Data Management in the GIS Environment with ArcGIS Desktop 10.5

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This reference and training manual was produced by
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University of Maryland Libraries
GIS and Spatial Data Center
McKeldin Library, Room 4118
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http://www.lib.umd.edu/gis

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GIS Facilities at the University of Maryland

McKeldin Library

ArcGIS 10.5 and QGIS (an open source GIS software package) are loaded on all public workstations in McKeldin Library, including those located in the McKeldin 6101 instruction laboratory. The laboratory is open to the public during library hours when not in use by a class or librarian. The laboratory schedule is posted on the window by the door and updated each week. Color printing and large format printing are also available in McKeldin Library.

The GIS laboratory is located on the fourth floor of McKeldin Library in room 4118. This laboratory is available for use by faculty, staff, and students using geospatial methods in their research at the discretion of GIS and Spatial Data Center Staff. ArcGIS 10.5 and QGIS are installed on all computers in this laboratory, as well as other geospatial, image processing, and statistical packages.

For a complete list of software packages available, please see our GIS Facilities link https://www.lib.umd.edu/gis/people-and-facilities

Other Facilities

There are other departmental (e.g., anthropology, architecture/urban planning, civil engineering, geographical sciences, and landscape architecture) GIS laboratories on campus that are restricted to faculty, staff, and students in each of those disciplines. Additionally, the Office of Information Technology's software licensing program (http://www.oit.umd.edu/slic) offers ArcGIS at special/reduced rates for faculty and staff at the University of Maryland.

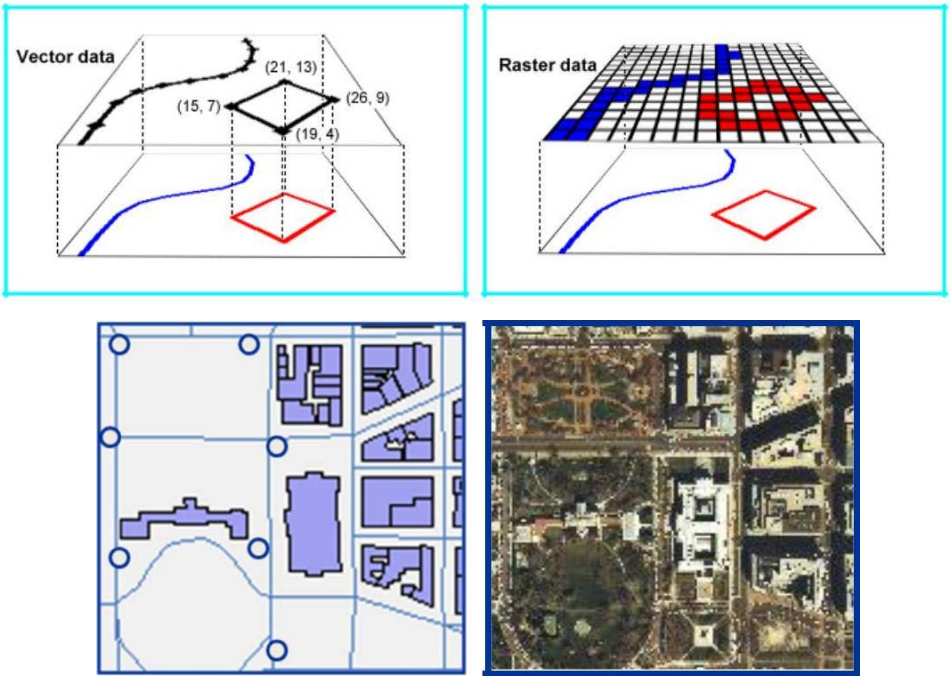
Data Types for GIS

Vector and **Raster** (or Grid) are the two types of data used in a GIS.

Data Types

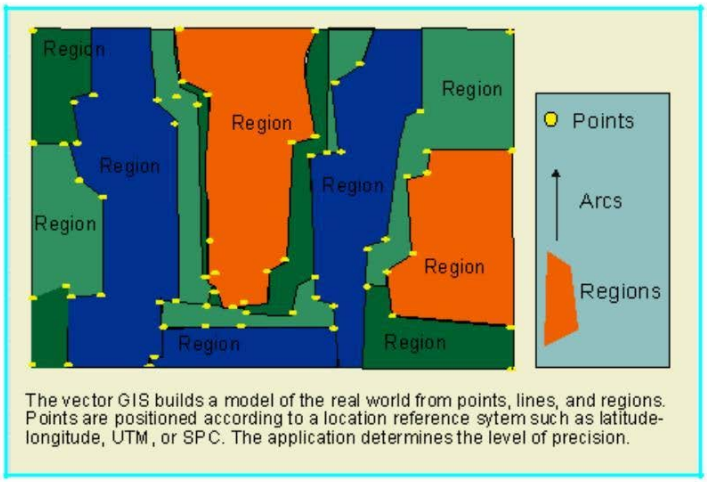
- Vector - uses geometric objects – points, lines and polygons – to represent real features on the earth's surface such as light poles, roads and buildings. Ideal for discrete themes with definite boundaries.

- Grid (Raster) - is composed of a continuous grid cells that represents a portion of the earth's surface. Ideal for continuous themes where there is lots of change.



Graphic Source: Crown, Inc. (http://www.ordsvy.gov.uk/gis-files/stage1/)

Remember: either can be used, but one or the other will be better suited to certain kinds of data.

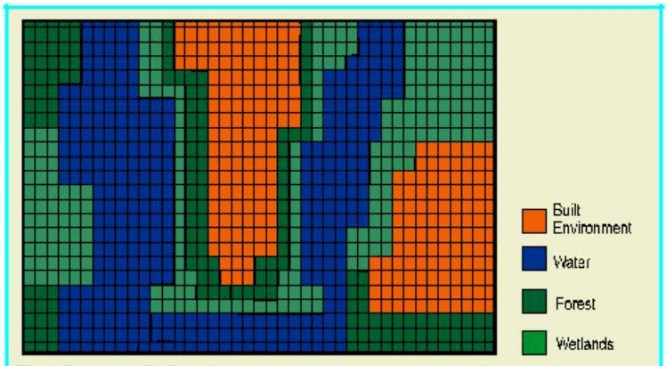


The vector GIS builds a model of the real world from points, lines, and regions. Points are positioned according to a location reference sytem such as latitude-longitude, UTM, or SPC. The application determines the level of precision.

Vector Data Model

Source: Kenneth E. Foote and Donald J. Huebner, The Geographer's Craft Project, Department of Geography, University of Texas at Austin.

Grid (Raster) Data Model



The Raster GIS references phenomena by grid cell location in a matrix. The grid cell is the smallest unit of resolution and may vary from centimeters to kilometers depending on the application.

Data Sources for GIS

- Digitized and Scanned Maps
- Databases, spreadsheets (tables)
  - dBASE III and dBASE IV (.dbf)
  - Microsoft Access (.mdb)
  - Microsoft Excel (.xls)
  - Tab-delimited text (.txt)
  - Comma-delimited text (.csv)
  - INFO files
- Global Positioning Systems
- Field Sampling
- Remote Sensing and Aerial Photography

Spatial vs. Non-Spatial data

ArcMap needs data to have a spatial component in order for it to be analyzed and put to its best use. This means the data has to have some correlation to a location on the Earth. That might be a place name, a specific code that relates to a place (such as a ZIP code or a FIPS code, or a street address), or a set of latitude/longitude coordinates.

