GIS Data

https://paititi.info/research-technology/geographic-information-systems/
GIS Data Models: Raster vs. Vector

1) Raster – Images consisting of pixels
   - Shows “real world” surface features
     - reflection & emission (wavelength)
     - brightness, color, contrast

2) Vector – Points, lines, polygons
   - Represents features symbolically
     - outlines, line weight/symbol
     - unique icon
     - colors/patterns
Both data models are:

- Spatial – geographic shape and extent
- Georeferenced –
  - tied to a particular location in space
  - referenced by a coordinate system
    (location on surface)
Some ArcGIS terminology:

- **Node** (end node is red): beginning & end points
- **Vertex**: intermediate points along the path
- **Line** segment (vector)
- **Polygon** boundary
- **Centroid**: center point of the polygon
Summary of Vector model

- Small file sizes: stores coordinate pairs, and line length and direction
- Joined with attribute data (a table)
  - Tied to each feature (point, line, or polygon)
- Vector datasets
  - can be displayed by GIS (symbolically)
  - can be projected in GIS (mathematical representation)
  - can be edited (add, change, delete node coordinates)
ArcGIS Vector Formats

Shapefile VS Geodatabase

Spring, 2024

D. M. Nelson
ArcGIS Vector - Shapefiles

<table>
<thead>
<tr>
<th>ICON</th>
<th>FILE TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>🗺️</td>
<td>Shapefile, point</td>
<td>Vector dataset, contains only point features</td>
</tr>
<tr>
<td>🛠️</td>
<td>Shapefile, line</td>
<td>Vector dataset, contains only line features</td>
</tr>
<tr>
<td>📦</td>
<td>Shapefile, polygon</td>
<td>Vector dataset, contains only polygon features</td>
</tr>
</tbody>
</table>

Files as seen in Catalog

```
- GlobalMars_vectors_ltlon
    - Crater_Catalogs_not_updated
    - Barlow_crater_version1
    - barlow_craters_all.shp
- Geology_IL802ABC
- Graticules
    - latlong.shp
    - WORLD30.dbf
    - WORLD30_line.dbf
    - world30.shp
- Tectonic
    - AA_tectonic_readme.txt
    - GCS_Mars_Mola_prj
    - Mars-Tectonics.mxd
    - tectonics_Compression.shp
    - tectonics Extension.shp
```

One Shapefile in Windows

- Database
- Projection
- Connection
- Connection
- Geographic
- Metadata

Early 1990s ArcView 2 format
- Mostly open format
- *.dbf & *.shp cannot exceed 2GB

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ArcGIS Vector - Shapefiles

Advantages:

- Small file sizes (usually a few 100k to several MB)
- Non-proprietary – can be used in other GIS software

Disadvantages:

- File size limited to 2GB (but that is a lot of features)
- Uses old data file formats (dbase: 1980s format)
- Many file components (3-7) make up single shapefile
### ArcGIS Vector - Geodatabases

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>🗺️</td>
<td>Geodatabase</td>
<td>A proprietary database format, can contain vector, raster, and tabular information.</td>
</tr>
<tr>
<td>🗺️ 📷</td>
<td>Geodatabase, feature dataset</td>
<td>A container within a Geodatabase that holds vector datasets which share common properties (e.g., projection)</td>
</tr>
<tr>
<td>🗺️ 🗺️</td>
<td>Geodatabase, point</td>
<td>Vector dataset within a geodatabase that contains only points. Can reside within or outside feature dataset.</td>
</tr>
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<td>Geodatabase, polygon</td>
<td>Vector dataset within a geodatabase that contains only polygons. Can reside within or outside feature dataset.</td>
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**Geodatabase viewed in Catalog**

**A Geodatabase viewed in Windows**
ArcGIS Vector - Geodatabases

Advantages:
- Single container of diverse spatial data
  - Vector, raster (increases GDB size dramatically), and tables
- Easily transferable to colleagues (.zip, .tar, .7z)
- Easily organized and managed
- Stable
- Large size limit (attributes: 65.5k columns, 2.1G rows)

