Cookbook 4 February 2013
What is GIS?

Overview

1. What is GIS?
2. GIS is NOT a map!
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4. Course Logistics
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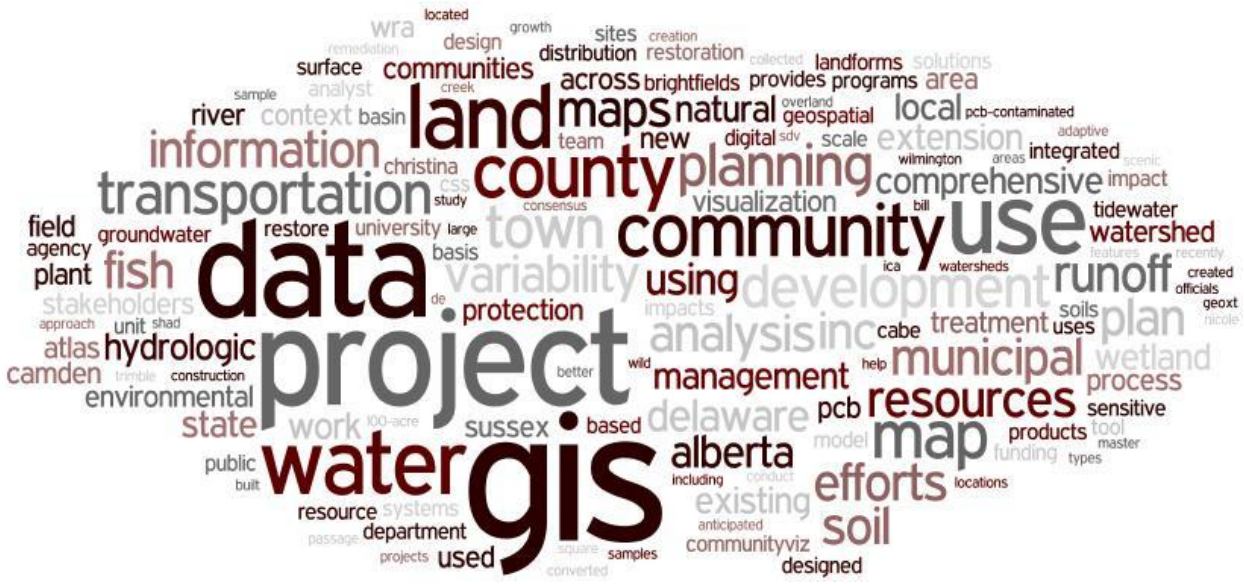


Course Website
http://www.westfield.ma.edu/cbraun/teaching/introduction-to-gis/

GIS Resources
http://www.westfield.ma.edu/cbraun/resources/gis-resources/

1) What is GIS?

This is a good place to start – what is GIS and why are we here?

1.1) Your Turn: *What is GIS?*

1. Why are you taking this class?
2. What do you want to learn in this class?
3. What is GIS?
4. What can you do with a GIS? List and explain at least 2 specific examples.

1.2) My Turn: *What is GIS?*

A GIS visualizes and analyzes data to quantify spatial relationships, patterns, and trends in the form of maps, reports, and charts.

= Intelligent and meaningful maps!

Geography

Geography is the scientific study of the spatial variations in physical and human phenomena on Earth.

- *Basically we try to figure out where, why, and how things happen on the Earth.*
- *I prefer this explanation: Geography is to Space what History is to Time!*

Geographic Information

Geographic information includes the location of the information in some kind of consistent mathematical format. This mathematical format can be simple street addresses, zip codes place names, latitude/longitude, or any other kind of (X,Y) coordinates. We use geographical information all the time!

- For example: Telling someone that it was 90° yesterday makes no sense at all, unless you also tell the person *where* on Earth it was 90°F yesterday.
- For example: Inviting someone to your 4th of July BBQ makes no sense at all, unless you tell the person *where* you are having your BBQ.

In a GIS we can specify the location of a feature using street addresses or latitude/longitude – whatever works better for a given application (see Section 2).

Geographic Information System

Geographic information that is systematically organized (= database)

➔ *If we have geographical information, organized in a systematic manner, then we can use a computer for quantitative geographic analysis.*

Remember: a computer is dumb, but a computer can perform repetitive tasks really fast. Thus, if you have geographic information in a systematic format, a computer can help you display it as a map and perform mathematical calculations for you.

FYI: database is really only a fancy world for a digital table, for example a MS Excel spreadsheet.

Good Videos

- http://www.youtube.com/watch?v=z5s8kbEdB68
- http://www.gis.com/content/answering-questions-gis
- http://www.esri.com/apps/esriclips/flash.cfm?path=71
- http://www.youtube.com/watch?v=BG6XsFi4gfo
- http://www.youtube.com/watch?v=yoNau0oOKtU

Big Picture: GIS is a Concept!

The location of objects and their interactions are (often) not random or independent. Instead, the world is characterized by spatial patters and relationships. A GIS allows us to visualize (map) and analyze these spatial patterns and relationships.

Daily Reality: GIS is Hardware, Software, Data, People, and Methods!

