



INTRODUCTION TO GIS USING ESRI ARCMAP

Basics in ArcMap and ArcCatalog

ABSTRACT

This lesson covers many basic functions in ArcMap that will enable you to conduct basic data organization, manipulation, and display. It works with data from the US Census Bureau, and affiliated TIGER/Line data sources

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TO USE THIS DOCUMENT

The document is arranged in sections, which can be overviewed in the Table of Contents. It is subsequently broken down as an outline.

Descriptions and purposes are listed in black

Instructions for execution are highlighted in purple

Questions are highlighted in green

~IMPORTANT~

When working with this tutorial, I strongly recommend downloading working files directly to a computer, a flash drive, or external hard drive. Writing into geodatabases on networked drives, such as the U-Drive, frequently fails. If you do not have a flash drive available, save your files to the “Downloads” folder, and at the end of the class ask the instructor to help you migrate your files to a safe location, or ask a CSSCR consultant for assistance.

TABLE OF CONTENTS

3..... INTRODUCTION and BASICS

5..... LOOKING AT YOUR DATA and GETTING ORGANIZED

 8... METADATA

12..... NAVIGATING ARCMAP + JOINS

 12... JOINING BY ATTRIBUTES

 15... SPATIAL JOINS

20..... FIELD CALCULATOR

3

INTRODUCTION and BASICS

1. GIS
 - a. What is GIS
 - i. Geographic: describes what is happening across space
 - ii. Information system: a way of organizing data as it relates to space
 - b. Two data types
 - i. Vector
 1. Points
 2. Lines
 3. Polygons
 - ii. Raster
 1. Pixel-based
 - c. Today we'll be using vector-based data and linked datasets
2. Vector Datasets
 - a. Great for maintaining accuracy across sizes and scales
 - b. Points expressed through single nodes
 - c. Lines are simply points connected together
 - d. Polygons are simply points connected together in such a way that they create an enclosed shape
 - e. When data is tied to these features, the data is assumed to be uniform throughout the entire coverage area

Now we'll get started... as noted on the cover page, it is best to either work directly on a computer or from a flash drive/external hard drive. If you do not have your own flash drive or external hard drive, work from Downloads or My Documents folder.

4

3. Feature Class vs. Shapefile vs. Geodatabase
 - a. A feature class is any data layer that displays spatial information and can be tied to a database (often but not always a spreadsheet)
 - i. Can be vector: point, line, polygon, shapefile...
 - ii. Can be raster: pixel
 - iii. Can be a digital elevation model: vector or pixel
 - iv. NOT ALL FEATURE CLASSES ARE SHAPEFILES
 - v. Let's unzip "ArcMaptut.zip"
 1. Right-click the ArcMaptut.zip file, and click "Extract All" from the drop menu
 2. Unzip the files in your desired location
 - vi. Now unzip "tl_2017_us_county.zip"
 1. Right-click the "tl_2-17_us_county.zip, and click "Extract All" from the drop menu
 2. Unzip the files to your desired location
 3. It creates a collection of files in a folder
 4. At first glance, shapefiles can appear to be pretty chaotic
 5. Shapefiles convey the shapely images that we observe in ArcMap, and also instruct ArcMap on which external pieces of information to tie
 - b. Geodatabases manage this problem, and more
 - i. Proprietary file type made by ESRI
 1. Just like the archive we just "unzipped", a geodatabase packages multiple files into one
 2. It goes a step further in that it can also aid in reading and linking files
 3. New files can easily be written in
 4. Like the zip file, it vastly reduces file size
 5. Makes all of your information easy to transport
 - ii. In the ArcMaptut folder, double click the folder labeled CSSCRGIS.gdb
 1. Its contents look like garbled nonsense! We can't modify geodatabases using windows, but we can access and edit files using ArcMap, ArcCatalog, and other ESRI utilities
4. Setting up the work environment
 - a. Adding Data
 - i. In the ArcMaptut folder, double click "CSSCRGIS.mxd" and start an instance of ArcMap. This should open a blank map
 1. Arc Catalog is an organization utility. You can also run geoprocessing functions more efficiently with this utility once you are familiar with your data.
 - a. On your top bar, click the icon with the yellow file cabinet for "Arc Catalog"
 - i. It will open a window on the right side of the screen
 - ii. At the top right, click the folder with a "+" on it
 - iii. Click your Downloads Folder (or wherever you placed the file archive)

