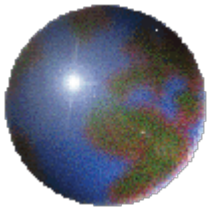


Introduction to GIS Analysis

Patti Haggerty, USGS FRESC

Objectives

- Describe fundamental GIS concepts
- What is the difference between Virtual Globe software and a GIS?
- Distinguish between analysis and map making
- Explain GIS data types
- Outline how GIS software is organized
- List methods of data classification
- Locate spatial data resources

What is GIS Analysis?

- Process for examining geographic patterns and relationships between features
  - Frame the Question
  - Understand the Data
  - Choose the Method
  - Process the Data
  - Examine the Results

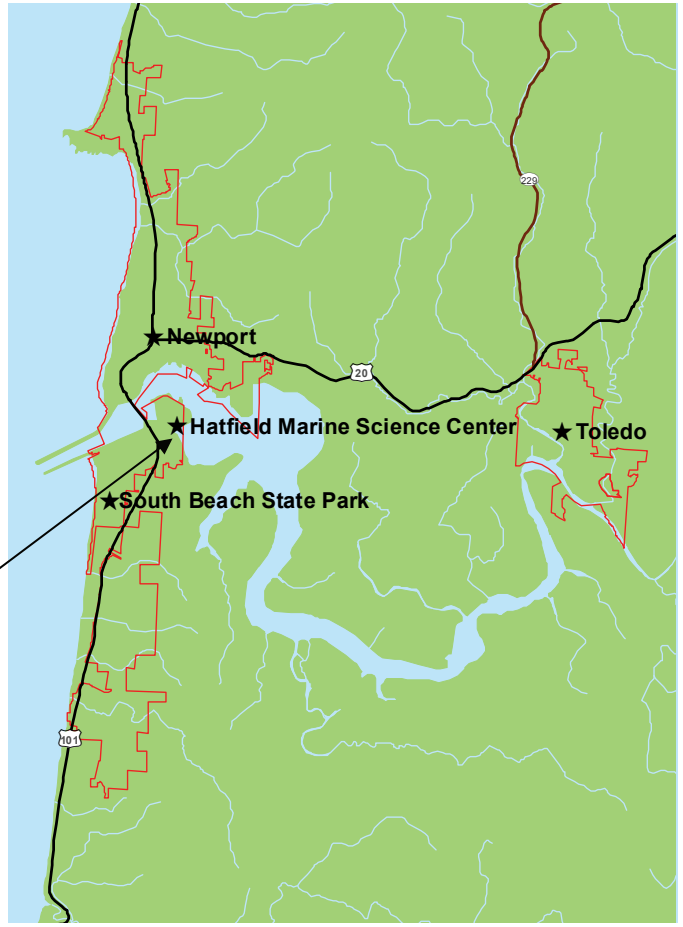
Virtual Globe Visualization - the Geoweb

- Virtual Globe software, like Google Earth, displays a 3D model of the earth imagery and geographic features
- Consumer driven, cheap, simple
- Relationships between features enabling analysis does exist (yet)
- Google and ESRI together? May 2008 announcement of many KML options added to ESRI products

Ways of thinking about Geographic Features – Discrete Features

- Actual location of lines or features can be pinpointed
- A feature is either present or not.
  - Buildings
  - Streams
  - City Limits
  - Roads

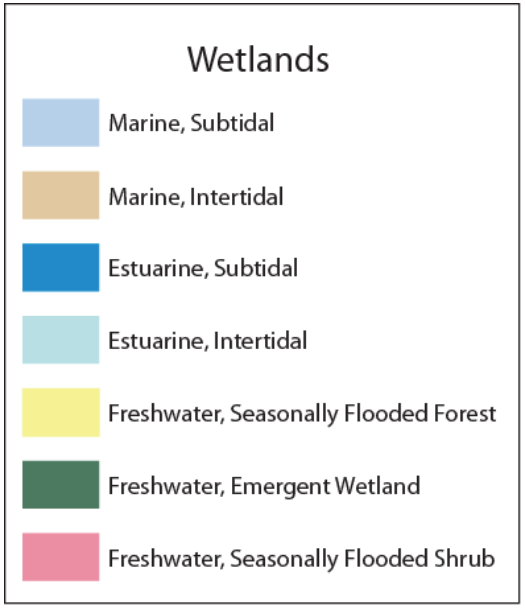
You are here!

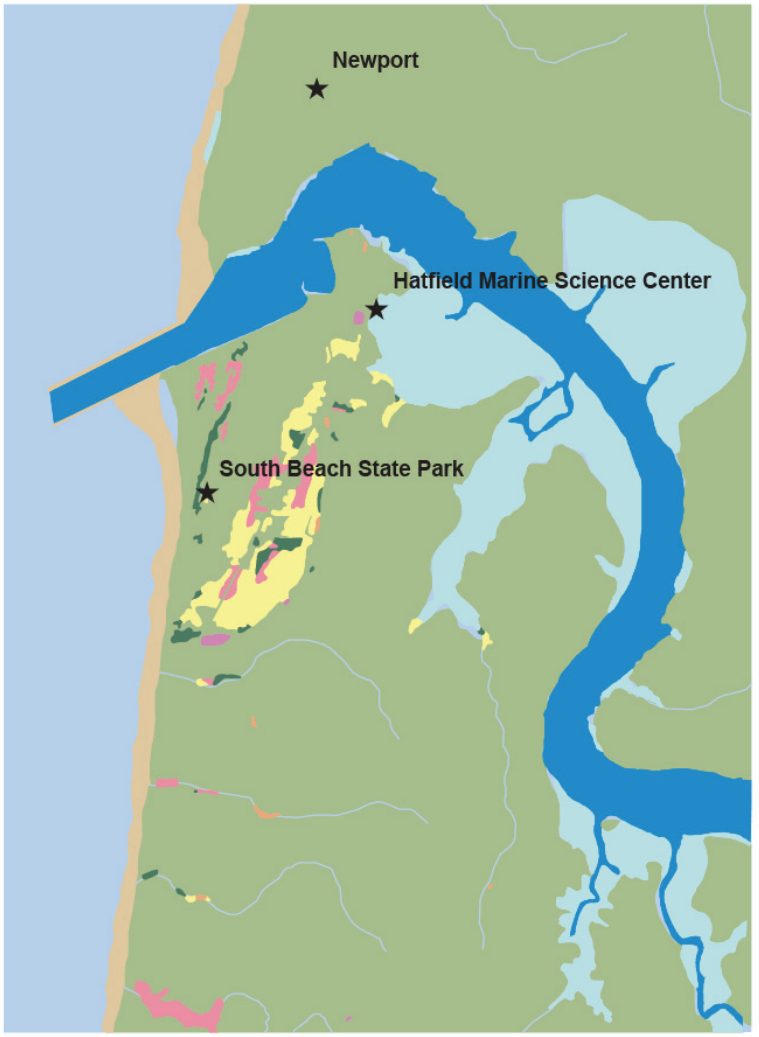


Ways of thinking about Geographic Features

– Less Discrete Features

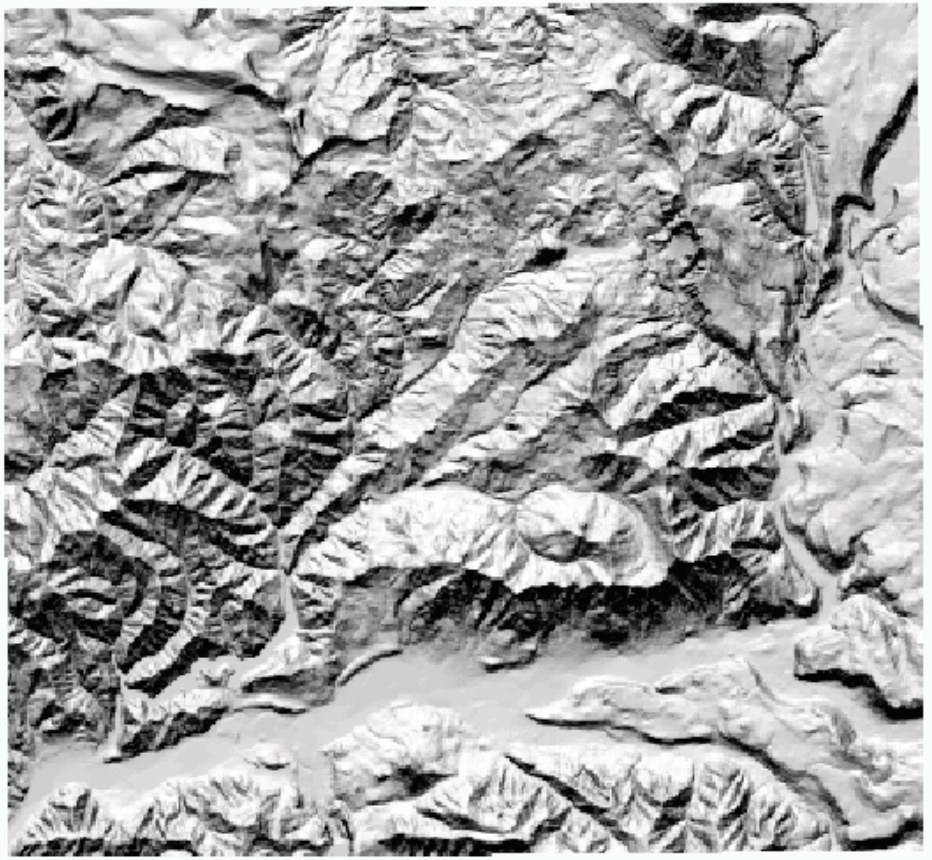
- Location of lines or features may be estimated or interpreted
- A feature represents a category or classification
  - Wetlands
  - Vegetation
  - Geology





