FE 257. GIS and Forest Engineering Applications

Week 7

Week 7

- Last week:
  - Spatial Projections
  - Questions?
- Next week- read:
  - Chapter 10: Updating GIS Databases
  - Chapter 12: Synthesis of Techniques Applied to Advanced Topics

This week's topics

- Mid-term
- Chapter 13: Raster GIS database analysis
- The ESRI geodatabase
- Chapter 9: Joining and Linking Spatial and Nonspatial databases

Geographic Information Systems

Applications in Natural Resource Management

Chapter 13

Raster GIS Database Analysis

Michael G. Wing & Pete Bettinger

Chapter 13 Objectives

- How landscape contour GIS databases are created from a DEM;
- How landscape shaded relief GIS databases are created from a DEM;
- How slope GIS databases are created from a DEM;
- How to calculate slope gradients for a linear landscape feature, such as a road, trail, or stream;
- How to conduct a viewshed analysis for a portion of a landscape; and
- How to create a watershed boundary based on digital elevation data.

Digital Elevation Models (DEMs)

- ______________________________
- Applications
  - Watershed delineation
  - Viewshed analysis
  - Slope analysis
  - Landscape topography or relief
- USGS makes these available for entire US
  - 10 and 30 m resolution
- Shuttle Radar Topography Mission (SRTM)
  - 30 m resolution for >80% of earth (2000)
- Chapter 13 focuses on DEM applications

Raster data format: cells with values

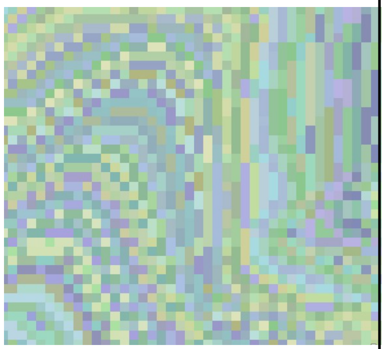
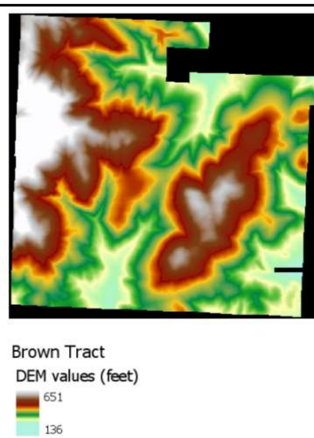


Figure 13.1. Raster grid cells from a digital elevation model (DEM).

Figure 13.2. Elevation categories for the Brown Tract using a 10 m DEM.



"No Data" values

- Why?
  - The raster structure requires that all databases be stored as a set of grid cells that form a square or rectangular shape
  - When landscape features don't match this regular shape, a null or No Data value can be assigned to a raster cell to indicate that no information (outside of location) is available for that cell
- No Data values default to __________ but still void other databases when processed in combination with them

Elevation contour intervals

- DEMs can create elevation contours
  - Lines that indicate constant elevation values
  - Used to create a sense of topography on maps
  - Usually a vector data structure
- User will need to select an elevation interval and have the option to set a starting elevation

Figure 13.3. A general process for the development of a contour line GIS database from a DEM.

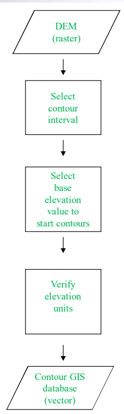
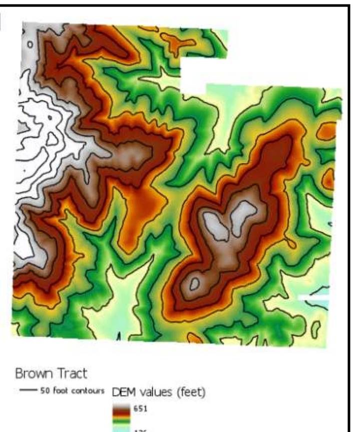


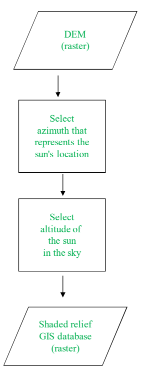
Figure 13.4. A contour line GIS database for the Brown Tract displayed on top of the Brown Tract 10 m DEM.