How to convert non-spatial data to spatial data

- Import Tabular Data → Joining/relating Tables
- XY Event Theme
- Address Event Theme or Geocoding

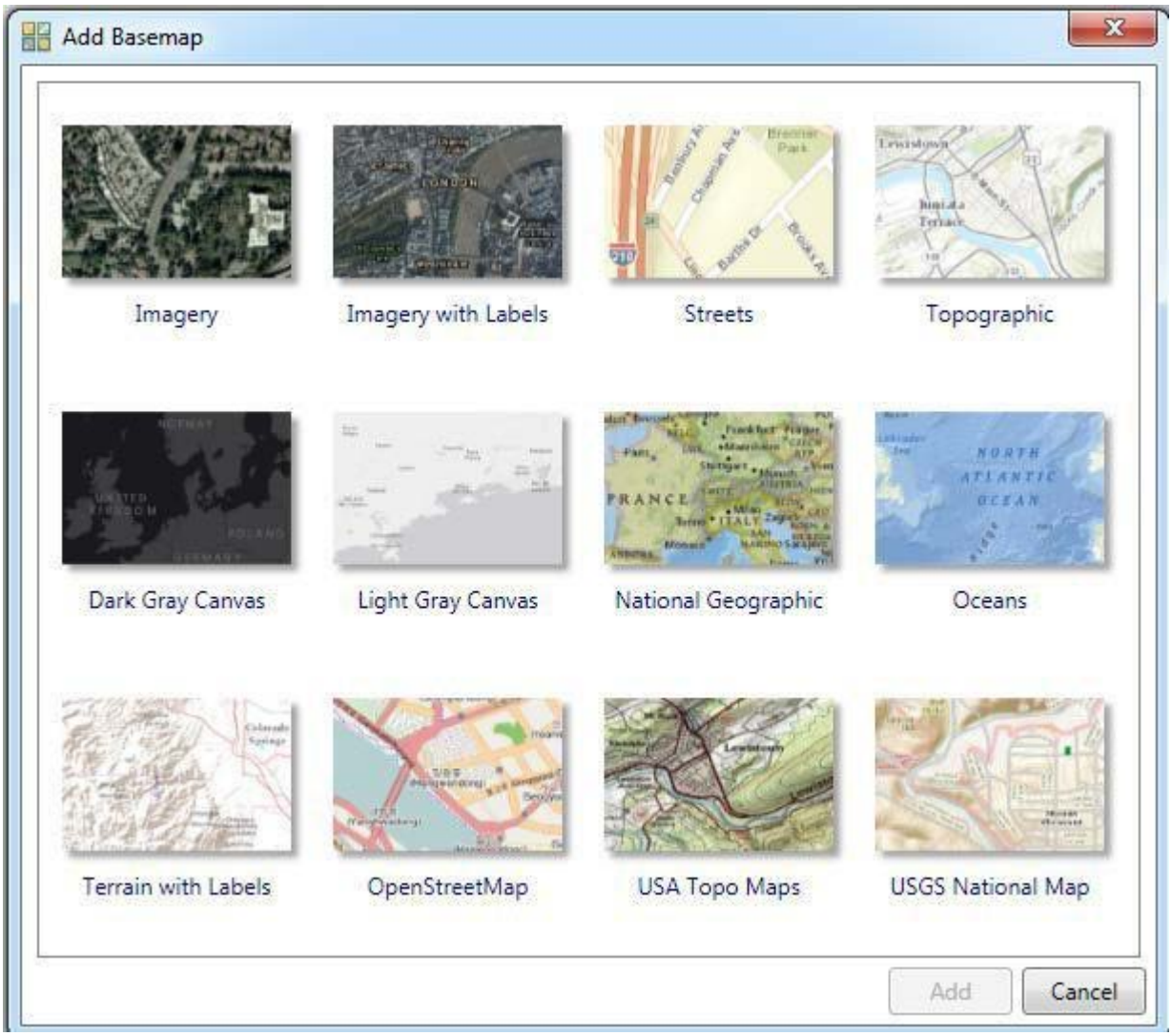
For raster (grid) data, if an image does not have embedded spatial information, you will have to **"georeference"** it. There are several ways to do this:

- You overlay the image and point out several places where it corresponds to known locations – then the computer can adjust the image to fit correctly.
- You tell the computer a set of coordinates which are where the top left corner of the image begins and what the definition is of the size of each cell (ex: 10x10 meters)

New in ArcGIS 10 – Basemaps

The GIS community is moving more toward online storage and sharing of data. Instead of having to search out raster data such as relief maps, topographic maps, street maps, or aerial photography for backgrounds, ArcGIS 10 has basemaps readily available through the Add Data button. Click the down arrow next to the + icon to view options.

Remember to still be aware of where the data is coming from and to evaluate its quality and its appropriateness for your needs.



You can also look at ArcGIS Online to create maps without using GIS software that can then be embedded into webpages. **http://www.arcgis.com/home/** You will have to create a free account to use this website or use your institutional login if you have been provided one

Joining and Relating Tables

Imported tables of outside or stand- alone data can be used in ArcMap by joining or relating them to an existing shapefile and its attribute table.

- Tables may be joined by a common field (a column that contains the same information).
- One of the columns should contain unique values (only one occurrence of each value).
- The data in the field must be an exact match (no spelling errors).
- The data in the field must be of the same type (number, character string, Boolean, or date).

Joining a table appends attributes from the new table to an existing one based on a common field.

Through a common field, known as a key, you can associate records in one table with records in another table.

The relationship is one-to-one or many-to-one.

Relating a table defines a relationship between two tables, also based on a common field, but does not append the attributes—instead, you can access the new data when necessary.

The relationship is one-to-many or many-to-many.

Relates can help you discover specific information within your data. For example, if you select a building, you can find all the tenants that occupy that building. Similarly, if you select a tenant, you can find what building it resides in (or several buildings, in the case of a chain of stores in multiple shopping centers—a many-to-many relationship).

Unlike joining tables, relating tables simply defines a relationship between two tables. The associated data isn't appended to the layer's attribute table like it is with a join. Instead, you can access the related data through selected features or records in your layer or table.

Relationships between Tables

When importing new tabular information for inclusion in your map, it's important to decide what relationship you want to establish between the common identifiers in each table. These relationships include: one-to-one, many-to-one, one-to-many, and many-to-many.

One-to-one relationships match one identifier in the first table with the shared one in the second. In this case, Allegany (county) in Table A will be matched with Allegany in Table B.

Table A

Name	Population	Area
Allegany	74946	492.7002
Baltimore	692134	419.3426
Calvert	51372	220.3898

Table B

Name	Males	Females
Allegany	35274	39672
Baltimore	330339	361795
Calvert	25487	25885

Many-to- one relationships match possible multiple records in the first table with one record in the second. Table C below shows multiple purchases with information about the store, transaction number, and date of purchase. Table D shows the identifying information about the store and acts as a lookup table for musical stores. In this example, the match is from store ID in Table C to store ID in Table D.

