Purpose and audience
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Number and types of features on maps

Internal > external audience

Special Use Maps
- Trail Map
- Campus Map

Reference Maps
- Topo Map
- Atlas Reference Map

Analysis Results
- Suitability Map
- Crime Hot Spots

Thematic Maps
- Census Data
- Atlas Thematic Map

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Audience

- Complexity of content
- Complexity of language
- Amount of contextual information

- Professionals like you
- Other professionals
- General public
- Policy makers
Cartography Cubed (Cartography$^3$)
Nature of the phenomena

- **Topographic**
  - Land form > hydrography > land cover / land use > human features
- **Environmental**
  - Physical phenomena and processes, e.g., hydrography
- **Network**
  - Connectivity, flow, e.g., traffic
- **Navigation**
  - Networks, orientation, route finding features, e.g., aeronautical charts
- **Demographic**
  - Statistics, sampling, enumeration areas
Data

- **Characteristics**
  - Spatially discrete / continuous
  - Qualitative / quantitative
  - Point, line, polygon, surface, volume
  - Temporal

- **Special characteristics**
  - Important values (mean, threshold, etc.)
  - Zero values
  - Missing data or unknown values
  - Uncertainty
Data

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  - Qualitative / quantitative
  - Point, line, polygon, surface, volume
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  - Important values (mean, threshold, etc.)
  - Zero values
  - Missing data or unknown values
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Switching between numeration areas

- Areal interpolation
  - Reaggregation of data from one set of polygons to another set of polygons
- A geostatistical interpolation technique that extends kriging theory to data averaged or aggregated over polygons

Obesity rates in school zones
Obesity density surface
Predicted rates for census block
Classing data
Classing data

Stepped Statistical Surface
Classing data

Smoothed Statistical Surface

Constant Isarithmic Interval
Classing data

- Look at the histogram
- Start with a standard classification (usually natural breaks)
- Adjust breaks to improve the map based on knowledge of the data and the audience
Classification schemes

- **Quantiles** - the same number of enumeration units assigned to each class; variation in calculated values produced by different types of standardization may be usefully seen as ranked values.

- **Equal intervals** - breaks the data range into equal segments for predictable and equal class ranges.

- **Natural breaks** - minimizes variation within classes and maximize variation between classes; enumeration units that share a color are statistically more similar to each other than to units in other color classes.

- **Standard deviations** - shows you how much a feature's attribute value varies from the mean; class breaks are created with equal value ranges that are a proportion of the standard deviation, usually at intervals of 1, \( \frac{1}{2} \), \( \frac{1}{3} \), or \( \frac{1}{4} \) standard deviations.
Classification schemes

• Three classifications of the same data set showing different patterns resulting from different classing methods
  - (a) quantile
  - (b) equal interval
  - (c) natural breaks

• The number of counties in each class is shown to the right of each legend
Adjusting classes

• A useful adjustment is to group extreme outliers into their own class and then class the rest of the data range using a standard method.

• Ex - High and low extreme values grouped into separate classes with the remaining range classed using equal intervals.

• When there are many zero values in a data set, it works well to separate them into their own class and then class the remainder of the data set.
Adjusting classes

- Apply natural breaks for good statistical breaks
- Then adjust classes to include the national rate
- Round data values to assist map reading by a general audience
Number of classes

- The more classes used, the less changeable the map pattern will be with different classing methods and adjustments.
- There are diminishing returns with increasing numbers of classes, and it becomes difficult to assign colors that readers can tell apart with too many classes.
- **Seven classes** is often the most you will want to use on a statistical map with classed values.
- An optimal number of classes can be found by examining diminishing reductions in variance with increasing numbers of classes.
Things to note

- A value can only belong to one class
  - 1-9, 10-19, 20-29, etc…
Things to note

• A value can only belong to one class
  - 1-9, 10-19, 20-29, etc…
  - Label breaks instead
Things to note

- A value can only belong to one class
  - 1-9, 10-19, 20-29, etc...
  - Label breaks instead

- Possibly add labels
  - Adds immediate understanding
  - Could change visual impression
Labeling features with values
Cartographic symbolization
Cartographic symbolization

Qualitative / quantitative + Point, line, polygon + Visual variables = Cartographic symbolization
Visual variables

<table>
<thead>
<tr>
<th>Points</th>
<th>Lines</th>
<th>Areas</th>
<th>Best to show</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape</strong></td>
<td>possible, but too weird to show</td>
<td>cartogram</td>
<td></td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td></td>
<td>cartogram</td>
<td></td>
</tr>
<tr>
<td><strong>Color Hue</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Color Value</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Color Intensity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Texture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Try to guess this
Visual variables

- Qualitative
  - Shape
  - Color hue
- Quantitative
  - Size
  - Color value
  - Color intensity
  - Texture
Color variables