Disadvantages:
- Proprietary file format, owned by ESRI
- Only usable in ArcGIS – AND SPECIFIC VERSION!
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<th>ICON</th>
<th>FILE TYPE</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raster, or Image file</td>
<td>Map or image information that is represented as an array of pixels, each of which has a numeric value. Can contain one or more bands.</td>
</tr>
<tr>
<td></td>
<td>Tables</td>
<td>Tabular dataset in a specific format (e.g., dbase)</td>
</tr>
<tr>
<td></td>
<td>XML files</td>
<td>An XML formatted text file</td>
</tr>
<tr>
<td></td>
<td>Text files</td>
<td>A general text file. Can be formatted as TAB or comma-separated values (*.csv) to be read in as spatial XY data.</td>
</tr>
<tr>
<td></td>
<td>Excel files</td>
<td>Microsoft Excel spreadsheet file</td>
</tr>
<tr>
<td></td>
<td>Layer file</td>
<td>A file that contains information about how shapefile or geodatabase features should appear. Contains no geographic data.</td>
</tr>
<tr>
<td></td>
<td>Projection file</td>
<td>A text file (*.prj) that describes projection information. It contains no geographic data.</td>
</tr>
</tbody>
</table>
ArcGIS – Database Connection Icons

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<tr>
<th>ICON</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
<td>Add Database Connection</td>
<td>A method that allows users to connect/log in to a database management system to access geodatabase data.</td>
</tr>
<tr>
<td><img src="image2" alt="Image" /></td>
<td>Add Database Server</td>
<td>Allows Internet connection to a remote server that contain databases</td>
</tr>
<tr>
<td><img src="image3" alt="Image" /></td>
<td>Add ArcGIS Server</td>
<td>Allows Internet connection to a remote server that hosts ArcGIS data through ArcGIS Server software</td>
</tr>
<tr>
<td><img src="image4" alt="Image" /></td>
<td>Add WMS Server</td>
<td>Allows Internet connection to a remote server that hosts ArcGIS data through a Web Mapping Service.</td>
</tr>
</tbody>
</table>

Icons for Geodatabase Connections
- Links to available data resources on the Internet

Spring, 2024
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Exercise 3: Working with Vector Data

1. Work with pre-existing project, including global datasets
2. Symbolize datasets with layer (*.lyr) files; save layer files (*.lyrx)
3. Import a shapefile, export it to a geodatabase
4. Create point Feature Class from a table
5. Select points by attribute and export to a geodatabase
6. Digitize line features & ensure end points snap
7. Convert closed lines to polygons
8. Add attributes to polygons
9. Color polygons with unique symbols based on attributes
3. Working With Vector Data

If ArcGIS Pro is open, close it!

In Windows File Explorer:
- Navigate to Exercise 3 directory: `GIS_Data\ArcGIS_Pro_Session2\Exercise_3_Vector_Data\Exercise_3`
- Double click: `Exercise_3.aprx`
3. Working With Vector Data

The ArcGIS Pro project opens with several Feature classes in a group layer.
3. Working With Vector Data

Review the symbology of the geology files

- **Mars_GeoStructure** and **Mars_GeoContacts** have useful line symbology based on their attribute tables
  - Right-click on the Feature classes to see the attribute table contents
  - Close the table when done
  - Click triangles next to file names

- **Mars_GeoUnits** is pretty bland. Its Symbology is saved as a **Layer File**.
  - Select Mars_GeoUnits in Contents
  - Click Feature Layer above the ribbon and click **Symbology** icon
    → Not the drop-down!

Line symbols referenced from attribute table

What about this?
3. Working With Vector Data

The **Symbology Pane** opens to the right

- In the Symbology Pane, click on the folder icon for Symbology Layer
- Navigate to: Exercise_3_Vector_Data\Mars_global_geology\Shapefiles
- Select `geo_units_EquidistCyl.lyr`
- Click Run
3. Working With Vector Data

The *.lyr is an ArcMap legacy file, but still works

- Export the file for future use in ArcGIS Pro
  - In Contents, select Mars_GeoUnits
  - Click **Share** in the Menu, click the **Layer File** icon
  - Navigate to: Exercise_3_Vector_Data\Symbology
  - Name the file: Mars_GeoUnits.lyrx
3. Working With Vector Data

- If the map is too bright or busy:
  - Turn off Mars_GeoStructure and Mars_GeoContacts
  - Set Mars_GeoUnits to **20% Transparency** under Feature Layer

- Add a 30° graticule (lat/lon grid) to the map:
  - In Catalog, navigate to Mars_global_geology > Shapefiles > Mars2000_Sphere and select `graticule30x30.shp`

