FE 257. GIS and Forest Engineering Applications

Week 2

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

Geographic Information Systems

Applications in Natural Resource Management

Chapter 4
Map Design

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

Map Definition

- 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…

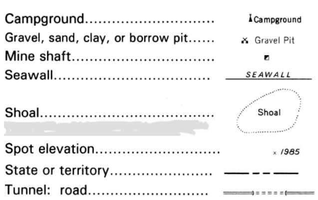
- ____________________________________
- The people who may use the map (the audience)
- The data that will be displayed in the map (the information available)
- The use of graphics software for displaying map information
- The final format of the printed or digital version of the map (the product)

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
- ______________________________



4.1. A subset of USGS topographic map symbols (USDI U.S. Geological Survey 2003).

4.2. A subset of the standard National Park Service pictographs for maps (USDI National Park Service 2003).

Direction: where's north?

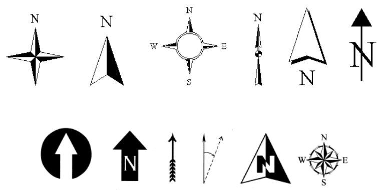
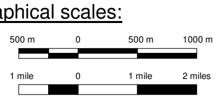


Figure 4.3. A variety of north arrow designs.

Scale

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

<u>Graphical scales:</u>



<u>Equivalent scales:</u>

1 inch = 1 mile
1 inch = 500 feet
1 inch = 10 chains
1 cm = 1,000 meters
1 cm = 5 kilometers

<u>Proportional scales:</u>

1 : 12,000
1 : 24,000
1 : 250,000

Figure 4.4. Graphical, equivalent, and proportional scales.

Legend: putting meaning to symbols

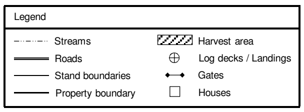
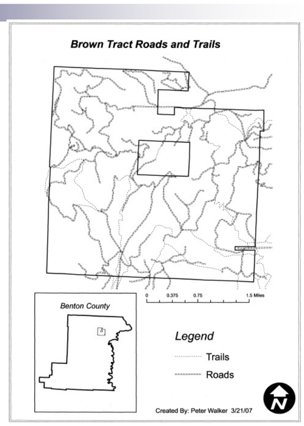


Figure 4.5. A map legend containing symbology and definitions.

Locational inset

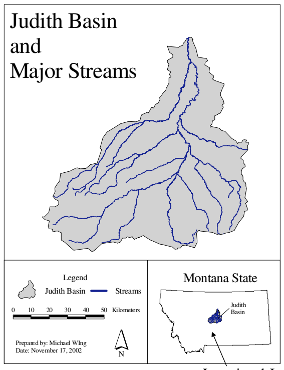
Figure 4.6. A map of the Brown Tract roads and trails containing a neatline, locational
inset, title, legend, scale, and north arrow.



Neatline

- ______________________________
  - ______________________________
- ______________________________
- Featured on many professional maps but not a requirement for mapping excellence

Locational inset and neatlines



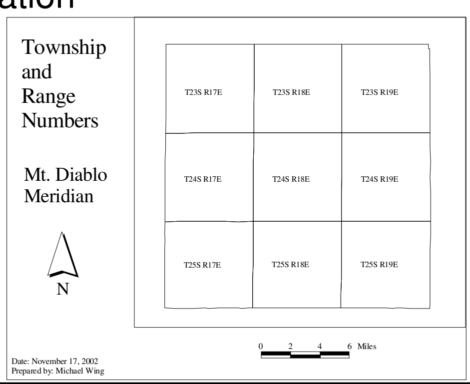
Neatline

Locational Inset

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



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

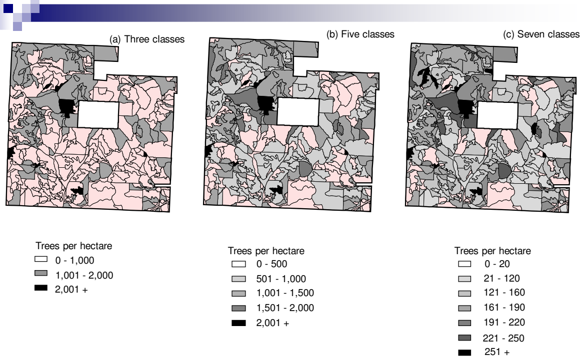


Figure 4.10. A range of classes of trees per hectare on the Brown Tract illustrated in a choropleth map.

