

Welcome to NR402 – GIS Applications in Natural Resources. This course consists of 9 lessons, including Power point presentations, demonstrations, readings, and hands on GIS lab exercises. Following the last lesson you will complete a final project where you have the opportunity to apply what you have learned to complete a GIS project using data of your own choice (or data we have used in the class).

Where and When?

- Lectures Monday & Wednesday 9:30 – 10:20 am in TLC 248. No class on Labor Day September 6
- Hands on labs Friday 8:30 – 10:20 or 10:30 – 12:20 in CNR room 26 (GIS lab)
- Class ends by October 30 (2 credits), but you have until Nov 15 to turn in the Final Project
- Access course material via Blackboard
- Reading: Karl Chang, *Introduction to Geographic Information Systems*, 3rd Edition (McGrawHill, 2005).
- Teaching assistant Nick Fordes
- Office hours Monday and Wednesday 1:30 – 2:30 pm CNR room 25A

REM402 goals

- Understanding of how GIS works and can be used in natural resource applications
- To quickly become comfortable using GIS as an analysis tool applied to natural resource management or research
- Refine the ability to independently assemble a GIS database and complete complex spatial analyses

The major goals of this course is that you gain understanding in how GIS can be used in natural resource applications and that you become comfortable using GIS applied to your own natural resource management or research questions.

Course overview



- Week 1: Review of GIS concepts
- Week 2: Accessing GIS data on the Internet
Map projections
- Week 3: GPS/GIS Integration + Digitizing
- Week 4: Wildlife application - Resource selection
- Week 5: Raster data and Spatial Analyst
- Week 6: Raster modeling
- Week 7: GIS Applications in Natural Resources
- Week 8-10: Independent work on Final Project

Final project



The final project gives the student an opportunity to apply gained knowledge to a GIS analysis project of your choice.

You can use your own data, data from the Internet, data that we have used in the class or data for projects provided by the instructor.

Grading criteria are provided.

Grading and Evaluation

Lab exercises:	50%
Quiz 1 & 2:	20%
Final project:	30%

50% of your grade will be based on the 5 GIS lab exercises that you will complete and turn in during the course of the class. 20% of the grade is based on two multiple choice tests and 30% of the grade is based on completing a final project.

