Space is everywhere, and so are spatial problems


• Congressional redistricting http://www.redistrictinggame.org/index.php?pg=game
Objectives for Today

• Content
• Motivation
• Mechanics and grading
Bloom’s Taxonomy of Learning

Higher Order Thinking Skills
- Evaluation
- Synthesis
- Analysis
- Application
- Comprehension

Lower Order Thinking Skills
- Knowledge

The diagram illustrates the hierarchy of cognitive skills from knowledge to evaluation, emphasizing the progression from lower order to higher order thinking.
## FNRM5131

Resources for FNRM 5131, GIS For Natural Resource Management

**Syllabus, Moodle, Lab Page.** Office hours: Paul Bostad, by appointment; Andy Jenks, T & Th 12:45-1:44 pm and **Google Hangout for Wednesdays 8-9 pm**

**Materials, Organized Chronologically,** Readings are from the book "GIS Fundamentals, Fifth Edition." by Paul Bolstad

<table>
<thead>
<tr>
<th>Week of</th>
<th>Chapters</th>
<th>Class Notes, Videos, Questions</th>
<th>Supplements</th>
<th>Lab Assignment</th>
<th>Assignments Due, Date</th>
</tr>
</thead>
</table>
| 1 - Sept. 5 | 1, 2 | *Introduction to GIS*  
*Course Mechanics Introduction, Basic Concepts, Raster Structure and Resampling, Data and File Structures, Coord. Questions*  
PDF notes: 1, 2 | *Geospatial Revolution, 422 visualizations, Nova/PBS video: The Search for Longitude, 3 Trillion Trees* | *Lab 1: Complete assignment in either ArcGIS or QGIS, not both,* instructions and data are on the *Lab Page.*  
*Start only ONE of the Semester-long Projects, see Lab Page* | None - start Lab 1, and start **ONLY 1** of the semester-long projects.  
Take Moodle Quiz 1 this week. There is a quiz every week that covers the readings for that week, and it **closes at the start** of the Tuesday lecture time. |
| 2 - Sept. 12 | 3 | *Geodesy, map projections*  
PDF notes: 1, 2 | *Understanding Map Projections, Minn. Projections, NADCON, HTDP, MNCON, Spherical Video, Interesting 3D Projections - Jason Davies* | *Lab 2, Geodesy, Coordinate Systems, Map Projections, Lab Page* | 1) Complete Moodle Quiz 2, it closes at the start of Tuesday lecture  
2) Turn in Lab 1, Due by 11:55 p.m. Friday, as are all subsequent labs unless noted |
| 3 - Sept. 19 | 4 | *Data Entry,  
PDF notes: 1, 2*  
*Image & Old Map Registration* | *Open Streetmap - crowdsourcing* | *Lab 3, Data Entry, Lab Page* | 1) Moodle Quiz week 3  
2) Lab 2  
3) On-Line Exam 1, on chaps. 1 - 3, Friday-Sunday |
Lab Exercises, FNRM5131, GIS For Natural Resource Management

Class Page, Moodle, Instructions to Set up ArcGIS on your home computer; instructor will provide you an authorization number via email

Lab Materials, Organized Chronologically:
Readings are from the book "GIS Fundamentals, 5th Edition," by Paul Bolstad

<table>
<thead>
<tr>
<th>Week</th>
<th>Lab Number &amp; Topic</th>
<th>Assignment</th>
<th>Instructional Video ArcGIS: All videos are on YouTube (unlisted)</th>
<th>Instructional Video QGIS: All videos are on YouTube (unlisted)</th>
<th>Data (for both ArcGIS and QGIS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lab 1, Introduction to the software</td>
<td>Lab 1 Instructions: ArcGIS or QGIS, Summary Overheads for Lab exercise Semester-long Projects (Pick ONLY one): 1) Hopkins ArcGIS, 2) St. Anthony Park ArcGIS, 3) Appalachian Watershed ArcGIS</td>
<td>Getting Started, More Configuration, Configure Toolbars, Relative Paths, Saving Project, Intro Symbology Layout, Export Print, More Symbols, Measure Tool, Data Frames, Topology</td>
<td>SetupPC, SetupMac, Symbols, Print Composer, Relative Paths, Polygon Symbols, Multi_Panel, Topology</td>
<td>Lab1 Data Hopkins Data, SAP Data, Wtrshed Data, Raster Clipping Video</td>
</tr>
</tbody>
</table>
Class Mechanics

• Do readings **in advance** for both lectures and labs
• Weekly quizzes, weekly lab exercises, two homeworks, 4-part semester-long exercise,
• Turn in materials on Moodle

plus

• Five online exams
Week 1 Introduction to GIS

Week starts Monday, September 5, 2016
First (in-person) class session Tuesday, September 6
Read Chapters 1 and 2

Do the reading quiz for this week, using the link below. This week’s quiz can be done anytime, but be warned: future reading quizzes will only be available UNTIL THE START of the Tuesday lecture.
Lab Mechanics

• Labs are due Friday night at 11:55 pm on Moodle one week after assignment.