Understanding Geographic Features – Continuous Phenomena

- No gaps in data
- Various formats: cells, hexagons, triangular irregular networks (TIN), Terrains which are a series of TINs
- A value can be determined at any location on the map
- Usually interpolated
  - Elevation
  - Precipitation

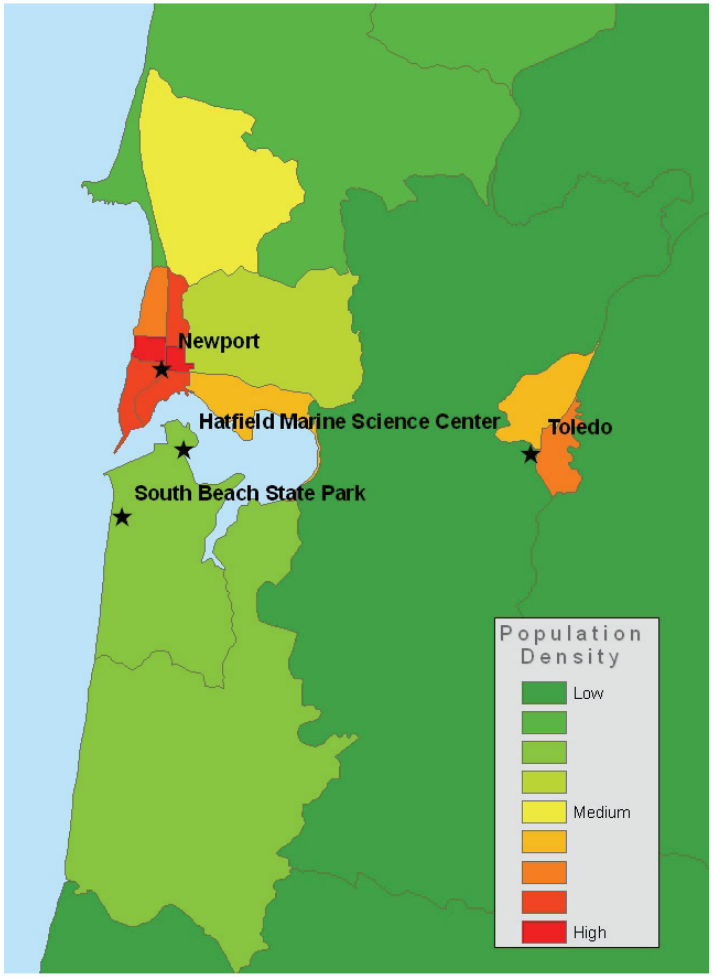


Understanding Geographic Features – Imagery, a form of continuous data

- Digital orthorectified imagery increasingly available from airborne or satellite sensors (multi spectral, radar, panchromatic, near IR)
- Classifications can be derived from analysis of imagery by pixel or by object.

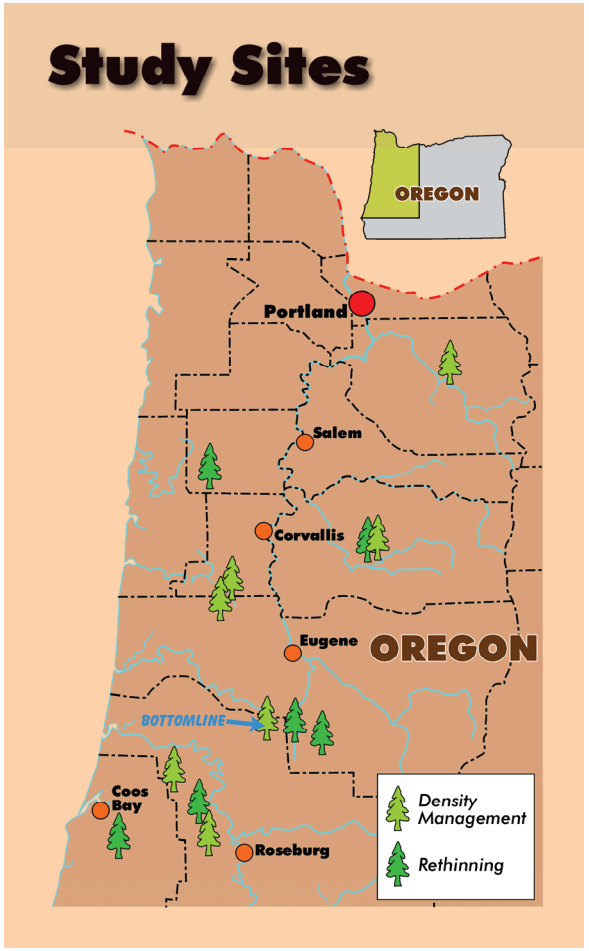
Understanding Geographic Features – Summary Data

- Counts or density summarized within area boundaries
- Value applies to entire area
  - Example: Census data summarized to display density of citizens by area
  - Stream length by watershed



From concepts to digital formats

- Vector Data



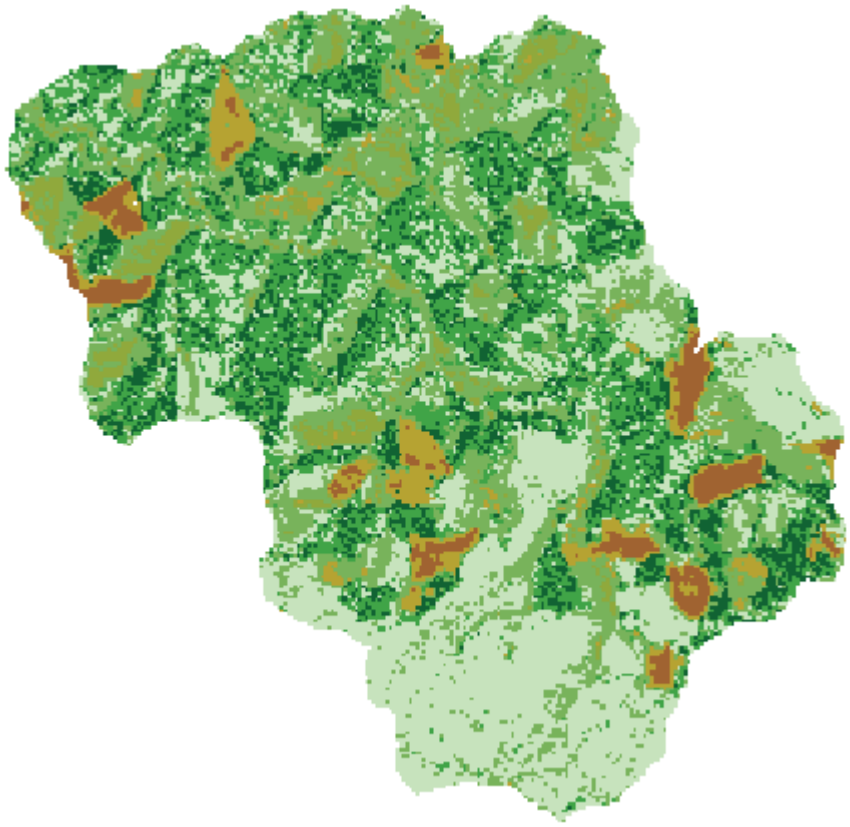
- Points – x,y coordinate pair
  - Study Sites
  - Telemetry locations
- Lines – series of x,y coordinate pairs
  - Streams
  - Flight paths
- Areas – closed polygons
  - Countries, states, watersheds