Hardware:	PCs, servers, GPS, printers, scanners, smartphones, tablets, WWW, etc.
Software:	ArcGIS, Google Earth/Maps, QGIS, IDRISI, etc.
Data:	Clouds-based, server-based, local (create/download, modify, update)
People:	Scientists, planners, consultants, police, military, business, etc.
Methods:	Spatial statistics, mapping, surveying, remote sensing, etc.

Key GIS Concept #1
The Layer or Sandwich Concept…the sum is more interesting than the individual parts or layers!

Key GIS Concept #2
The Database Concept…the data underlying the GIS is stored on your computer in series of database tables.

Key GIS Concept #3
A GIS makes Maps! True! Today we make maps on the computer using a GIS.

But, that alone is boring!

Today we also write on a computer or do math on a calculator or spreadsheet.

A GIS makes intelligent and meaningful maps!

- Maps that you can edit and update.
- Maps that contain new layers of information.
- Maps that quantify relationships and patterns.

2) GIS is NOT a Map!

Sure, you can make maps with a GIS, but that's only the start!
Or one of the ends – depending on how you look at it…

2.1) Demo: *MS Excel vs. ArcGIS*

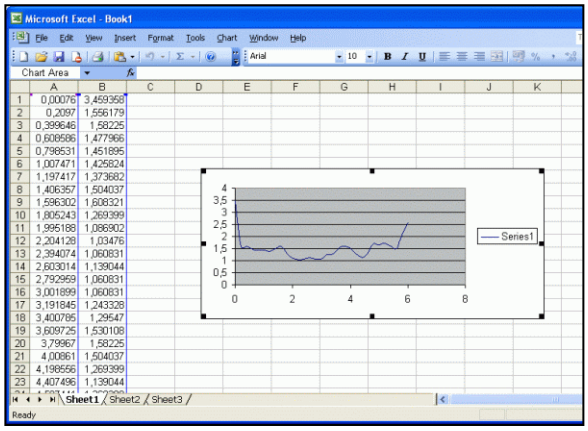
State	Population (2007)
ME	1352536
VT	636590
NH	1235786
MA	6349097
CT	3556875
RI	1085885

Type into a MS Excel spreadsheet and follow along!

2.2) A GIS is NOT a Map!

A GIS is not a map, but rather a database that (can) create a map!

The MS Excel Analogy to GIS



In MS Excel the data are stored as a table with columns and rows – essentially a database.

You can enter data, look at data, change data, etc. inside the table. You can also perform calculations and analysis, for example the average of a range of cells or more advanced statistical calculations.

You can also create graphs to display the data in your table. Graphs are helpful to visualize trends, patterns, or correlations.

In MS Excel, the graph and the underlying data table are separate, but linked:

If you change a cell value in the table, the linked graph changes accordingly.
If you change the graph (graph type, colors, symbols, labels, etc.) the data in the underlying table does NOT change!

There is a one-way street connecting the data and its visualization!
Changing the data changes the visualization – which is good!
But, changing the visualization does NOT change the underlying data – which is also good!

A GIS is NOT a Map!

The same applies to a GIS: A GIS is geospatial data stored in database tables and you, the user, can decide to create a (linked) map from those data.

- You can create whatever map you want and make the map look the way you want to…the underlying data remain unchanged.
- But, if you change your underlying data…your map will change accordingly.

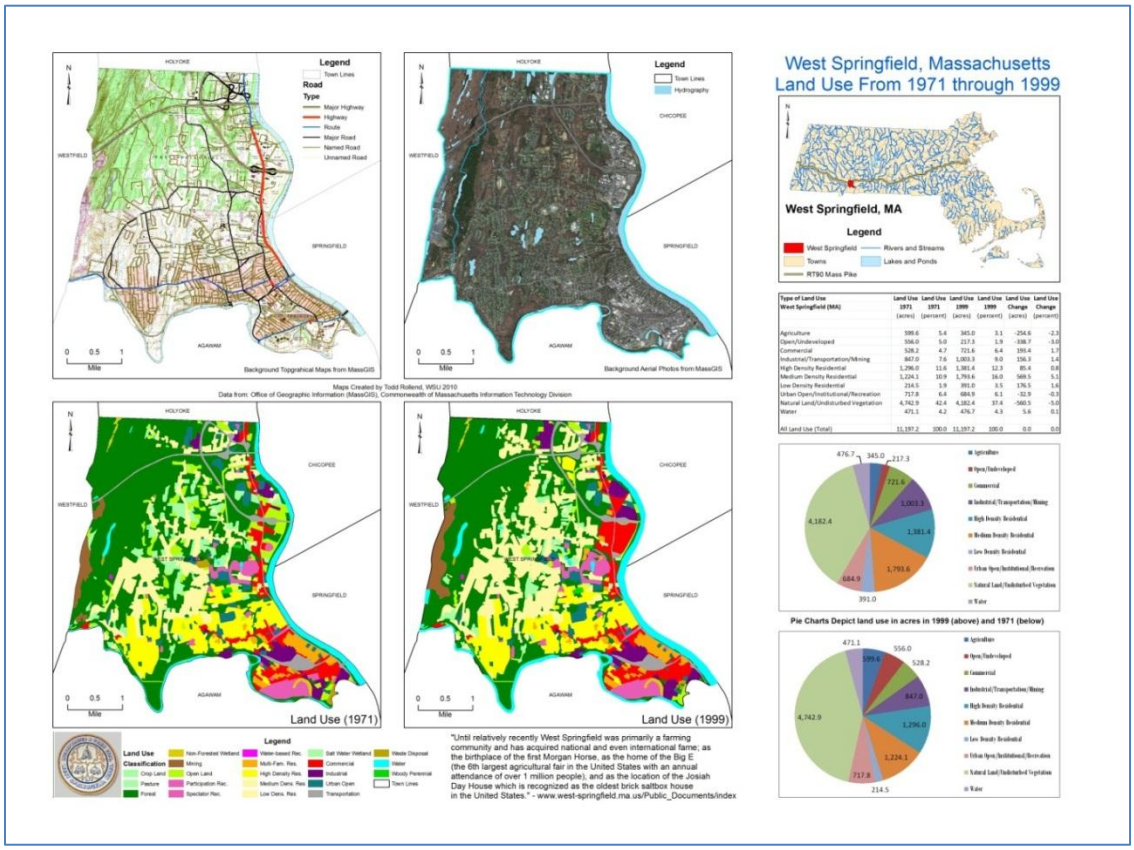
Maps are great and creating maps is one of the unique capabilities of a GIS. But maps are not the only way sometimes not the best way to present the results of a GIS analysis.