• Labs up to 1 week late are penalized 33%

• Labs more than 1 week late are penalized 100%

• Arrange scheduling difficulties in advance
## Grading - Straight Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>A+ (&gt;100%)</th>
<th>B+</th>
<th>C+</th>
<th>D+</th>
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<tr>
<td></td>
<td>87.5 – 89.99</td>
<td>77.5 – 79.99</td>
<td>60.0 – 64.49</td>
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<tr>
<td>A (90-100)</td>
<td>82.5 – 87.49</td>
<td>70.0 – 77.49</td>
<td>50.0 – 59.99</td>
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<tr>
<td>A- (Not given)</td>
<td>80-82.49</td>
<td>65 – 69.99</td>
<td>&lt; 50%</td>
<td></td>
</tr>
</tbody>
</table>
Points

- Weekly readings, with quizzes, 3 points each quiz
- Weekly lab assignments, each 15 points except last one, @30 points.
- Two homeworks, 15 points each
- Semester-long project, 55 labs worth
- Lecture questions, 10-20, 1 pt each
- Five exams, 45 pts each
- Extra credit labs, 35 points worth total

Total points about 610
Course Topics

- Motivation: why GIS?
- Data Models
- Map Projections and Coordinate Systems
- Data entry - digitizing
- Data entry - GPS
- Data entry - digital data
- Image data
- Tables
- Basic Spatial Analysis
- Raster Analyses
- Spatial Models and Modeling
- Interpolation
- Data Quality
- The Future
Any Questions?
Why GIS?
Developing new information
Why GIS?

Sustaining Lobster Fisheries in Penobscot Bay

Why is it important? Fisheries stocks dwindling, lobster an economic mainstay with sustainable harvests
From Observations and Process Knowledge to Prediction and Action

Distribution of lobster larvae: Stages I and IV
Eastern Gulf of Maine, August 1999

Sampling for lobster larvae

Early Benthic Phase Lobster Abundance, 1999 (lobsters 20 - 39 mm in CL)

Eric Annis, University of Maine

Stage I
Stage IV (postlarvae)
GIS Software Tools

GIS started at universities as research tools

Primary flavors
ESRI (ArcGIS)        Intergraph
Microimages       Autocad       MapInfo
ERDAS             Idrisi        Manifold
GRASS
GIS Software Tools (the frustrating part)
Caveat

Tools for data management

Tools for generic analysis

Scientific analysis and specific tools often lacking
What is in it for me?

Take a sheet of paper, put your name and major at the top. Then,

In a five minute free write, answer the questions:
What spatial analysis will you be doing in five years?
What do you want from this class?
Steps for Successful GIS Analysis
(Goals defined, methods exist)

• Define bounds, geographic region of interest
• Choose best data model
• Define the grain size
• Identify existing spatial data
• Determine coordinate system for analyses
• Develop digital database
• Document database (origin, quality)
• Perform analyses
• Report results
• Update Database
Two key questions:
Grain size (smallest thing I want to resolve, and
Extent (spatial scope of my analysis
- What resolution (how fine scale)?
- How big an area?
Errors Often Increase with Extent
Data Costs Increase as Grain Decreases
REPRESENTATION AND DATA STRUCTURES

• Most common data models define thematic layers.

• Typically, layers, one layer for each distinct view of a theme.

Geographic data are often in layers which represent specific surface features, or themes, e.g., soils, roads, or elevation.
phenomena that exist

An abstraction, relevant phenomena and properties

computer representation
Cartesian Coordinates
$360^\circ$ to circle the sphere

60', or 60 minutes, for each degree

60", or 60 seconds, for each minute
Cartesian Coordinate Systems

2 - Dimensional

3 - Dimensional

origin, $x=y=z=0$
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<thead>
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<th>Building Name</th>
<th>Floors</th>
<th>Roof Type</th>
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<tbody>
<tr>
<td>1</td>
<td>Hodson Hall</td>
<td>6.0</td>
<td>flat, sealed tar</td>
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<tr>
<td>2</td>
<td>Borlaug Hall</td>
<td>5.5</td>
<td>pitched 9/12, tile</td>
</tr>
<tr>
<td>3</td>
<td>Guilford Technology Bldg.</td>
<td>4.0</td>
<td>flat, gasket</td>
</tr>
<tr>
<td>4</td>
<td>Shop Annex</td>
<td>2.5</td>
<td>flat, sealed tar</td>
</tr>
<tr>
<td>5</td>
<td>Animal Sciences Bldg.</td>
<td>1.0</td>
<td>pitched 12/12, tile</td>
</tr>
<tr>
<td>6</td>
<td>Administration Bldg.</td>
<td>14.0</td>
<td>pitched 6/12, metal</td>
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<tr>
<td>7</td>
<td>Climate Sciences Center</td>
<td>6.0</td>
<td>flat, sealed tar</td>
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<tr>
<td>8</td>
<td>Grantham Tower</td>
<td>1.0</td>
<td>pitched, 9/12, tile</td>
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<tr>
<td>9</td>
<td>Biological Sciences Bldg.</td>
<td>9.0</td>
<td>pitched 12/12, tile</td>
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Enforced Uniformity
Raster – The Mixed Pixel Problem