Vector Data Model

- Some types: Shapefile, Coverage, Geodatabase
- Each feature is a row in a table
- Each feature is defined by X,Y location in space
- Features can be discrete locations or events, lines, or areas.
- Analysis processes includes buffer, overlay and intersection, and clipping procedures

Raster Data

- Described by cell size, rows and columns, and starting coordinates
- Cells too large; data is lost
- Cells too small; larger files slower processing

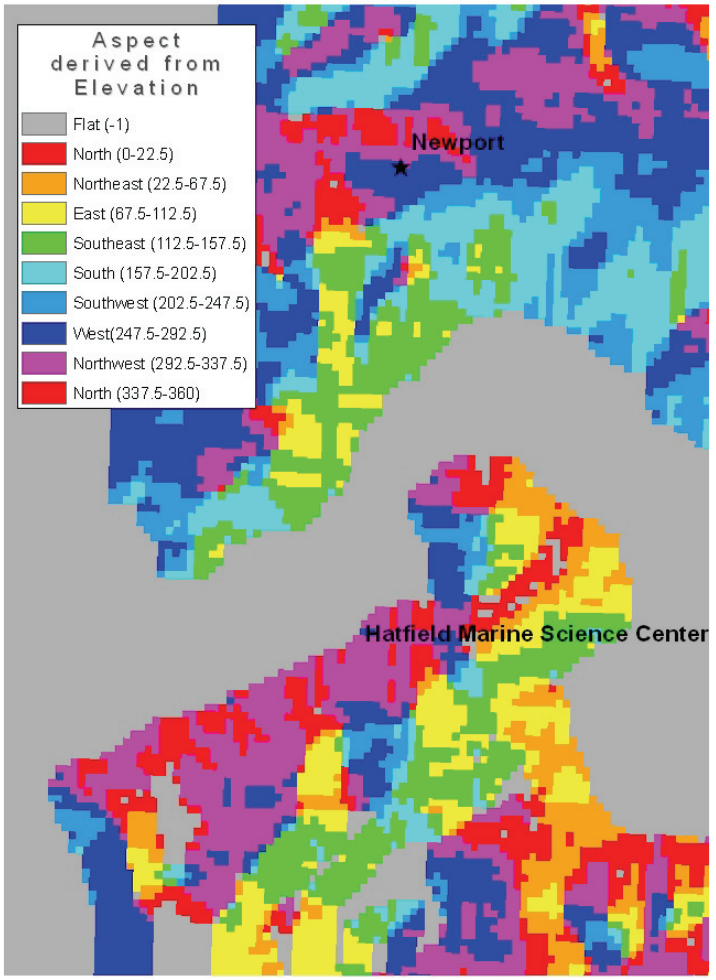


Raster Data Model

- Features represented as a matrix of cells in continuous space
- Each layer represents one attribute
- Attributes can be categorical or numeric
- Numeric attributes can be continuous or integer

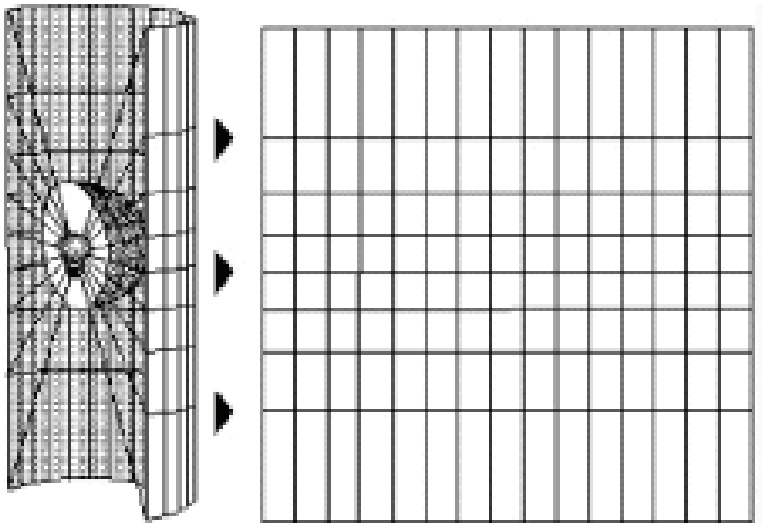
Raster Data Model

- Analysis achieved by combining layers to create new layers with new cell values using a variety of logical and numeric operators (map algebra)



The Globe to a Map – Projections

- A projection translates 3D earth locations from a spheroid to a flat surface
- All projections contain distortions of area, distance, or direction
- What's best? It depends on the goal
  - Conformal preserves shape
  - Equal-area preserves area
  - Equidistance preserves distance from center of projection



Coordinate Systems

- A coordinate system specifies the units used to locate features in two-dimensional space and the origin point of those units.
  - Longitude/Latitude is a coordinate system, not a projection. Units are angular degrees.
  - DMS degrees, minutes, seconds, or DD decimal degrees, or DDM degrees decimal minutes.
    123°46′30.18″W, 30°36′45.31″N *DMS* = -123.7751, 39.6126 *DD*
  - UTM - Universal Transverse Mercator Projection, 60 north and south zones, units as meters:
    Hatfield MSC: Northing 4941191, Easting 417041
    UTM Zone 10 North

Datums

- What is a Datum?
  - Shape of the spheroid on which a projection is based, better measurements improve the shape!
  - North America – USGS quadrangles used NAD27, NAD83 now widely used, XY shifts not equal!
  - GPS/Telemetry now use WGS84, about the same as NAD83
  - Vertical datum based on sea level, in N America, currently use NAVD 88 vs. older NGVD 29 – the difference may be 1 meter, what about rising sea levels?

GIS power comes from Attributes

- Non-spatial data associated with a feature
  - Identify
  - Describe
  - Magnitude
- Categories
  - Grouped by similarity
  - Coded (numeric or text)
- Ranks
  - Order from high to low
- Counts and Amounts
  - Actual counts or measures
- Ratios
  - Relationship between two quantities

Data Tables

- Every feature layer has an associated attribute table
- GIS analysis entails working with data tables, various database formats used (.dbf, MS Access)
- Common operations
  - Selecting
  - Calculating
  - Summarizing

Selection

- Choose a subset of data
- Assign a new attribute value

select <attribute> = <value>

typical logical operators

= < > <> 'like'

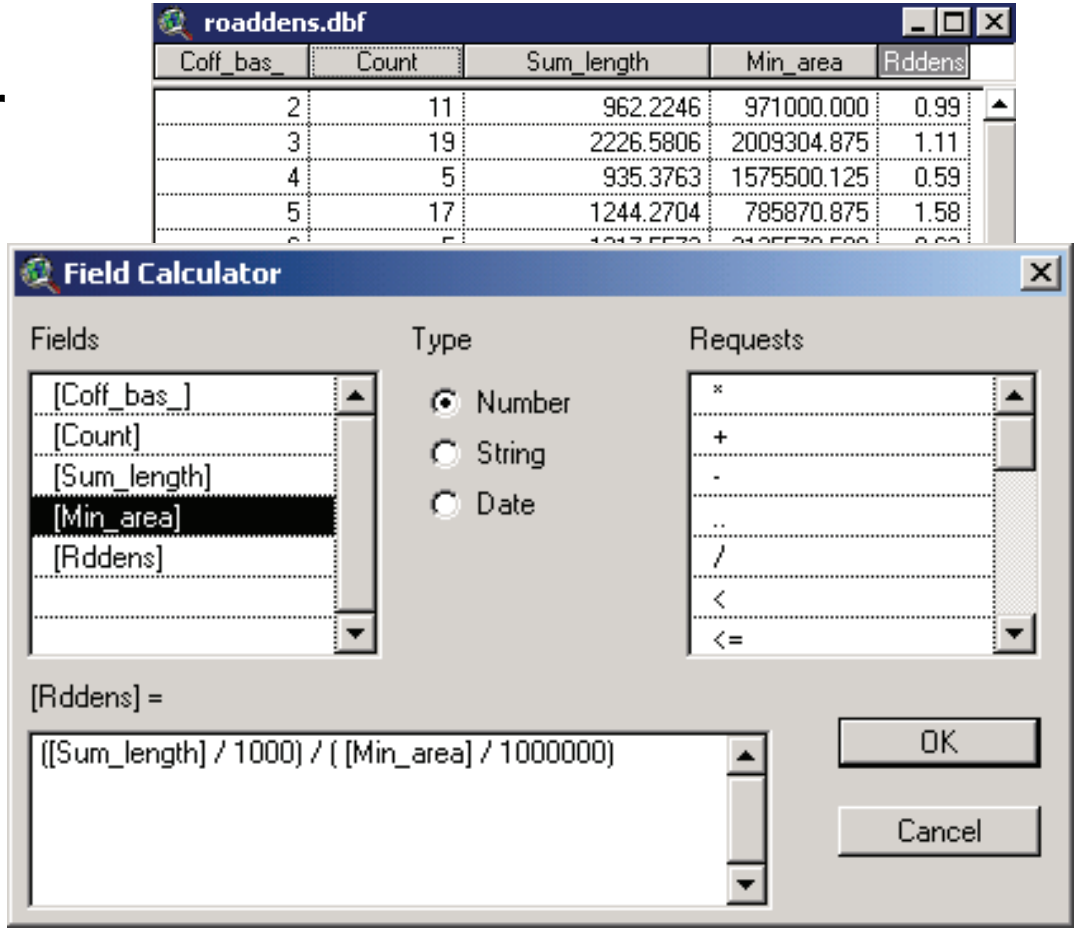
SELECT * FROM hydro WHERE:

"PLANFLOW" = 'P'

WTRBODYTY	STREAMORD	PLANFLOW	FISHBEARIN
ST	1	I	ANV
ST	4	P	ANV
ST	1	I	ANV
ST	0	X	
ST	1	I	
ST	4	P	ANV
ST	4	P	ANV
ST	4	P	ANV
ST	1	I	
ST	1	I	
ST	2	P	
ST	1	I	
ST	2	I	

Calculate

- Add a new field for calculated values
- Assign a value based on existing values
- Directly assign a new value to selected set



Summarizing for Statistics or Frequency

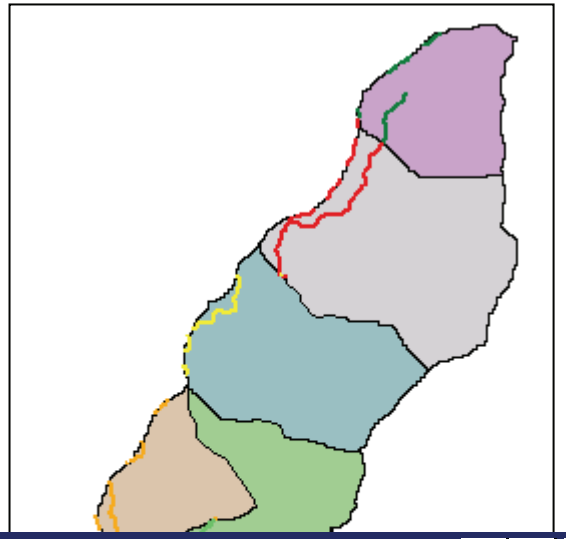
Attributes of Coff_bas

Shape	Area	Perimeter	Coff_bas#	Coff_bas-id	Gri
Polygon	971000.000	4820.000	2	1	
Polygon	2009304.875	7669.491	3	21	
Polygon	1575500.125	6699.495	4	55	
Polygon	785870.875	4789.726	5	58	

Statistics for Area field

Sum: 8389800.000
Count: 6
Mean: 1398300.000
Maximum: 2135579.500
Minimum: 785870.875
Range: 1349708.625
Variance: 348384182036.737
Standard Deviation: 590240.783

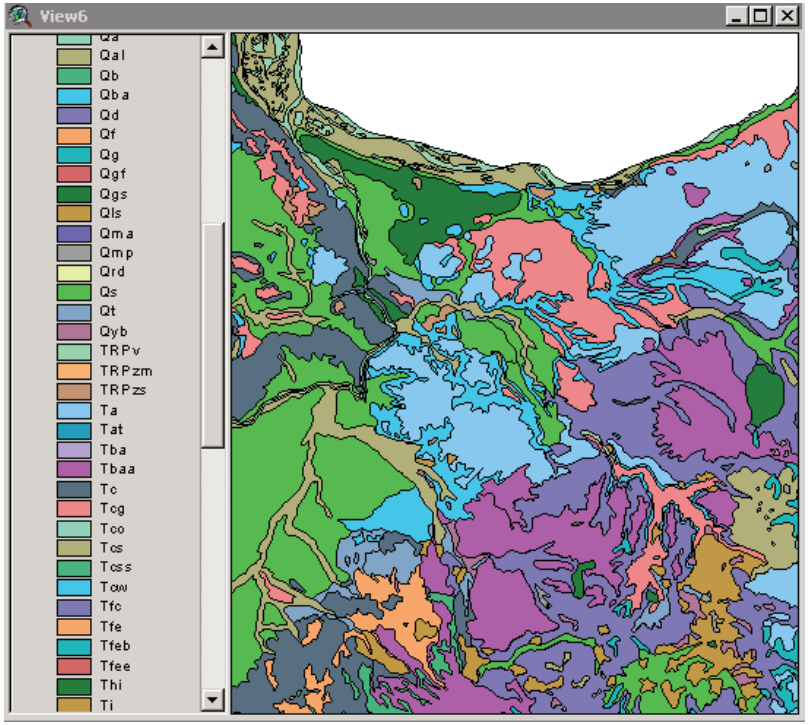
OK

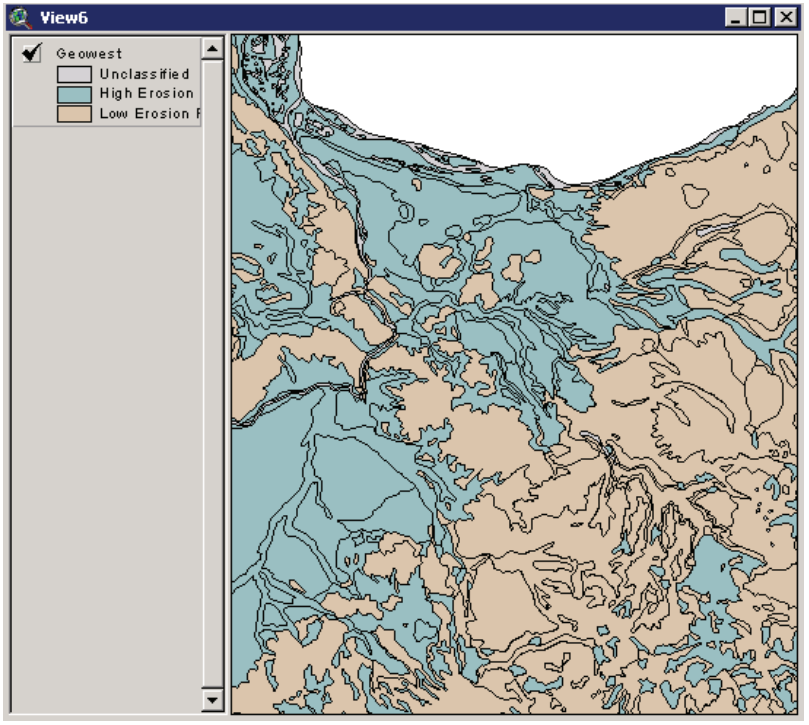


roaddens.dbf

Coff_bas_	Count	Sum_length	Min_area	Rddens
2	11	962.2246	971000.000	0.99
3	19	2226.5806	2009304.875	1.11
4	5	935.3763	1575500.125	0.59
5	17	1244.2704	785870.875	1.58
6	5	1317.5572	2135579.500	0.62
7	30	3300.0404	912544.625	3.62