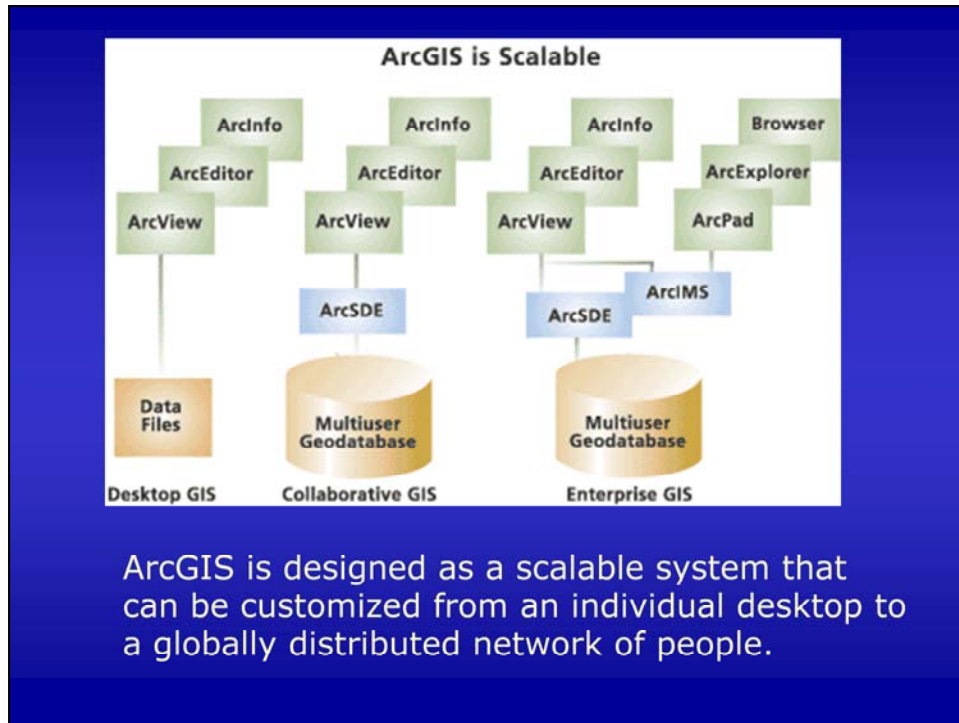
Five steps in GIS awareness

- 1) **Excitement:** GIS is supposed to be an important tool – I want to learn how to use it!
- 2) **Frustration:** I basically understand the concepts of GIS but I don't know what tools to use to make it do the analysis
- 3) **Technical competence:** GIS can solve most problems and I am a great GIS analyst!
- 4) **Doubt:** Polygons don't exist, the world is not made up of raster pixels, scales don't match – why use this tool
- 5) **Professional competence:** I am a competent GIS analyst and I have an understanding of what the limitations and errors in my analyses are.

What level are you at?

The image shows a screenshot of the ESRI website homepage. At the top, there are two main navigation menus. The first menu includes 'products & services' (with sub-items: software, data, books, consulting, gis store) and 'company information' (with sub-items: news, events, careers, about esri). The second menu includes 'support & solutions' (with sub-items: support, education & training, gis for your specialty, partner solutions, library). Below these menus is a header section with a globe image on the left labeled 'top sites', the ESRI logo in the center, and a quote on the right: "The application of GIS is limited only by the imagination of those who use it." attributed to Jack Dangermond, President, ESRI. The main content area is a large blue rectangle containing a list of services, each preceded by a diamond symbol: Support - Knowledge Base, Software, Books, Education and Training, Virtual Campus, Geography Network – Online Data, and Conferences and Events. At the bottom of this blue area is the URL <http://www.esri.com>.

Find out more about ArcGIS, ESRI and GIS analysis on the ESRI web page (<http://www.esri.com>). The 'Knowledge base' on the ESRI web page lets you find the information you need by searching ESRI's database of known bugs, "how-to" documents, white papers, system requirements, and common error messages for all of our software. The Knowledge base is an invaluable tool for any ArcGIS user!



ArcGIS is designed as a scalable system that can be customized from an individual desktop to a globally distributed network of people.

In this course we will be using the Desktop GIS.

What is ArcGIS 9.3?

ArcView, ArcEditor and ArcInfo 9.3 are designed with the same Windows user interface and include Visual Basic for Applications for customization.

ArcView, ArcEditor & ArcInfo
consist of three desktop
applications:

ArcMap

ArcCatalog

ArcToolbox

ArcGIS is composed of three applications: ArcCatalog, ArcToolbox, and ArcMap.

ArcGIS also comes in three versions: ArcView, ArcEditor, and ArcInfo. All three versions of the software are composed of the same basic interface that contains the three applications ArcMap, ArcCatalog, and ArcToolbox. The difference is the capability of the program version, where ArcInfo has full capability, ArcEditor has reduced capability in ArcToolbox, and the capabilities are even further reduced in ArcView.

ArcCatalog

With ArcCatalog, you can browse, manage, create, and organize your geographic and tabular data.

ArcCatalog comes with support for several metadata standards to allow you to create, edit, and view metadata.

ArcMap

ArcMap for all map-based tasks including cartography, map analysis, and editing. ArcMap gives you the power to:

- **Visualize.** Finding patterns you couldn't see before
- **Create.** It is easy to create maps to convey your message.
- **Solve.** Working geographically lets you answer questions such as "Where is...?", "How much...?", and "What if...?"
- **Present.** You can make publication-quality maps and create interactive displays that link graphs, tables, drawings, photographs, and other elements to your data.
- **Develop.** The ArcMap customization environment lets you tailor the interface to suit your needs .