- Add the shapefile to the project **geodatabase**:
  - Right-click the shapefile and add to current map
  - After the shapefile has been added to Contents
  - Right-click and select: Data > Export Features
3. Working With Vector Data

Adding a shapefile to a Geodatabase (continued)

- Click the folder icon next to Output Feature Class
- Navigate into the project directory to Ex3_Mars.gdb
- Name the file Mars_graticule_30x30

- The new feature class is added to Contents automatically
- Remove the shapefile from Contents
- Click the triangle next to Mars_graticule_30x30 and click on the symbol. In the symbology pane, select: Black Outline (1pt)
- For the selected symbol in the Symbol pane, click Properties
- Change the Outline width to 0.4 and click Apply
Add Tables to Maps as Point features

- Tables that include latitude and longitude information can be added to a project to create a point Feature Dataset
- In Catalog: r-click on RobinsonCraterDatabase2014.csv
- Add To Current Map

The file is now listed in Contents

Note that the file does not display on the map

What kind of file is this?
3. Working With Vector Data

To view the table:
- R-click on file name, select Open
- Scroll left-right for more fields, up-down for more entries

![Map and table image]
3. Working With Vector Data

To display on Map:
- R-click on file name, select Create Points From Table > XY Data To Point

From the drop-down menu, select from Geographic > Solar System > Mars

Ignore warning after processing
3. Working With Vector Data

There are a lot of craters on Mars!

- In Contents, r-click on: Craters_Robbins2014 > Attribute Table
  - 384,278 entries are listed at the bottom of the table
- Close table & turn off point Feature
- Remove RobbinsCraterDatabase2014.csv from Contents
  (not Craters_Robbins2014 shapefile!)

- We will come back to the craters later

- Next, we’re going to add a study area
3. Working With Vector Data

Add image of Gusev Crater study area – all familiar steps!

- In Catalog, navigate to Exercise_3_Vector_Data > Raster_Data
- R-click GusevBasemap.tif > Add To Current Map
- In Contents, r-click GusevBasemap.tif > Zoom To Layer
- In Contents, select Mars_GeoUnits, then click Feature Layer above ribbon and set Transparency to 50%
- In Catalog, navigate to Exercise_3_Vector_Data > Ex3_Mars.gdb
- R-click Site_Boundary > Add To Current Map
- Click triangle on Site_Boundary, double-click on polygon symbol
- In Symbol pane, double-click Black Outline (1pt)
- Add a Group Layer to the Map, name it Gusev Crater. Drag it below the Mars Geology group layer
- Add Site Boundary and GusevBasemap.tif to Gusev Crater

See if you can do this on your own!
3. Working With Vector Data

Gusev Crater region

- Turn on Craters_Robbins2014 in Contents.
- We will clip out just the craters in the study area
Select Attributes based on location:

- In order to pull out the desired subset of craters, use the process **Select by Location**, in the Map ribbon

- Set Relationship to: Intersect
- Navigate to Ex3_Mars.gdb and select Site_Boundary
- Or: drag from Contents into text window

Run & keep form open

Run & close form
3. Working With Vector Data

The selected attributes are highlighted in cyan.
3. Working With Vector Data

Export the selected features into a new feature dataset

- With the features still highlighted, r-click on Craters_Robbins2014 in Contents > Data > Export Features

- Set to these parameters:
  - Input Features: Craters_Robbins2014
  - Output Feature Class: Craters_GusevCrater
  - Make sure to save to Ex3_Mars.gdb

Note the number of selected points: Records to be processed: 898
3. Working With Vector Data

The new clipped dataset is added to your Map

- Remove Craters_Robbins2014 from Contents
- Experiment with different symbols for the crater points
3. Working With Vector Data

Re-symbolize point features:

- In Contents, double-click on point symbol to open Symbology pane
- Select and modify a symbol: click Apply to set
- In Symbology/Gallery pane, click on a symbol to select
- In Symbology/Properties, change line color & thickness, fill pattern

Double-click on the symbol, not the name.
3. Working With Vector Data

Select by Attributes:

- With Craters_GusevCrater selected, click: Map > Select By Attributes icon
- In Select By Attributes form, Input Rows and Selection Type are left to default
- Set Expression: DIAM_CIRCLE_IMAGE is less than or equal to 5
- Click Apply
3. Working With Vector Data

Select by Attributes:

- All attributes that meet the criteria are highlighted, both in the map and in the attribute table.

