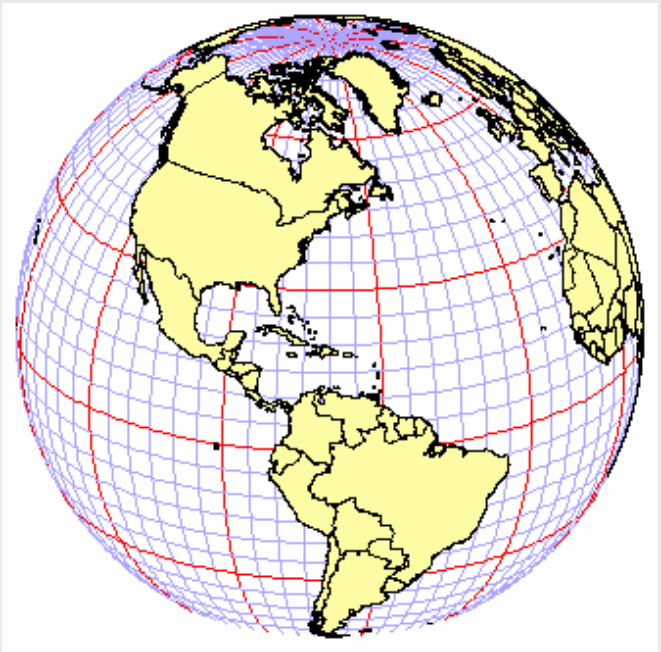
GIS

Geographic Information Systems (GIS)
and
Spatial Data



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What is a GIS?

At the most basic level, a GIS is a computer system capable of storing and manipulating spatial data

What is GIS?

GIS began in the late 1960's as software for cartographic analysis. GIS is now embraced by groups and disciplines who use data with a strong *SPATIAL* component:

- Examples:
  - Federal, State and Local governments
  - Utilities (water, electricity, gas)
  - Police (for Crime prevention)
  - Natural resources and conservation
  - Defense
  - Climate modeling

What is a GIS?

- Mapping is a key output of GIS but is not the whole story.
  - GIS stores the spatial data that is used to make maps.
  - GIS is an analysis tool

A GIS is a tool to answer spatial questions …

- Where is a site where certain conditions are satisfied?
- What changes have occurred since the last time data was collected?
  - How will the runoff rate for a basin change if the land use changes?
- What spatial patterns exist in your data?

What makes GIS a special kind of database tool?

- SQL queries in a relational database plus information retrieval based on location – making maps interactive.

Questions the user needs to ask:

- Using a GIS, a suggested process for users:
  - What questions do you want answers for?
  - What data do you need to find the answers?
  - How do you process your data to find the answers to your questions?

How does a GIS work?

- Data acquisition
  - Field collection with GPS
  - Scan maps
  - Digitize Maps
- Data integration
  - Projection and registration
  - Data structures or data types (raster vs vector)
- Mapping and analysis tools

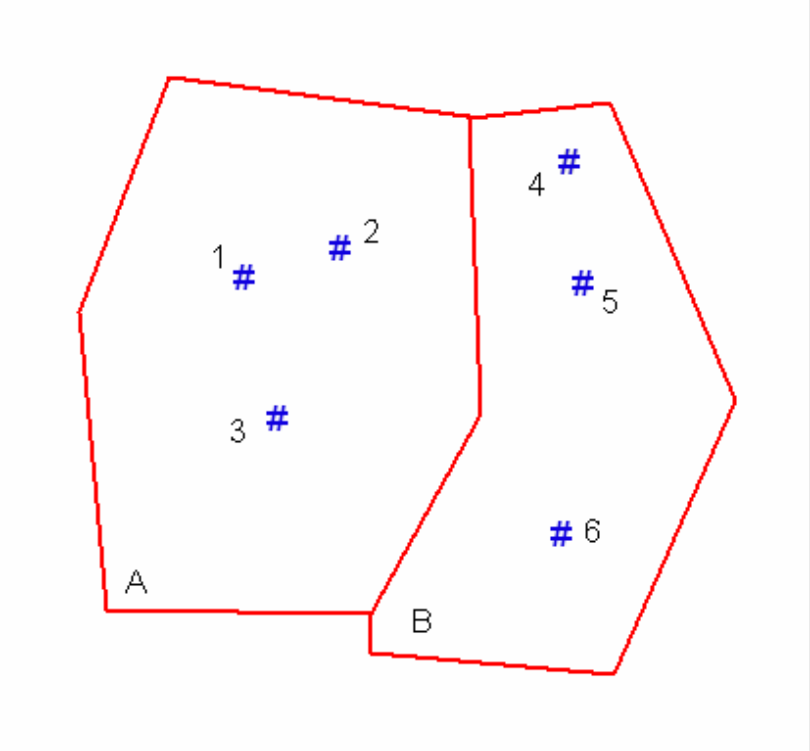
Spatial Reference Systems – Map Projections