ArcToolbox

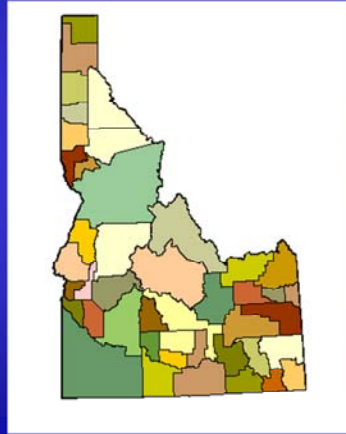
ArcToolbox is an application containing many GIS tools used for geoprocessing.

- ❖ There are two versions of ArcToolbox: the complete ArcToolbox that comes with ArcInfo and a lighter version that comes with ArcView and ArcEditor software.
- ❖ ArcToolbox for ArcInfo comes with more than 170 tools for geoprocessing, data conversion, map sheet management, overlay analysis, map projection, and much more.
- ❖ ArcToolbox for ArcView and ArcEditor contains 40 commonly used tools for data conversion and management.

In ArcGIS 9.3 ArcToolbox is incorporated in ArcMap.

Spatial Data

Spatial Data is a record of the geographic location
.....of objects such as topographic contours, individual plants, roads, culverts or parcels.

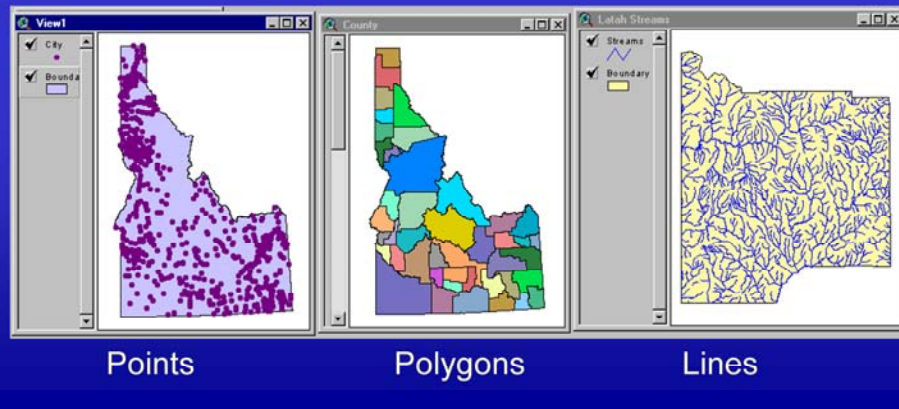


Spatial data is a geographic record that has map coordinates. The objects can be represented by points, lines, polygons or raster pixels.

Vector Data

Coordinate-based data structures commonly used to represent map objects. Each object is represented as a list of X,Y coordinates

Examples - tree, poles, roads, housing developments, zoning districts



In geographic information systems there are two different strategies for representing the world: Vector and Raster.

Vector data is a coordinate based structure where objects are represented by a list of X and Y coordinates. There are three representations of vector data: Points, lines, and polygons.

The image to the left shows a GIS layer of the incorporated places in Idaho. Each point represents a place. Each point is located at a known location (coordinate pair).

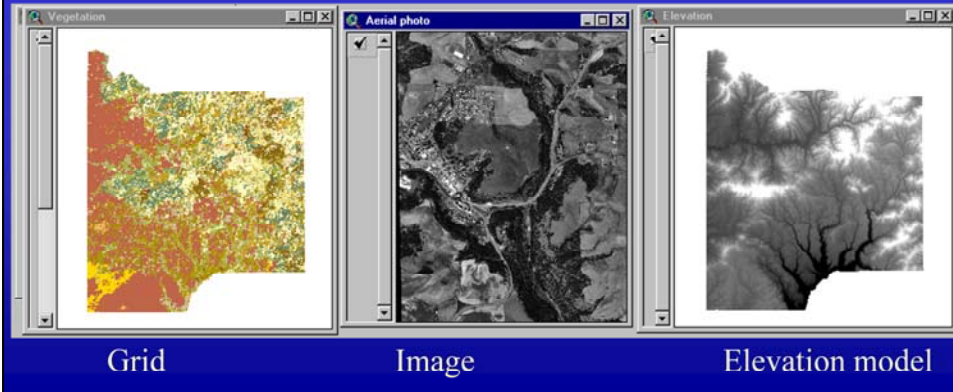
The middle image shows the counties of Idaho represented by a polygon layer. Each polygon has an area and a perimeter and represents on county.