- **Hue**

- **Value / lightness**

- **Intensity / saturation / chroma**

Often used together
Qualitative data

- Color hue symbolizes categorical difference in counts for two race groups.
- Pie chart symbols are scaled to a constant size and show relative proportions of mortality for two populations: black and white males.
Color schemes

a. **Sequential**, single hue scheme (blue)

b. **Sequential** scheme with hue transition (yellow-green-blue)

c. Spectral scheme used as a **diverging** scheme with the lightest colors marking the overall U.S. rate (blue-green-yellow-orange-red)
Diverging color schemes

a. Spectral scheme modified to accommodate color blind map readers by skipping green hues (using blue and red)

b. Two hues (green and purple) diverging from a central light class at the U.S. rate

c. Change in rates between two time periods with diverging reds (increasing rates) and blues (decreasing)
Mapping methods
Mapping methods

- Qualitative / quantitative
- Point, line, polygon
- Visual variables

= Cartographic symbolization

↓

Standard mapping methods
Proportional symbols

- Point + size

- Each map symbol is scaled to an individual county value

- Legend shows example symbol sizes and data values they represent
Graduated symbols

- Point + size
- Each map symbol is grouped into a class
- Legend shows symbol sizes and data values they represent
- On this map, size is used for the count variable (rows; larger symbols for more deaths)
- We’ll talk about how this map is also bivariate in a minute
Choropleth

- Area + lightness
- Choro = area + pleth = value
- Because the method assumes homogeneity within areas, you must normalize the data
Special classes

- Zero deaths are separated to a class
- Significance and sparse data symbols are overlayed on a diverging choropleth representation

_Note - This map also shows more complete wording for a thematic map, with general information in the map title, and specific information about the calculation and data mapped in the legend title and note_
Bivariate choropleth

- A bivariate choropleth map offers a visual combination of two variables, making visible their covariation
- Breaks between classes for white male death rates separate columns
- Breaks for black male death rates separate rows
- Overall U.S. rates for black and white groups are used as class breaks for both races
Bivariate map

- A bivariate map showing both number of deaths and death rates
- As we saw, size is used for the count variable (rows; small to large)
- Hue and lightness are used for the rate data (columns; light yellow to dark red)
- The combination of small size and color reduces the visual prominence of counties with few deaths and thus less reliable rates
Bivariate map

- Proportional point symbols for rates overlay choropleth symbols for number of deaths
- Counts of zero, <6, and <12 are used to indicate sparse populations and suggest caution in judging rates (especially extreme rates) in these counties
Map series - quantiles

- Each map classed separately using quantile classing
- The maps are a time series
Map series – same class breaks

- The same map series with all maps sharing the same set of classes to aid map comparison within the time series
- Class breaks based on the U.S. rate for each time period are included on all maps
- The U.S. rate for the 5-year period mapped is highlighted in each maps’ legend
Politics

During the nineteenth century, Oregon politics were fairly stable. Republicans were the majority party, but the Democrats were active and moderately successful. During this time, Oregon was a one-party state, with the Republican Party holding virtual control. In fact, the Republican Party's dominance was so strong that it was often referred to as the "Republican Party of Oregon." The Democratic Party was able to make some gains in the early 1900s, but it was generally a minority party. The Democratic Party's successes were largely due to the popularity of Democratic governors, such as John A. Douglas, who was elected to four consecutive terms as governor.

The election of 1908 saw a major change in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1912 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1916 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1920 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

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The election of 1960 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

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The election of 1972 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1976 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1980 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1984 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1988 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1992 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 1996 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.

The election of 2000 saw a major shift in Oregon politics. The Republican Party was unable to maintain its dominance, and the Democratic Party was able to make significant gains. This was largely due to the popularity of Democratic governor James B. McCall, who was elected to two consecutive terms.
Transformational view of cartography
Information transformation

DATA COLLECTOR

Transform 1

Geographical environment

Census
Ground survey
GPS
Remote sensing
Compilation
Etc…

Recognized geographical data

Selection
Classification
Simplification
Exaggeration
Symbolization
Generalization
Projection
Etc…

CARTOGRAPHER

Transform 2

Map

Reading
Analysis
Interpretation

MAP READER

Transform 3

Map reader’s image of the map

Geographical environment

Census
Ground survey
GPS
Remote sensing
Compilation
Etc…

Recognized geographical data

Selection
Classification
Simplification
Exaggeration
Symbolization
Generalization
Projection
Etc…

Map

Reading
Analysis
Interpretation

Map reader’s image of the map
Basic characteristics of maps

- All maps are concerned with two primary elements
  - Locations and attributes
- All maps are reductions of reality
  - Scale
- All maps are abstractions of reality
  - Generalization and its components
- All maps are transformations of space
  - Map projections and coordinate systems
- All maps use signs and symbolism
  - Cartographic symbolization
Basic characteristics of maps