- You do not have to create a map. You can also create graphs, tables, or reports – whatever makes the most sense in a given situation.
- Maps are great and very often you will use your GIS to create a map. But, sometimes it is better to present the results of your GIS analysis as a graph or table.

The Big Difference MS Excel vs. GIS!

You can create a map with a GIS because your data are both spatial and attribute data = geospatial data. MS Excel handles only attribute data – MS Excel cannot create maps. Well…at least not in the way a GIS can. In fact, you can create maps with MS Excel, but that's a topic for another class.

Consider this example:



This 'map' shows the results of a land use change analysis for West Springfield (MA). This is not really a map, but rather a canvas or poster compiling various ways you can present data and analysis.

- 5 frames with maps.
- 1 table summarizing the results, created in MS Excel.
- 2 pie charts illustrating one important aspect of the results, created in MS Excel.
- Text explaining the analysis and the results.
- A written report documenting the analysis, presenting the results, and discussing the implications.

The entire poster with the 5 map frames and associated legends was created in ArcGIS. The table and pie charts were created in MS Excel and copied/pasted into ArcGIS.

➔ ***That's a GIS!***

3) Key GIS Concepts

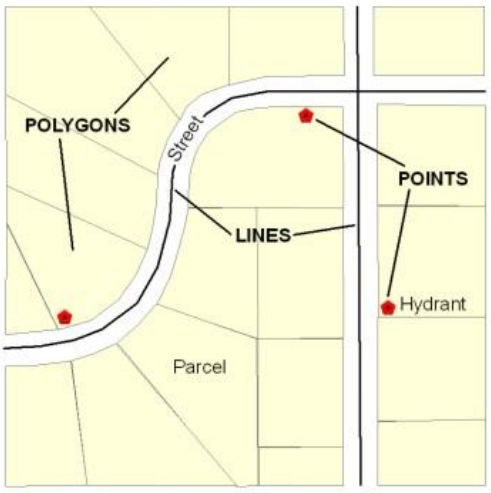
How do we abstract reality in a GIS?
In other words: how do we make reality digital?

3.1) Geospatial Data = Spatial Data *and* Attribute Data

In GIS, we distinguish between three types of objects – these are called spatial features.

Point Features
A point feature is an object that is a single point or that we can represent as a single point. Examples: a tree, a well, the location where we took a soil sample, utility pole, etc. It gets a bit trickier in some cases. For example, the location of a city may be shown on a map as a point, even though the city limits are really a polygon. That depends of the scale and detail of your map.

Line or Polyline Features
Line = straight (start point, end point)
Polyline = has wiggles (start point, end point, and many points or nodes in-between)
In reality, every line is actually a polyline when you look close enough. These are features that are long and skinny, for example rivers, roads, and railroad tracks. Again, it depends a bit on the scale and detail of your map. On a map of the entire USA we would show the Connecticut River as a line. On a map of downtown Springfield, on the other hand, the width of the Connecticut River is important and we would use a polygon.



Polygon Feature
In reality, everything is a polygon when you show it in enough detail. Even a tree or utility pole has an area. A polygon can be as simple as a triangle (3 sides, 3 nodes) or extremely complex (many side, many nodes). Examples: Lakes, state outlines, county lines, oceans, building foot prints, etc.

Spatial Data

Spatial data is the geographic location and geometry of a feature (for example a point, polyline, or polygon). Therefore, the spatial data provides the location of a feature in some kind of systematic mathematical format.

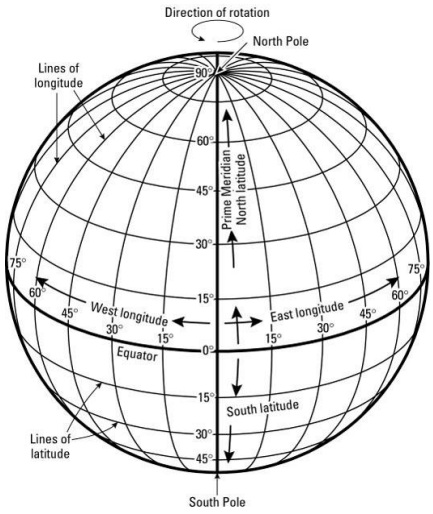
Where is it?	(= Location, latitude and longitude)
What is it?	(= Geometry, point, line, or polygon)
What's next to it?	(= Topology, adjacency, etc.)