Table C

Store ID	Transaction #	Date
T456	001	01/15/06
T456	002	03/21/06
M541	003	06/28/06

Table D

Store ID	Name	City
T456	Tom's Music Store	Greenbelt
M541	Music Plus	Baltimore
L655	Larry's Guitars	Fallston

Joining Tables

You may find that you need to access information from several different tables. For example, a project involving homeowners might require a tax assessment table, a demographic table, and a real estate transactions table. All that is required to join tables is that they have a field (column) that is common (contains the same information) to both tables. This field is called the ***common identifier***. For example, if you have a table that lists house address and assessed value and another table that lists house address and owner's name, you could join the tables based on house address and create a virtual table that lists house address, owner's name, and assessed value.

It is important to remember that the information in the common field must match exactly. For example, if you are matching on the field County Name, "Prince George's" will not match with "Prince Georges," "Prince George's County" or "Prince George's Co." because the characters in the field are not exactly the same. Additionally, the field must contain the same type of data, ***character string*** or ***numerical***.

Numerical data consists of numbers and may contain decimals or a negative sign. The computer knows that it can perform mathematical functions on numerical data. On the other hand, a character string may contain letters, letters and numbers, or only numbers. However, the computer cannot perform mathematical functions on data in a character string, even if it consists solely of number symbols. A character string field and a numerical field cannot be joined even if the symbols in the field appear the same.

An example of this can occur when working with census data. A number designates a census tract. However, a census tract is often represented in a database as a character string composed of numerical symbols because the number represents a name, not a quantity. This prevents people from attempting mathematical operations on the name of the census tract. After all, you wouldn't expect to multiply Montgomery County by Prince George's County and get a sensible result. When you import a text file into the GIS, it may interpret the numbers in the census tract name column to be a numerical string. If this were to happen, you can't join the two tables because, although the data appears to be the same, one is a character string and the other is numerical. You would need to manipulate the table data outside of the GIS before importing it to ensure that it is read as the correct form of data.

Relating Tables

There are times when you want information associated with a particular layer, but do not want to join the information to it. **Joining tables establishes a one-to-one or many-to-one relationship. Relating tables, however, allows you to create a one- to-many or many-to-many relationship.** For instance, you may want to include information on the many organizations in one county. Instead of creating a traditional relationship, relating tables allows you to access supplementary information about the organizations.

In **One-to-many relationships** one record (Company) in Table E is potentially matched with many records in Table F.

Table E

Company	City	Color
ABC	College Park	Red
UPS	Beltsville	Green
Target	Laurel	Blue

Table F

Employee	Age	Company
John	45	ABC
Cathy	32	ABC
Mark	22	Target

In **Many-to-many relationships**, multiple records from each table can correspond.

Route	Bus Driver	Day
122	Bob	Monday
122	George	Friday
122	Jen	Wednesday
114	Carol	Monday

Bus Driver	Route
Bob	122
Bob	136
Bob	114
Carol	114

When relating tables, it is best to relate a table that is in .dbf format rather than delimited text.

Exercise: Mapping Locations by (x,y) Coordinates

ArcMap allows you to add XY data in the form of a pair of coordinates, such as longitude and latitude, within a table. We can import tables of information that contain coordinate data, such as that captured from a global positioning system (GPS), and convert them to a point coverage by using the latitude and longitude to represent the X and Y values in a Cartesian coordinate system. The data included in the table can then be turned into a layer.

To do so requires a dBASE (extension .dbf) or tab or comma-delimited text file with separate columns for the latitude and longitude in order for ArcMap to plot the points. GPS is used in fieldwork for surveying; tracking animal movements; locating sampling points, crimes or accidents; etc. Locations can be recorded precisely and accurately using the GPS and incorporated with other data, and then imported into the GIS for mapping, analysis, and visual display. We will be working through an example with stream sampling data.

Note: You can bring in an Excel spreadsheet that has X,Y coordinates and display it successfully in ArcMap, but you cannot select, query, or edit the features in the resulting layer because there is not an object ID field. It is usually best to turn the spreadsheet into a dbf file (right click > Data > Export).

Creating a Table with XY Coordinates

XY tables are an easy, accurate, and quick way to import data into a GIS. All that is required is some form of tabular data in which two of the columns contain location information (longitude and latitude) **in decimal degree format**. For this exercise we will use real-time stream flow data that is posted by the United States Geological Survey (USGS) on the Internet to create a sample point location theme. We will do this by importing into ArcMap a dBASE file (.dbf) that contains the latitude and longitude of stream sampling points in Maryland and use this information to create a point theme that maps the location of each sampling point. The information about each sampling point will be stored in the attribute table for the new theme.

Importing the Data

To begin, navigate to the GIS workshop page https://www.lib.umd.edu/gis/workshops. Scroll down and look for the GIS Data Management workshop materials. Click on Data under Materials. Click on the Download button you see on the top right corner. Unzip and save the files in Downloads. Note the Geocoding_data folder within your Data folder. This will be used for geocoding exercises.

For this exercise, we created a dBASE file (.dbf) from textual data downloaded from the USGS's list of all the stream gauges in the United States. For more information on stream gauges take a look at http://waterdata.usgs.gov/nwis/rt.

1. **Open ArcMap** if you have not done so already **by clicking on the ArcMap**  **icon on the desktop or by going to Start > Programs > ArcGIS > ArcMap 10.5.**

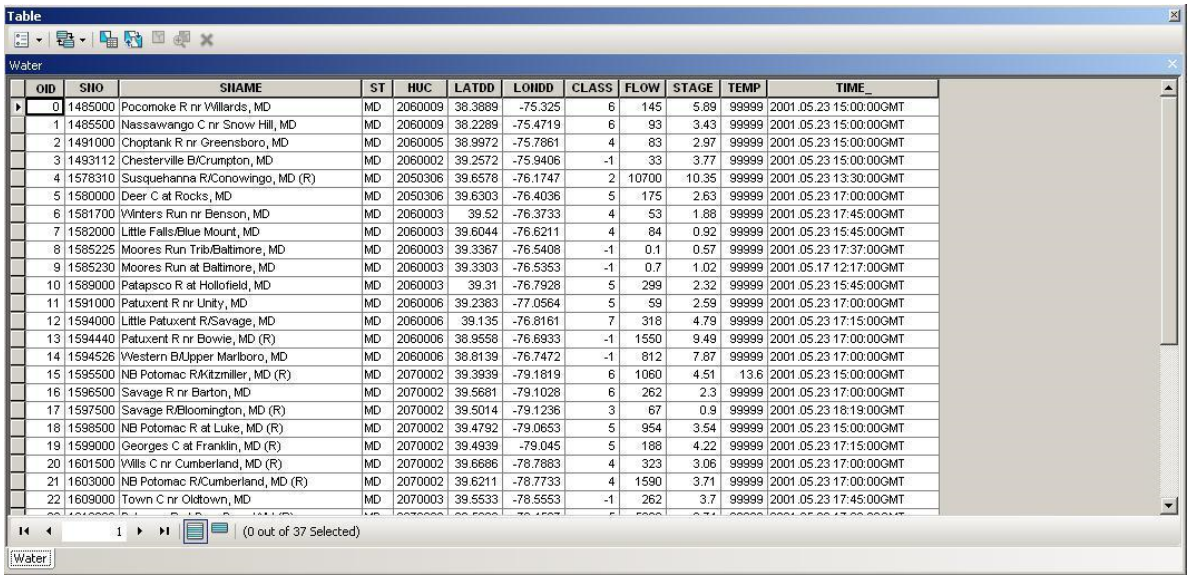
- ***If you are opening ArcMap for the first time in this exercise and are prompted about a template, just click 'Cancel'. You will then be in a blank map.***
- ***If you already have ArcMap open:***

  - Click on new map and don't save the changes to the old map.