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Basemaps and overlays

Basemap – reference information to provide geographic context

Overlay – mapped statistical data

Administrative boundaries
Hydrography
Transportation
Land cover
Associated labels

Administrative boundaries
Associated labels
Generalization

Map scale 1:5,000,000

A

B

Map scale 1:1,000,000

C

D
Detailed country boundary data
Detailed country boundary data + volcanic eruptions
Generalized country boundary data
Generalized country boundary data + volcanic eruptions
Volcanoes + cased point symbols
Map projection

- (a) No projection is set so latitude and longitude remain in the square-grid default arrangement
- (b) Albers equal area projection for the U.S.
- (c) Albers modified by adjusting the central meridian to the center of the mapped area to position north as up

**Note** - The gray-filled counties had more than five prostate cancer deaths for black males, 1970–1994
WGS84 (Geographic)
New Zealand – WGS84
New Zealand Transverse Mercator
New Zealand Transverse Mercator
New Zealand – Albers equal area
New Zealand – Albers equal area
New Zealand – Web Mercator (web maps)
New Zealand – Web Mercator

So distorted in shape that it does not even fit in the window anymore
New Zealand projections

WGS84 | Web Mercator

New Zealand Transverse Mercator | New Zealand Albers equal area
Map compilation
Five basic cartographic principles

• Figure-ground
• Contrast
• Legibility
• Visual hierarchy
• Balance
Figure-ground
Contrast
Visual hierarchy
Marginalia

- Title
- North arrow
- Scale bar
- Inset maps
This sample shows the differences in linear and areal measurements performed in Web Mercator, State Plane, and UTM. The *State Plane and UTM values are appropriate for northwestern Oregon only*. If you want to use this sample code in a different geographic location, you need to modify the well-known IDs (WKIDs) for StatePlane and UTM. Click [here](#) to view a list of WKIDs for projected coordinate systems.
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Inset maps

Area Shown at Left

Enlarged areas are shown on the following two pages.

Page 200

Page 201

See enlargements below

See also Reference Map Pages 250-251

See Los Angeles area detail map at right
Locator maps

Emphasize location relative to southwestern Pacific Ocean

Emphasize location relative to Australia

Emphasize location relative to Antarctica
Affective objective

- The “affect” of the map
- The “look and feel” of the map
- Aesthetic appeal
- Get peoples’ attention, then keep it
Additional topics

- Legends
- Map series
- Multivariate maps
- Spatio-temporal maps
- Other mapping methods
- Web maps
5 minute warning
Design and technical considerations

• “What size will it be?”
• “What geographic extent will I show?”
• “What map scale will that make it?”
• “What map projection will I use?”
• “Will it be in color?”
• “What will the print resolution be?”
What size will it be? 17” – 19” monitor
What geographic extent? *Larger than the screen*
What map scale? *Multiple map scales*
What map projection?  Web Mercator???
Will it be in color? Yes

What will the resolution be? 96 dpi
2 minute warning
Design and technical considerations

- “What size will it be?”
- “What geographic extent will I show?”
- “What map scale will that make it?”
- “What map projection will I use?”
- “Will it be in color?”
- “What will the print resolution be?”

- “How will readers interact with the map?”

- “How to I publish the map?”
Over the four year period 103,112,536 beneficiaries were sampled. The national average for the total standardized cost per capita is $8,580. The total standardized cost per capita for the OK - Oklahoma City HRR is $9,926 in 2010.
Hospital 30-day death (mortality) rates for heart failure patients in 2010 for the OK - Oklahoma City is 11.3% in 2010.

Death from Heart Failure in 2010

- Standardized Costs
- What Drives Costs
- 30-day Readmissions

Death from Heart Failure in 2010

- Low
- High
Hospital 30-day death (mortality) rates for heart failure patients in 2010 for the OK - Oklahoma City is 11.3% in 2010.

Death from Heart Failure in 2010

Low
High
Hospital 30-day death (mortality) rates for heart failure patients in 2010 for the OK - Oklahoma City is 11.3% in 2010.

Death from Heart Failure in 2010

[Map showing hospital 30-day death rates with a focus on Oklahoma City and surrounding areas.]
Death from Heart Failure in 2010

Hospital 30-day death (mortality) rates for heart failure patients in 2010 for the City of Oklahoma City is 11.3% in 2010.
To learn more…

- Mapping Resource Center – esriurl.com/mapping
- Mapping blog – esriurl.com/mapping > Blog
- Mapping Center – mappingcenter.esri.com
- ArcUser magazine (online and print)
- ArcWatch online monthly newsletter
References (in order of appearance)

- Online atlas maps - [http://serverx.esri.com/javascript_examples/compare_measurements.htm](http://serverx.esri.com/javascript_examples/compare_measurements.htm)
Thank you!
abuckley@esri.com