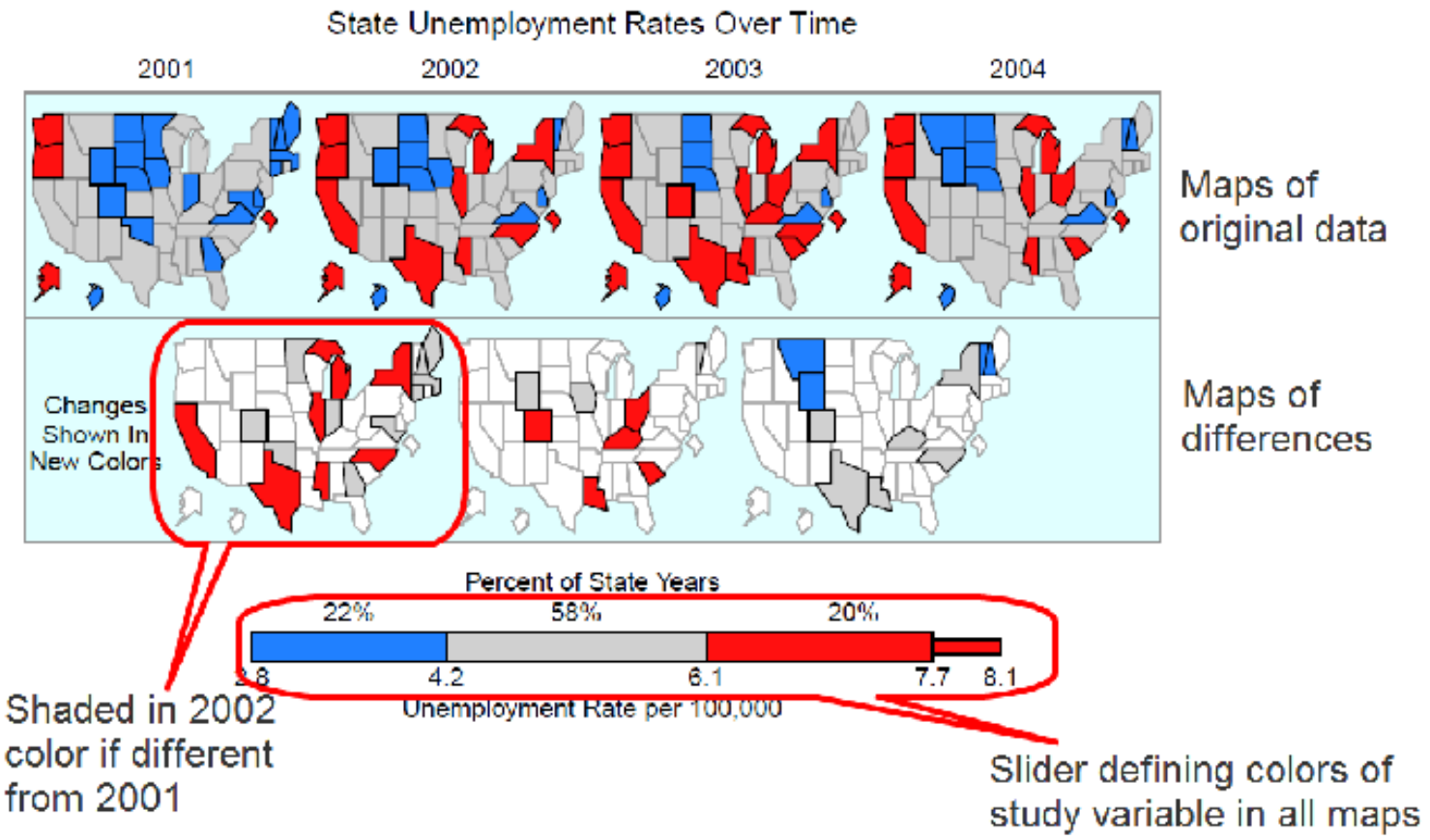
Data Visualization Design Principles

- Enable accurate comparisons
- Strive for simple appearance
- Engage the analyst