- Examples of spatial data: the location and geometry of a wetland (polygon), a river (polyline), or utility pole (point).
- Spatial data tells us where something is located, but not what it is.

We use two different mathematical formats for locations:

Street, City, State, Zip Code.
That's the system that we are all used to.
One problem: the address system is not uniform between different countries of the world, which makes it difficult when you deal with different countries.

Latitude and Longitude = the Geographic Grid.
The geographic grid is great because it works the same way no matter where you are on the planet!



➔ ArcGIS (our GIS software) allows us to use both systems and even converts easily between them!

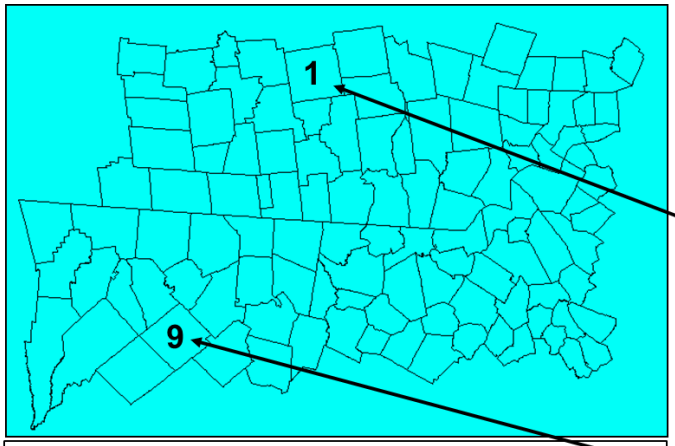
Example: My House

Street Address	Geographic Coordinates	
110 Haywood Street	Latitude:	42.598631°N
Greenfield, MA 01301	Longitude:	-72.586614°W
USA		

Both formats are useful. If you want to send me a present with the U.S. Postal Service you would use my street address. If you want to find my house in a GIS you can use both formats!

Geospatial Data: ***Where and how do you live?***

Spatial Data	**Spatial Data**
Street/Mailing Address:	Latitude: Longitude: Elevation:
Attribute Data	
Describe your home:	



Spatial Data
For example polygons representing towns

Attribute Data (in table)
Data about the towns

USER_ID	TOWN_POP	TOWN_AREA
1	1474	75.38544
2	5094	103.7568
3	5203	103.5642
4	9068	90.18682
5	2410	52.15469
6	1519	67.40694
7	2231	17.79875
8	5705	83.71561
9	19530	75.35339
10	5516	40.01531
11	1294	80.4007
12	99567	90.42961
13	1213	62.07863
14	22185	86.59508

Attribute Data

Attribute data tells us what a feature is (i.e. its characteristics), but not where it is located. Attribute data is stored in a table, hence the term attribute table is used in GIS.

- What are its characteristics?
- Examples of attribute data: the height of a mountain and its rock type, the bio-diversity of a wetland, and whether a road is paved, dirt, private, etc.

The power of a GIS is that it can handle, display, and analyze both types of data together.
You can ask "Where is something?" and "What does it do?"

Spatial Data
Tells you where something is located, but not what it is.

Attribute Data
Tells you what something is, but not where it is located.

Carsten's House: Spatial Data

Street Address
110 Haywood St
Greenfield, MA
01301, USA

Geographic Coordinates
Latitude: 42.598631°N
Longitude: -72586614°W

Now you know where my house is, but nothing more.

Carsten's House: Attribute Data

4 bedrooms, 2 baths
red roof
2-car garage
2,000 square feet
natural gas heat
etc.

Now you know what my house is, but not where it is located.

Now you know the spatial data of my house = where it is!
And you know the attribute data = what it is!

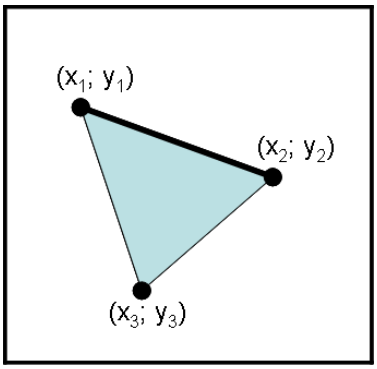
Geospatial Data = Spatial Data *and* Attribute Data

3.2) Vector vs. Raster Data

In a GIS we distinguish between two different data types: Vector Data and Raster Data.

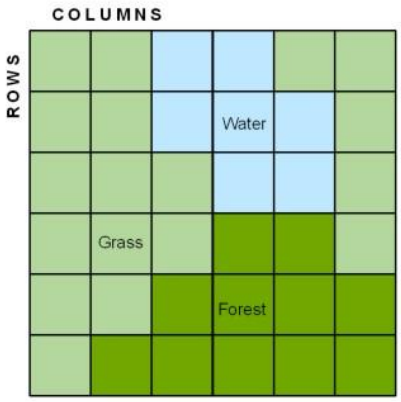
Vector Data
Vector data uses points and their (x, y) coordinates to construct spatial features (such as points, polylines, polygons).