The image to the right shows the hydrography (streams) of Latah county as a line data layer. The streams are composed of stream segments of a certain length.

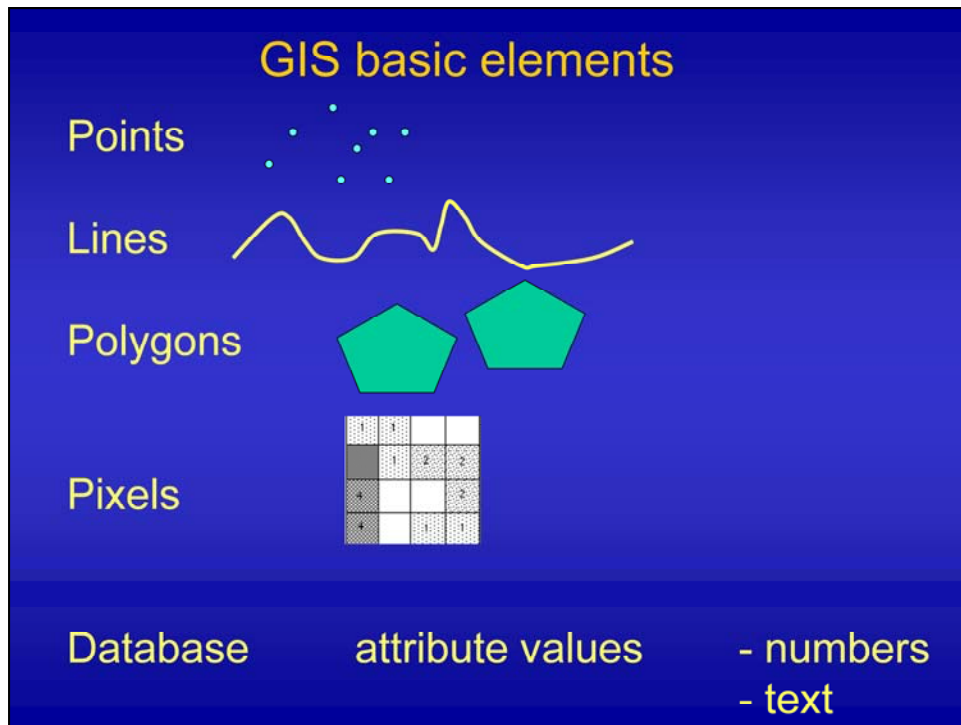
Raster Data

Cell-based representation of map features. Each cell has a value. A group of cells with the same value represent a feature.

Examples - satellite imagery, aerial photography and some come from software packages like ArcInfo GRID and ERDAS.



Raster data is a cell based representation of the world where the data layer is made up of pixels (cells, squares) with a certain size. The picture on the left represents the vegetation in Latah county, Idaho. The brown pixels are agricultural lands and the various shades of green and yellow represent pixels that are forest lands. Aerial photographs or satellite imagery are other types of raster data. The digital elevation model (DEM) to the right is made up of pixels with a 30 meter size. Each pixel contains the elevation (in meters) at a particular location. In this DEM the dark pixels represent low elevation and the white pixels represent high elevation.



In summary, the basic elements for representing objects in a GIS are Points, lines, polygons, and pixels (raster data). In addition to the spatial representation a GIS also contains a database where attribute values are stored. For example, an attribute table for a point data layer contains information about each point in the dataset.