- Conversion of data locations from spherical coordinates (latitude and longitude) to Cartesian coordinates for ease of calculations
- Maximizes benefits or minimizes costs of the conversion
  - Area
  - Distance
  - Direction
  - shape

Spatial Analysis

- Compare different layers of spatial data
- Combine elements of diverse data

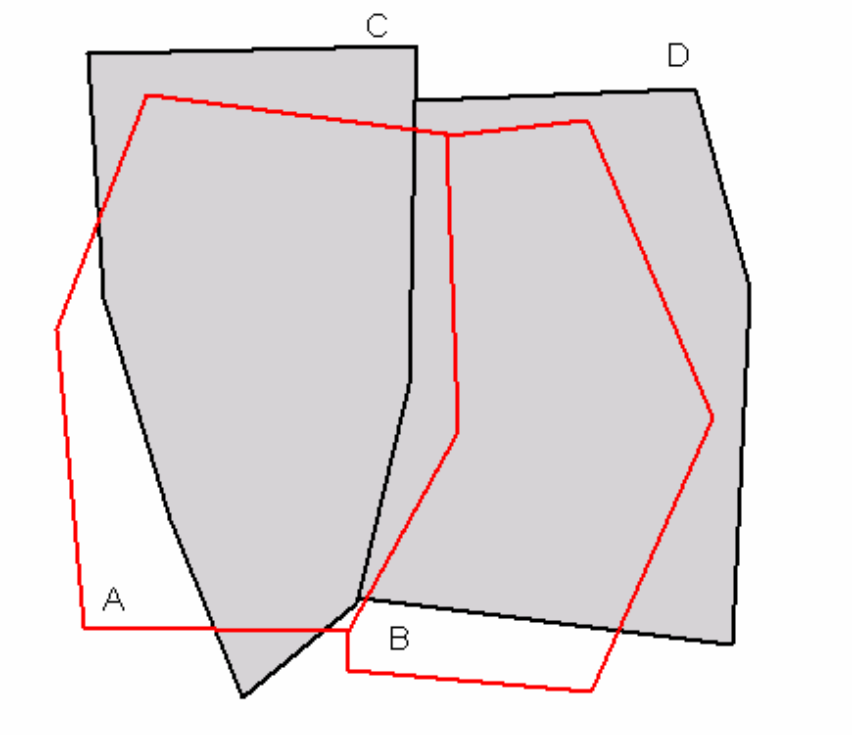
Points in Polygon



Vector processing

Which land use is well #1 sited in?