- The information about the spatial feature stored as attributes in a linked attribute table.
- Vector data are best for showing discrete spatial features (e.g. roads, rivers, utility poles, wetlands, states, etc.)



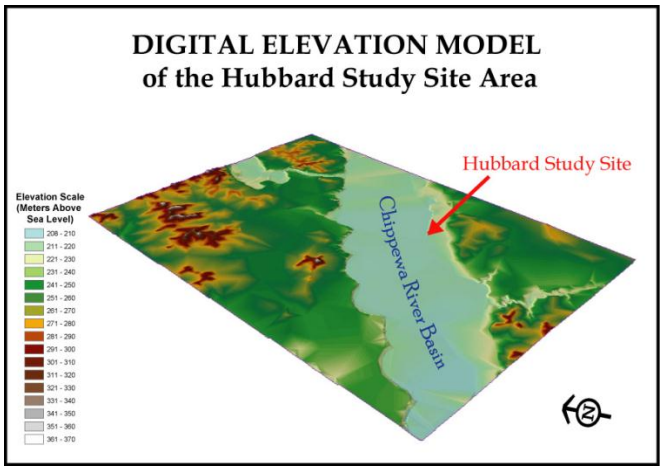
Raster Data
Raster Data uses a grid and grid cells to represent the spatial variations of a parameter.

- The information about the parameter is the grid cell value.
- Raster data are suitable for representing continuous parameters (e.g. elevation, temperature, wind speed, etc.)
- The most commonly used raster data are air photos, satellite images, and digital elevation models.

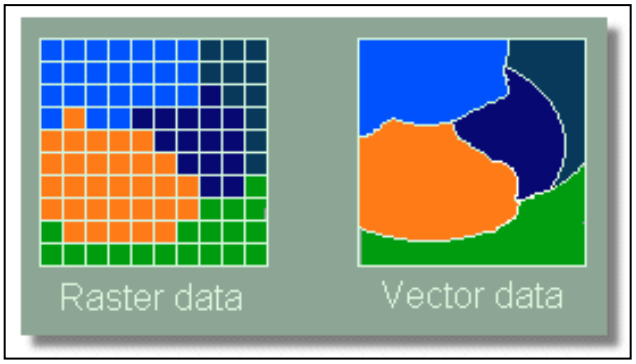


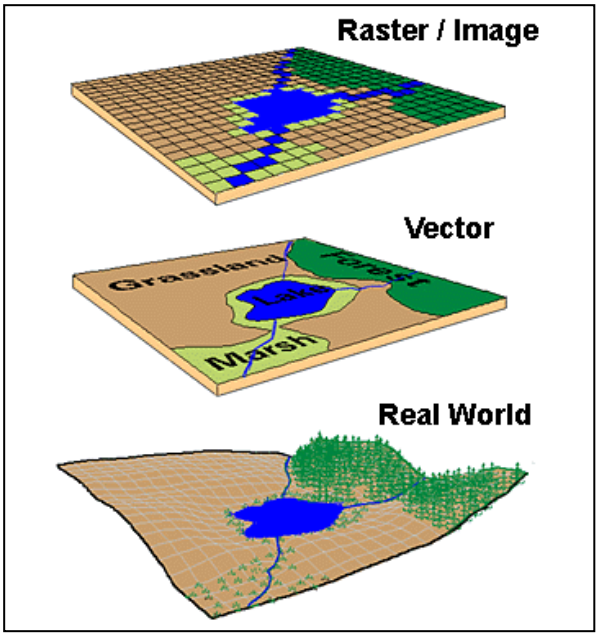
Raster Data: Digital Elevation Model
A digital elevation model is a uniform grid of elevation data.

- Each grid cell has an x-coordinate (or column number), a y-coordinate (or row number), and a z-coordinate (= grid cell content = elevation).
- The GIS now uses the grid cell content to assign different colors for display.



Of course, the real-world consists of both…vector and raster data. In other words, we can show the real world in vector or raster format.