ArcGIS File Formats

Vector data

- Shape files
- Coverages
- CAD drawings (dxf/dwg)

Raster data

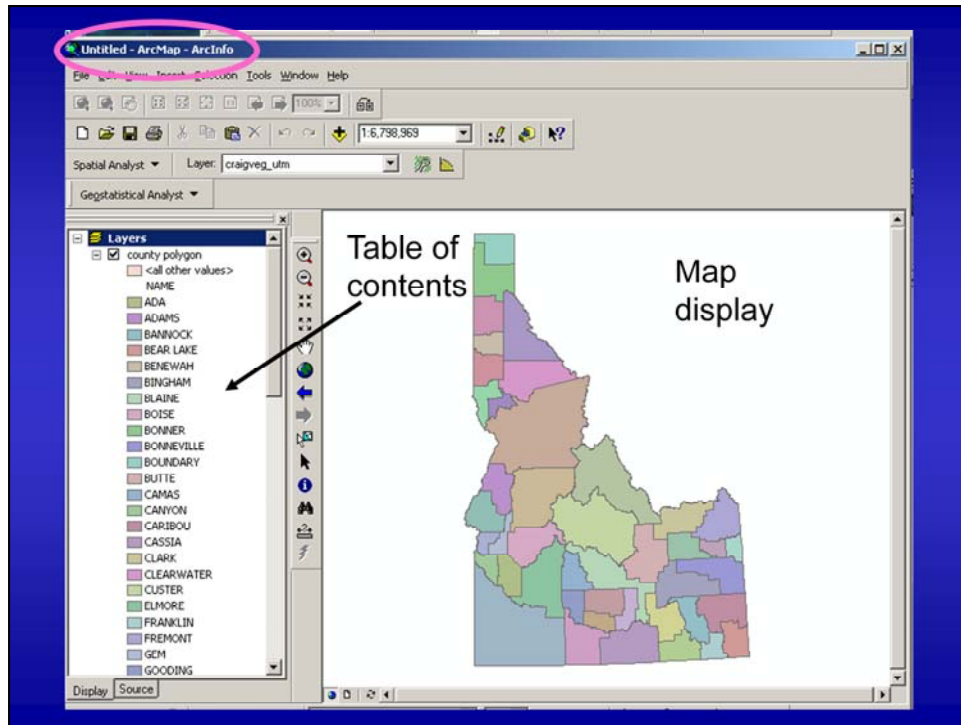
- GRIDS
- Images

- Personal Geodatabases
- Multiuser Geodatabases

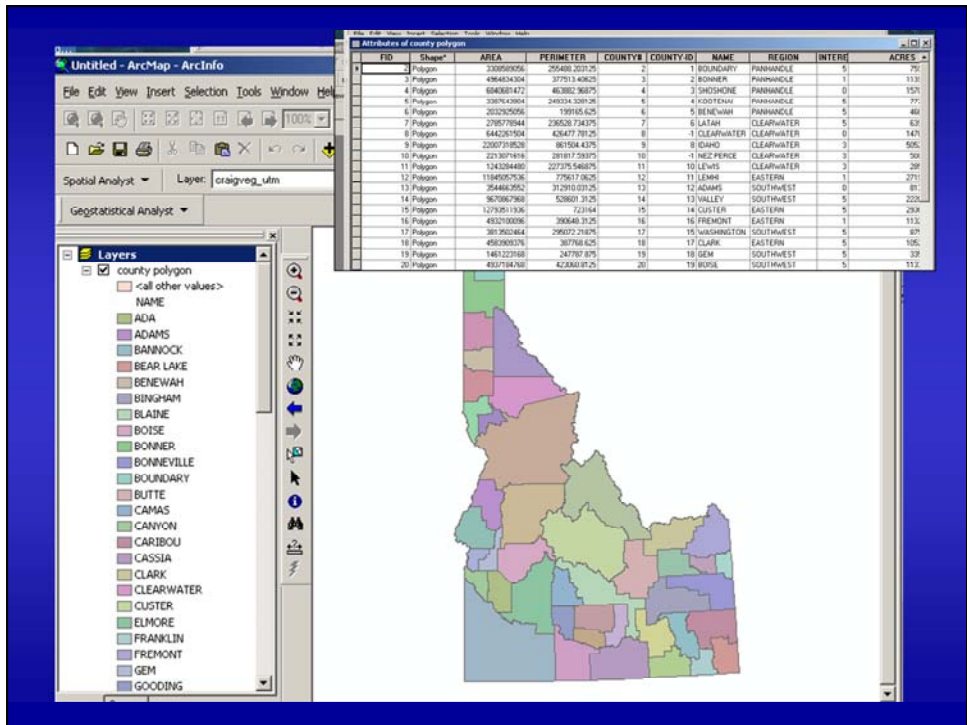
ArcGIS can utilize many different kinds of file formats. Common vector data formats are shape files and ArcInfo coverages. Coverages has topology while shape files do not. Topology within coverages means that there is node in every arc intersection with the result that polygons are never overlapping and there are no empty spaces between polygons. Shape files are not built in a rigid topological network of nodes and arcs and polygons are allowed to overlap. Read more about topology in Chang chapter 3.

Images and ArcInfo grids are two types of raster data.

A new file type introduced by ESRI within the last couple of years is the Geodatabase. A Geodatabase is a container for storage of primarily vector datasets. We will not use Geodatabases in this course



This is the ArcMap interface. Notice that in this case we are running the ArcInfo version of the ArcGIS software. The interface of ArcMap is divided into two basic parts: the map display and the table of contents. In this map you can see the counties of Idaho displayed in different colors.