2. **Click on the 'Add Data' icon.** 
3. **Navigate to C:\USERS\"YourDirectoryID"\DOWNLOADS\DATA\ and add 'mdcounties.shp' and 'Water.dbf'.**

Let's take a look at the table. In the Table of Contents area, **right click on 'Water.dbf' > 'Open'.**

The table contains the water gauge name, state, and information about water flow. Notice that the coordinates (in decimal degrees) are contained in two columns–one for latitude and one for longitude. The fields must be numeric. Columns that are left justified are ***character strings*** and columns that are right justified contain ***numerical data*** that you can perform mathematical functions on.



Table

Water

OID	SNO	SNAME	ST	HUC	LATDD	LONDD	CLASS	FLOW	STAGE	TEMP	TIME_
0	1485000	Pocomoke R nr Willards, MD	MD	2060009	38.3889	-75.325	6	145	5.89	99999	2001.05.23 15:00:00GMT
1	1485500	Nassawango C nr Snow Hill, MD	MD	2060009	38.2289	-75.4719	6	93	3.43	99999	2001.05.23 15:00:00GMT
2	1491000	Choptank R nr Greensboro, MD	MD	2060005	38.9972	-75.7861	4	83	2.97	99999	2001.05.23 15:00:00GMT
3	1493112	Chesterville B/Crumpton, MD	MD	2060002	39.2572	-75.9406	-1	33	3.77	99999	2001.05.23 15:00:00GMT
4	1578310	Susquehanna R/Conowingo, MD (R)	MD	2050306	39.6578	-76.1747	2	10700	10.35	99999	2001.05.23 13:30:00GMT
5	1580000	Deer C at Rocks, MD	MD	2050306	39.6303	-76.4036	5	175	2.63	99999	2001.05.23 17:00:00GMT
6	1581700	Winters Run nr Benson, MD	MD	2060003	39.52	-76.3733	4	53	1.88	99999	2001.05.23 17:45:00GMT
7	1582000	Little Falls/Blue Mount, MD	MD	2060003	39.6044	-76.6211	4	84	0.92	99999	2001.05.23 15:45:00GMT
8	1585225	Moores Run Trib/Baltimore, MD	MD	2060003	39.3367	-76.5408	-1	0.1	0.57	99999	2001.05.23 17:37:00GMT
9	1585230	Moores Run at Baltimore, MD	MD	2060003	39.3303	-76.5353	-1	0.7	1.02	99999	2001.05.17 12:17:00GMT
10	1589000	Patapsco R at Hollofield, MD	MD	2060003	39.31	-76.7928	5	299	2.32	99999	2001.05.23 15:45:00GMT
11	1591000	Patuxent R nr Unity, MD	MD	2060006	39.2383	-77.0564	5	59	2.59	99999	2001.05.23 17:00:00GMT
12	1594000	Little Patuxent R/Savage, MD	MD	2060006	39.135	-76.8161	7	318	4.79	99999	2001.05.23 17:15:00GMT
13	1594440	Patuxent R nr Bowie, MD (R)	MD	2060006	38.9558	-76.6933	-1	1550	9.49	99999	2001.05.23 17:00:00GMT
14	1594526	Western B/Upper Marlboro, MD	MD	2060006	38.8139	-76.7472	-1	812	7.87	99999	2001.05.23 17:00:00GMT
15	1595500	NB Potomac R/Kitzmiller, MD (R)	MD	2070002	39.3939	-79.1819	6	1060	4.51	13.6	2001.05.23 15:00:00GMT
16	1596500	Savage R nr Barton, MD	MD	2070002	39.5681	-79.1028	6	262	2.3	99999	2001.05.23 17:00:00GMT
17	1597500	Savage R/Bloomington, MD (R)	MD	2070002	39.5014	-79.1236	3	67	0.9	99999	2001.05.23 18:19:00GMT
18	1598500	NB Potomac R at Luke, MD (R)	MD	2070002	39.4792	-79.0653	5	954	3.54	99999	2001.05.23 15:00:00GMT
19	1599000	Georges C at Franklin, MD (R)	MD	2070002	39.4939	-79.045	5	188	4.22	99999	2001.05.23 17:15:00GMT
20	1601500	Wills C nr Cumberland, MD (R)	MD	2070002	39.6686	-78.7883	4	323	3.06	99999	2001.05.23 17:00:00GMT
21	1603000	NB Potomac R/Cumberland, MD (R)	MD	2070002	39.6211	-78.7733	4	1590	3.71	99999	2001.05.23 17:00:00GMT
22	1609000	Town C nr Oldtown, MD	MD	2070003	39.5533	-78.5553	-1	262	3.7	99999	2001.05.23 17:45:00GMT

1 (0 out of 37 Selected)

Water

4. **Close the table.**

Mapping the Coordinates

Now let's map the newly added data.

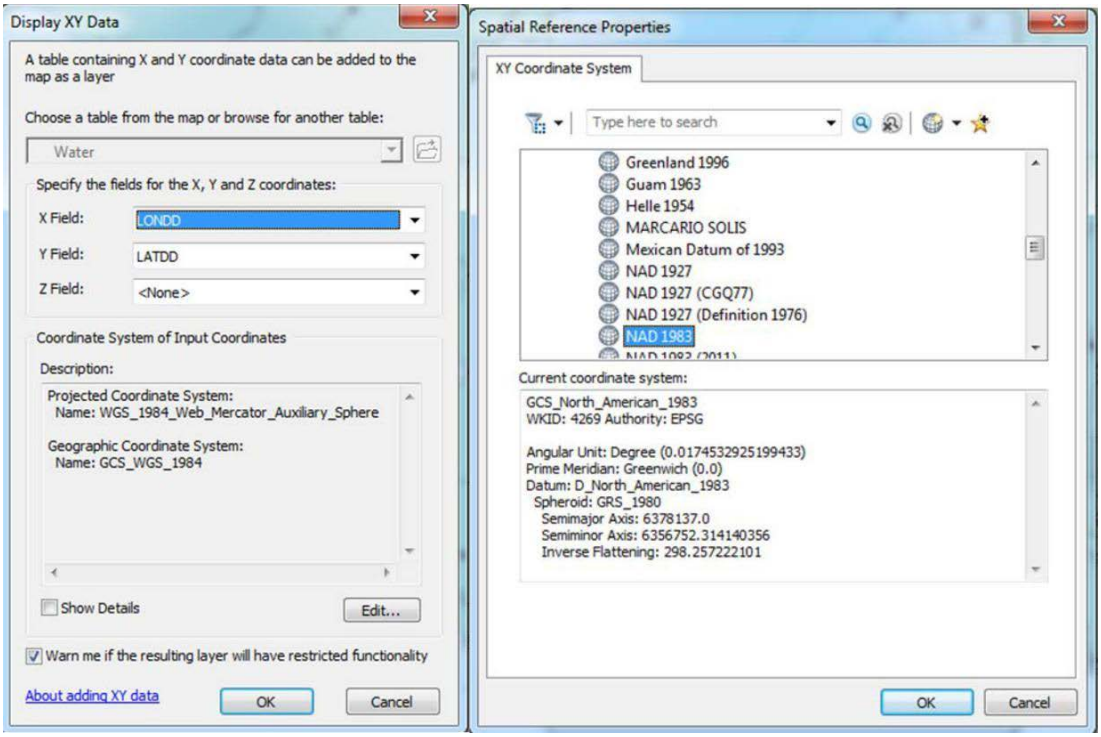
Right click on the 'Water' table layer and choose 'Display XY Data'. The 'Add XY Data' window will open.