Modifying , recoding categories

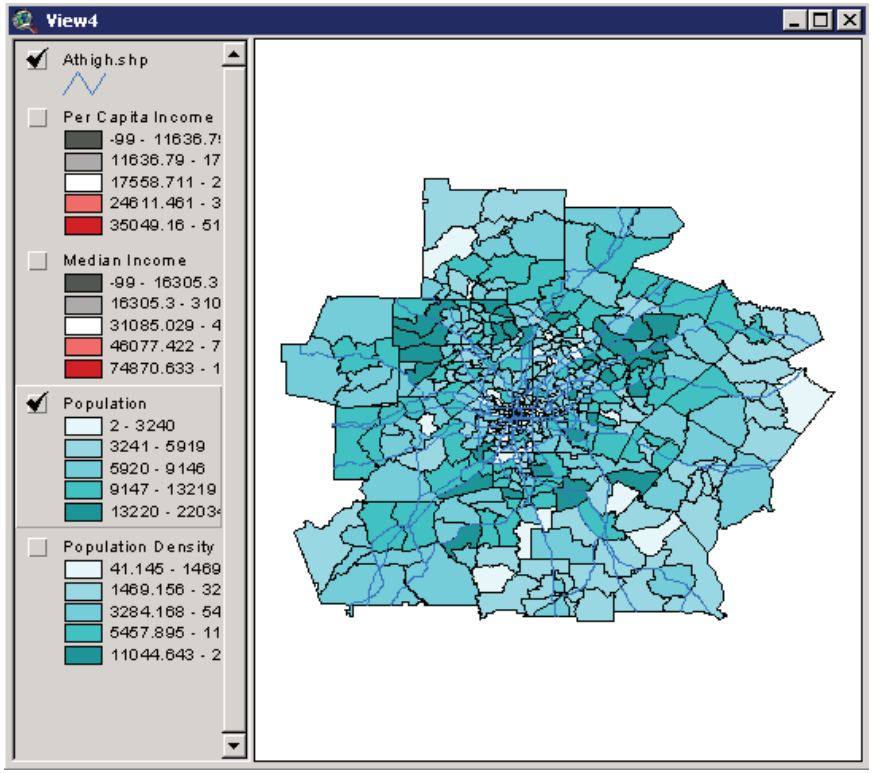


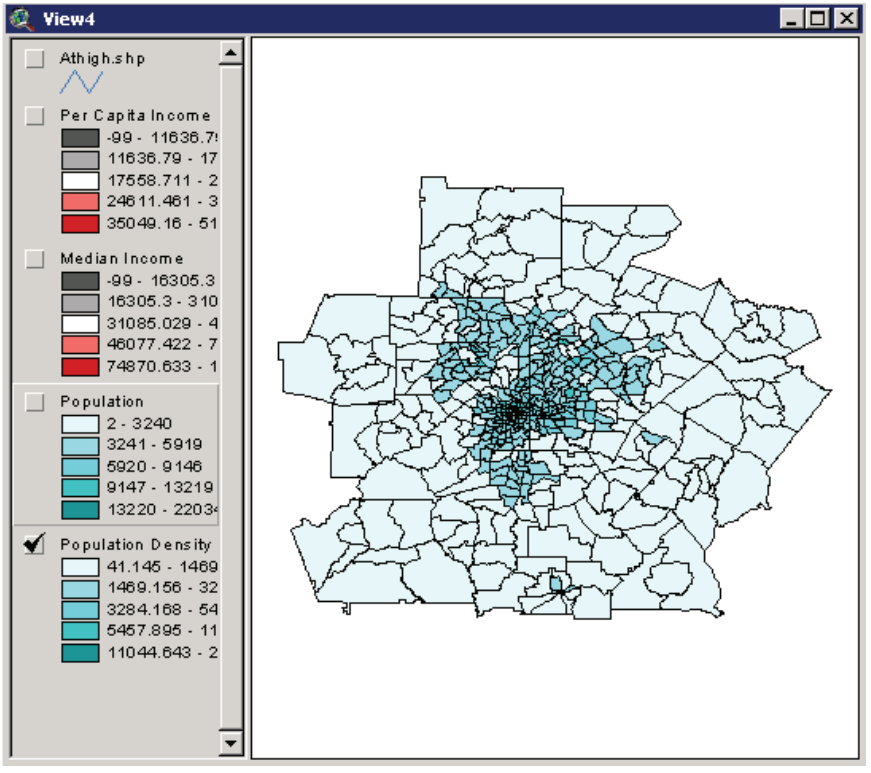


Geology:
Complex; many categories

Erosion Potential:
Simple; few categories

Quantifying Data - Ratios





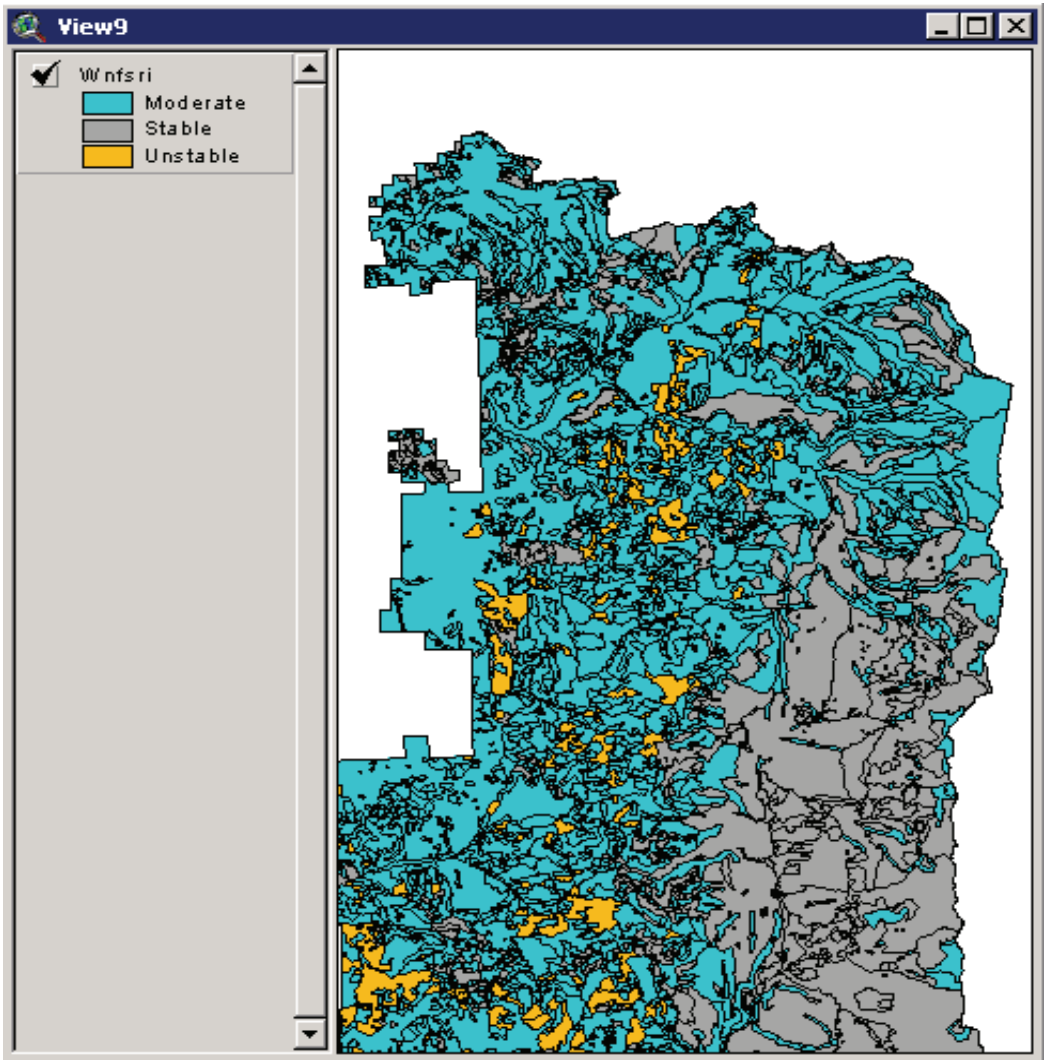
Population

Population Density =

Pop98 / Square Kilometers

Quantifying Data - Ranks

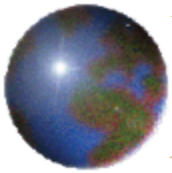
- Ranks represent complex data in a meaningful way



Quantifying Data - Classification

- Using Individual Values
  - Directly displays data
  - Can show pattern in raw data
  - May be hard to decipher

- Data Classification
  - Group features with similar values
  - Establish class ranges to make differences between classes as great as possible

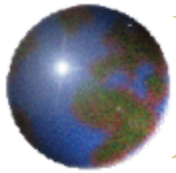


Outliers

- Examine closely and fix if possible
  - Database error?
  - Sample size error?
- If outliers are valid data
  - Put each in its own class
  - Group them in one class, if clustered
  - Display using a special symbol and legend entry

Concepts of Scale

- Map Scale
  - Ratio of distance on the map to distance on the ground 1 map unit : x ground units
    - 1:10000 1 cm : 10000 cm or 100 meters
- Data Scale: Rule of Thumb
  - Combine data up to 2.5X in scale
    - 1:24000 hydro with 1:12000 veg is OK
    - 1:24000 hydro with 1:100000 contours is OK
    - 1:12000 veg with 1:100000 contour is ???