Idaho counties is a polygon data layer (vector data). In addition to the polygons the dataset also contains a table (attribute table) that contains information about each county, for example area, county name, population etc.

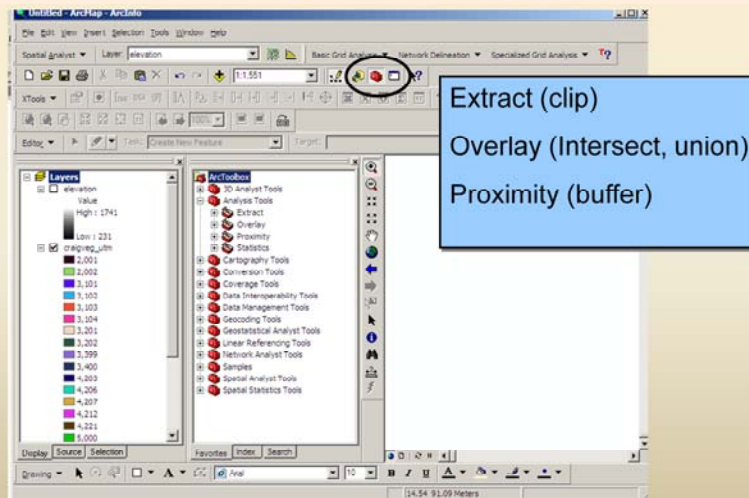
GIS Analysis

- Overlay Analysis
- Proximity Analysis
- Distance analysis

- Working with tables
 - export table to Excel
 - work with tables in ArcMap

GIS is a tool where you can explore two or more data layers together to reveal relationships that were previously unknown. In Lab 2 you will use the ArcToolbox analysis tools to perform an overlay analysis and a proximity analysis on vector data. Vector data analysis commonly result in tabular data. These tables can be further analyzed in the GIS software or exported to other database programs such as Microsoft Excel or Access.

Analysis Tools in Arc Toolbox



ArcToolbox is launched directly from ArcMap – the icon looks like a red toolbox. In exercise 2 you will be using tools located under the ‘Analysis Tools’ tab in ArcToolbox. In Exercise 2 you will be using the *clip*, *intersect*, and *buffer* tools.