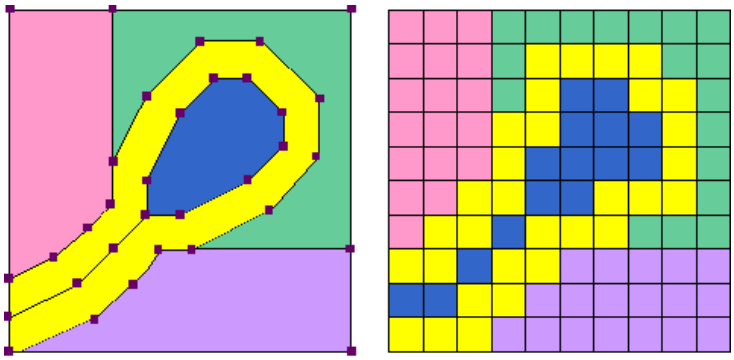




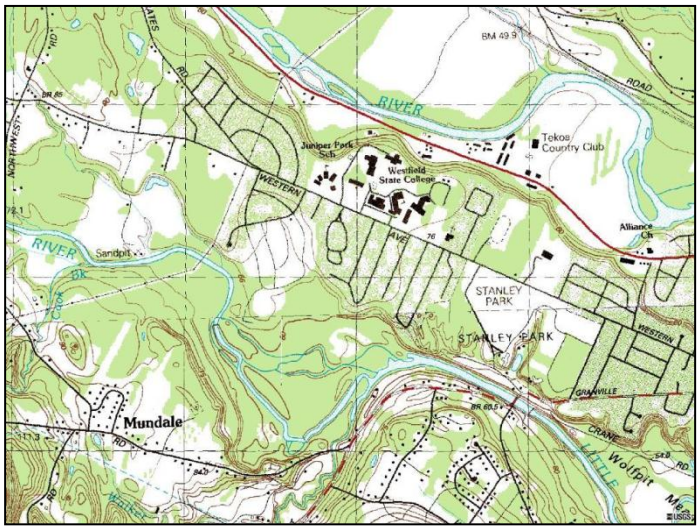
For example: A Lake

You can show a lake as vector data, namely as a polygon. You can show the lake shore very detailed if you add many nodes and sides to your polygon. Or, you can simplify things because you are not interested in the details of the lake shore. You can even show the lake as a point if the actual shape of the lake is not relevant for your map or analysis.

But, you can also show a lake as raster data. Here you break the lake apart into squares. If you use really small squares (e.g. 1 foot) you can show the lake in great detail. If you use larger squares (e.g. 100 yards) your lake shore will be much simplified.



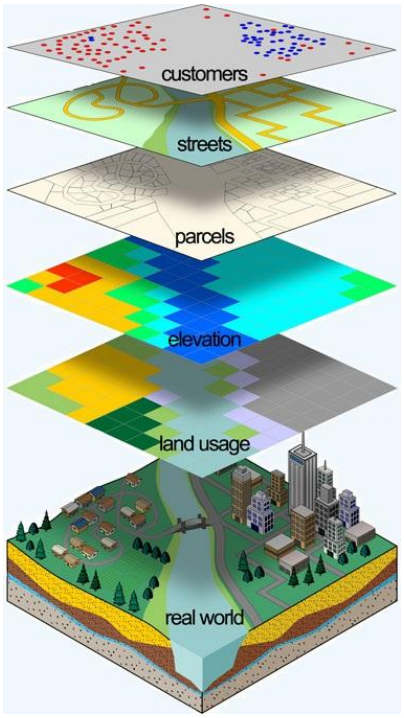
Real map making, for example the topographic maps produced by the United States Geological Survey, always uses both vector and raster data. Why? Makes sense! You use whatever data is best suited for your specific map!



➔ ***ArcGIS can handle and analyze both vector and raster data. It can even convert one into the other!***

3.3) The Data Layer Concept

Data Layer Concept



In a GIS or on a paper map, the geographic information is represented by a series of layers. For example, one layer might be topography, another layer might be roads, and a third might be wetlands. These different layers are displayed laid on top of each other in a so-called mash-up.

- In a paper map, the map maker decided what layers to overlay and how.
- In a GIS, you as the user have the choice and can optimize the overlay of the different data layers for display and analysis for a specific purpose.

GIS = Dynamic or intelligent map
Paper Map = Static map

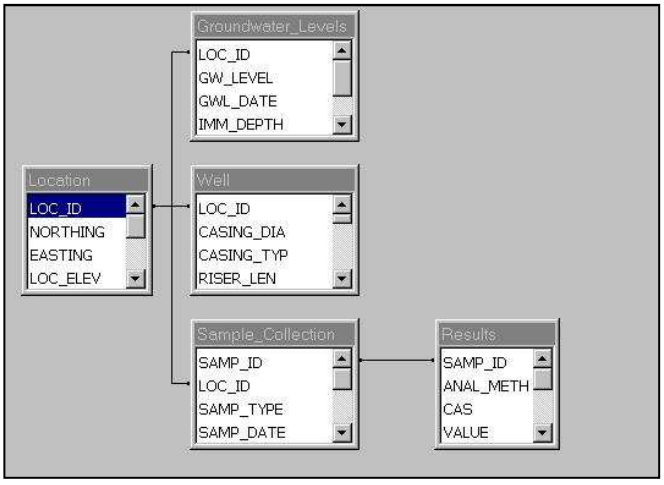
In a GIS, you make the choice what layers that you want to show for a given task. With a paper map, the map maker and map publisher decided for you as in the famous quote from Henry Ford: *A customer can have a car painted any color that he wants so long as it is black*.

Consider the BLT Sandwich Analogy
Bacon, lettuce, and tomatoes are delicious on their own. But, when you layer them onto top of one another, between two slices of toast, you get a whole new dimension of flavor!

- That's the same with geographic data. A wetlands map is interesting, a map of gas stations is interesting, and a map of drinking water wells is interesting. But when you overlay them you begin to see patterns and relationships, for example where are the gas stations that are within 100 feet of a wetland and a drinking water well?

3.4) The Database Concept

In a GIS, the geospatial data are stored in a relational data base, which is series of tables interconnected by a common field. This means that you can change the attribute of a feature (for example the value of a property parcel) in one table, and the change "cascades" through the entire linked data base and the associated map.