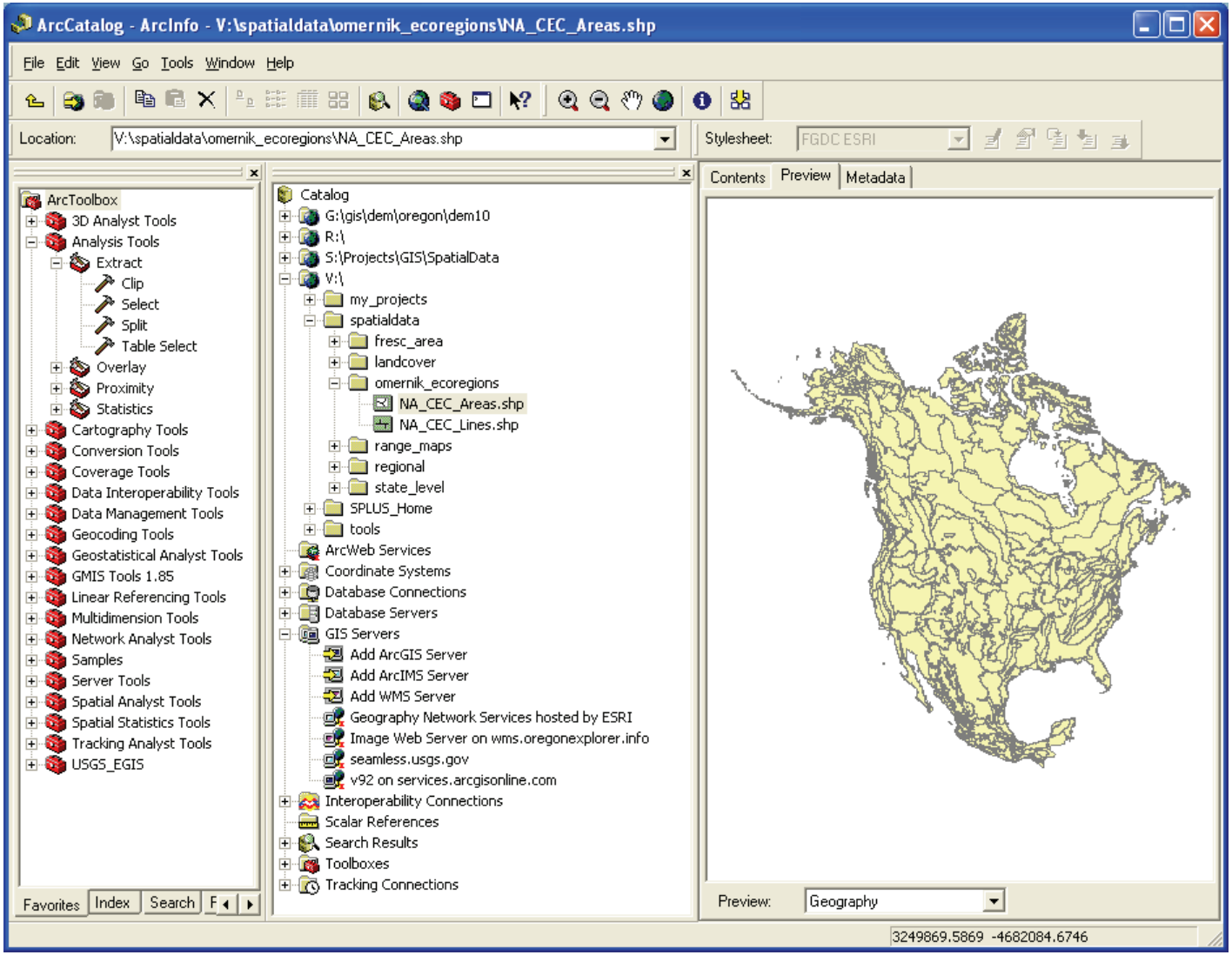
Other Display Considerations

- How many classes?
  - Human eye can distinguish 7 colors or patterns at once
  - Four or five classes usually reveal patterns
- Making classes easier to understand
  - Explore data and modify classes
  - Rename classes to mimic ranked data
    - High, Medium, and Low

GIS Software

- 'Industry Leader' Commercial Software
  - ESRI GIS software products: ArcGIS products descended from ArcInfo
  - Available at many universities and government agencies
  - ESRI Virtual Campus: online training, some is free
- Other Commercial Software
  - MapInfo, Maptitude, Manifold
  - Remote Sensing software with GIS capabilities such as ERDAS Imagine