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

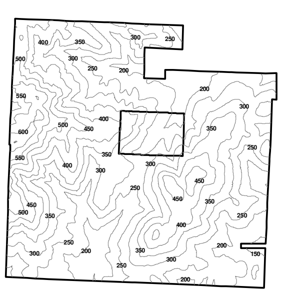


Figure 4.13. A contour map of the Brown Tract (elevation in meters above sea level).

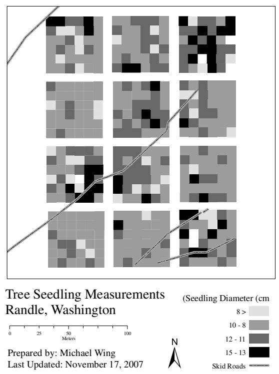


Figure 4.14. A raster map of tree seedling measurements.

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

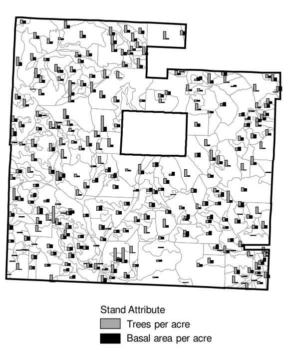
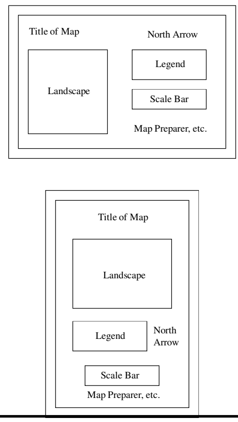
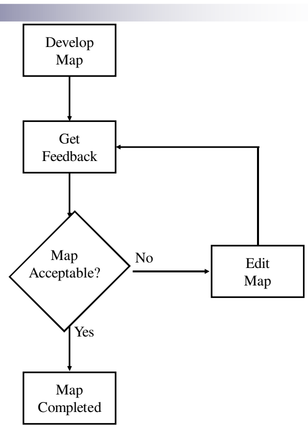


Figure 4.16. A cartogram map illustrating two measures of forest density for each stand - trees per acre and basal area per acre on the Brown Tract.



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

Geographic Information Systems

Applications in Natural Resource Management

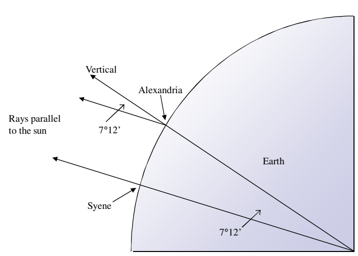
Chapter 2
GIS Databases:
Map Projections, Structures, and Scale

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



360 / 7°12' = 1/50

500 miles * 50 = 25,000

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

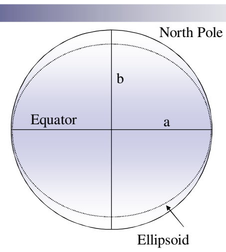
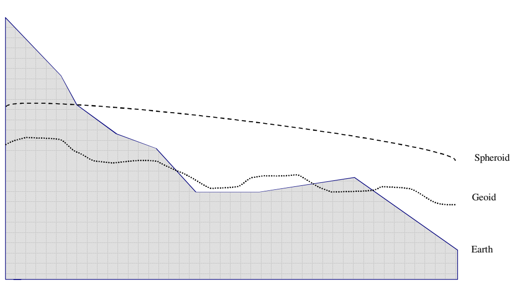


Figure 2.2. The ellipsoidal shape of the Earth deviates from a perfect circle by flattening at the poles and bulging at the equator.
Isaac Newton (end of the 17th century) theorized this shape.
Field measurements, beginning in 1735, confirmed it.

Earth measurements & models

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

Figure 2.3. Earth, geoid, and spheroid surfaces



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

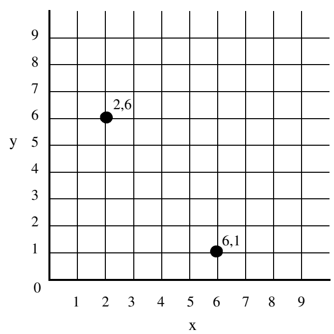


Figure 2.4. Example of point locations as identified by Cartesian coordinate geometry.

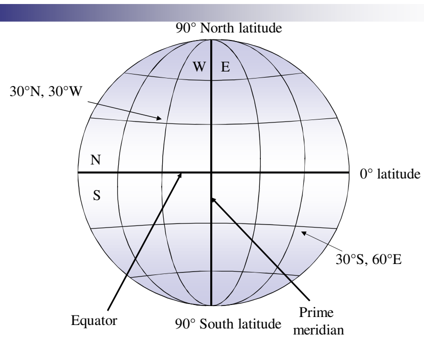
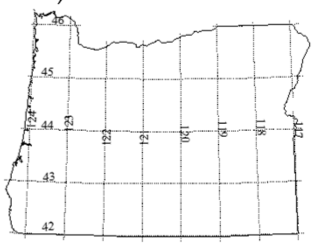


Figure 2.5. Geographic coordinates as determined from angular distance from the center of the Earth and referenced to the equator and prime meridian.