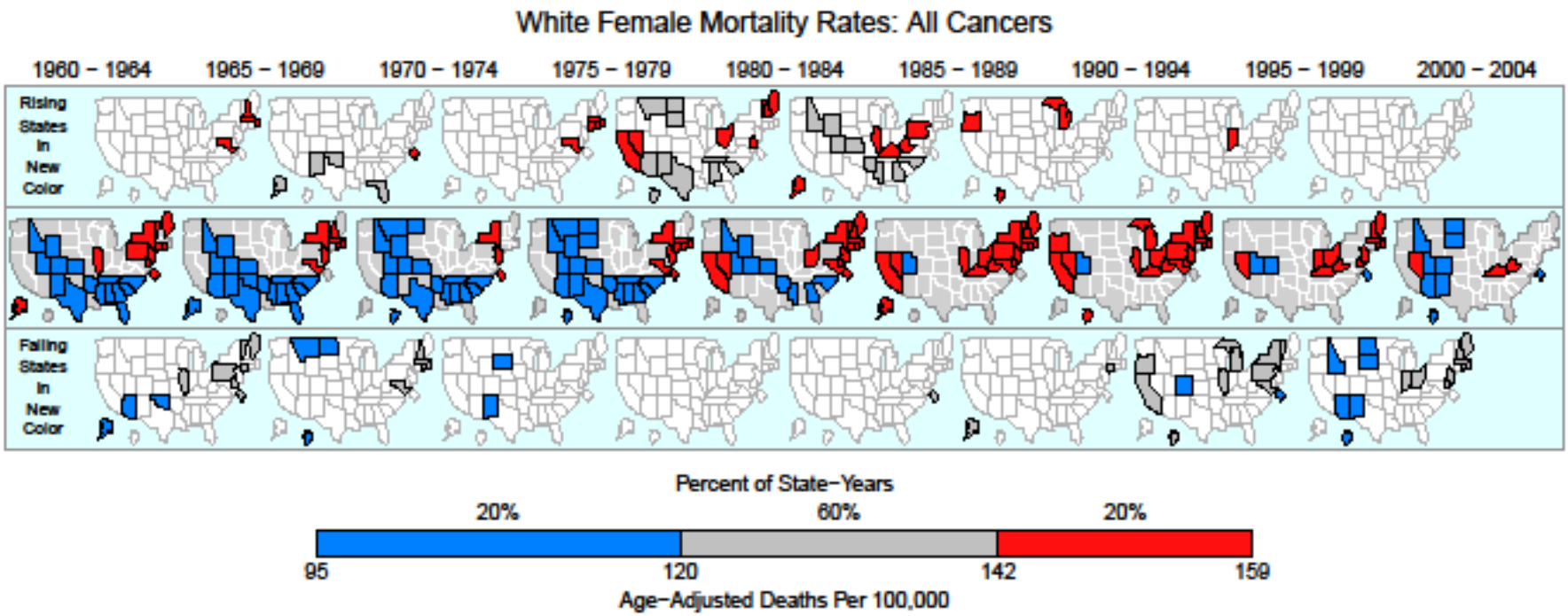
Comparative Micromap Design Principles

- Purpose: show spatial-temporal patterns
- Show small multiples of maps rather than animation to avoid change blindness & limited working memory
- Show pairwise differences between maps in order to use most basic cognitive process to judge patterns; i.e., seeing explicit differences is quicker than calculating them