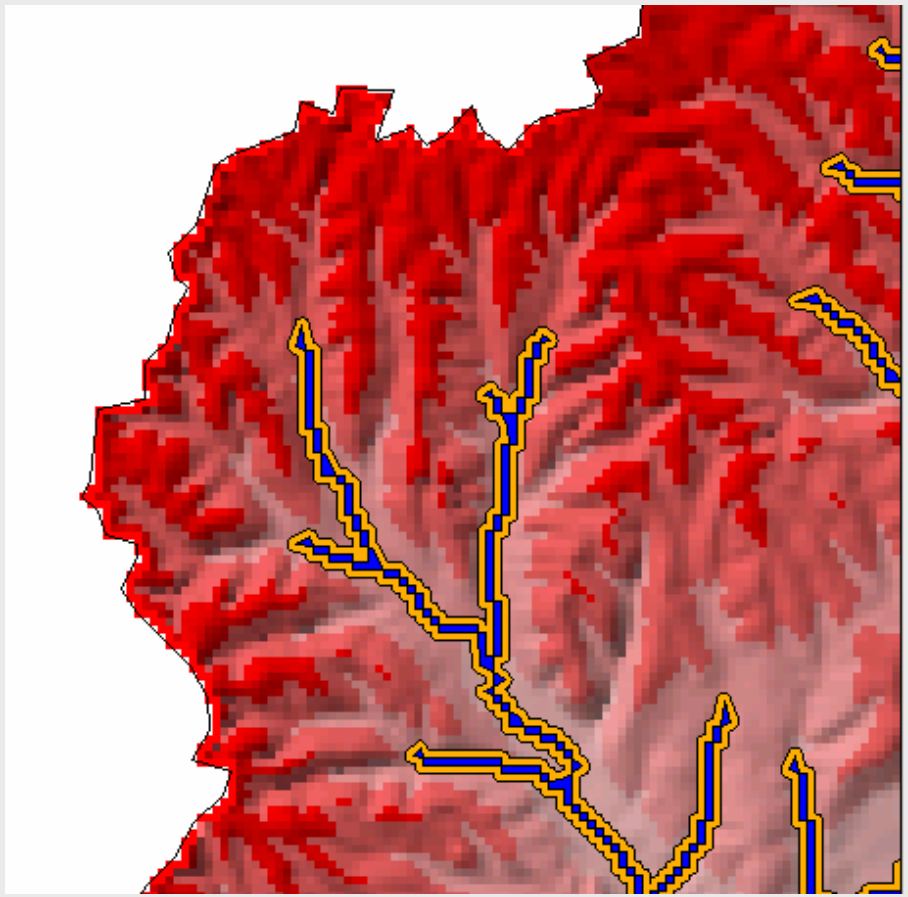
Polygon on polygon overlay



Vector processing

Which parts of land use polygon A fall inside of soil Polygon C.