- iv. Click “OK”
- v. Open the “tl_2017_us_county” folder, and observe the shapefile
- vi. Now open the CSSCRGIS.gdb file (icon looks like a tube)
 - 1. Its contents look like stand-alone shapefiles
 - 2. Click and drag the Cities, WA_State_Polygon, US_State_Polygon, Counties, KingCo_CT, and WA_CT shapefiles to the Table of Contents box on the left

5. Table of Contents

- a. On the left side of the screen, you will see the “Table of Contents” box
 - i. At the top, you will see several option buttons
 - 1. List by Drawing Order: your primary work option
 - a. Objects listed in the table of contents are listed in a hierarchy of visibility
 - b. Conventionally, points go on top, followed by lines (if you have them), and then polygons
 - 2. List by Source
 - a. This lists items by their location of origin
 - i. So far all files in use are stored in CSSCRGIS.gdb
 - ii. Click the “Add Data” button
 - iii. Add “DP03CensusData.csv”
 - iv. Now there should be a new subsection for the folder that contains DP03CensusData.csv
 - ii. Click the “List by Drawing Order” button, and note how the data table is no longer listed. It hasn’t gone anywhere, but since it doesn’t yet have a spatial component, it has not been listed.
- b. Environments
 - i. Geoprocessing → Environments
 - ii. Click “Workspace” at the top of the window
 - 1. Change Current Workspace and Scratch Workspace to “CSSCRGIS.gdb”
 - 2. This way, when we begin selecting out and creating new shapefiles, they will immediately be directed to a place that is easy to find
- c. Geoprocessing
 - i. Geoprocessing is any operation that writes new data files or modifies existing data files
 - ii. These operations can take some time, and it can be helpful to monitor their status, as well as view messages that result from these actions
 - iii. Click Geoprocessing → Results
 - 1. You should now see a “Results” box. It will populate as we carry out geoprocessing actions

LOOKING AT YOUR DATA and GETTING ORGANIZED

1. Visualizing layers
 - a. Deactivate WA_State_Polygon and US_State_Polygon to view the Counties layer
 - i. The Counties layer has a lot of detail, but it is hard to tell where one state ends and the other begins.
 - ii. We can play with the “Symbol Selector” to create the visual effects that we want
 - b. Below WA_State_polygon, double-click the colorful box
 - i. This opens the Symbol Selector. Here you can adjust the basic representation of vector features
 - ii. Click the fill color box and set the fill color to “No Color” (hollow)
 - iii. Click the outline color box and use the color palate to set the outline color to a shade of purple
 - iv. Set the outline width to 1.5
 - v. Click “OK”
 - vi. Now we can see through Washington state, but it is still boldly outlined
 - c. Below US_State_Polygon, double-click the colorful box
 - i. Repeat the steps above, hollowing out the fill and making the outlines for the states dark green or brown
 - d. Finally, set the color for counties to a color scheme that is easy to distinguish
 - e. Now you should be able to see all of the county lines, the Washington state line distinctly colored, and the lines surrounding all other states

2. How to look at your stuff
 - a. Top left, you’ll see a Magnifying Glass, a Hand, and a Globe
 - i. The magnifying glasses will zoom you in and out of where you click
 - ii. For a more accurate zoom, click and drag go make a box
 - iii. Zoom in on your home state
 - iv. Let’s zoom out to the full extent (click the globe)
 - b. Selecting
 - i. The US is more than just the 50 sates. There are several territories around the globe, as well
 - ii. Click the “Select Features” tool (White arrow with cyan map beneath)
 - iii. Move your mouse over to one of the distant island clusters to the east, click, and drag a box around a cluster
 - iv. Since we have the “County” layers active, right-click “Counties” in the Table of Contents to the left
 1. “Open Attribute Table”
 2. You should see a list that is probably mostly white