In the ‘Choose a table…’drop- down box ‘Water’ should be listed. In addition, the ‘X Field:’ should be ‘LONDD’ and the ‘Y field:’ should be ‘LATDD.’ If these are not included, change them as indicated below.

Click on the ‘Edit” button beneath the coordinate system description. In the Spatial Reference Properties window, click the down arrow next to the globe icon and select ‘clear.’
All coordinate information should disappear.

Navigate to Geographic Coordinate Systems > North America > NAD 1983. Click OK. The new coordinate system should appear.

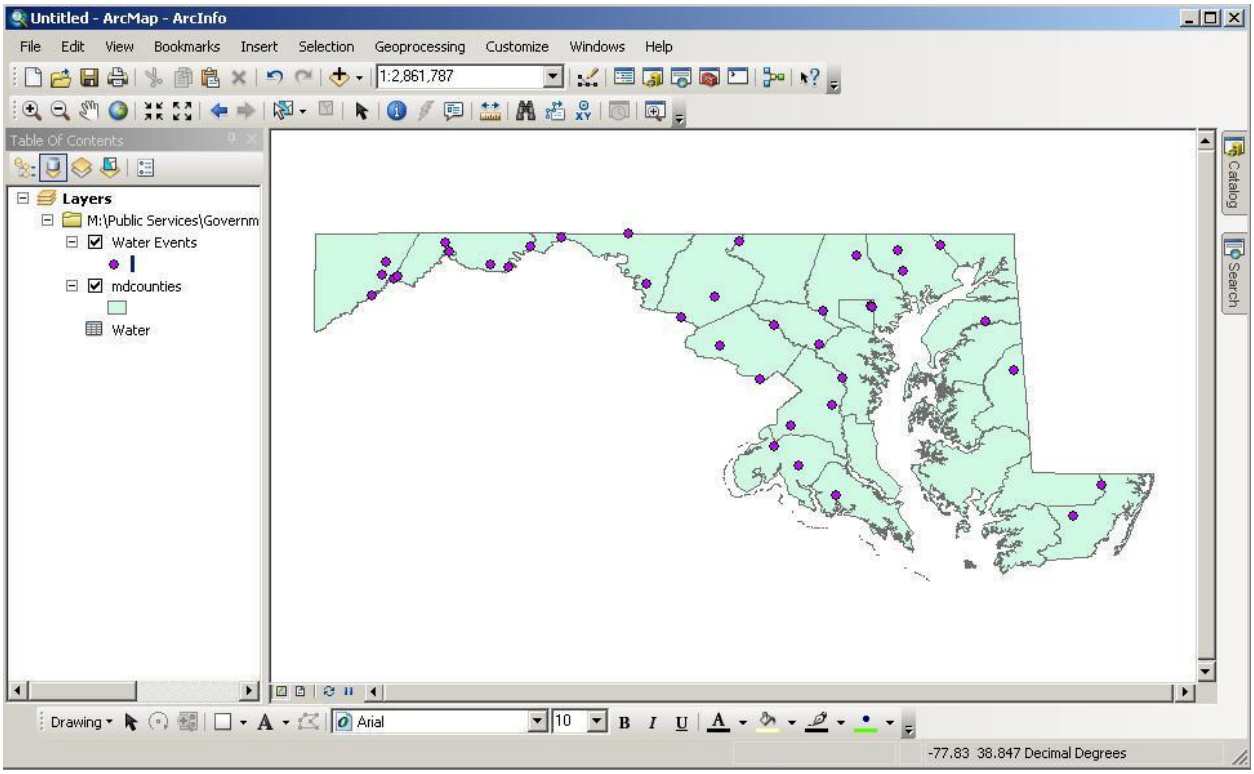
Click OK in the Display XY Data.



You should see the layer ‘Water Events’ added to the table of contents. The points should draw overtop of the Maryland data. If the points do not draw over the Maryland make sure the latitude and longitude were in the correct fields. If you reverse them, the points will be located somewhere around Australia.

TECHTALK

Before importation it is important to make sure that all the records accurately reflect the spatial locations of the information. One of the most common mistakes is to not include a negative symbol for western and southern hemisphere longitude or latitude records. The world is divided into two east-west hemispheres and two north-south hemispheres. Each is assigned either a positive or negative value for latitude (southern is negative and northern is positive) and longitude (eastern is positive and western is negative).



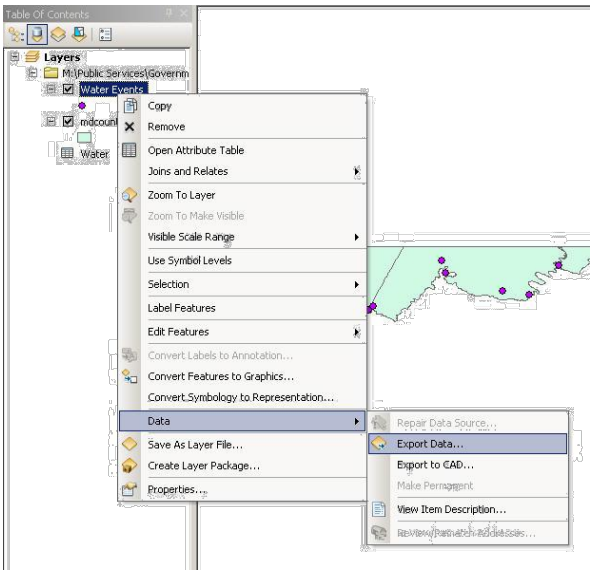
Explore the data by zooming in and out. Identify some of the points. Zoom back to the full extent.

Convert 'xy-event' to a Shape File

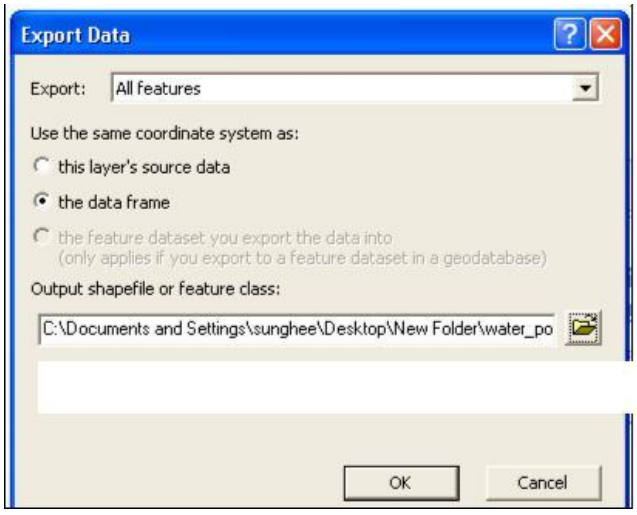
The layer 'Water Events' added to the table of contents **is not a permanent file**, meaning it will disappear when ArcMap is closed.