In the example on the right, four tables are interconnected using the common field LOC_ID, whereas two tables are interconnected using the common field SAMP_ID.

Even better: Your database tables are dynamically-linked to your maps! So, once you change the values of a property parcel in the database tables your map will automatically change accordingly.

MS Excel Analogy
Let's say you have a simple spreadsheet with the cities in Hampden County as rows and you have, for each city, the total population in second column. In MS Excel you can now easily make a bar graph that shows the height of each bar as a function of the population of the respective city. If you change the value for population in the spreadsheet (e.g. enter 500,000 for Westfield) the bar representing Westfield in your bar graph will get much higher because the spreadsheet and the graph are dynamically-linked.

3.5) The Concept of Topology in GIS

To recap: A Geographic Information System (GIS) is a computer system for collecting, storing, querying, analyzing, and displaying geospatial data. Geospatial data describes the location and characteristics of objects (e.g. roads, timber stands, lakes, utility poles, schools, etc.)

In short, a GIS knows:

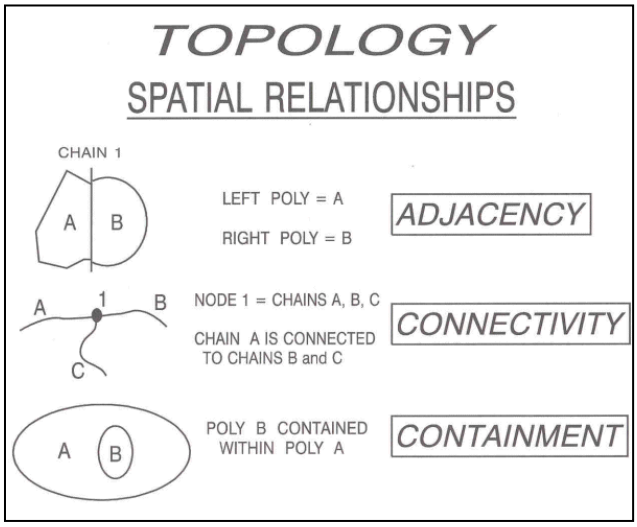
- Where an object is located (= its location)…spatial data
- What an object is (= its attributes)…attribute data
- What is located around the object (= topology)…adjacency/incidence

Topology

Topology is the relationship between objects that remains constant under certain transformations, such as bending and stretching.

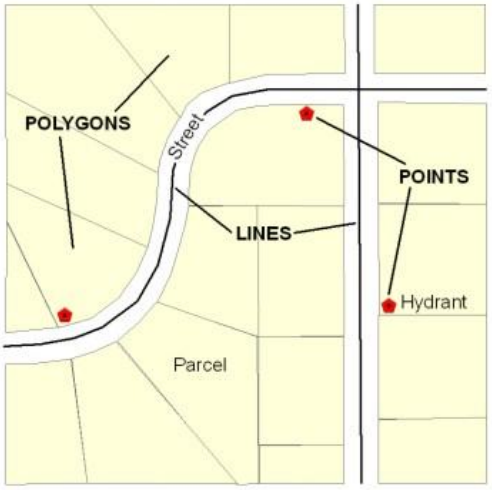
Image you have a map printed onto a rubber sheet. You can stretch and bend the rubber sheet, thereby distorting the map. But the basic spatial relationships between objects on the map will always stay the same:

Objects next to each other will stay next to each other.
Objects that connect/intersect will continue to do so.
Objects that are contained within each other will remain so.



For example, with topology the GIS not only knows the location, geometry, and characteristics of the Connecticut River.

But also knows what is located to the right and left of the river (for example Vermont and New Hampshire) and what it is connected to (for example the Westfield River or the Atlantic Ocean).



That's topology – a bit of a weird concept at first!

Here's another example: Imagine you have a map of properties in your town. Each property line represents a border to another property, as well as the property line of that adjacent property.

For example: My property is a simple rectangle.

3 of my property lines are the borders with my neighbors, thus are also their property lines.

1 of my property lines is the road I live on, owned by the town. That's topology!

4) Course Logistics

This is a high-powered, difficult, and time-consuming course!

- Missing class is a huge problem!
- Significant time required outside of class.
- Scaffold course – you need to keep-up with the material and assignments.
- You will need to figure things out on your own!
- I will not teach you basic computer skills.
- It is your responsibility to keep-up with the material.
- The course resources are mandatory.
- The due dates are mandatory.
- I expect active engagement and professional work at all times.

The details are in the syllabus!

- 11 Homework Assignments.
- 3 GIS Projects.
- The weekly homework assignments and projects include significant writing.
- No test, quizzes, memorizing, etc.

➔ ***My job is to help you succeed!***
➔ ***It is your job to seek that additional help, advice, and support!***

4.1) IT Quiz

This class does not have pre-requisites, but robust computer and statistical skills are absolutely necessary for success in this course – please consult with me if you have any concerns.

➔ ***I will not be teaching basic computer skills!***

- Please note: this course a prerequisite for GARP0344 (Advanced Geographic Information Systems)

If using your own computer…

- Your own computer = your own problem!
- Your own Internet connection = your own problem!
- No support from me or our IT Helpdesk!