Shaded relief maps

- Intended to simulate the sun-lit and shaded areas of a landscape, given that the sun is positioned at a particular location in the sky
- The brightness or shading defaults to a gray tone
- Bright features indicate features that face the sun
- Shaded relief mapping is useful for illustrating topography and provides a three-dimensional perspective of the landscape

Figure 13.5. A general process for the development of a shaded relief GIS database from a DEM.



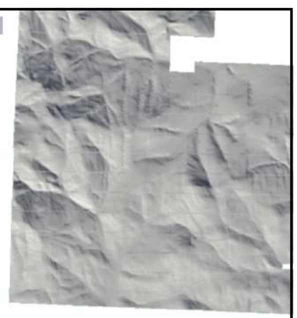


Figure 13.6. Shaded relief map of the Brown Tract using a 10 m DEM, an azimuth of 210°, and an altitude of 45°.

Slope maps

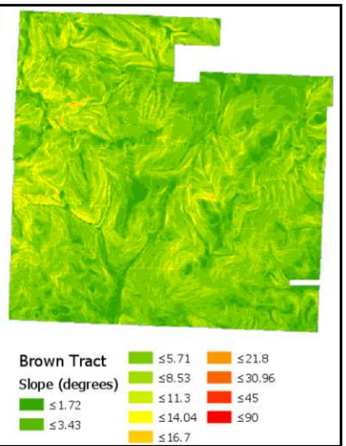
- Slope, or gradient, describes the ______________ change of a landscape
  - Flow of people, water, or vehicles over a landscape
- Since DEMs contain both horizontal (coordinate) and vertical (elevation) information, they can be used to create slope maps

Slope value calculation

- Computed differently depending on the GIS package
- Many GIS packages look at each cell and the 8 neighboring cells when calculating a slope
  - Other neighborhood patterns and searches are possible

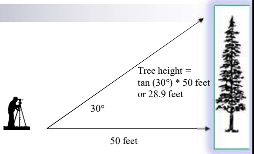
1 302 m	2 300 m	3 298 m
4 290 m	293 m	5 295 m
6 287 m	7 288 m	8 290 m

Figure 13.8. Brown Tract slope class GIS database created from a 10 m DEM.



Slope values

- Degrees or percent?
  - Degrees splits each angle into a fraction of a circle (0-360)
  - Percent is the rise length / run length
    - Percent = tan (degrees) * 100
  - Make sure you know which one of these you are reporting!



Angle (degrees) = 30°
Angle (percent) = (28.9 feet / 50 feet) * 100 = 57.7%

tan (30°) * 100 = 57.7, providing a quick conversion from degrees to percent slope

Interaction of raster and vector databases

- Some GIS packages can simultaneously analyze raster and vector databases
- This ability should increase in sophistication in the future
- Two examples:
  - Slope characteristics of land management units
  - Examination of the slope class characteristics of streams

Forest stand slopes

- Task: calculate slopes in support of a forest thinning operation
- Slopes will help define what type of ground-based equipment (skidder, harvester, or forwarder) might be appropriate or whether a cable-based logging system is needed for highly sloped areas
- Crews could occupy the management units with clinometers or other surveying equipment
- Or a DEM could be used

Process: Slope characteristics of land management units

- Stand units (polygons) are draped on a DEM (raster)
  - DEM cell values within each polygon are aggregated to give DEM values for all polygons

Figure 13.10. A general process for the development of a slope class condition information for each stand (management unit) on a landscape.

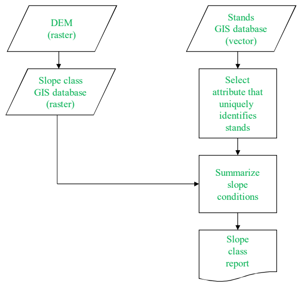


Table 13.1. Output of percent slope values for management units.