Geographic coordinates

- Longitude, latitude (degrees, minutes, seconds)



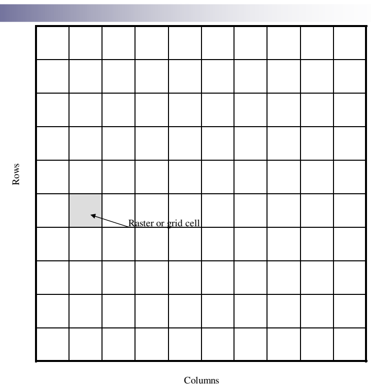
Map Projections

- 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)

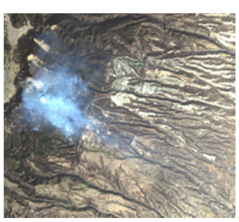


Figure 2.12. Landsat 7 satellite image captured using the Enhanced Thematic Mapper Plus Sensor that shows the Los Alamos/Cerro Grande fire in May 2000. This simulated natural color composite image was created through a combination of three sensor bandwidths (3, 2, 1) operating in the visible spectrum.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

Figure 2.13. Digital elevation model (DEM).

Figure 2.14. Digital orthophoto quadrangle (DOQ).

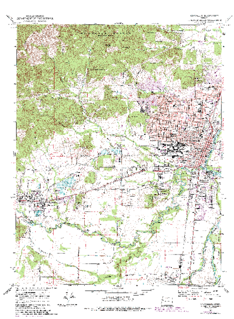


Figure 2.15. Digital raster graphics (DRG) image.

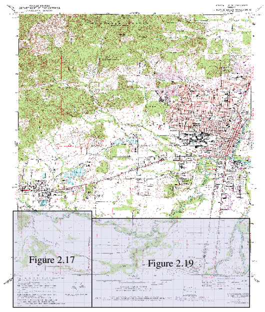


Figure 2.16. Corvallis Quadrangle with neatlines around map areas to be described in detail.

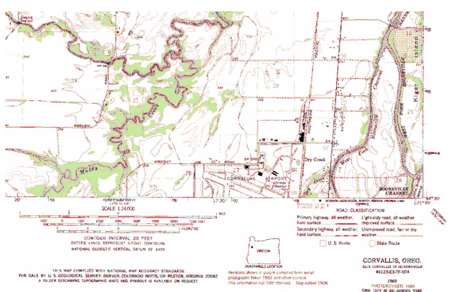
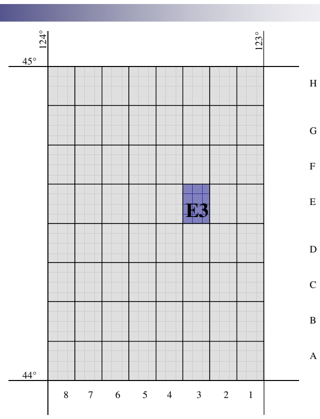


Figure 2.17. Lower right-hand corner of the Corvallis Quadrangle.

Figure 2.18. Ohio code location of the Corvallis Quadrangle



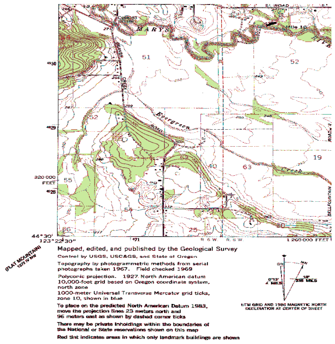


Figure 2.19. Lower left-hand corner of the Corvallis Quadrangle.

United States National Map Accuracy Standards

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. **Horizontal accuracy.** For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.
2. **Vertical accuracy,** as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.
3. **The accuracy of any map may be tested** by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.
4. **Published maps meeting these accuracy requirements** shall note this fact on their legends, as follows: "This map complies with National Map Accuracy Standards."
5. **Published maps whose errors exceed those aforestated** shall omit from their legends all mention of standard accuracy.
6. **When a published map is a considerable enlargement** of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."
7. **To facilitate ready interchange and use of basic information for map construction** among all Federal mapmaking agencies, manuscript maps and published maps, wherever economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size.

Issued June 10, 1941
Revised April 26, 1943
Revised June 17, 1947

U.S. BUREAU OF THE BUDGET

Figure 2.20. National Map Accuracy Standards.