3. At the bottom of the Attribute Table window, click the cyan colored list
 - a. This will activate a window that shows only your selected features
 - b. What did you find? _____
 - c. Close the window
 4. To the right of the Select Features tool, click the white map – this clears the current selection
 5. Click and drag to zoom in on Washington State – use the hand tool to center if necessary, or box zoom to your liking
 6. To the right of the Select Features tool, you’ll see a black arrow and a blue circle with an “I” in it
 - a. The black arrow selects individual features rather than multiple features
 - b. The blue circle is the “Identify Tool”
 - c. “Identify” pulls up a window with all of a single selected element’s information – click somewhere inside WA state
 - d. You were probably aiming for a county, but the program selected a state, since the “WA_State_Polygon” and “US_State_Polygon” shapefiles are on top in your table of contents
 - e. At the top of the Identify window, click the “Identify From” drop menu, and select “Counties”
 - f. Now you should be able to click any county using the identify tool and pull up its information
 - g. Which county did you select? _____; what are some Field items that you see? (first column) _____
 7. Go back to your table of contents, right click and click “open attribute table”
 - a. Note how all of the column heads match the titles in the “Field” column in the “Identify” window
 - b. Select any county
 - i. What is the county’s name? _____
 - ii. What is STATEFP? _____
 - iii. What is the COUNTYFP? _____
3. Reducing the extent of your data
- a. Since we’re only going to be looking at Washington State data, we don’t need to have all of this extra spatial data for the rest of the country
 - b. Look to your left and activate the “King_Co_CT” layer and the “WA_CT” layer
 - c. King_Co_CT represents “King County Census Tracts”
 - d. WA_CT represents “Washington State Census tracts”
 - e. Deactivate all other layers so that only the census tract layers are visible
 - f. Practice activating and deactivating the KingCo_CT layer by clicking the checkbox to the left

- g. It looks as if someone took a cookie cutter to the statewide layer and has extracted King County's census tracts
- h. We want to do the same for all counties in Washington State – “cookie cutting” it out from the
- i. Deactivate the “King_Co_CT” layer and the “WA_CT” layer by unchecking the box to the left
- j. Remember your STATEFP value from the bottom of **2Biv7?** That is the state FIPS code
 - i. FIPS stands for *Federal Information Processing Standard*
 - ii. All data produced with federal funds or intended to be linked with federal resources utilizes this unique labeling system
 - iii. Every state, county, census tract, census block, etc. has its own unique code
 - iv. Every county in the state of Washington has a state FIPS code tag of “53”
- k. Here we will use the “Select by Attributes” Function
 - i. At the top left, click Selection → Select by Attributes
 - ii. In the drop menu at the top of the window, select the “Counties” layer
 - iii. ArcMap's GUI interface uses SQL query commands to make selections. I recommend clicking to build commands until you become comfortable with typing out the proper syntax
 - iv. Double-click “STATEFP” and then click “=”
 - v. Click “Get Unique Values” – this will populate the white box above with unique Values, all FIPS codes that are unique to each state
 - vi. Scroll to “53” and then double-click it
 - vii. Your syntax should read STATEFP = ‘53’
 - viii. Click “Verify”. It should say “The Expression was Successfully Verified”
 - ix. Click “Apply”
 - x. You may need to slide your table out of the way or shrink it a little but all counties in WA state should be highlighted
 - xi. Click “OK”
 - xii. Click “Show selected records” in your table
 - 1. It should say 39, as there are 39 counties in WA
 - xiii. Next, right click the “Counties” layer in the table of contents
 - 1. Data → Export Data
 - 2. It should open directly to your geodatabase
 - 3. If not, click on the folder to the right, and in the drop menu, change “Save as type:” option to “File and Personal Geodatabase feature classes”
 - 4. In the “Look in” drop menu, find your working folder, then navigate to CSSCRGIS.gdb
 - 5. Change the file name to “WA_Co”, and click “Save”
 - 6. In the next window, click “OK”
 - 7. A new window will open asking if you would like to add the newly created feature as a new layer. Click “Yes”

9

The new WA_Co layer should now be at the very top of your table of contents. Since it is a new layer for all of us, it will have assigned us all different colors. If the color of the new layer is easy to distinguish from the others and you are satisfied with it, you may skip this step.