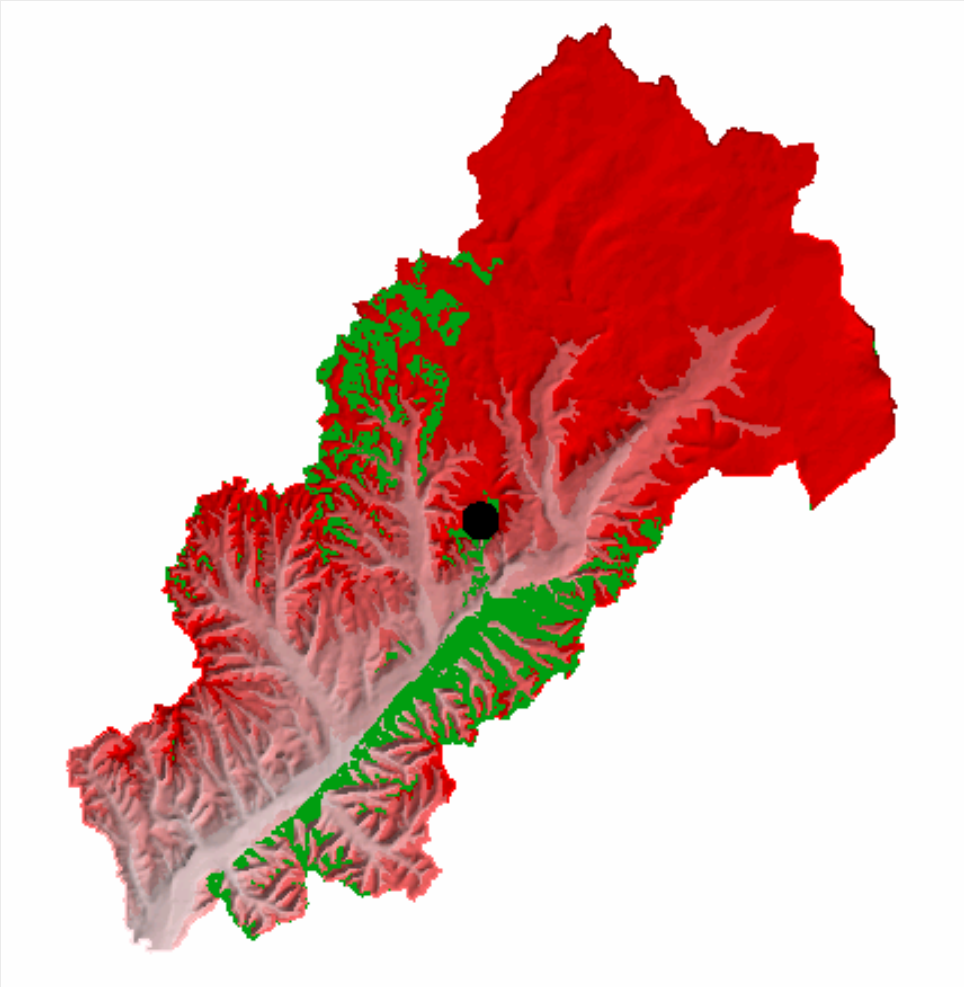
Buffers



What are the characteristics of land within 50 meters of a stream?

Vector processing

Visibility



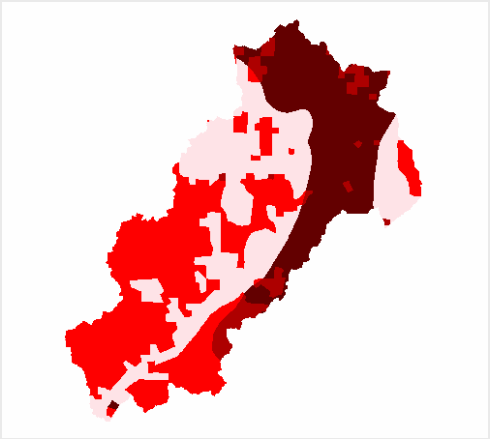
What land is visible from the selected location?

Raster processing

Modeling

How much precipitation contributes to runoff?

Runoff Curve Number



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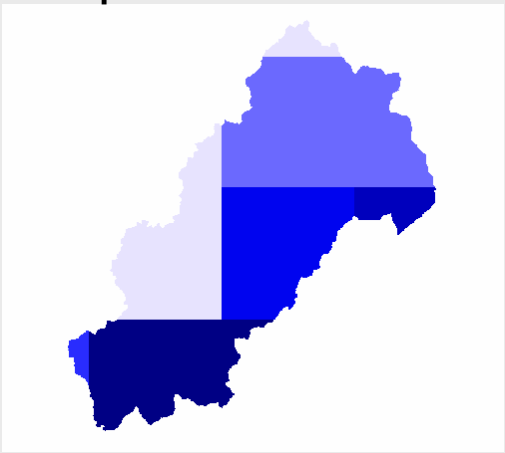
Precipitation



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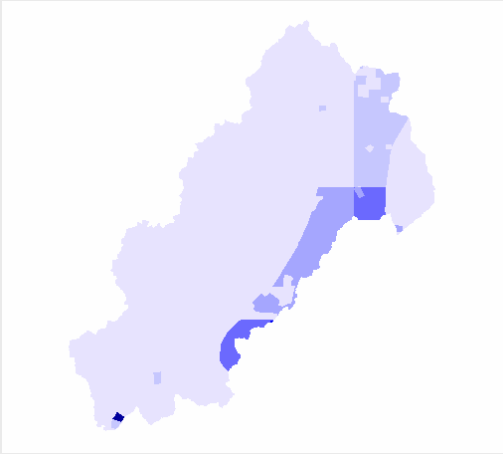
Runoff



Raster processing

Data in a GIS ...

What is spatial data?