Toggle between selected and not selected.
Digitizing lines:
- Create or edit a Feature class (point, line, or polygon)
- Two methods: point & click; streaming
- For lines, ensure the ends are “snapped” together (for closed features)

In this exercise:
- Digitize several crater rims as lines
- Export the digitized crater rims as polygons

To prep:
- Turn off all map in Contents except those in the Gusev Crater group layer
- Close Symbology pane if still open
3. Working With Vector Data

Digitizing lines: Create a line Feature class
➢ In Catalog > Exercise_3_Vector_Data, r-click on Ex3_Mars.gdb, then select: New > Feature Class

6 steps: do first 3 then click Finish

Additional Fields could be added to the attribute table here, or later
3. Working With Vector Data

Digitizing lines:

- The new line Feature Class is automatically placed in Contents. Move it into the Gusev Crater group layer.
- R-click on Crater lines to open the Attribute Table
  - It is currently blank because there are no lines, but it has headers for when lines are added
- Close the Attribute Table

- To begin, zoom in to an interesting crater on the basemap
- To zoom in/out: right-click and hold mouse, move forward and back
- To pan: left-click and hold, move cursor any direction
Digitizing lines: Editing

- Unlike ArcMap, where you have to turn editing on and off, in ArcGIS Pro, once the Edit ribbon is activated for a selected file, **editing is live**.

- Click on Crater Lines then click Edit on the menu. There are a lot of options.

To start this exercise:

- Click on Edit > **Snapping** dropdown menu and toggle it off

- Then click the Create icon to open the Create Features pane.
Digitizing lines: Create Features pane

- Before creating a line, first select the feature class to be edited, then select the line type to be digitized.


- Click the Line icon.
Digitizing lines: Create Features pane: Line, trace
- When Line is selected, the cursor appears as a crosshair on the map, and a small tool bar appears at the bottom.
- With the cursor, trace the outline of a crater rim, placing a point as close or as far apart as desired to approximate the shape of the crater rim.
- Double-click the last point to end the drawing.
- The small green squares represent vertices and the red square is the ending node.
3. Working With Vector Data

Digitizing lines: Create Features pane: Line, trace
- To release the line from selection, click the Edit > Clear icon
- To stop digitizing, click on another icon on the ribbon, whether it is to be used or not

Saving Edits:
- Saving digitized features is NOT the same as saving a Project!
- When you want to save your edits:
  - Click on Save icon in Edit ribbon
  - If there are no edits to save, the icon will be gray
3. Working With Vector Data

Digitizing lines: Create Features pane: Line, streaming

- When creating a line, point and clicking can be tedious and jagged. An alternative Line method is streaming.
- On the Line toolbar at the bottom of the image, click on the dropdown arrow on the fourth icon from the left, and select Streaming.

  - When Streaming is selected, the distance between vertices must be set. **Map resolution** must be considered.
  - Move the crosshair cursor over the map and type the letter ‘o’
  - In the Stream Options form that pops up, set the **stream tolerance to 100 m**
Digitizing lines: Create Features pane: Line, streaming

- Find another crater to digitize. Switch the Menu item to Map and click on the Explore icon. Use the mouse to zoom & Pan. Then select Edit from menu again.
  - Make sure the Streaming option is selected on the digitizing menu
  - Move the cursor to the edge of the crater, then click and drag out an outline of the crater. It takes a steady touch!

- At the end of the drawing, either:
  - Double-click to finish
  - or
  - Right-click and select Finish Sketch
Digitizing lines: Create Features pane: Line

- If you don’t like what you digitized, you can delete it or edit it.