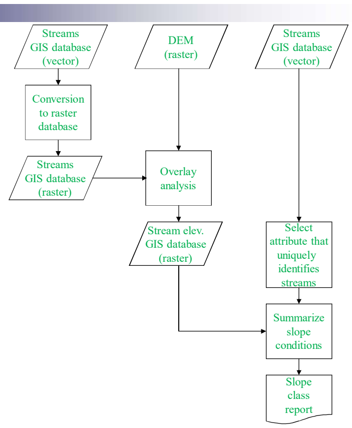
Stand	Count	Area	Min	Max	Range	Mean	Std	Sum
1	319	343603	0.11	15.44	15.33	5.31	3.81	1692.78
2	2186	2354595	0.34	23.55	23.21	9.41	3.76	20564.20
3	770	829386	0.44	22.46	22.02	10.22	4.15	7866.61
4	2884	3106428	0.28	23.01	22.73	9.54	3.66	27521.07
5	533	574107	1.71	19.80	18.09	8.34	3.14	4446.68
6	1195	1287164	0.44	23.72	23.28	8.51	4.24	10168.51
7	338	364068	0.20	15.15	14.95	6.20	3.52	2096.76
8	2494	2686349	0.15	26.11	25.95	13.65	4.27	34040.15
9	337	362991	3.20	25.41	22.21	15.03	3.91	5066.74
10	2395	2579714	1.55	24.25	22.70	11.52	3.90	27591.07

Count = number of 10 m grid cells
Area = square feet
Min = minimum value in the database
Max = maximum value in the database
Range = (max value - min value)
Mean = average slope
Std = standard deviation of slope
Sum = sum of the slope for all units

Stream slope calculation

- Task: determine slope for watershed streams
  - Understand implications of large rainfall
  - Support for fish populations
- Crews could occupy the streams with clinometers or other surveying equipment
- Or a DEM could be used
- One twist: the slope values surrounding the streams are not of interest
  - Solution: create a stream elevation database from the stream vector layer

Figure 13.11. A general process for the development of slope class information for each stream on a landscape.



Other DEM-based analyses

- Viewshed analysis
  - _______________ by others on a landscape?
- Watershed delineation
  - Where are the drainage boundaries?

Viewshed analysis

- May be an important tool for land managers interested in being a good neighbor
  - Consider limiting some operations to places of low relative visibility
- May also be an important tool for structure locations
  - Fire lookout towers
  - Wind turbines

Visibility process

- Viewpoints (observers) are often point locations
- Operator can set limits (distance, angle, height)

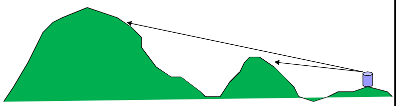
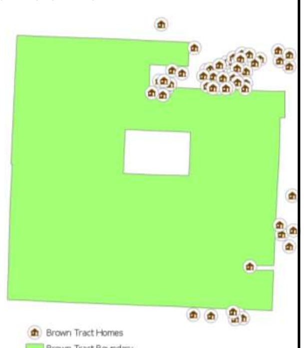


Figure 13.12. Line of sight from a viewing site to the surrounding landscape.

Brown Tract application

- What is visible from the second floor of homes surrounding the Brown Tract?
- Observer height: 5.5 ft + 10 ft = 15.5 ft
- Viewshed performed using homes, DEM, and tree height layers



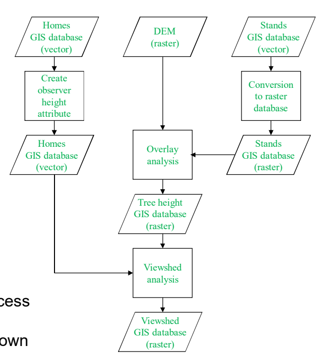


Figure 13.14. A general process for the development of a viewshed analysis for the Brown Tract based on a set of viewshed sites (nearby homes).

Viewshed results

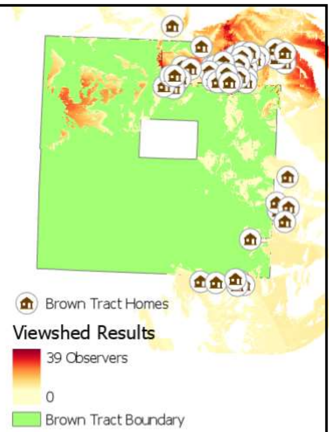
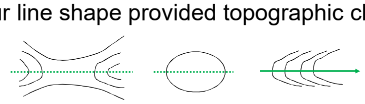


Figure 13.17. Areas within and surrounding the Brown Tract that are visible from the nearby homes.