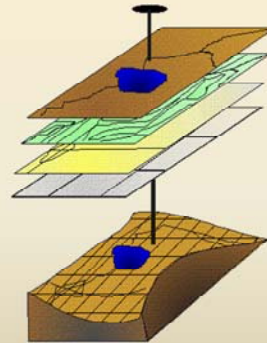
Overlay analysis point data

“Piercing Needle” Approach

Multiple layers of data are in relative position with one another - inserting a "digital pin" through the stack of overlaid data.

This allows questions to be answered concerning *everything* occurring at a particular location.

This view of the world limits focus to a particular point and precludes wide-area landscape analysis



Two overlay analysis principles will be described here: 1 – the piercing needle approach 2 – the cookie cutter approach. Both methods involves extracting data from multiple GIS data layers at locations of interest. In the ‘piercing needle approach’ information from one or more data layers are extracted at one single point (point – polygon overlay). For example, you may want to know the habitat type and canopy cover at bird nest locations. In this case the bird nests are represented by a point layer and the habitat type, elevation and canopy cover is represented by individual polygon data layers. The result of such an analysis will be a table that contains the habitat type and canopy cover for each bird nest location in your dataset.

Overlay Analysis for Regions

Region Wide: "Cookie Cutter Approach"

Vector data

- Clip
- Intersect – Union

Raster data

- GRID clip (masking)
- Zonal statistics (GRID)
- Combine



The other overlay approach is the 'cookie cutter approach'. This is an example of a polygon to polygon overlay analysis. Going back to the bird nest example, rather than extracting data from the exact bird nest location it might be interesting to analyze the conditions within a 100 meter buffer around the bird nest.

The first step in such an analysis would be to create a 100 m buffer around the points (nests). The buffers will be represented in a new polygon layer in GIS. Next you would *clip* or *intersect* the habitat and canopy cover layers with the buffer layer and finally summarize the habitat types and canopy cover classes within the buffers.

If your habitat and canopy cover layers are represented by raster data you would use the raster tools *masking*, *zonal statistics* or *combine* rather than the vector tools *clip* and *intersect*.

Questions that can be answered with GIS overlay analysis

- How much ponderosa pine forest is there on Moscow Mountain?
- How much mature timber burned in the Roberts fire?
- How many harvesting units on the UI Experimental Forest grow on slopes steeper than 30%?
- What is the typical vegetation within 200 m of Lewis's woodpecker nests?
- What is the area of aspen woodlands in the game management area?

Do you have a question that could be answered using GIS overlay or proximity analysis?

Overlay Analysis - points

Overlay type	Tool to use in ArcGIS 9x
Point to Polygon	Join and Relates: Join – Join data based on spatial location Hint: Right-click on the point layer, select Joins and Relates
Point to Grid	Spatial Analyst: Convert the point file to a raster based on a unique point ID. Perform the overlay analysis in the Spatial Analyst Raster Calculator by typing at the command line: <i>Overlaygrid = combine(pointgrid, valuegrid)</i> where <i>overlaygrid</i> is the name of the output grid <i>pointgrid</i> is your converted point grid <i>valuegrid</i> is the grid you want to extract information from

Different overlay analysis tools are used in ArcGIS depending on what type of overlay analysis you want to do. Different tools are used for vector and raster data and the tool used also depends on the vector data type, point, line or polygon.

The instructions on this slide helps you find the correct tool for the overlay analysis you want to do.

Overlay Analysis - area

Overlay type	Tools to use in ArcGIS 9x
Poly to Poly	ArcToolbox- Analysis Tools - Overlay – Clip, Intersect or Union
Poly to Grid	Convert the polygon cover to a grid or the grid to a polygon and use the 'poly to poly' or 'grid to grid' techniques Spatial Analyst – Zonal Statistics (can handle overlay between polygon layers and grids)
Grid to Grid	Spatial Analyst: Raster Calculator <i>Outgrid = Combine(grid1, grid2)</i> or ArcToolbox – Spatial Analysis Tools

Different overlay analysis tools are used in ArcGIS depending on what type of overlay analysis you want to do.