Comparative Micromaps for Time Series

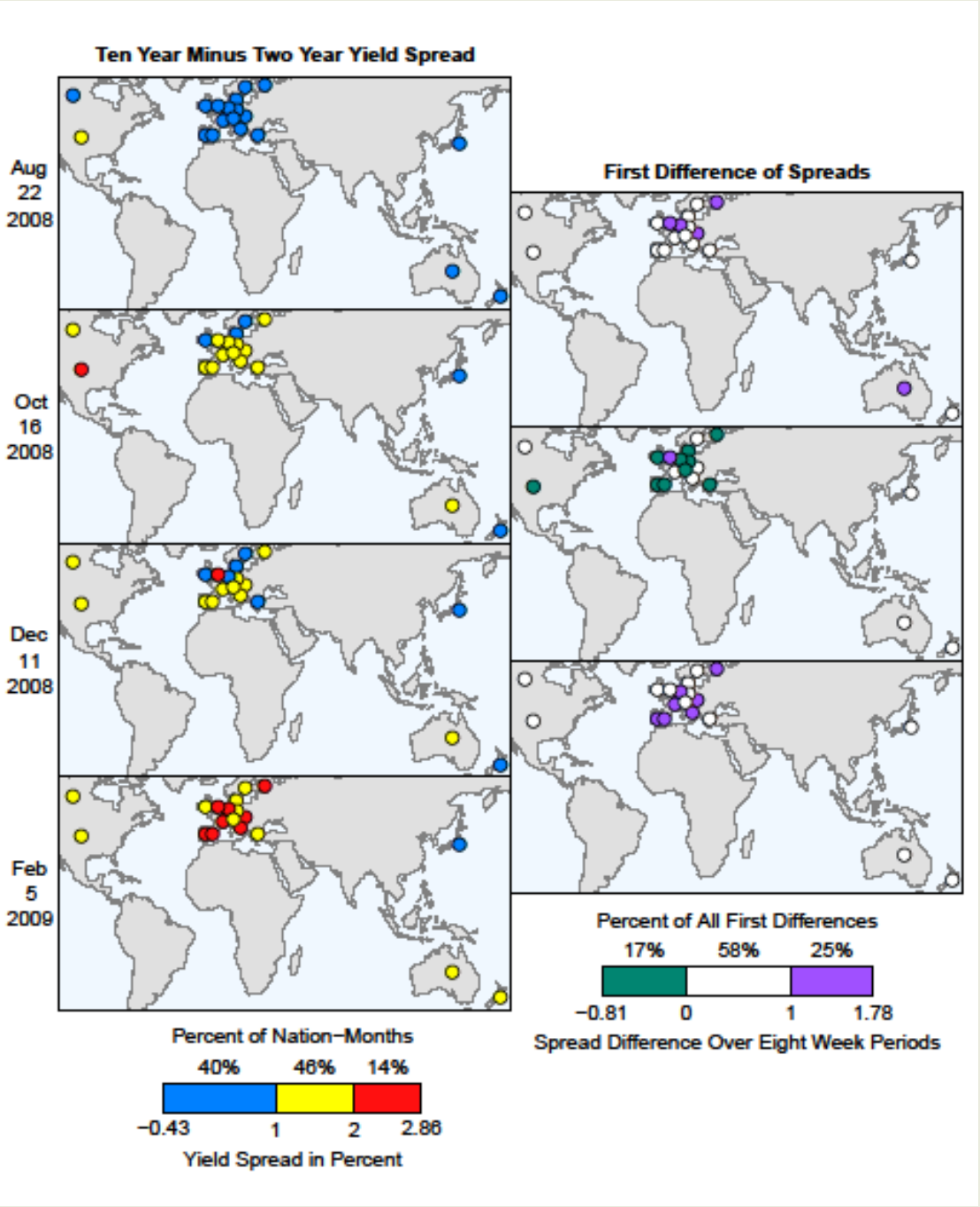


A Long Time Series with Differences Shown in 2 Rows