4. Selecting a color scheme
 - a. Double-click the “WA_Co” layer
 - i. Click the “Symbology” tab
 - ii. Click the colorful box in the “Symbol” section below
 1. This will pull up a new window with a few default color options feel free to select one of those, but avoid “Hollow” and “Lake” for now
 2. You may also play with the “Fill Color” and Outline Color” buttons to the right
 3. Click “OK” when you are satisfied, and “OK” again to close the Layer Properties window

METADATA

5. What is “metadata”?
 - a. Metadata is information that more deeply describes the origins and functionality of datasets
 - b. Metadata can be embedded within the file itself or presented as an adjacent file that describes some characteristics of the dataset

6. Examining shapefile metadata
 - a. As we observed in a previous step, a shapefile is a collection of several file types that are instructed to launch simultaneously through the .shp file, but store information about the file on several other documents
 - b. Shapefile metadata is among those simultaneously readable files, and is stored as an .xml document
 - i. If you open the .xml document in an internet browser, it is more or less readable, as-is, but is best viewed using ArcGIS’s file utility called ArcCatalog
 1. Briefly open one of the .xml documents in a browser and scroll to the bottom – it is quite lengthy
 2. Close the browser window
 - c. Open ArcCatalog from the Windows “Start” panel: ArcCatalog is also a stand-alone utility
 - i. Open you working folder, and inside the “tl_2017_US_County” folder, click the “tl_2017_US_County.shp” listing
 - ii. To the right, click the tab that says “Description”
 1. Below you will find a plethora of information about the agency that produced the data and when it was produced
 2. However this is significantly shorter than the .xml document we observed in the previous step... scroll to the bottom of the page and you

will see a message that says you are viewing metadata as an “item description”

- iii. At the top of the window, click Customize → ArcCatalog Options
 1. Click the “Metadata” tab
 - a. In the “Metadata Style” box, click the drop menu that currently says “Item Description” and select “FGDC CSDGM Metadata”
 - i. A dialog box may open asking if you want to upgrade your metadata viewing method – click “No” for now, and then click “OK” to close the “ArcCatalog Options” window
 2. The Description tab wont update immediately, so click on the “Preview” tab to observe the dataset
 - a. Click back to the Description tab, and now the full listing of the metadata should be available
 - b. This includes information such as field names and their various characteristics scale, geographic reference, etc.

7. Examining metadata and importing tabular data

- a. Now we will work on making these datasets meaningful
- b. These are from the US Census Bureau, and were exported using the American Fact Finder
 - i. This data is taxpayer funded, and free for you to access at any time
 - ii. Additionally, the feature classes we are using for this exercise are from the US TIGER/Line data server
 - iii. TIGER/Line data is already idealized for paring with tabular data from the US Census Bureau, as well as many other federal and state agencies
- c. Open ArcCatalog
 - i. On the left, you will see hierarches of accessible folders
 - ii. Find your geodatabase, either in the “downloads” folder, or the geodatabase may be accessible on its own
 - iii. Inside, you will see several feature classes and tables
 - iv. Click “ACS_16_5YR_DP05” and then click the “Preview” Tab
 - v. This will pull up the data table for the American Community Survey’s “Demographic and Housing Estimates 5-year estimates published in 2016”
 - vi. Scroll right. What do you see as column headers? _____
 - vii. Don’t panic, these are just tags that identify different “fields” or “attributes”
 - viii. Look to your left and click “ACS_16_5YR_DP05_metadata”
 1. This file will show you all of your matching tags and what they mean
 2. Note: you may need to resize the columns
 3. What piece of data does HC01_VC04 represent? _____
 4. What piece of data does HC04_VC86 represent? _____
 - ix. If you like, examine the Description tab for the datasets. The metadata tab reveals some helpful information, such as the data type, but otherwise lacks the

same standardized, detailed information as the shapefile. This is because metadata from the ACS (when accessed in this way) is stored in separate files

- x. Close ArcCatalog
- xi. Now that we've had a quick look at our data, let's import it to ArcMap
 1. Go back to your ArcMap window. At the top left, click the black "+" positioned over the yellow diamond – "Add Data"
 2. It should open directly into your geodatabase. If not, use your knowledge of folder hierarchies to find it
 3. Click "ACS_16_5YR_DP05", and then click "Add"