- Any data that is associated with a specific geographic location
  - Aerial photography
  - Remotely sensed imagery
  - Road networks
  - Wetlands delineation
  - Stream gauges
  - Dam sites

Spatial Data

- Representation of the physical or social world in which the complexity of the real world is simplified
  - Simplifying features
  - Eliminating features
- Scale, as it exists on maps, applies to spatial data
  - Sampling of data
  - Controls degree of simplification and the selection of features to eliminate

Spatial Data Types

- Raster
  - Remotely Sensed Imagery (with data for individual bands), DEMs
- Vector
  - Points
  - Lines
  - Polygons
- Image
  - (scanned images, georeferenced)

Raster data

- Matrix of numbers (or cells)
- Represents the entire area, whether any of the map phenomena exists or not
- Best representation for phenomena that varies continuously over the surface of the earth (rainfall, elevation)

ASCII storage of raster data

230	230	232	234	236	238
229	230	231	232	235	237
228	229	230	232	234	236
226	228	230	232	234	235
224	227	229	230	232	234

X1 = -72.2, Y1 = 41.0, cell size = 30 meters

Display of raster data

A portion of a USGS DEM

Each “cell” in the database represents a single elevation.

The cell size is 30 meters. The elevation is the average of all samples within the cell.

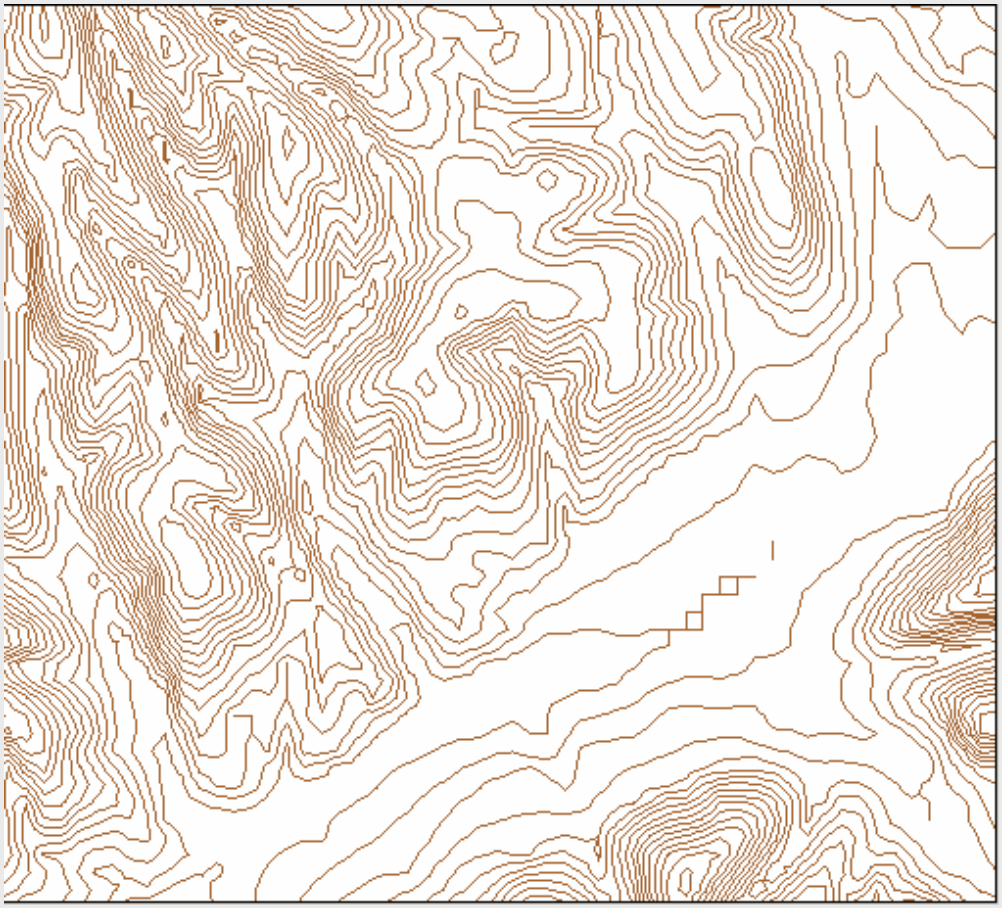
Vector data

- A network of points, lines, or polygons
- Points are the basic unit
- Lines connect points
- A group of lines enclose a polygon
- Represents where phenomena exist
- Best representation of discrete data (roads, wells, utility lines)

ASCII storage of vector data

```
230
-72.2  41.0
-72.1  40.9
-72.0  40.8
-71.9  40.7
-71.8  40.6
```

Display of vector data



Contour lines created from the DEM

Each line represents a line of equal elevation.