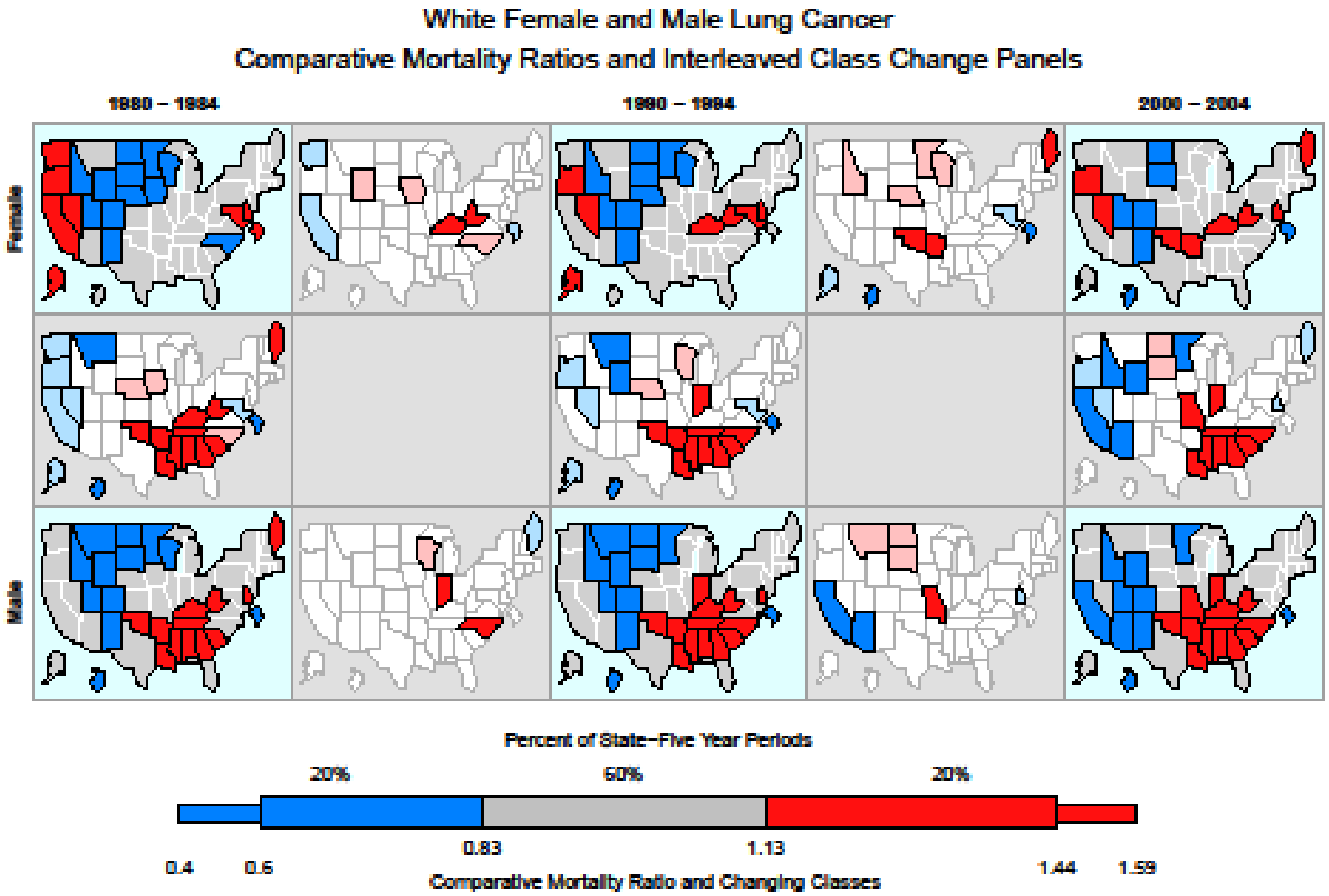


Comparative Micromaps with Symbols

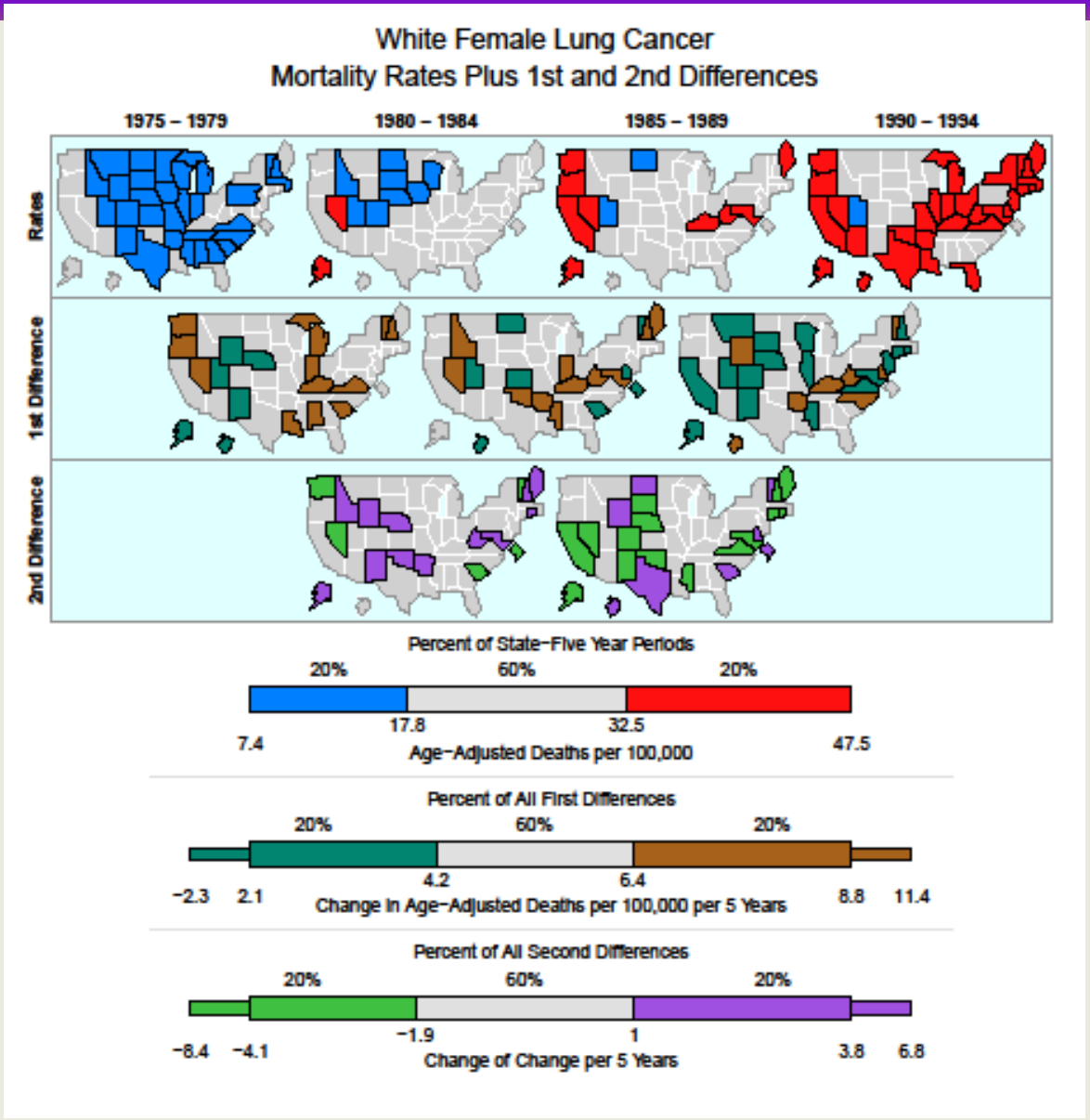
- Simplified country boundaries
- Reduced ocean areas
- Rotated from standard row orientation due to aspect ratio