NAVIGATING in ARCMAP + JOINS

JOINING WITH ATTRIBUTES

1. Open the ACS_16_5YR_DP05 table and the WA_Co table
 - a. Note at the bottom of the table window, you can now click between tabs
 - b. Note how the DP05 table has 40 entries, while the WA_Co layer has 39.
 - i. What is the extra entry? _____
 - c. “Join” functions can be carried out either through the usage of attributes or spatially
 - d. For tables, we must use attributes, since the ACS_16 table does not have spatial information
 - e. Remember FIPS codes? FIPS codes are the basis of GEO.IDs
 - i. The GEO.ID is simply the combined total of all FIPS codes arranged from broadest to finest area
 - ii. **0500000US** is the FIPS for the US
 - iii. **53** is the FIPS for Washington
 - iv. **001** for Adams County
 - v. Thus, the complete GEO.ID for Adams County is **050000US53001**
 - f. For federal datasets, the ideal way to join by attributes is by using the complete GEO.ID or GEO.id2 (a truncated version of the federal GEO.ID) if available
 - i. Depending on the producer of the overall data, this information may have different headings – use your judgment to identify similarities
 - g. In which column can the complete GEO.ID be found in ACS_16? _____
 - h. In which column can the complete GEO.ID be found in WA_Co? _____
 - i. Awkward, but again, use your judgment to figure out how the varying data sources list these fields.
2. Right-click WA_Co → Joins and Relates → Joins
 - a. In the window, click the drop menu, and choose “Join attributes from a table”
 - i. 1. Choose the field (column) in this layer that the join will be based on – this will be your answer from question h in the previous section
 - ii. 2. Choose the table to join to this layer, or load the table from disk – this will be your answer from question g in the previous section
 1. ArcMap may have already selected ACS_16. If not, select it from the drop menu
 - iii. Click the “Validate Join” button
 1. If you picked the right fields, it should say that 39 of 39 records were successfully matched
 - a. Reminder: only 39 features need to match, despite the fact that ACS_16 has 40 records. That stray record is for Washington state, which is not a relevant geographic measure at this time
 2. Click OK – it might take a few seconds to load
 - iv. Click on the WA_Co tab in your table and scroll to the right

1. LOOK AT ALL THOSE RECORDS!
2. You can now begin to analyze ACS_16 in conjunction with your spatial data

NOTE: A few people have gotten stuck at this juncture based on trying to conduct a join with GEO.id2 in ACS_16, and GEO.ID in the WA_Co dataset. When you try to conduct a join and you select GEO.ID in the drop menu, GEO.ID2 doesn't come up. Yet, the two columns appear to present cardinal data. What's up with that???

If you would like to move on with the lesson and skip this troubleshooting trick, use
and

This mismatch is a common problem related to file types and data types. Let's explore further below.

- ACS_16 AFGGEOID from WA_Co
3. Open the ACS_16 and WA_Co attributes tables
 - a. Right-click the column header for GEO.id2 in ACS_26
 - i. What is the data type?: _____
 - b. Right-click the column header for GEO.id in WA_Co
 - i. What is the data type?: _____

Especially as you work with your own custom datasets or lightweight datasets that are saved as .CSV files, you will consistently run into this differing data type problem. .CSV files do not store data about file types, so when ArcMap opens, it must make the best guess possible to assign data types. Since the FIPS codes are all numbers, it assigns a "Long Integer" classification as its best guess.

There are a couple of ways to address this problem, but this method is the surest trick to get you past these data troubles as you construct your own datasets and work towards adapting datasets from non-geographic sources to your own uses.

4. Method: Field Calculation – This must be done to correct a mismatch in a .CSV file that is housed outside of a geodatabase
 - a. In the ACS_16 table, click the white list at the top-left corner, and click "Add Field"
 - i. Name the field "GEO.id_Str"
 - ii. Set the type to "Text"
 - iii. Click "OK"
 - b. Scroll to the right until you see the new field, and right-click field header for GEO.id_Str
 - i. Click "Field Calculator"
 - ii. ArcMap uses a unique coding system called VBScript, which is based in SQL. You can also use Python, but for now we will stick with VBScript
 - iii. Observe the text above the box that says "GEO.id_Str ="
 1. We simply need to fill in the text box with the contents of GEO.id2, so double click "GEO.id2" in the fields box to the left, and click "OK"
 - c. Now try to conduct the join again with GEO.id_Str and GEO.ID in WA_Co
5. Method 2: Arc Catalog – This only works if the dataset as not been edited and saved in ArcMap, and is either a stand-alone .DBF file or located in a geodatabase

