Week 2

- Syllabus- questions?
- Last week:
  - GIS Definitions
  - History
  - Questions?
- Read W&B chapters 5 and 6 for next week

Week 2 Topics

- Cartographic Principles – (W&B Chap 4)
  - What is a map?
  - Typical elements
- GIS Databases– (W&B Chap 2)
  - We will get into more specifics about map projections in week 6
- GIS Lab 2: Creating Maps of Watershed Analysis Results
Chapter 4 Objectives

- The main components, or building blocks, of a map
- The qualities of a map that are important in communicating information to map users
- The types of maps that can be developed to visually and quickly communicate information to an audience.

Cartographic Principles

- The science of making maps
- One of the contributing disciplines to GIS
- The ability of GIS to graphically portray geographic analysis results sets it apart
- People relate to maps
- Maps have the potential to relay information quickly
A map is a “_________________________.”
Muehrcke and Muehrcke (1998)

All maps are abstractions of real world phenomena
Maps, within natural resource applications, should:
- _________________________
- _________________________

Mapmakers need to understand…
- The people who may use the map (the audience)
- The data that will be displayed in the map (the information available)
- The use of graphics software for displaying map information
- The final format of the printed or digital version of the map (the product)

Map components
- Symbology
- Direction
- Scale
- Legend
- Locational inset
- Neatline
- Typography
- Color and contrast
- Ancillary information (caveats and disclaimers)
Symbology

- The art of expression
- Using graphics and text to convey meaning

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Direction: where's north?

Figure 4.3. A variety of north arrow designs.

Scale

- The representation of map figures to their on the ground equivalents
- A key part of most maps
- Several different approaches

- ____________________________
- ____________________________
- ____________________________

Figure 4.4. Graphical, equivalent, and proportional scales.

Graphical scales:

- 500 m
- 1,000 m
- 2,000 m

1 mile 2 miles 1 mile

Equivalent scales:
- 1 inch = 1 mile
- 1 inch = 500 feet
- 1 inch = 10 chains
- 1 cm = 1,000 meters
- 1 cm = 5 kilometers

Proportional scales:
- 1 : 12,000
- 1 : 24,000
- 1 : 250,000
Legend: putting meaning to symbols

- Streams
- Roads
- Stand boundaries
- Property boundary
- Houses
- Harvest area
- Log deck / Landings

Figure 4.5. A map legend containing symbology and definitions.

Locational inset

Figure 4.6. A map of the Brown Tract roads and trails containing a neatline, locational inset, title, legend, scale, and north arrow.

Neatline

- Featured on many professional maps but not a requirement for mapping excellence
Locational inset and neatlines

Annotation: text that adds meaning to mapped features
- Ownership
- Road numbers or names
- Surveying information: PLSS or measurement control markers
- Stream names

Annotation based map

Township and Range Numbers
Mt. Diablo Meridian

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Color and contrast

- Although men and women react similarly to color, some reactions may vary depending on culture (Valdez & Mehrabin 1994)
- How do you react to different colors?

Emotional reactions to colors by southeastern college students (Kaya and Epps 2004)

- Green - relaxed, calm, and comforted, associated with nature
- Blue - relaxed, calm, and comforted, yet associated with sadness or loneliness
- Yellow - lively and energetic, associated with summertime
- Red - color with love or romance, but also with anger
- Purple - relaxed and calm, associated with childhood or power
- White - innocence, peace, purity, or emptiness, and also snowfall or cotton
- Black - sadness, depression, fear, and darkness, yet also with richness, power, and wealth
- Gray - negative emotions, bad weather, and foggy days

Ancillary information

- Author
- Date
- Location of map file(s) and supporting data
- Source data
Caveats, warranties, and disclaimers

- Caveats

- Warranties
  - written guarantees of the integrity of a map, and of the map maker’s responsibility for the repair or replacement of incorrect maps

- Disclaimers
  - used by mapmakers to distance themselves from any legal responsibility for damages that could result from use of their map

Types of maps

- Thematic maps
- Contour maps
- Raster maps
- Dot density maps
- Cartogram maps

Thematic maps

- Use colors, shades, or symbols to describe spatial variation of one or more landscape features

- Choropleth maps are the most common type of thematic map
Figure 4.10. A range of classes of trees per hectare on the Brown Tract illustrated in a choropleth map.

Figure 4.11. An equal interval classification and a quantile interval classification of trees per hectare on the Brown Tract.

Figure 4.13. A contour map of the Brown Tract (elevation in meters above sea level).
Figure 4.14. A raster map of tree seedling measurements.

Figure 4.15. A dot density map of basal area on the Brown Tract.