Watershed delineation

- A watershed is an area that shares a common _______________
  - Where water would leave a landscape area according to slope conditions
- Watershed delineation was once done almost exclusively with the aid of hard-copy topographic maps
  - Contour line shape provided topographic clues



Watershed delineation example

- Determine the watershed area for a portion of the stream network in the Brown Tract

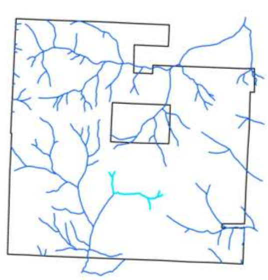


Figure 13.19. Portion (in bright blue) of the stream network within the Brown Tract for which a watershed area is to be created.

Watershed delineation process

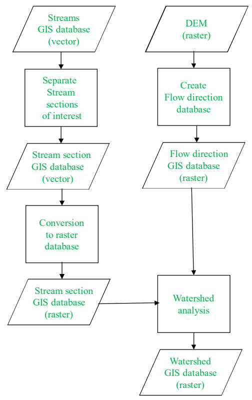


Figure 13.20. A general process for the delineation of a watershed area for a portion of the stream network in the Brown Tract.

Watershed results

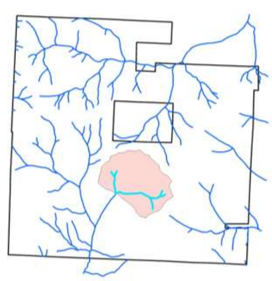


Figure 13.21. The watershed (in beige) for a portion of the Brown Tract stream network.

The Geodatabase

The newest spatial database format from ESRI

ESRI Data Formats

- ArcInfo Coverage (1980s)
  - Interchange file, e00 file, cover
  - The original vector data format
  - Used for both vector and raster structures
- ESRI shapefiles
  - Created for ArcView (1990s)
  - Could only handle vectors
- Geodatabase
  - Designed for ArcGIS (2001)
  - Vector, Raster, and other structures
  - Personal (MS Access) and RDMS (Oracle, SQL Server, Informix, DB2)

The Geodatabase

- A container for many structures
  - CAD
  - Raster
  - Shapefiles
  - Coverages
  - Non-spatial attribute tables
- Designed to centralize the storage of all data for a GIS

Geodatabase Storage: 3 types

- File geodatabase (most recent)
  - 1TB limit
  - All databases in a folder (with a .gdb extension)
- Personal geodatabase
  - Microsoft Access (.mdb extension)
  - 2GB limit (Rasters stored separately)
- Enterprise geodatabase
  - Stored in a RDBMS, requires ArcSDE
  - Virtually not limited in size
- All use same ArcGIS tools

Geodatabase Elements

- Tables
- Feature Datasets
  - Feature classes that share a common spatial reference
- Feature Classes
  - Collections of lines, points, or polygons
- Rasters
- Raster Catalogs
  - Collections of rasters
- Geometric Networks
  - Line an point features along a linear network
- Toolboxes
  - Geoprocessing tools
- Topologies
  - Definitions of spatial relationships
- Rules
  - Definitions of acceptable spatial relationships

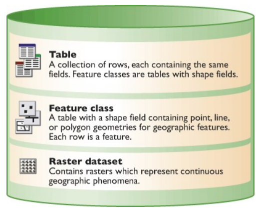
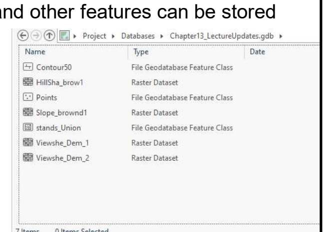


Image courtesy of ESRI

Feature Datasets

- Containers for feature classes of the same spatial reference
- Behave like folders in Catalog View
- Points, lines, polygons and other features can be stored within a feature dataset
- Benton County
  - Roads
  - Streams
  - Urban growth boundaries
  - Census Data
  - DOQs
  - Survey Benchmarks