The Analysis Tools in ArcToolbox are useful for overlay analysis between two polygon data layers while the Spatial Analysis Tools in ArcToolbox are specific to raster data. In the lab exercises we will use many of these tools.

Xtools

Third party software, available free www.esri.com (support - downloads)

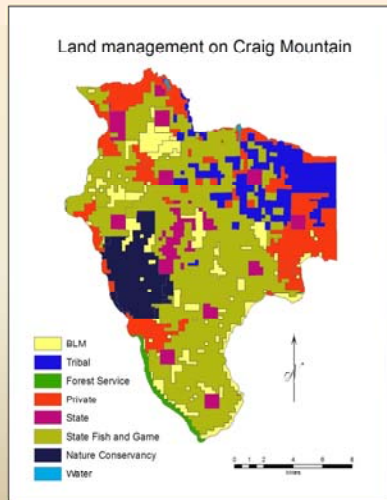
- Update area after overlay or proximity analysis
- Table frequency (table summations)
- Add XY coordinates to a table

Xtools is a 'third party software' available at the ESRI web site.

During this course we will use Xtools in three applications

1. Update area after performing and overlay analysis. This is necessary because a *clip* or *intersect* operation creates new polygons that may have an area different than the original area of the polygon.
2. Table summations can be performed in Xtools or directly in the tables in ArcMap
3. You can use Xtools to add the numbers for the X and Y coordinates of a point file.

What is a summary table



Attribute table

FID	Shape	AREA	PERIMETER	CRAIGMOUNTID	OWNERNAME	CRAIGMOUNTID
80	Polygon	590559	3924.2	80	Private	2372
81	Polygon	2756262	8554.8	81	Private	2373
82	Polygon	868271	3362.34	82	Private	1383
83	Polygon	1021803	2160.3	83	State Fish and Game	2374
84	Polygon	845341	3223.28	84	Private	2375
85	Polygon	131487	1498.79	85	State	1374
86	Polygon	252471	3275.47	86	State	1375
87	Polygon	122510	2448.2	87	BLM	1385
88	Polygon	8925.9	3881.82	88	BLM	1389
89	Polygon	1272765	3554.8	89	State	1384
90	Polygon	142427	1413.77	90	State	1388
91	Polygon	487880	18168.8	91	BLM	1388
92	Polygon	328217	2425.88	92	State Fish and Game	1389
93	Polygon	1008880	4268.24	93	State Fish and Game	1389
94	Polygon	4764205	68228.8	94	TNC	1387
95	Polygon	2517002	7385.53	95	State	1387
96	Polygon	2979885	8422.83	96	State	1382
97	Polygon	875483	3478.7	97	State Fish and Game	1387
98	Polygon	3682147	4218.84	98	State	1165

Summary table

OID	OWNERNAME	Sum Hectar	Count
0	BLM	6738.234740	83
1	Bureau of Indian Affairs	6947.486560	13
2	Forest Service	660.829288	1
3	Private	11651.642950	92
4	State	4446.332948	22
5	State Fish and Game	29785.407618	20
6	TNC	5233.472266	9
7	Water	88.885923	36

A polygon attribute table in ArcGIS contains one row for each polygon in the dataset. You are here looking at a polygon layer of land managers on Craig Mountain in Idaho. Commonly a land manager manages more than one polygon on the map. For example the Bureau of Land Management (BLM) manages all the 'yellow' areas (polygons) on the map and hence the attribute table contains many rows where the land manager is BLM.

In the summary table all areas managed by the BLM are summarized (expressed in hectares in this example) and the table contains only one line per land manager. A summary table is sometimes called a frequency table.

Questions?

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