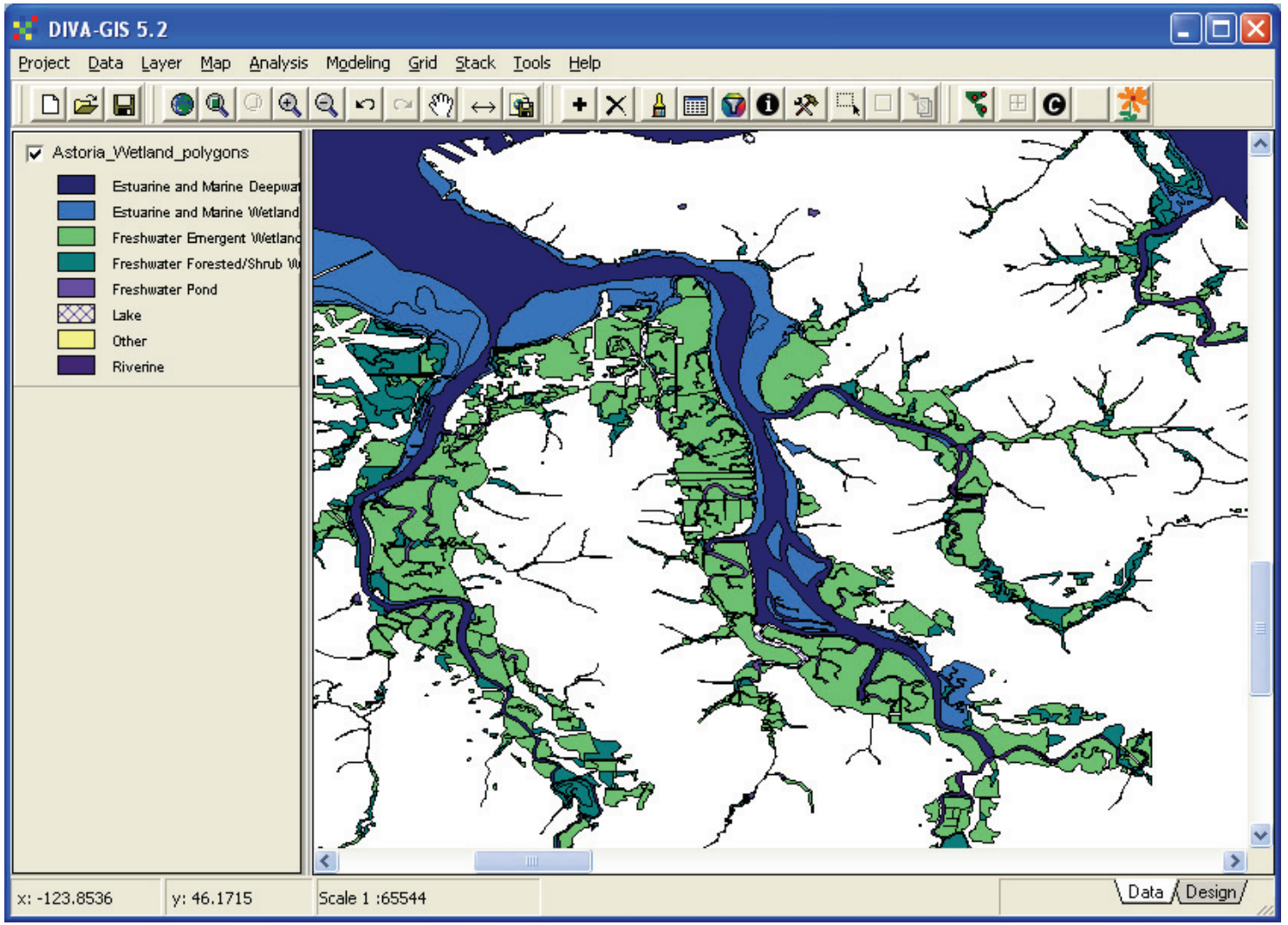
ArcCatalog and ArcToolbox



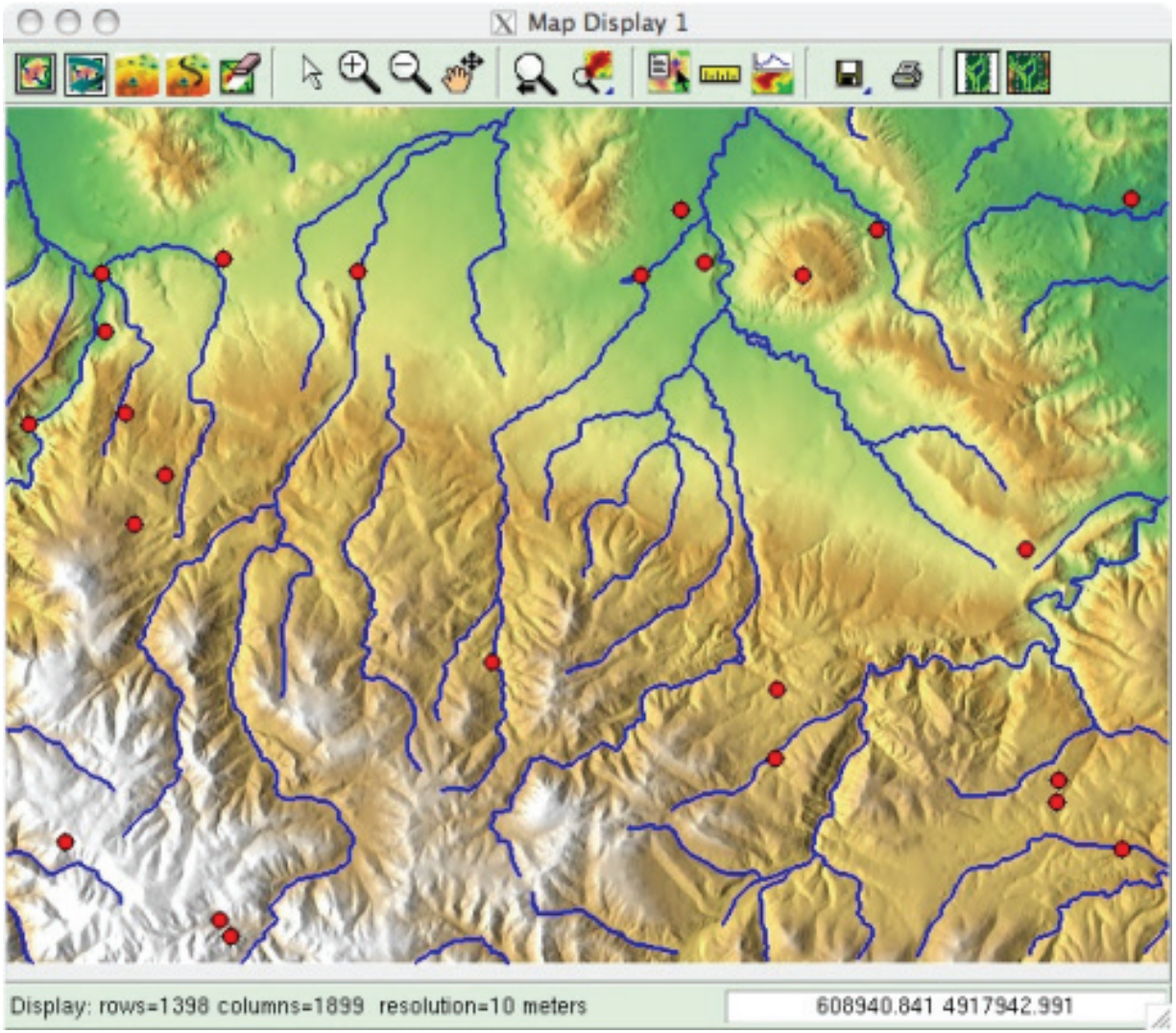
Open Source GIS Software

- Free/open source GIS software applications are expanding
- Some are 'viewers', some are single purpose, some are multi-purpose with more features
- Variety of operating systems: Linux, Apple OSX, Unix
- Variety of development languages: PERL, Python, Java
- Granddad of free GIS, GRASS
- Others: QGIS, Diva, Spring

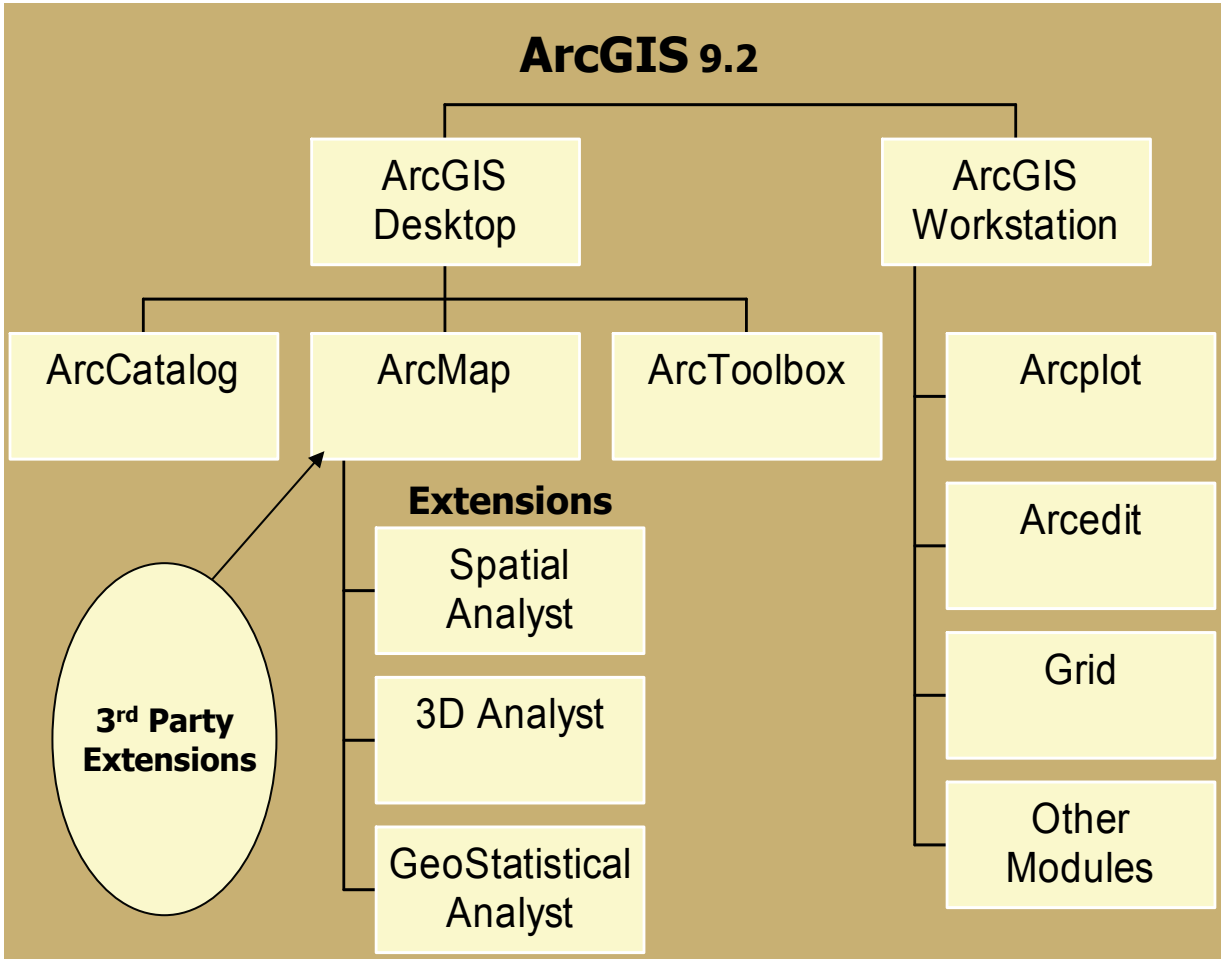
Other GIS software (Diva in Windows XP)

