GIS for Research III:
Geoprocessing, Analysis, and Web GIS

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• GIS Specialist
  Scholarly Commons, Main Library at the University of Illinois at Urbana-Champaign

Previously:
• GIS Manager
  Carnegie Museum of Natural History

• Master of Science in Geography, concentration in GIS and Cartography
  Indiana University of Pennsylvania

• Bachelor of Arts in Zoology
  Ohio Wesleyan University
GIS at Scholarly Commons

• Provide GIS research consultations and services

• Provide GIS workshops and training

• Manage the University Library’s geospatial data and GIS software resources

• Act as a central resource for the University’s GIS community and promote the use of GIS in research and teaching
GIS for Research Core Workshops

- GIS for Research I: Introduction to GIS Concepts, Software, and Data
- GIS for Research II: GIS Research, Data Management, and Visualization
- GIS for Research III: Geoprocessing, Analysis, and Web GIS

Slides available at http://guides.library.illinois.edu/gis
Special Topics GIS Workshops

• ArcGIS Online and Story Maps
• ModelBuilder and Python in ArcGIS
• Field data collection techniques and Collector for ArcGIS
• Geocoding and georeferencing
• Spatial Analysis Techniques: Interpolation, Clusters, Statistics, and more
• Lidar and 3D mapping techniques
Learning Objectives

• Continue understanding of how to think spatially and how GIS fits into the overall research framework

• Learn how to use ArcGIS for Desktop for different geoprocessing and analysis workflows

• Understand the difference between vector and raster analyses

• Learn to create and export simple maps for use in web GIS (ArcGIS Online)
Review GIS Research Process
GIS and the Research Process

• Frame the Research Question(s)

• Explore, Acquire, and Prepare Possible Data Sources

• Determine Final Product or Outcome Needed

• Identify analyses and tools
GIS and the Research Process

• Design the Analysis and Workflow

• Examine, Review, and Modify Analysis and Workflow

• Visualize Data (Cartographically)
Coordinate Systems and Map Projections
Coordinate Systems in GIS

Two types in GIS:

• Geographic Coordinate Systems (GCS)

• Projected Coordinate Systems (PCS)
Geographic Coordinate Systems

- Based on a *spheroidal* model of the earth

- Reference lines are parallels (latitude) and meridians (longitude)

- Uses geographic coordinates and angular measurements \((x,y)\) – where \(x\) is lon., \(y\) is lat) to define unique positions on the earth

- Defined primarily by a geographic datum
Projected Coordinate Systems

- Portrays curved/spherical surface of the earth to planar or flat surface
  - Systematic mathematical transformation of the earth's lines of longitude and latitude onto a plane
  - Uses length-based units (m and ft)

- Introduces distortion of the map data, but designed to minimize:
  - Distance → Equidistant
  - Area → Equal area
  - Shape → Conformal
  - Direction → Azimuthal
Choosing a Coordinate System

• Data often starts off in a different coordinate system

• Data many times needs to be projected, or transformed, to a different coordinate system

• Primary goal: minimize error and distortions
Choosing a Coordinate System

• Where in the world is the project area?

• What scale and extent is the analysis?
  – Small scale, large extent (World to State)
  – Large scale, small extent (County to City)

• What type of measurements will be performed?
  – Simple locations (Geographic Coord. Sys.)
  – Distances (Equidistant Projected Coord. Sys.)
  – Areas (Equal Area Projected Coord. Sys.)

• What coordinate system is the data already in?

• How will changing the coordinate system affect raster data?
Spatial Analysis and Geoprocessing
What is Spatial Analysis?

- Process of examining the locations, attributes, and relationships of features in spatial data through overlay and other analytical techniques.

- Addresses questions to gain useful knowledge by extracting or creating new information from spatial data.
What is Geoprocessing?

- Provide tools and framework for performing spatial analysis and managing geospatial data
- Allows for analysis workflows to be automated
Spatial Measurements

- Coordinates
- Distance and Buffers
- Area
Overlays

• Intersect, Union, and Spatial Joins

• Clipping and Erasing
Spatial Patterns

• Geographic Distribution
• Density and Cluster Analysis
• Nearest Neighbor Analysis
Should I Use Vector or Raster Data?

Is your data **Discrete** or **Continuous**?

- **Discrete**
  - Individually distinguishable
  - Phenomenon does not exist between observations
    ex. lakes and roads

- **Continuous**
  - Gradual variation across a range of values
  - Values exists between observations, but maybe not always measurable
    ex. temperature and elevation

- **Both Vector and Raster data can model discrete and continuous data, but...**
  - Vector data → better for discrete data
  - Raster data → better for continuous data

- **Decision also depends on the scale or resolution of data, analysis workflow, and tools available**
# Data Measurement Types

<table>
<thead>
<tr>
<th>Discrete</th>
<th>Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classified</strong></td>
<td><strong>Absolute</strong></td>
</tr>
<tr>
<td>Nominal Land Use</td>
<td>Ratio Rain fall</td>
</tr>
<tr>
<td><strong>Ranked</strong></td>
<td><strong>Relative</strong></td>
</tr>
<tr>
<td>Ordinal Road type</td>
<td>Interval Contours</td>
</tr>
<tr>
<td><strong>Qualitative</strong></td>
<td><strong>Quantitative</strong></td>
</tr>
<tr>
<td>Text</td>
<td>Integer/Date</td>
</tr>
<tr>
<td>Integer/Date</td>
<td>Float/Double</td>
</tr>
</tbody>
</table>


Is Contour Data Discrete or Continuous?