To delete:
- Click the Select icon, then click on the line
- Click the Delete icon to delete it

- Editing is more complicated.
  - Go back to the first line
  - Click the select icon, then click on the line
  - Click on the Edit Vertices Icon. The vertices will appear along the dashed line
Digitizing lines: Create Features pane: Line - Editing

- With the cursor, hover over one of the vertices until it changes into a diamond shape
- Click and drag the vertex to a new location
- Another option, when the cursor has changed over a vertex, right-click to bring up an option menu

The r-click menu provides more options:
- Vertex placement
- Add/Delete vertices
- Finish the sketch
Digitizing lines: Create Features pane: Line, Freehand

- The third digitizing option is the smooth Freehand
- Instead of straight-line segments, they are curved segments
- Vertices are placed at the center of a curve within the line

Again, it takes a steady hand!
3. Working With Vector Data

Digitizing lines: Create Features pane: Line, Freehand

- Editing is problematic with curves:
  - Passing through each vertex is a tangent line
  - The barbells at each end can be manipulated to tweak the curve. This can make for unpredictable shapes
Digitizing lines: Snapping line ends

- Often lines are created to represent linear features: faults, rilles, scarps, ridges, channels, etc.
- If lines need to intersect other lines or make a closed shape, the ends need to perfectly touch the end points

The first digitized line looks closed, but on closer inspection...
3. Working With Vector Data

Digitizing lines: Snapping line ends

- To fix this, turn on Edit > Snapping
- Make sure just the second icon is selected: snap to endpoints

- The other snapping options are useful, especially:
  - Snaps to nearest point feature
  - Snaps to nearest vertex
  - Snaps to nearest edge
Digitizing lines: Snapping line ends

- Close the crater rim line
- With the line selected, click the Edit Vertices icon
- Hover the cursor over the red end point (node)
- Click on the node and drag to the other end point

- The cursor and point will move on their own and snap to the other vertex.

- Fix other digitized lines
- Digitize 3 more lines, either with the trace or streaming option
- Save edits when done
Digitizing lines: Attribute Table

- When done digitizing and edits have been saved:
  - Open the Attribute Table for Crater Lines
- Shape lengths are automatically calculated based on projection units
- Other Attribute columns can be added later
Converting Lines to Polygons:

- A standard practice in geologic mapping is:
  1) draw out the contacts between units
  2) generate polygons that make up the geologic unit areas

- Lines that form a **closed shape** can be turned into polygons.
3. Working With Vector Data

Converting Lines to Polygons:
- Select Analysis from the Menu and click the Tools icon
- The Geoprocessing pane appears in the right column
- In the Text window, enter Feature to Polygon and hit enter
3. Working With Vector Data

Converting Lines to Polygons:

- The Feature to Polygon form replaces the search window
- Drag Crater Lines from Contents into the Input Features text window. Leave the second line blank.
- Enter the name Crater_Polygons in Output Feature Class. Make sure that the file will be saved into Ex3_Mars.gdb

- Click Run at the bottom right of the form
Converting Lines to Polygons:

- A new Feature class is added to Contents with a random color symbol
- R-click on Crater_polygons and open the Attribute table

Both perimeter and area of the polygons are calculated.
3. Working With Vector Data

Add an attribute to polygons:

- Add a text column to the attributes to name the polygons
- At the top of the Attribute Table for Crater_polygons, click Add
- A new form opens for Current Layer Crater_Polygons
- Add a Field Name, Alias, and select Text for Data Type from drop-down menu, enter 50 for Length
Add an attribute to polygons:

- After making the changes, right-click on the new row.
- In the pop-up menu, select Save.
- The new row has been added with <Null> values.
3. Working With Vector Data

Update attribute values:

- With the Attribute Table still open, double-click the <Null> value for the first entry. Type **Crater 1** and hit enter.

- Enter names for the other craters (**Crater 2**, **Crater 3**)

- Click the Save edits icon when done
3. Working With Vector Data

Give the polygons unique symbology:

- Vector features can be given unique symbol patterns based on attributes
  - Click on Crater_polygons in Contents
  - Click Feature Layer from above the Menu
  - Click the drop-down menu for Symbology and select Unique Values
  - The Symbology pane opens in the left column
3. Working With Vector Data

Give the polygons unique symbology:

- In Symbology Pane, set Primary symbology to **Unique Values**
- Set Field 1 to Name
  - Unique random colors are given polygons with like attributes

- Double-click the symbol color to choose a different color
- Change the text of the 2nd text column
- Remove the <all other values> row by r-click and select delete from the menu
3. Working With Vector Data

Exercise 3: Working with Vector Data

1. Used vector data: points, lines, and polygons
2. Worked with new project and symbolize datasets with layer files
3. Imported a shapefile, export it to a geodatabase
4. Created point feature from a table export subset to GDB
5. Digitized line features in three methods & ensured end points snapped
6. Converted closed lines to polygons
7. Added attributes to polygons & symbolize based on attributes