To create a permanent file,

1. **Right click on 'Water Events' > Data > Export Data.**



2.
3. **Under Use the same coordinate system as: select the data frame.**



C:\Documents and Settings\arcgis\Desktop\GIS_TEMP

3. **Click on the folder icon. Navigate to the DATA folder in DOWNLOADS and give the new file a meaningful name. Change the file type to Shapefile. Click SAVE. Then click OK.** If asked if you would like to add the exported data to the map as a layer, click Yes.

4. **Check your folder to see if the shapefile has been created.**

Exercise: Adding, Editing, Joining, and Relating Tables

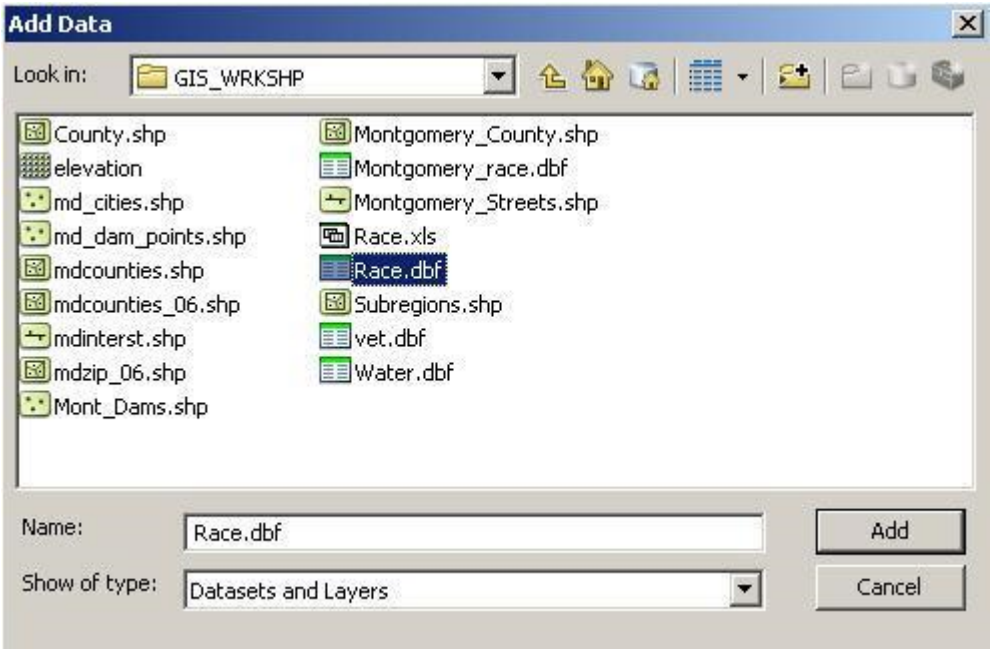
There are a few ways to use tables in ArcGIS. You can add tabular data to a project, connect to a database, or create a new table to which you can add data from within ArcCatalog. In this tutorial we will add tabular data that we have stored in a separate file in the computer, as well as edit, join, and relate it.

Adding a table

We will be adding an existing table with race data (Race.dbf) and joining it to a MD county shapefile. Let's add the shapefile and the table to ArcMap now.

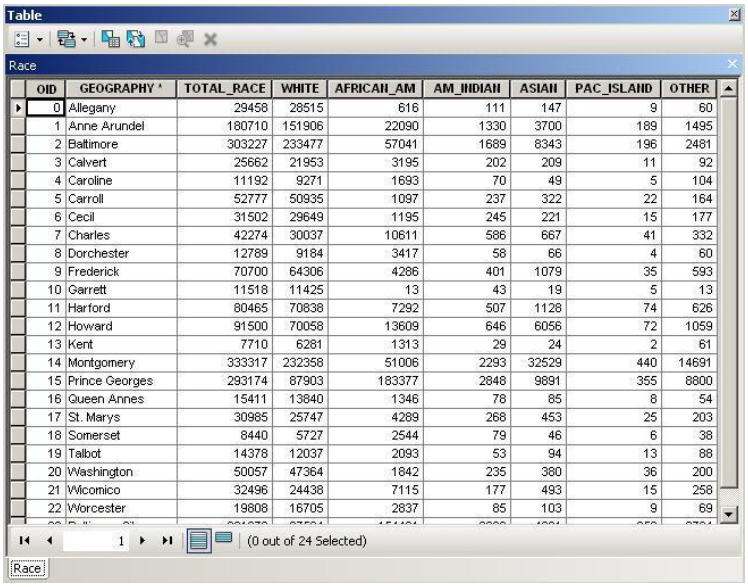
1. **Open ArcMap and a new empty map.**

2. **Add 'Race.dbf' to ArcMap by clicking on the Add Data icon** 



3. **In the table of contents in ArcMap, right click on 'Race' and click on 'Open'**

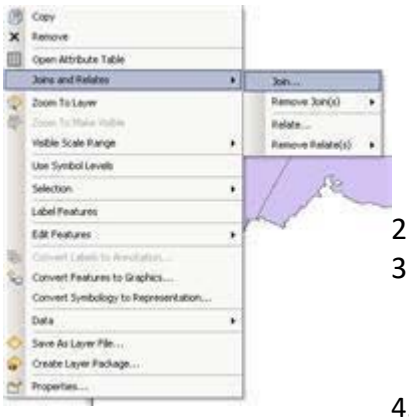
You can see that ArcMap has read the information in the file and placed it in the table so the information is displayed in neat columns. Columns that are left justified are ***character strings*** and columns that are right justified contain ***numerical data*** on which you can perform mathematical functions.



OID	GEOGRAPHY	TOTAL_RACE	WHITE	AFRICAN_AM	AM_INDIAN	ASIAN	PAC_ISLAND	OTHER
0	Allegany	29458	28515	616	111	147	9	60
1	Anne Arundel	180710	151906	22090	1330	3700	189	1495
2	Baltimore	303227	233477	57041	1689	8343	196	2481
3	Calvert	25662	21953	3195	202	209	11	92
4	Caroline	11192	9271	1693	70	49	5	104
5	Carroll	52777	50935	1097	237	322	22	164
6	Cecil	31502	29649	1195	245	221	15	177
7	Charles	42274	30037	10611	586	667	41	332
8	Dorchester	12789	9184	3417	58	66	4	60
9	Frederick	70700	64306	4286	401	1079	35	593
10	Garrett	11518	11425	13	43	19	5	13
11	Harford	80465	70838	7292	507	1128	74	626
12	Howard	91500	70058	13609	646	6056	72	1059
13	Kent	7710	6281	1313	29	24	2	61
14	Montgomery	333317	232358	51006	2293	32529	440	14691
15	Prince Georges	293174	87903	183377	2848	9891	355	8800
16	Queen Annes	15411	13840	1346	78	85	8	54
17	St. Marys	30985	25747	4289	268	453	25	203
18	Somerset	8440	5727	2544	79	46	6	38
19	Talbot	14378	12037	2093	53	94	13	88
20	Washington	50057	47364	1842	235	380	36	200
21	Wicomico	32496	24438	7115	177	493	15	258
22	Worcester	19808	16705	2837	85	103	9	69

4. **Close the Race table.**
5. **Navigate to C:\USERS\"YourDirectoryID"\DOWNLOADS\DATA\ and add 'mdcounties.shp'.**

We will be joining the 'Race.dbf' table to the 'mdcounties' attribute table. Take a look at the attribute tables of each to see if there is a common field that can be used to make a join.