Elevation Contours

- What is being visualized?
- Are Contours vector or raster data?
Scale vs. Resolution

Scale → Vector

Resolution → Raster

• In general:

Map Scale Denominator = Raster resolution (in meters) * 2 * 1000

<table>
<thead>
<tr>
<th>Map scale</th>
<th>Detectable size (in meters)</th>
<th>Raster resolution (in meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1,000</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>1:5,000</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>1:10,000</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>1:50,000</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>1:100,000</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>1:250,000</td>
<td>250</td>
<td>125</td>
</tr>
<tr>
<td>1:500,000</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>1:1,000,000</td>
<td>1,000</td>
<td>500</td>
</tr>
</tbody>
</table>

• It is not good practice to perform analyses on data intended for different scales/resolution

Geoprocessing Pane
What is the Geoprocessing Pane?

- Contains geoprocessing tools for using GIS software and on GIS data

- Hundreds of tools organized into toolboxes

- Tools can be automated and strung together using ModelBuilder or Python scripting

- Some tools require specific licensing or extensions
Tool Parameters

- Tool parameters are a simple text string or number that tells the tool what data to use or what you want it to do.

- Parameter have their own user interface (UI) control and validation rules.

- Click Run to execute the tool.
Exercise 1

Geoprocessing Tools for Organizing Data

Acquire Geospatial Data

Analyze Geospatial Data

Present Geospatial Data
Exercise 2

Geoprocessing Tools to Estimate Affected Population
Exercise 3

Extracting and Summarizing Raster Data
Spatial Joins
What is a Spatial Join?

- Joins attributes from one feature to another based on the spatial relationship
- Many different types of spatial relationships:
  - Intersect
  - Within a distance
  - Contains
  - Completely contains
  - Within
  - Completely within
  - Are identical to
  - Boundary touches
  - Share a line segment with
  - Crossed by the outline of
  - Have their center in
Types of Spatial Joins

• One-to-One:
  Only one feature is returned for each spatial relationship or target feature

• One-to-Many:
  Multiple features may be returned for each spatial relationship or target feature
Exercise 4

Spatial Joins
ArcGIS Online
What is ArcGIS Online

• Part of the ArcGIS platform

• Cloud-based web software

• Use, create, and share interactive web maps, apps, and data

• Public vs. Organizational accounts

What is ArcGIS Online

- Collaboration
- Citizen Engagement
- Executive Access
- Work Anywhere
- Content Management
- Workflow Integration
- Catalog
- Maps
- Apps
- Content
- Groups
- Hosting
- Services

Cloud GIS

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Feature Layer Services

Feature Layers → Vector

• Published from vector datasets

• Individual feature attribute information is accessible

• Can be used for GIS analysis on the web
Tile Map Layers

**Tile Layers → Raster**
(or Raster-like)

- Pre-drawn map images tiled to appear seamless
- Good for fast map visualization over the web
- Good as basemaps to give geographic context
- Individual feature attribute information NOT ALWAYS accessible
What is an ArcGIS web map?

• Interactive display of geographic information

• Opens in a standard internet browser (IE, Firefox, Chrome, etc.), mobile devices, and other ArcGIS map viewers

• Contains:
  – Basemaps and Layers
  – Legend and navigation tools

• Saved to your contents in ArcGIS Online account
What is an ArcGIS web map?

1. **Choose an area.**
   Pan and zoom the map to an area or search by its name or address.

2. **Decide what to show.**
   Choose a Basemap then Add layers on top of it.

3. **Add more to your map.**
   Add map notes to draw features on the map.
   Display descriptive text, images, and charts for map features in a pop-up.

4. **Save and share your map.**
   Give your map a name and description then share it with other people.
Demo

Extracting and Summarizing Raster Data
GIS for Research Workshops

• GIS for Research I: Introduction to GIS Concepts, Software, and Data
  – Thurs. Sept. 21 1-3pm & Fri. Nov. 3, 1-3pm, rm. 314

• GIS for Research II: GIS Research, Data Management, and Visualization
  – Thurs. Sept. 28 1-3pm & Weds. Nov. 8, 1-3pm, rm. 314

• GIS for Research III: Geoprocessing, Analysis, and Web GIS
  – Thurs. Oct. 5 1-3pm & Fri. Nov. 11, 1-3pm, rm. 314
Special Topics GIS Workshops

• **Sharing Research with Story Maps**
  – Tues., October 17, 3-4pm, room 314
  – Thurs., November 2, 2-3pm, room 314

• **Geocoding**
  – Thursday, October 19, 2 – 3 pm, room 314
Special Topics GIS Workshops

• Introduction to Python for ArcGIS
  – Friday, December 1, 1 – 4pm, room 314

• Advanced Python for ArcGIS
  – Friday, December 8, 1 – 4pm, room 314
Library Resources

• Scholarly Commons GIS Services:
  – GIS data discovery and research services
  – GIS consultations by appointment
  – [http://www.library.illinois.edu/sc/datagis](http://www.library.illinois.edu/sc/datagis)
  – [http://guides.library.illinois.edu/gis](http://guides.library.illinois.edu/gis)

• Map Library:
  – Geospatial datasets, GIS reference books and journals, aerial photos, paper maps, etc.
  – [www.library.illinois.edu/max](http://www.library.illinois.edu/max)
Thank You!

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Please feel free to contact me for further assistance.