Creating Geodatabases

- Catalog view
  - The centralized data management utility
- Importing data
  - Tables and shapefiles
- CASE tools
  - Computer Aided Software Engineering
  - Microsoft Visio or Rational Rose
- Geoprocessing tools in ArcGIS
  - ArcGIS Pro Tools
  - ModelBuilder
  - Scripts (Python is ESRI's choice)

Geodatabase Exchange

- File and personal geodatabase
  - Share the parent folder or .gdb/.mdb
  - Rasters will involve additional files/folders
- All geodatabase versions
  - Use XML
    - **Ex**tensible **M**arkup **L**anguage
    - Can export and import entire geodatabase contents
    - A safer method that ensures all parts of a geodatabase are received or transferred

Geographic Information Systems

Applications in Natural Resource Management

Chapter 9

Joining Spatial and Non-spatial Databases

Michael G. Wing & Pete Bettinger

Chapter 9 Objectives

- How two or more databases can be temporarily joined without creating a new database, modifying a database table, or modifying landscape features;
- The GIS processes that are available when there is a need to join data;
- How non-spatial data can be joined with spatial databases
- How two spatial databases can be joined; and
- What it means to relate (link) two tables, and how this process is different than joining databases.

Join and relate processes

- Processes in chapters 6-8 introduced operations (e.g erase, clip, buffer, combine) that led to the creation of a new and permanent database
- Join and relate brings spatial and nonspatial databases together in a temporary manner that doesn't change the original databases
- The goal of both join and relate is bring data from two databases into the perspective of a single database
  - Data from two sources is being brought together

Join and relate definitions

- The join and relate processes both require that a common attribute be present in both databases
  - ___________
- When two databases are joined, the visual affect is as if the databases are physically joined (they appear as one database)
- When two databases are related, no physical link appears to exist yet records selected in one of the databases (either through attribute or spatial queries) will also be selected in the related database

Joining non-spatial data to spatial

- Why?
  - Bring data in from another application or process
  - Field data collection
  - Results from other software
  - Changes in attribute values

"Stand", "HSI1", "HSI2", "HSI3"
1, 0.256, 0.312, 0.325
2, 0.458, 0.495, 0.516
3, 0.333, 0.365, 0.372
4, 0.875, 0.885, 0.889

Joining non-spatial data to spatial

- Several possibilities exist
  - One-to-one
    - Assumes that there is a direct match between all records in both databases
  - One-to-many
    - Each record in source database may match with more than one record in the destination database
  - Many-to-one
    - Two or more records in the source database may match up with a single record in the destination database
    - Can also have many-to-many

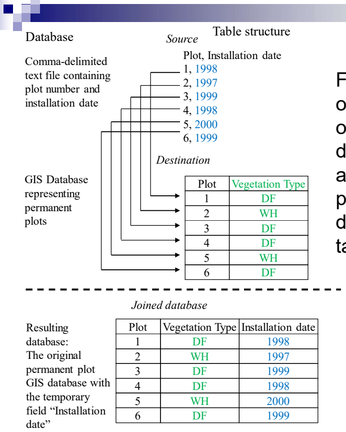


Figure 9.1 Performing a one-to-one join using a file of installation dates as the source table, and the Daniel Pickett permanent plots GIS database as the target table.

Figure 9.4 Performing a one-to-many join using a file of buffer distances as the source table, and streams GIS database as the target table.

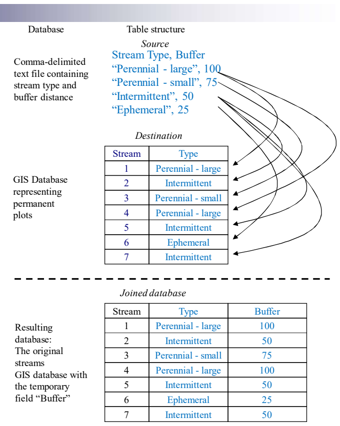


Figure 9.5 Performing a many-to-one join using a file of buffer distances as the source table, and a streams GIS database as the target table.