- a. Right-click DP503_CT in the item list located in CSSCRGIS.gdb
 - i. Click Properties → Fields
 - ii. Click the box that corresponds to “GEO.id2” under the “Data Type” column and select “Text”, then click “OK”

SPATIAL JOINS

6. Now we're going to play with Spatial Joins: these join based on an objects position on the map
 - a. Activate the "Cities" layer and open the table
 - b. Look at the CityFIPS column
 - i. It tells us the state and city FIPS codes
 - ii. County FIPS is housed separately
 - c. Spatial Joins can happen in two directions, each with their own unique outcomes
 - i. Right-click the Cities layer -> Joins and Relates -> Join
 - ii. In the drop menu, select "Join data from another layer based on spatial location"
 - iii. 1. Choose the layer to join to this layer, or load data from disk – Choose "WA_State_Polygon"
 - iv. Each point will be given all the attributes of the polygon that... – make sure the first radio button "it falls inside" is selected
 - v. 3. The result of the join will be saved into a new layer. Specify output shapefile or feature class for this new layer – click the folder. This function doesn't always obey the environment we set up
 1. In the drop menu "Save as type", select *File and Personal Geodatabase Feature Class*
 2. Navigate to your geodatabase CSSCRGIS.gdb
 3. Name your file "Cities_WA_Join"
 4. Click "Save"
 5. Click "OK" – the window will close
 - vi. All spatial joins create a new feature class
 1. Deactivate the "Cities" feature class
 2. Open the attribute table for Cities_WA_Join layer and scroll to the right
 - a. Now all of the data from the Washington state feature class has been grafted into the new cities layer
 - d. Let's do it in the other direction!
 - i. Activate the WA_Co Layer, right-click → Joins and Relates → Joins
 - ii. 1. Choose the layer to join to this layer, or load data from disk – Choose "Cities"
 - iii. It has given us new options. Since we have multiple point cases occurring in singular spatial boundaries, we are given quantitative options
 - iv. 2. Each polygon will be given a summary of the numeric attributes of the points that fall inside it, and a count field showing how many points fall inside it... How do you want the attributes to be summarized? – Leave all of these options blank for now
 1. This dataset doesn't provide us with any numerical stats to summarize
 - v. 3. The result of the join will be saved into a new layer. Specify output shapefile or feature class for this new layer – click the folder. This function doesn't always obey the environment we set up
 1. The output should be more cooperative now, but do open the folder and repeat the steps from the previous section if necessary -

2. In the drop menu “Save as type”, select *File and Personal Geodatabase Feature Class*
 3. Navigate to your geodatabase CSSCRGIS.gdb
 4. Name your file “WA_Co_Cities_Join”
 5. Click “Save”
 6. Click “OK” – the window will close
- vi. Scroll all the way to the right, and you’ll see a field that says “Count”
1. This is the sum total of Cities that are present within each county boundary
7. We’ll take this to the next level
- a. Open the ACS_16_5YR_DP05_metadata file in a spreadsheet viewer (Excel, Open Calc, Google Sheets, etc...) or ArcCatalog, and look for **HC01_VC03**
 - i. What does that column tell us? _____
 - b. **HC01_VC03** will be the statistic we follow for this sample
 - c. Activate your “WA_State_Polygon” layer and your “WA_Co” layer
 - d. **We’ll need to do some prep**
 - i. Right-click your WA_Co layer → Data → Export Data
 - ii. Rename the file “WA_Co_DP05” – this is the layer we joined to the ACS_16 table in a previous section
 - iii. Click “Save” “Okay” and “Yes”
 1. Now you have a permanent feature class with ACS_16 data
 - e. Open tables for the original WA_Co file and the new WA_Co_DP05 layer
 - i. They look similar, but they have one distinct difference – a Join by attributes is not permanent
 1. Right-click the WA_Co layer -> Joins and Relates -> Remove Joins **BUT DON’T CLICK ANYTHING**
 2. Observe that there is a list of features that are joined: ACS_16_5YRDP05
 3. Do the same for the WA_Co_DP05 Layer: there’s no list!
 4. I recommend taking this step for the sake of program stability. In the future when you begin heavy geoprocessing and quantitative work, many functions won’t execute on a Join, as these functions may overwrite the joined file. ArcMap will often prevent us from doing that, however it is up to the user to ensure safe data practices
 5. For a quick sample of why stability is so important, open the WA_Co_Cities_Join attribute table
 - a. This was made from a joined shapefile + table, and the cities point dataset
 - b. Since we didn’t provide ArcMap with any instructions on what to do with the joined data in relation to the point data it was summarizing, it failed to transfer the joined data
 6. Creating a permanent feature class with the joined data will be more stable and flexible – this is to your advantage