Now let's join the tables together.

1. **Right click on 'mdcounties' to open the context menu.**
2. **Click on 'Joins and Relates'**
3. **Click on 'Join…'**

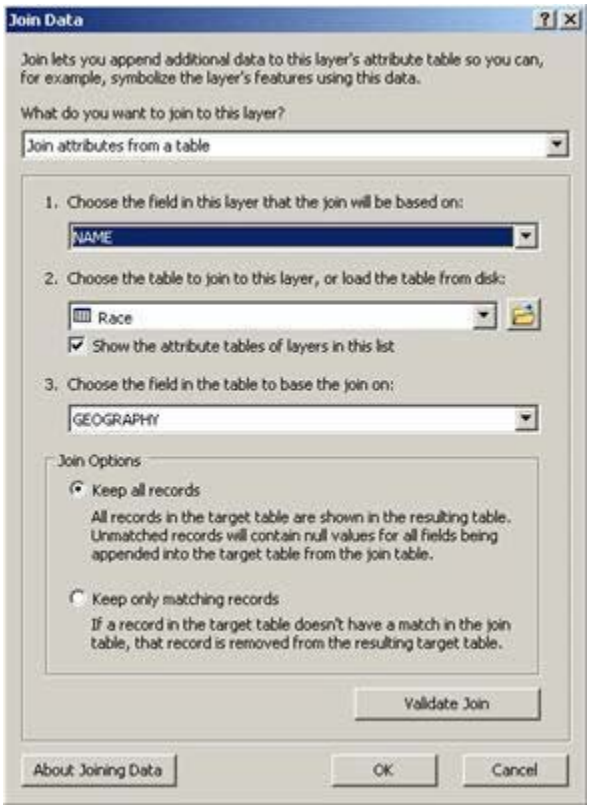
The Join Data window will open.

4. As we want to join attributes from the 'Race.dbf' table to 'mdcounties', **keep the default 'Join attributes from a table' in the top box.**
5. **In box 1, choose 'NAME'.** This is the column in the 'mdcounties' layer that we are matching to the table.

6. **In box 2, choose 'Race'.** This is the table we want to join.

7. **In box 3, choose 'GEOGRAPHY'.** This is telling the ArcGIS what column in the table (Race) we are matching to the layer.

8. **Click 'OK'.**



9.

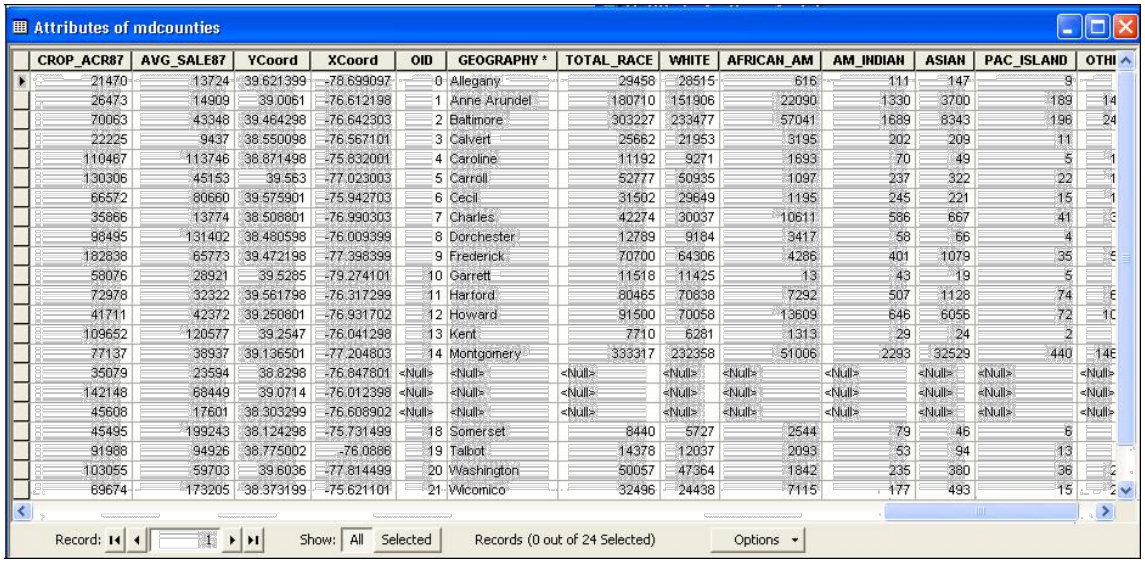
10. **A "Create Index' window may open. If you see this message - "would you like to automatically create an index for the join field in the join table now?" click 'Yes'.**

Now let's check the 'mdcounties' layer to see if the new information has been added to the attribute table.

1. **Right click on 'mdcounties' to open the context menu.**
2. **Scroll down to 'Open attribute table.'**
3. **Scroll to the very end of the attribute table to see if the new information has been added**
4. **Take a close look at the attribute table.** If you have <Null> values in some of the Geography fields, your join was not complete.

TECHTALK

Are there rows that have "<Null>" in them? This will appear anytime you don't have information for every row in the layer or when the data in the column you are using to join (in the table) does not exactly match the column in the attribute table.