Figure 4.16. A cartogram map illustrating two measures of forest density for each stand - trees per acre and basal area per acre on the Brown Tract.
Map setup and balance

Design loop

What should be on your map?
- Audience- are they all familiar with your study area? Is an inset required?
- Will others need to track your sources?
- Do you need to record where the map is stored?
- Are revisions expected or will the study area change (date)?
- Publication outlets may have their own guidelines
Common map problems

- Wrong audience
- Omitting a necessary element
- Too much detail (annotation)
- Plotter or printer produces something different than what you see on the screen

Cartographer Responsibility

- How to Lie with Maps (Monmonier 1996)
- Drawing the Line, Tales of Maps and Controversy (Monmonier 1995)
- Models of reality
- Many simply accept maps at face value
- Be discriminate in your appraisal and interpretation of maps
- Be clear and ethical in your creation of maps
Chapter 2 Objectives

- Definition of a map projection, and the components that comprise a projection
- Components and characteristics of a raster data structure
- Components and characteristics of a vector data structure
- The purpose and structure of metadata
- Likely sources of GIS databases that describe natural resources within North America
- Types of information available on a typical topographic map and
- Definition of scale and resolution as they relate to GIS databases

Big questions…

- What is the size and shape of the earth?
- Geodesy:
  - We are still refining our approximation of the earth’s shape but are relying on GPS measurements for much of this work

Figure 2.1. Eratosthenes’ (276-194 BC) approach to determining the Earth’s circumference.

360 / 7°12’ = 1/50
500 miles * 50 = 25,000
Figure 2.2. The ellipsoidal shape of the Earth deviates from a perfect circle by flattening at the poles and bulging at the equator. Isaac Newton (end of the 17\textsuperscript{th} century) theorized this shape. Field measurements, beginning in 1735, confirmed it.

Earth measurements & models

- Datums
  - Horizontal and vertical control measurements
- Ellipsoids (spheroids)
  - The big picture
- Geoids
Coordinate Systems

- Used to describe the location of an object
- Many basic coordinate systems exist
  - Instrument (digitizer) Coordinates
  - UTM Coordinates
  - Geographic
- Rene Descartes (1596-1650) introduced systems of coordinates
- Two and three-dimensional systems used in analytical geometry are referred to as Cartesian coordinate systems

![Figure 2.4. Example of point locations as identified by Cartesian coordinate geometry.](image)

![Figure 2.5. Geographic coordinates as determined from angular distance from the center of the Earth and referenced to the equator and prime meridian.](image)
Geographic coordinates

- Longitude, latitude (degrees, minutes, seconds)

Map Projections

- Map projections are attempts to portray the surface of the earth or a portion of the earth on a flat surface
  - Earth features displayed on a computer monitor or on a map
  - Earth is not round, has a liquid core, is not static, and has differing gravitational forces
- Many different projection types exist:
  - Lambert, Albers, Mercator
- We’ll explore in more detail in week 6

Two primary GIS data structures: Raster & Vector

- Two different approaches to capturing and storing geographic data
- “Yes raster is faster, but raster is vaster, and vector just seems more corrector.” C. Dana Tomlin 1990
- Decision to use one or both structures will be based on project objectives, existing data, available data, and monetary resources
Figure 2.11. Generic raster data structure.

Raster data

- Many different types of raster data
  - Landsat TM, IKONOS, AVHRR, SPOT
  - Aerial imagery
    - LIDAR, color and infrared digital photography
  - Digital raster graphics (DRGs)
  - Digital orthophoto quadrangles (DOQs)

Figure 2.12. Landsat 7 satellite image captured using the Enhanced Thematic Mapper Plus Sensor that shows the Los Alamos/Cerro Grande fire in May 2000. This simulated natural color composite image was created through a combination of three sensor bandwidths (3, 2, 1) operating in the visible spectrum. Image courtesy of Wayne A. Miller, USGS/EROS Data Center.
Figure 2.13. Digital elevation model (DEM).

Figure 2.14. Digital orthophoto quadrangle (DOQ).

Figure 2.15. Digital raster graphics (DRG) image.
Figure 2.16. Corvallis Quadrangle with neatlines around map areas to be described in detail.

Figure 2.17. Lower right-hand corner of the Corvallis Quadrangle.

Figure 2.18. Ohio code location of the Corvallis Quadrangle.
Figure 2.19. Lower left-hand corner of the Corvallis Quadrangle.

Figure 2.20. National Map Accuracy Standards.

Table 2.1. Map scales and associated National Map Accuracy Standards for horizontal accuracy.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1,200</td>
<td>± 3.33 feet</td>
</tr>
<tr>
<td>1:2,400</td>
<td>± 6.67 feet</td>
</tr>
<tr>
<td>1:4,800</td>
<td>± 13.33 feet</td>
</tr>
<tr>
<td>1:10,000</td>
<td>± 27.78 feet</td>
</tr>
<tr>
<td>1:12,000</td>
<td>± 33.33 feet</td>
</tr>
<tr>
<td>1:24,000</td>
<td>± 40.00 feet</td>
</tr>
<tr>
<td>1:63,360</td>
<td>± 105.60 feet</td>
</tr>
<tr>
<td>1:100,000</td>
<td>± 166.67 feet</td>
</tr>
</tbody>
</table>
Vector data structure

- In contrast to raster, not necessarily organized in a pattern
- Vector data are usually irregular in shape and represent precise locations
- The vector world is organized using three basic shapes
  - referred to as the GIS feature model

Topology

- Determines
  - Distance between points
  - Whether lines intersect
  - Whether points, lines, or polygons are within the extent of a polygon

Figure 2.21. Point, line, and polygon vector shapes.
Figure 2.22. Examples of adjacency, connectivity, and containment.