The elevation value is stored as an attribute of the line.

Image data

- Reference for other data
- Data source – digitize directly from scanned, georeferenced image

Display of Image Data

Both images are georeferenced (can be viewed with other spatial data)

Orthophoto of part of MIT Campus

Scanned image of part of U.S.G.S Topographic map

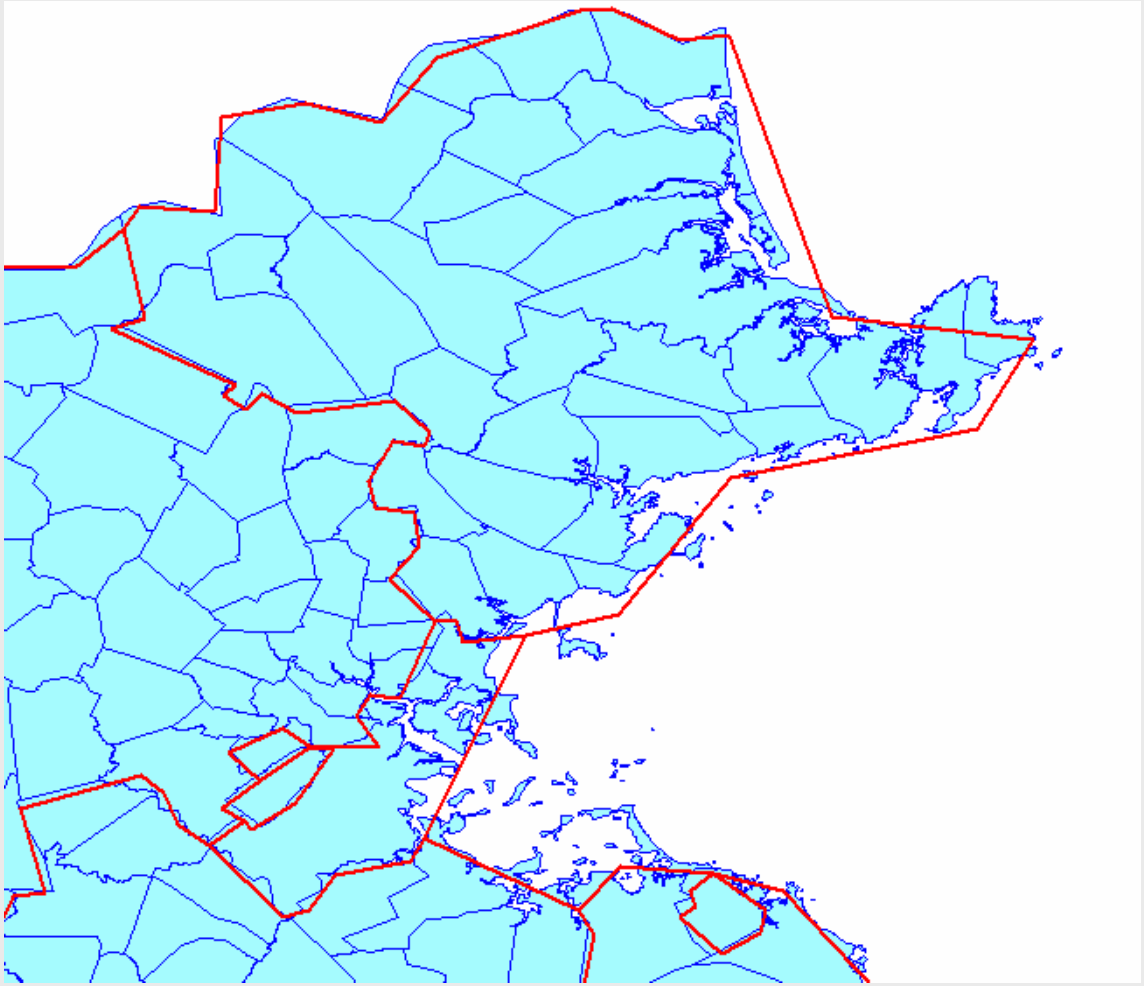
Raster vs Vector data

- Precision of geographic representation
- Processing speed
- Data storage requirements
- Characteristics of the data
- Sampling requirements