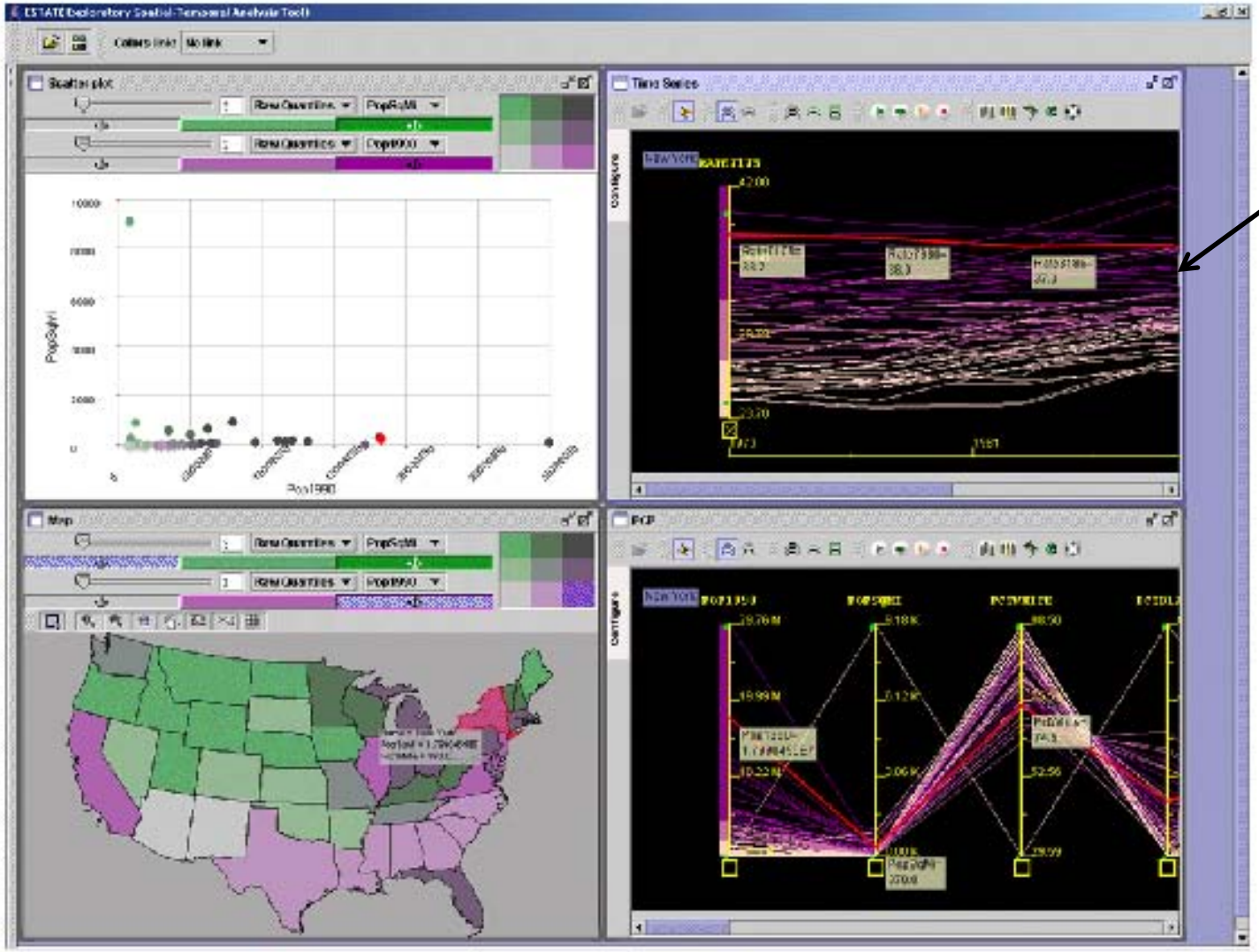
Comparative Micromaps for 2 Categories



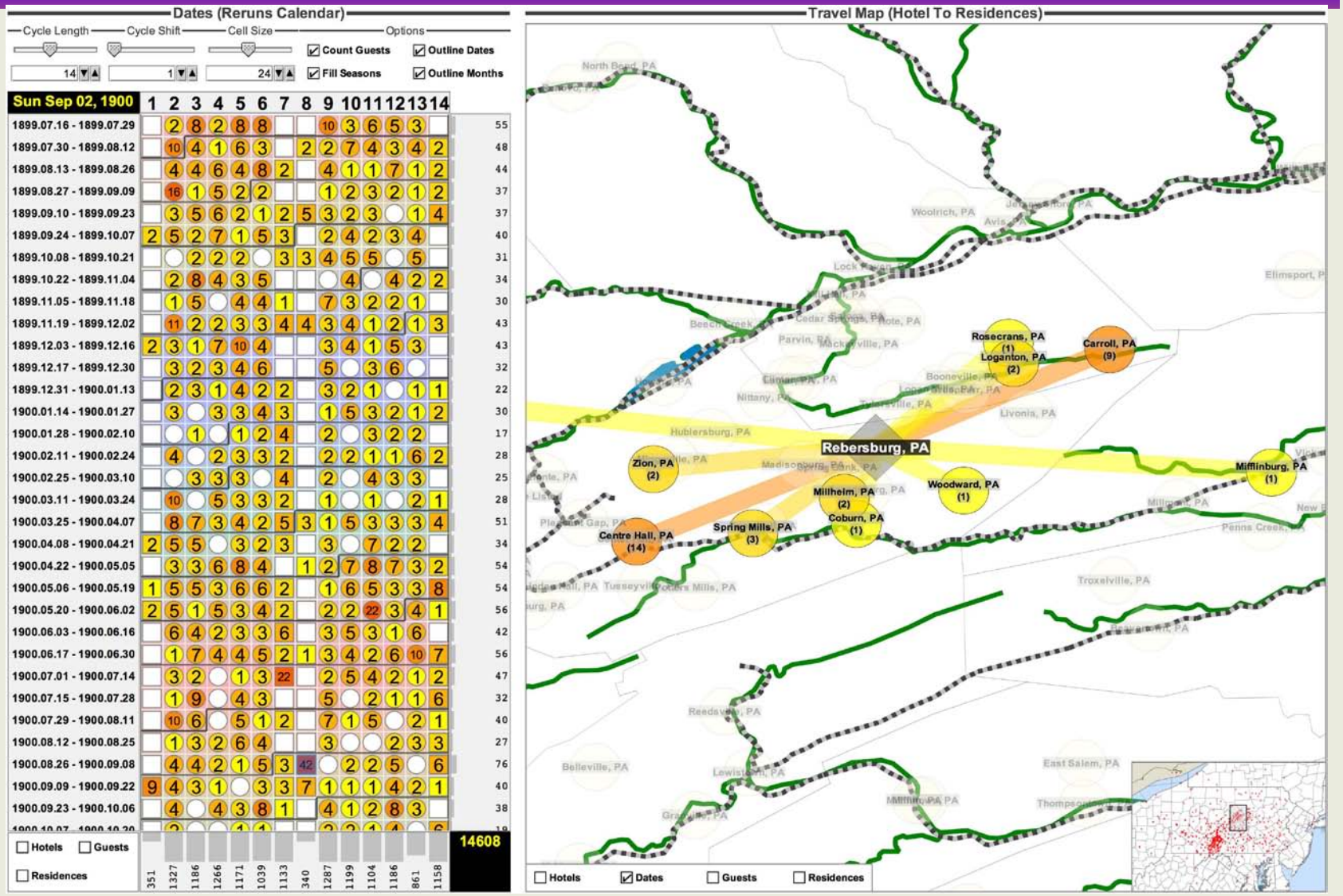
Extending Comparative Micromaps to Show 1st & 2nd Differences



Alternative Presentation: Linked Windows



Alternative Presentation: Variable-width Temporal Window



Source: *Visualizing Data Patterns with Micromaps*, by Daniel B. Carr & Linda Williams Pickle, CRC Press, 2010

Questions: Linda@StatNetConsulting.com