Topological building blocks

- Topology needs to be coded and described mathematically
- All vector shapes must be isolated and located using a coordinate system

Figure 2.23. Examples of nodes, links, and vertices.
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**Figure 2.24.** Vector topological data. Network of nodes, links, and polygons (a), node coordinate file (b), and topological relationship file.

<table>
<thead>
<tr>
<th>Link</th>
<th>Begin node</th>
<th>End node</th>
<th>Left polygon</th>
<th>Right polygon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>5</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>6</td>
<td>A</td>
<td>E</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>2</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>6</td>
<td>E</td>
<td>B</td>
</tr>
</tbody>
</table>

Node X Y

1 1.1 4.2
2 3.4 5.2
3 4.4 2.5
4 6.1 5.7
5 8.0 9.3
6 4.7 1.1

**Figure 2.25.** Examples of topological errors. In the first (a), an undershoot has occurred and instead of a closed figure creating a polygon, a line has been created. In the second (b), a small loop has been formed extraneously adjacent to a polygon. This might represent a digitizing error or the result of a flawed overlay process.

**Raster & vector: must I choose one?**  
- These are complimentary data structures and you will use both if you conduct GIS analysis
- More commonly, GIS software will allow you to read both data types
- Some software (ArcGIS) will allow you to analyze both types simultaneously
- Demonstrated in chapters 13 and 14
Figure 2.26. Point, line, and polygon features in a raster or grid

A forest stand boundary in vector format (a) scanned or converted to a raster format using 25 m grid cells (b), then converted back to vector format (c) by connecting lines to the center of each grid cell.

Summary of Raster and Vector Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Raster</th>
<th>Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure complexity</td>
<td>simple</td>
<td>complex</td>
</tr>
<tr>
<td>Location specificity</td>
<td>limited</td>
<td>not limited</td>
</tr>
<tr>
<td>Computational efficiency</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Data volume</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>limited</td>
<td>not limited</td>
</tr>
<tr>
<td>Representation of topology among features</td>
<td>difficult</td>
<td>not difficult</td>
</tr>
</tbody>
</table>
Other types of data structures/models

- Other hybrid forms of data structures exist
  - May help you solve spatial analysis challenges
- TINs
  - Landforms
- Regions
  - Area
- Routes
  - Linear features

Triangular Irregular Network

- A generic (not dominated by a specific software manufacturer) reference to a data structure that is similar to vector yet possesses
- An alternative to raster in representing continuous surfaces
- May help reduce some of the ambiguities presented by a raster structure

Figure 2.27. McDonald Forest (perspective view from SW corner)
Regions

- Not all GIS software can accommodate regions
- ArcGIS can
- Allows for overlapping polygons
- May reduce database complexity
- Large woody debris study
- Large woody debris study

Figure 2.28. Large Woody Debris

- One record for each log possible
- Reduces data storage needs

Routes

- Dynamic Segmentation
  - Traditionally linked to ESRI products
- For linear networks but can also handle points
- Stream habitat
- Delivery / emergency routing
- Recreation use patterns
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**Routes Example: Aquatic Habitat Database**

- One record to represent the many links that make up a primary channel
- Simplify structures
- Reduce data storage redundancy

**Map scale and resolution**

- GIS databases are often described in terms of their scale or resolution
- Scale and resolution will often provide guidance in the application of a GIS database for specific purposes

**Map Scale**

- Scale is the relationship between a linear feature on a map or photograph and the actual distance on the ground
- Scale is usually expressed as a representative fraction
  - 1:24,000
    - One inch on the map or photograph represents 24,000 inches (or 2000 feet) of on the ground distance
  - 1:200,000
    - One cm on the map or photograph represents 200,000 cm (or 2000 m) of on the ground distance
- Scale plays a strong role in determining the proper use of a spatial database
Map Scale

- Scale is tied to on the ground measurements
- Most scale measurements of vector data usually come to us from the scale derived from aerial photograph measurements
  - A relationship between the focal length of the camera lens and the height of the lens above terrain

Resolution

- With raster data, scale is often expressed in terms of resolution or the amount of ground that each side of a pixel, or cell, covers
  - Measurements typically are the same on all sides of a pixel or cell
  - 1 meter, 10 meter, 30 meter

Map Scale

- Relative size of scales is dependent on the representative fraction
  - 1:100,000 is usually considered a small scale map, at least in comparison to 1:24,000
- You may also use the terms fine and coarse-scale resolution to avoid confusion
Figure 2.29. Map of stream network displayed at scales of 1:100,000 and 1:24,000.

Map Scale and Resolution

- Be wary of mixing data themes that are drawn from widely different scales or resolutions
  - Mixing 1:24,000 scale data with 1:250,000 is probably not a good idea
  - Sometimes, there may be no alternatives and you'll have to take "your best shot"