7. **It is also good practice to keep copies of original documents intact and unmodified**

- f. We will now summarize the outcomes from calculating the populations of each county
 - g. Right-click WA_State_Polygon → Joins and Relates → Join
 - i. 1. Select WA_Co_DP05
 - ii. 2. Select all six summary options
 - iii. 3. Rename the file “WA_CoDP05_Sum”
 - iv. ...and then Save. It may take a moment.
 - h. Open the table for the WA_State_DP05_Sum layer and scroll to the right until you find the summary outcomes of HC01_VC03
 - i. What is the Sum? _____
 - ii. What is the Average? _____
 - iii. What is the Minimum? _____
 - iv. What is the Maximum? _____
 - v. What is the Variance? _____
 - vi. What is the Standard Deviation? _____
8. We can use functions simultaneously, as well. We'll join based on selected features
- a. Deactivate layers as needed until you can see the Cities layer overlaying the WA_Co layer
 - b. Right-click the WA_Co layer → Joins and Relates → Remove Joins → Remove All Joins
 - c. Go to Selection → Select by Attributes
 - i. Click “Clear” to remove any previous syntax
 - ii. In the drop menu, select “Cities”
 - iii. Scroll down the list, and select “Major City”
 - iv. Select “=”
 - v. Click the “Get Unique Values” button, and click “yes”
 - d. Right-click the WA_Co layer → Joins and Relates → Joins
 - i. In the drop menu, select Cities
 - ii. Rename the file “WA_Co_MajCit” and then save
 - e. Open the attribute tables for WA_Co_MagCit and WA_Co_Cities_Join
 - i. In both tables right-click the “Name” field, and select “Sort Ascending”
 - ii. In both tables, right-click the “Name” field, and select “Freeze/Unfreeze Columns”
 - iii. Scroll to the right until you see the “Count” column
 1. What does Freeze/UnFreeze Columns do? _____
 2. What is the count for Adams County in WA_Co_MajCit? _____
 3. What is the count for Adams County in WA_Co_Cities_Join? _____
 - iv. In both tables, right-click the Count Field and “Sort Descending”
 1. Which county has the highest count in WA_Co_MajCit?

 2. Which county has the lowest count in WA_Co_MajCit?

3. Which county has the highest count in WA_Co_Cities_Join?

4. Which county has the lowest count in WA_Co_Cities_Join?

5. By selecting out only major cities in the opening steps, we were able to isolate major cities exclusively for the basic count function
6. This can be repeated in the usage of the summary functions we used during the creation of the WA_CoDP05_Sum feature class

9. Working in the Symbology Tab

- a. The Symbology tab allows us to generate cartographic productions that help us visualize our data
- b. I could dedicate several classes just to cartographic representation, but we'll just do some basics
- c. Make sure that only WA_Co_DP05, WA_State_polygon, US_State_Polygon, and Counties are open
 - i. Right-click, WA_Co_DP05, and click "Properties"
 - ii. Click the Symbology Tab → Quantities → Graduated Colors
 - iii. In the *Value* drop menu, select HC01_VC03
 - iv. Leave the classification on "Natural Breaks (Jenks)
 1. Natural Breaks: The Jenks optimization method, also called the Jenks natural breaks classification method, is a data clustering method designed to determine the best arrangement of values into different classes. This is done by seeking to minimize each class's average deviation from the class mean, while maximizing each class's deviation from the means of the other groups. In other words, the method seeks to reduce the variance within classes and maximize the variance between classes. It's not the best method, but we'll play with it anyway
 2. Keep the copper color ramp, and click "OK"
 3. For more info on Jenks Natural Breaks:
https://en.wikipedia.org/wiki/Jenks_natural_breaks_optimization
 - v. Right-click WA_Co_DP05 "Label Features"
 1. You should now see the names of the counties
 2. If you don't, right-click WA_Co_DP05 → Properties → Labels, and in the *Label Field* drop menu, select "NAME", and click "OK"
 - vi. Which county has the highest population? _____
- d. Let's try another classification
 - i. Right-click, WA_Co_DP05, and click "Properties"
 - ii. Click the Symbology Tab → Quantities → Graduated Colors
 - iii. In the *Value* drop menu, HC01_VC03 should still be selected
 - iv. Click the "Classify" button to the right
 - v. In the "Method" drop menu, select "Quantile"
 1. How do the selection ranges change?