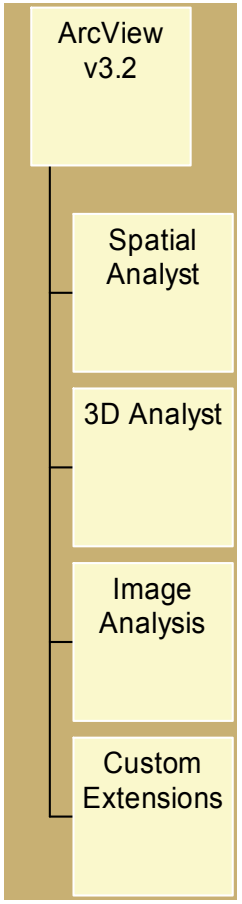


Other GIS software: GRASS on a Mac



ESRI Software





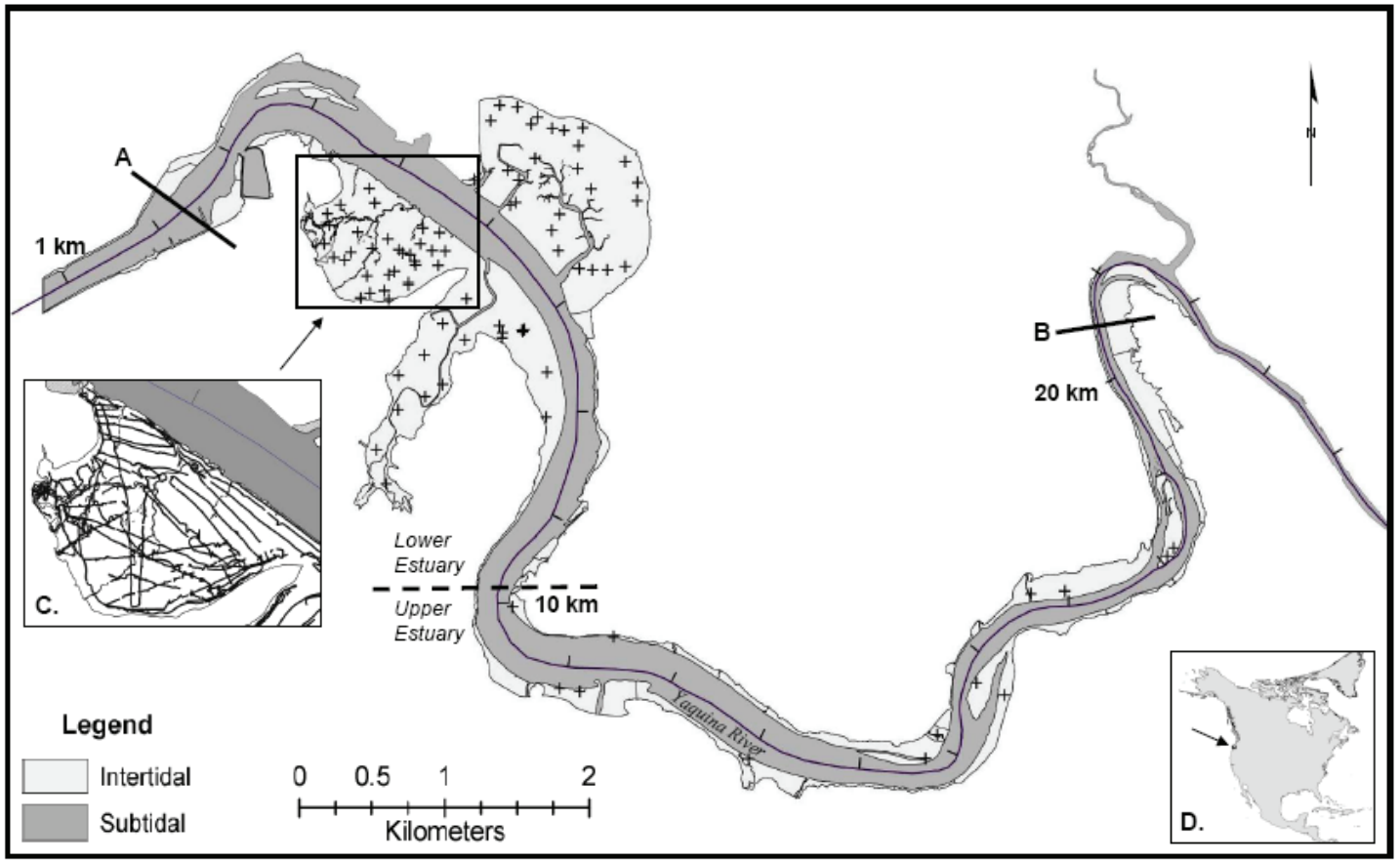
Cartography 101 – Elements of a Map

- Extent and projection
  - Remember map projections contain distortions
  - Map projections have been developed to display features based on extent of interest
    - Global, continental, regional, local?
    - Map layouts can be rotated to fit projected data views
- Scale bar, graticule, north arrow, legend?
  - Elements depend on the goal and audience
  - Styles: general public, journal publication, check on directions for authors!
  - Interactive web maps, maps for sight limited users, colorblind?

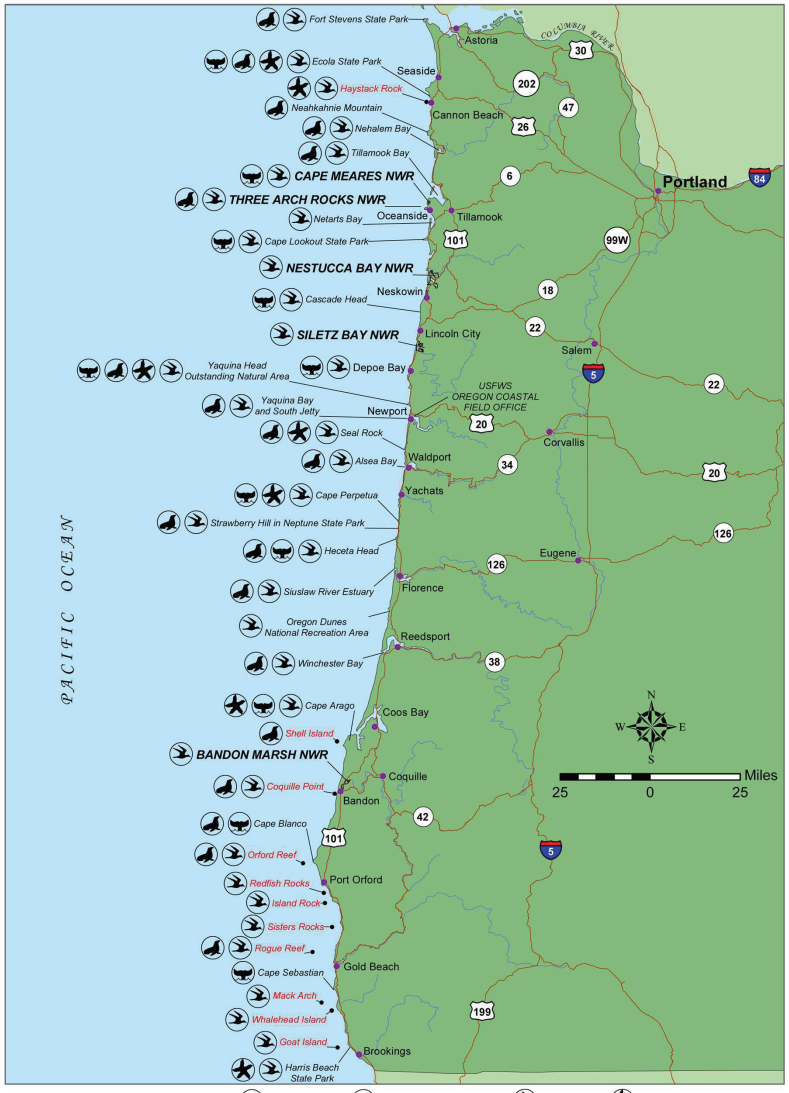
Displaying Geographic Patterns

- Deciding what to map
  - Locations
  - Feature type by location, time
- Appropriate presentation
  - How complex is the issue?
  - How informed is the audience?
  - Can you make your point with simplified data?
  - Do you need reference layers (roads, streams…)?
  - Poster, page or web?
  - Cartographic elements: Scale, Legend, North arrow, graticule, color

Journal Sample



Interpretive



WILDLIFE WATCHING on the Oregon Coast

All coastal islands, reefs, and offshore rocks are part of Oregon Islands National Wildlife Refuge and are closed to visitors at all times.

Please Note: Wildlife viewing opportunities vary by season and tidal phase.

For more information about the Oregon Coast National Wildlife Refuges please visit our website at http://oregoncoast.fws.gov or contact us at (541) 867-4550.
Oregon Coast National Wildlife Refuge Complex 2127 SE Marine Science Drive Newport, OR 97365

Author: Mariana Lincoln April 25, 2003 Map Design: PPI Data Sources: ESRI, USFWS GCS North America 1983, UTM NAD 1983 Software: ArcGIS 8.1

Searching for Data

- Examine local sources
- ESRI Conservation GIS, Conservation International, The Nature Conservancy
- Online Map Servers
- Examine web resources
  - Use FGDC Clearinghouse
  - Many Internet directories
  - http://www.tec.army.mil/gis/ - a good summary of links from the Corps of Engineers