Landcover map – Two classes, land or water
Cell A is straightforward
What category to assign for

B, (1=land, 2=water)
C, or D?
Connecting data, contrast with vector

a) Vector, one-to-one

attribute table

<table>
<thead>
<tr>
<th>IDorg</th>
<th>class</th>
<th>area</th>
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<tbody>
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<td>16.8</td>
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<td>B</td>
<td>11</td>
<td>22.2</td>
</tr>
<tr>
<td>C</td>
<td>15</td>
<td>18.4</td>
</tr>
<tr>
<td>D</td>
<td>21</td>
<td>16.4</td>
</tr>
<tr>
<td>E</td>
<td>10</td>
<td>3.8</td>
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</table>
Many-to-one much more common, to tame the attribute table
c) Raster, many-to-one

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<tr>
<td>10</td>
<td>18.4</td>
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<td>15</td>
<td>21.6</td>
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<tr>
<td>21</td>
<td>13.6</td>
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</tbody>
</table>
Multi-part vs. Single-part Shapes

Any problem with a 1 to 1 correspondence, polygon to attribute row, for states?
Data and File Structures: Why Should I Care?
Data and File Structures: Why Should I Care?
Architecture/Landscape Architecture/Design data path
Data and File Structures: Why Should I Care?

Hydrologic analysis data path
When you want this...  You get this:
Data and File Structures

Data are stored as binary numbers

Bits are 0 or 1

Bytes are 8 bits

Data (e.g., raster cells) are often references as 1 byte, two byte, etc.

<table>
<thead>
<tr>
<th>binary</th>
<th>decimal</th>
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<tr>
<td>00000001</td>
<td>1</td>
</tr>
<tr>
<td>00000010</td>
<td>2</td>
</tr>
<tr>
<td>00000011</td>
<td>3</td>
</tr>
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<td>00000101</td>
<td>5</td>
</tr>
<tr>
<td>00000110</td>
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<td>00001010</td>
<td>10</td>
</tr>
<tr>
<td>00001011</td>
<td>11</td>
</tr>
</tbody>
</table>

Binary Columns

1 1 0 1

8 + 4 + 0 + 1 = 13
Which is bigger, 1) 0100, or 2) 0011?

What is the largest number you can store with 8 digits, 1) 8, or 2) 24, 3) 64, 4) 128, or 5) 256?

Which can store a larger number, 1) an unsigned 8-bit integer, 2) signed 8-bit integer, or 3) they store the same?
Data and File Structures

Data often have specific organization to
• reduce size
• speed access
• ease updates
Example: ESRI Shapefiles
Landcover dataset, wash_lc

is a cluster of files,

wash_lc.shp - containing the coordinates
wash_lc.dbf - containing the attributes
wash_lc.shx - containing linkages, other info
wash_lc.prj - optional, containing projection information
wash_lc.sbn - an optional indexing file

Generally, all files are needed for useful data

If you mess with one file, you can “break” the data
What is Resampling?
Raster Resampling - inter/intra-cell averaging
Raster resampling - our data have different grains

a) 100 meter, 4 cells

b) 50 meter, 16 cells

c) 25 meter, 64 cells
Raster Resampling - a distance weighted average to calculate raster values
Raster Resampling -
Related to, but not to be confused with image sharpening
SHARPENING is a kind of resampling that improves images, but ruins spatial data.
What are nominal data?

ordinal data?

interval/ratio data?
Does it make sense to resample nominal data?

Does it make sense to resample ordinal data?

Does it make sense to resample interval/ratio data?
Resampling Ambiguity

The diagram illustrates the concept of resampling in a grid format. The left side shows a grid with numbers and letters, while the right side demonstrates the resampling process with colored points representing the sampled data.
What if the cells aren’t “well behaved”
nearest neighbor assigns an output cell value from the nearest corresponding input cell

bilinear interpolation uses the nearest cell and next three closest cells in a weighted average

cubic-convolution includes the cells used for bilinear interpolation and the next 12 closest cells to compute a weighted average for each output cell
What is the value of $Z_{out}$?

\[
Z_b = Z_4 + \frac{(Z_3 - Z_4)}{c} d_1
\]

\[
Z_b = 1.4 + \frac{(4.6 - 1.4)}{5} \times 2.9 = 3.26
\]

\[
Z_u = Z_2 + \frac{(Z_1 - Z_2)}{c} d_1
\]

\[
Z_u = 4 + \frac{(6 - 4)}{5} \times 2.9 = 5.16
\]

\[
Z_{out} = Z_b + \frac{(Z_u - Z_b)}{c} d_2
\]

\[
Z_{out} = 3.26 + \frac{(5.16 - 3.26)}{5} \times 2.2 = 4.1
\]