- vi. Click “OK”
 - 1. How does the map look now? _____
- vii. Quantiles: each of any set of values of a variate that divide a frequency distribution into equal groups, each containing the same fraction of the total population.
- viii. For more info on Quantiles: <https://en.wikipedia.org/wiki/Quantile>

FIELD CALCULATOR

1. Field Calculator: The Field Calculator enables us to conduct basic quantitative analyses and calculate geometries
 - a. CALCULATE GEOMETRIES
 - i. Open the attribute table for WA_Co_DP05
 - ii. Right-click the “Name” field and select “Freeze/Unfreeze Column”
 - iii. At the top left, click the “Table Options” drop menu and click “Add Field”
 - iv. Name it “Area”
 - v. In the *Type* drop menu, select “Double”, Click “OK”
 - vi. You’ll now have a field that is filled with <Null>, but not for long
 - vii. Right-click the field name “Area” and select “Calculate Geometry”
 - viii. Don’t mind the warning message – click “Yes”
 - ix. In the *Property* drop menu, select “Area”
 - x. Be sure to select *use coordinate system of the data frame*
 - xi. In the *Units* drop menu, we’ll pick “Square Miles”
 - xii. Click “OK”
 - xiii. Don’t mind the error message – click “Yes”
 - xiv. You now have a field for square mileage
 - xv. Right-click the Area field name and select “Sort Ascending”
 1. Which county has the largest land area? _____
 2. Which county has the smallest land area? _____
 - b. Using formulas to calculate fields
 - i. At the top left, click the “Table Options” drop menu and click “Add Field”
 - ii. Name it “Pop_Dens” for “Population Density”
 - iii. In the *Type* drop menu, select “Float”, Click “OK”
 - iv. Right-click the field name “Pop_Dens” and click “Field Calculator”
 1. Double-click “HC01_VCO3”
 2. Click the “/” division operation
 3. Double-click “Area” (all the way at the bottom of the list)
 4. Use the click functions until you are familiar with SQL syntax
 5. Click “OK”
 - v. Right-click the Pop_Dens field name, and select “Sort Ascending”
 1. Which county has the highest population density? _____
 2. Which county has the lowest population density? _____
 - vi. Let’s assess this further...
 1. Right-click the Pop_Dens field name, and select “Statistics”
 2. This will give us a histogram and some basic statistics about population density
 - a. What is the standard deviation of population densities?

 - b. What does this mean? _____

3. You can use the drop menu to assess other columns without backing out of the window
 - a. Select HC01_VC03
 - i. What is the standard deviation of the total population? _____
 - ii. What is the mean of the total population? _____
4. Looking at the histogram, it seems that most counties have very low population densities as well as overall populations
 - a. ArcMap isn't optimal for displaying this kind of data,
 - b. The histograms are mashed up, and we lose a lot of detail in the lower counts where most of the counts exist
5. In order to get better counts, we can export a table with this information to be assessed in a better program, such as SPSS or Tableau
 - i. At the top left of your table, click "Table Options"
 - ii. At the bottom of the list, select "Export"
 - iii. In the *Export* drop menu, select "All records"
 - iv. In the *Save as type* drop menu, select dBASE Table
 - v. Navigate to your "Downloads" folder (or wherever you are working from)
 - vi. Rename the file "DP05Export", click Save and OK
 - vii. Open your downloads folder, and now you will have a stand-alone file that can be imported to SPSS, Tableau, or your other preferred data analysis tool