Data Issues in a GIS

- Scale problems
  - Scale based on presumed use
  - Different scales lead to different precision of data
- Database tiling
  - Data is available in different geographic units

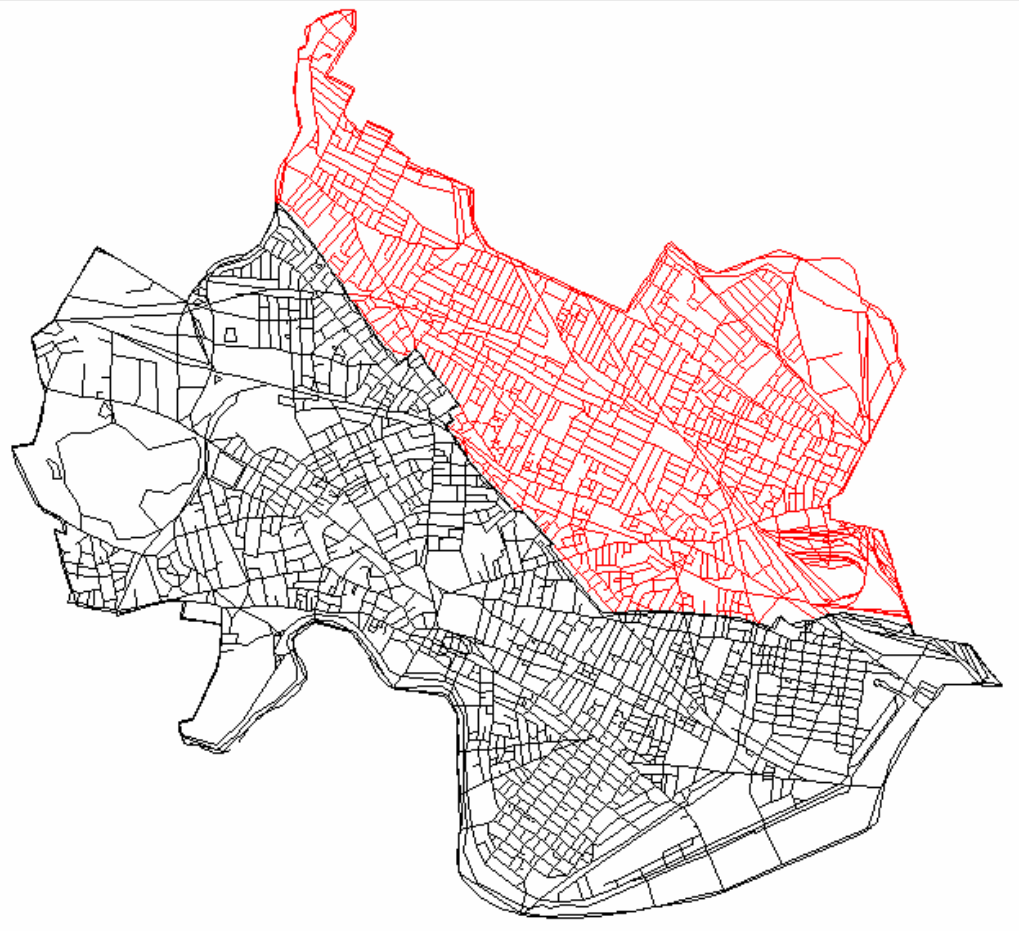
Scale problems



Massachusetts towns (blue) and county outlines (red).

Town data was Digitized at 1:250,000 scale. County data was Digitized at 1:6,000,000

Database tiling issues



Cambridge (black) and Somerville (red) street network.

Census street files are distributed by town.

What is ArcGIS and ArcMAP?

- A desktop GIS software that:
  - Displays spatial and tabular data
  - Uses SQL to query spatial data
  - Finds attributes of spatial features
  - Classifies features for mapping
  - Selects features based on its attributes or proximity to other features
  - Finds places where different features overlap

Basics of ArcGIS

- Map is the “view” of data
- Data are added to the map view as “layers”
- A layer can be used for analysis whether or not it has been added to the map

What data can be used in ArcGIS?

- Vector data
- Image data
  - Air Photos
  - Remotely sensed imagery
- Raster data

On to the exercise