Scale	Standard
1:1,200	± 3.33 feet
1:2,400	± 6.67 feet
1:4,800	± 13.33 feet
1:10,000	± 27.78 feet
1:12,000	± 33.33 feet
1:24,000	± 40.00 feet
1:63,360	± 105.60 feet
1:100,000	± 166.67 feet

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

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

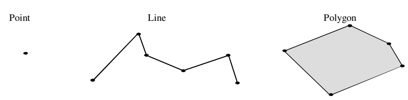


Figure 2.21. Point, line, and polygon vector shapes.

Topology

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

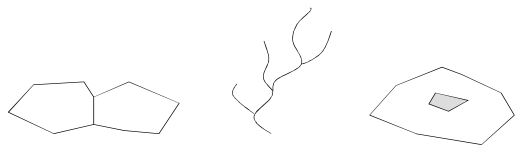


Figure 2.22. Examples of adjacency, connectivity, and containment.

Topological building blocks

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

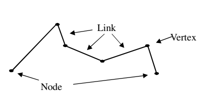
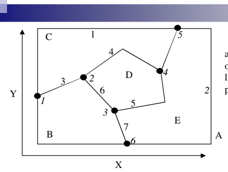


Figure 2.23. Examples of nodes, links, and vertices.



a. Network of nodes, links, and polygons

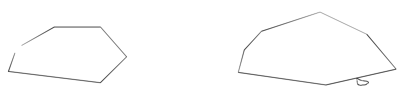
Node	X	Y
1	1.1	4.2
2	3.4	5.2
3	4.4	2.5
4	8.1	5.7
5	8.9	9.9
6	4.7	1.1

b. node coordinate file

Link	Begin node	End node	Left polygon	Right polygon
1	1	5	A	C
2	5	6	A	E
3	1	2	C	B
4	2	4	C	D
5	4	3	E	D
6	3	2	B	D
7	3	6	E	B

c. topological relationship file

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



a. An un-closed polygon

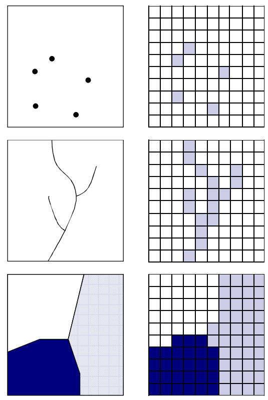
b. An extraneous polygon

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.

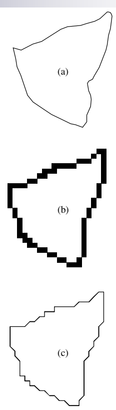
Raster & vector: must I choose one?

- 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

Characteristic	**Raster**	**Vector**
Structure complexity	simple	complex
Location specificity	limited	not limited
Computational efficiency	high	low
Data volume	high	low
Spatial resolution	limited	not limited
Representation of topology among features	difficult	not difficult

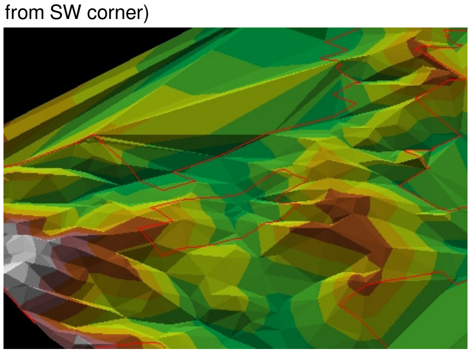
Other types of data structures/models

- 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

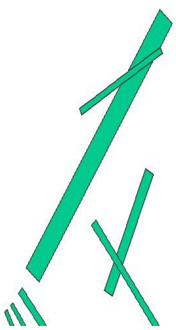
Figure 2.27. McDonald Forest (perspective view from SW corner)



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

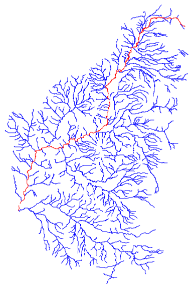


- One record for each log possible
- Reduces data storage needs

Routes

- Dynamic Segmentation
  - Traditionally linked to ESRI products
- For linear networks but can also handle points
- Stream habitat
- Delivery / emergency routing
- Recreation use patterns

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

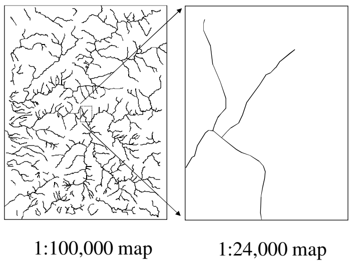
Resolution

- 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"