➔ ***You must have access to a reliable and modern PC and a reliable high-speed Internet connection.***

All PCs in the campus computer labs in Wilson and Bates Hall have all the required software installed.

Technical issues will come up when you use your own computer and your own Internet connection – you need to be able to deal with them!

Please ask yourself the following questions. You have three answer choices:

Yes!
No!
Maybe? Somewhat? No idea? What are you talking about?

1) Do I have a working Westfield State University network and Email account?

2) Do I know how to log onto the Westfield State University network from on-campus, from my dorm room, and from off-campus?

3) Do I have a reliable and modern computer?
This must be a PC running Microsoft Windows 7/8/ XP/2000. ArcGIS does NOT run on a Mac unless you are an expert Mac user. If not you should use the campus computer labs for your course work.

4) Do I have reliable high-speed Internet access at-home?
If not you should use the campus computer labs for your course work.

5) Do I know the basics about my computer and its operating system? For example: Use of USB flash drives, creating/storing/copying files/folders, data backup, etc.

6) Do I know how to send and receive Email attachments?

7) Do I know how to download files from a website, save them into a specific folder, and unzip them if needed?

8) Do I know how to use Microsoft Word?
For example: insert page numbers into footer, insert page breaks, insert images from the web or from your USB flash drive, etc.

9) Do I know how to use MS Excel?
For example: add columns, perform basic calculations, calculate basic statistics, create graphs, etc.

10) Do I understand basic statistical concepts such as percentages, histograms, means, standard deviations, pie charts, etc.?

11) Do I know how to search the WWW for help, information, tutorials, how-to videos, and other solutions for problems that I will encounter?

12) Do I know how to use the Help tools and resources included in modern software applications to find information and solutions for problems that I will encounter?

13) Do I know – using the instructions provided – how to install software and tutorial data on my computer or on my USB flash drive?

If you have answered with anything less than a resounding *Yes!* to any of these questions:

- Consider taking a basic Computer Skills course such as MGMT 0107 Software Applications before GARP 0244. This is also a requirement for the GIS Minor and a prerequisite for the GIS Certificate.
- There are plenty of free resources available on the WWW to teach yourself these necessary computer skills on your own time!
- Talk to me about any specific questions and concerns.

5) Homework Assignment #1

This homework assignment has two parts. Part 1 simply involves getting yourself organized for the rest of the course. Part 2 involves some research, review, thinking, and writing.

Part 1 (due Monday 11 February 2013)

1. Review the course syllabus. Contact me for clarification as needed.
2. Review the IT Quiz. Contact me for clarification as needed.
3. Acquire the GIS Tutorial. You need it no later than Monday 11 February 2013.
4. Acquire a dedicated USB flash drive for this class. Size: 16 GB or greater.
5. Acquire a 3-ring binder just for this class. Size: 2 inch or more.
6. Sign-up for the free Google and ESRI accounts. We need those next week.

➔ ***Contact me for help or clarification of this assignment or my expectations as needed.***

Part 2 (due Monday 11 February 2013)

This homework assignment reviews some of the material and concepts we explored this week in-class. In addition, you will investigate GIS questions online and summarize your research and understanding as a written report.

Question 1: What is GIS?

- Your friend asks you: *You're taking GIS – cool! What is GIS anyways? What can you do with GIS? I work for _____ [select a profession of your choice] how can I use GIS?* Well, your friend has some great questions! Provide answers and explanations and give him/her a few specific examples.

Question 2: GIS vs. Paper Map vs. MS Excel

- Compare a GIS to a paper map – what are the similarities? What are the differences?
- Compare a GIS to MS Excel – what are the similarities? What are the differences?

Question 3: Online GIS

Spend some time exploring the online GIS of the City of Westfield and the Town of Amherst – pretty cool stuff! Here are the two website addresses:

- http://gis.cityofwestfield.org/fl/westfieldmapublic/main.html
- http://www.amherstma.gov/index.aspx?NID=400
- Why do you think these two cities (and many others) provide all this information online for everyone to see? After all – creating and maintaining such websites costs money!

Question 4: MassGIS

Spend some time exploring MassGIS at http://www.mass.gov/mgis/massgis.htm, especially OLIVER, the MassGIS Online Data Viewer at http://maps.massgis.state.ma.us/map_ol/oliver.php

- Why do you think the Commonwealth of Massachusetts is providing this resource – creating and maintaining such websites costs money!

Question 5: GIS Websites

- Find and list at least 3 helpful websites about GIS. Include the web site address and a short description of each website.

Question 6: GIS Figures

- Find and include two useful figures (diagrams, graphics, cartoons, drawings, etc.) illustrating what a GIS is. Include the figure source (= the web site address) and a brief caption explaining the figure.
- Insert these two figures as the two last pages of your report.

Deliverables

Please submit professional, well-written report using proper English language and professional formatting and layout that covers all six questions. Think in terms of using this report as a writing sample for a job interview.

- Include a cover page and page numbers in the page footer.
- Your report will have about 6 pages in total (cover page, ~3 pages of writing, and the two last pages with the two figures).
- Due Date: Monday 4 February 2013 at the beginning of class.
- Grading: 10 points for each of the six questions = 60 points, 20 points each for the figures = 40 points, 100 points total.

➔ ***Contact me for help or clarification of this assignment or my expectations as needed.***