Database	Table structure
Comma-delimited text file containing stream type and buffer distance	*Source* Stream Type, Buffer "Perennial - large", 100 "Perennial - small", 75 "Intermittent", 50 "Ephemeral", 25 "Ephemeral", 35

GIS Database representing permanent plots

Destination

Stream	Type
1	Perennial - large
2	Intermittent
3	Perennial - small
4	Perennial - large
5	Intermittent
6	Ephemeral
7	Intermittent

Resulting database: The original streams GIS database with the temporary field "Buffer"

Joined database

Stream	Type	Buffer
1	Perennial - large	100
2	Intermittent	50
3	Perennial - small	75
4	Perennial - large	100
5	Intermittent	50
6	Ephemeral	25
7	Intermittent	50

Figure 9.6 Performing a many-to-many join using a file of buffer distances as the source table and a streams GIS database as the target table.

Database	Table structure
Comma-delimited text file containing stream type and buffer distance	*Source* Stream Type, Buffer "Perennial - large", 100 "Perennial - small", 75 "Intermittent", 50 "Ephemeral", 25 "Perennial - large", 125

GIS Database representing permanent plots

Destination

Stream	Type
1	Perennial - large
2	Intermittent
3	Perennial - small
4	Perennial - large
5	Intermittent
6	Ephemeral
7	Intermittent

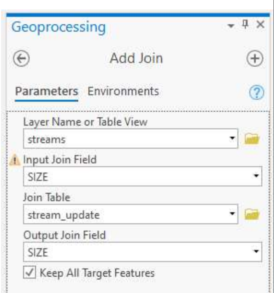
Resulting database: The original streams GIS database with the temporary field "Buffer"

Joined database

Stream	Type	Buffer
1	Perennial - large	100
2	Intermittent	50
3	Perennial - small	75
4	Perennial - large	100
5	Intermittent	50
6	Ephemeral	25
7	Intermittent	50

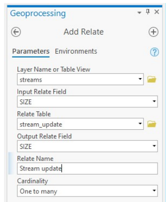
Join process in ArcGIS Pro

- In the table of contents, right-click the target layer
- Select 'Joins and Relates', then select the 'Add Join' option
- Make sure the right layer is selected
  - Pick the Join Field
- Pick the table to join (sometimes called the source data)
  - Pick the Join Field



Relating (linking) databases

- Relating keeps databases visually separate but records selected in one database will also be selected in the linked database
- This may help you by reducing the visual size and dimensions of databases you want to bring together

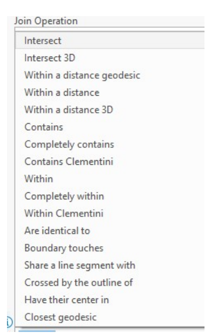


Joining two spatial databases

- With spatial joins, the objective is to use the spatial locations of database features to guide database associations
- This is a powerful GIS capability
- In ArcGIS Pro, a new layer is created from a spatial join
- Some limitations for the type of features (point, line, or polygon) that can be spatially joined
  - Can't perform a nearest feature operation on two polygon databases

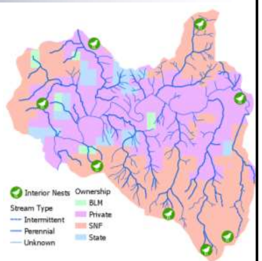
Spatial join possibilities

- Finding the nearest feature
- Finding what's inside a polygon
- Finding what intersects a feature
- Many others



Closest feature (nearest neighbor)

- Sometimes called nearest neighbor
  - Euclidean distance is used
- A distance calculation can be added to the output database
- Typically, point or linear features compared to other points, lines, or polygons



Nest and nearest stream type

InsideID	Distance	Strmtype
1	253	Unknown
2	237	Perennial
3	363	Unknown
4	113	Perennial
5	401	Perennial
6	143	Perennial
7	105	Unknown
8	169	Unknown

Finding what's inside a polygon

- A point-in-polygon or line-in-polygon process
- The result will be the identification of the polygon that each point or line sits inside

Nest and land ownership

InsideID	OWN
1	SNF
2	SNF
3	SNF
4	SNF
5	Private
6	Private
7	SNF
8	Private

ArcGIS Pro spatial join

- In the table of contents, right-click the target layer
- Select 'Spatial Join'
- Make sure target layer is correct
- Select layer to join
- Enter output name and destination
- You can select whether to keep all or only some attributes
- Set the type of spatial join