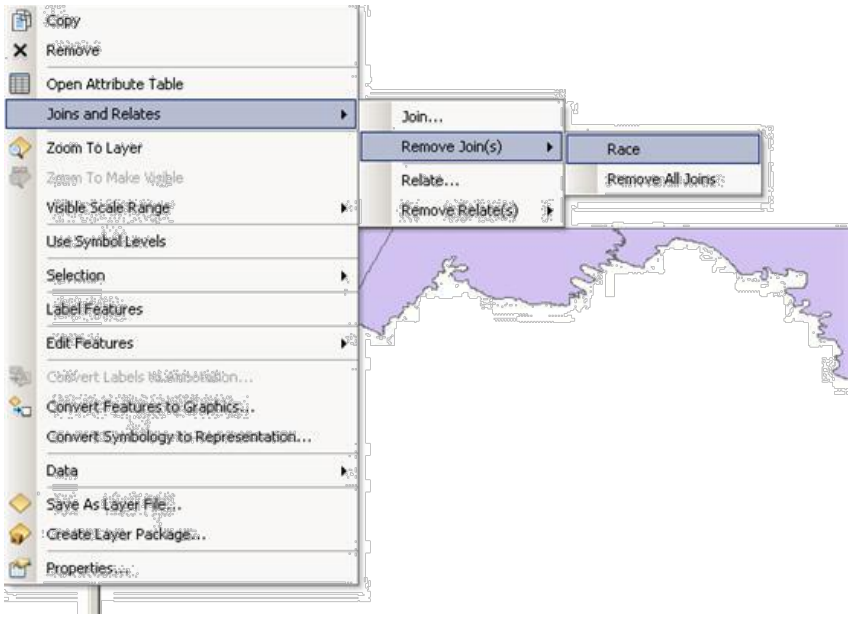
CROP_ACR87	AVG_SALE87	YCoord	XCoord	OID	GEOGRAPHY *	TOTAL_RACE	WHITE	AFRICAN_AM	AM_INDIAN	ASIAN	PAC_ISLAND	OTHI
21470	13724	39.621399	-78.699097	0	Allegany	29458	28515	616	111	147	9	
26473	14909	39.0061	-76.612198	1	Anne Arundel	180710	151906	22090	1330	3700	189	14
70063	43348	39.464298	-76.642303	2	Baltimore	303227	233477	57041	1689	8343	196	24
22225	9437	38.550098	-76.567101	3	Calvert	25662	21953	3195	202	209	11	
110487	113746	38.871498	-75.832001	4	Caroline	11192	9271	1693	70	49	5	1
130306	45153	39.563	-77.023003	5	Carroll	52777	50935	1097	237	322	22	1
66572	80660	39.575901	-75.942703	6	Cecil	31502	29649	1195	245	221	15	1
35866	13774	38.508801	-76.990303	7	Charles	42274	30037	10611	586	667	41	3
98495	131402	38.480598	-76.009399	8	Dorchester	12789	9184	3417	58	66	4	
182838	65773	39.472198	-77.398399	9	Frederick	70700	64306	4286	401	1079	35	5
58076	28921	39.5285	-79.274101	10	Garrett	11518	11425	13	43	19	5	
72978	32322	39.561798	-76.317299	11	Harford	80465	70838	7292	507	1128	74	8
41711	42372	39.250801	-76.931702	12	Howard	91500	70058	13609	646	6056	72	10
109652	120577	39.2547	-76.041298	13	Kent	7710	6281	1313	29	24	2	
77137	38937	39.136501	-77.204803	14	Montgomery	333317	232358	51006	2293	32529	440	146
35079	23594	38.8298	-76.847801	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
142148	68449	39.0714	-76.012398	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
45608	17601	38.303299	-76.608902	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
45495	199243	38.124298	-75.731499	18	Somerset	8440	5727	2544	79	46	8	
91988	94926	38.775002	-76.0886	19	Talbot	14378	12037	2093	53	94	13	
103055	59703	39.6036	-77.814499	20	Washington	50057	47364	1842	235	380	36	2
69674	173205	38.373199	-75.621101	21	Wicomico	32496	24438	7115	177	493	15	2

Common problems that can cause <Null> values in a join:

- Spelling is not in agreement
- Apostrophes or other punctuation marks are not in agreement (ex: Prince George's in one table, Prince Georges in another)
- Case sensitivity is not in agreement

When a join is unsuccessful, you will need to unjoin, clean up data in one table or the other so that they are in agreement, and rejoin.

To unjoin, right click on 'mdcounties' > 'Joins and Relates' > 'Remove Join(s)' > 'Race.'



Editing Tables

If there are small errors in your table that are causing <null> values and an unsuccessful join, you may want to edit the table. If there are large-scale changes to be made, you will do better to edit the table outside of ArcGIS and then bring it back in. **Please note that you cannot edit an Excel spreadsheet table in ArcGIS.** Before we can edit tables, we first need to activate the "Editor toolbar." To turn the toolbar on:

1. **Navigate to 'Customize' (on the main menu bar) > 'Toolbars' > and click on 'Editor' to turn it on.**
2. **Open the 'Race' table.**
3. **Go to the editor toolbar and click on** 

4. **Click on 'Start Editing'. Select 'Race' and click OK.**
5. **Double click on a field in the table to make changes.**
6. Once you have made the necessary changes, **go back to the 'Editor Toolbar' > 'Editor' > 'Stop Editing'.**
7. **Click 'Yes' when it asks if you want to save your edits.**
8. **Close the table. Close or dock the Editor toolbar.**

Repeat the joining process.

1. **Right click on 'mdcounties' to open the context menu.**
2. **Click on 'Joins and Relates'**
3. **Click on 'Join…'**
4. When the join window opens, **keep the default 'Join attributes from a table' in the top box.**
5. **In box 1, choose 'NAME'.**
6. **In box 2, choose 'Race'.**
7. **In box 3, choose 'GEOGRAPHY'.**
8. **Click 'OK'.**

You may be asked if you wish to index this file. If so, select 'Yes'.

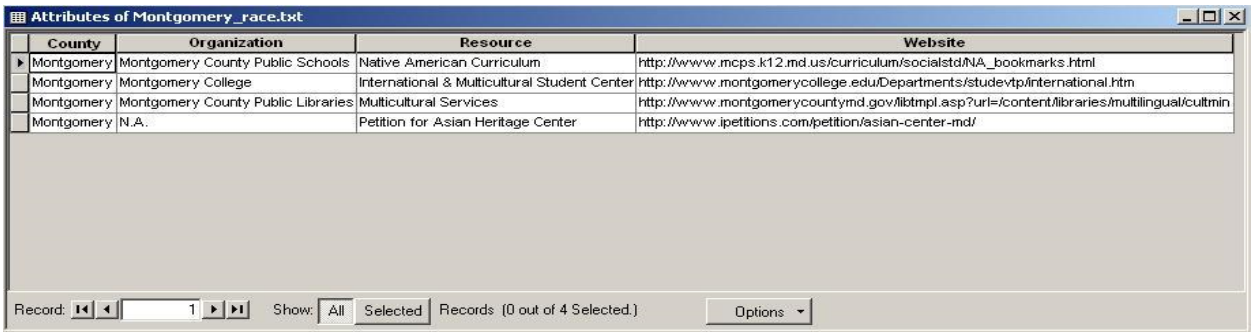
Now our tables should be joined. **Open the attribute table again for 'mdcounties' to check if it joined correctly.**

Because we have joined this new information to our attribute table, we can make maps with it. Practice making color, dot density, or chart maps with the new race data.

Relating Tables

In our case, we are going to relate a table showing multicultural resources in Montgomery County. Although Montgomery County is one of the counties in our attribute table, we could not have conveniently listed more than one resource to the record we already joined.

1. **Select the 'Add Data' button.**
2. **Change directories until you find C:\USERS\"YourDirectoryID"\DOWNLOADS\DATA\.**
3. **Click on 'Montgomery_race.dbf'.**
4. **Click the 'Add' button.**
5. **Open the table. Right click on 'Montgomery_race.dbf' and click 'Open'.**

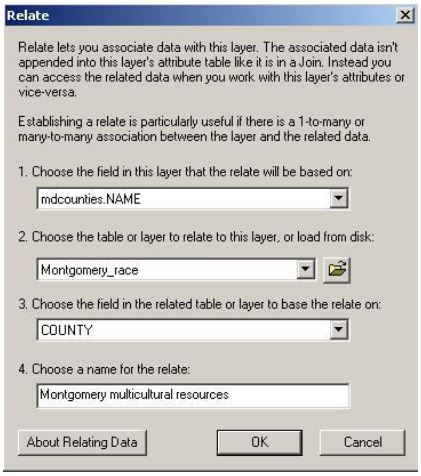


When you are finished looking at the attribute table close it.

We'd like this new table to be associated with our 'mdcounties' layer.

1. **Right-click on 'mdcounties.'**
2. **Click on 'Joins and Relates.'**
3. **Click on 'Relate.'**

The Relate window will open.



Using the first drop down box, scroll down and select 'NAME'. We are saying that the data in our table is related to the counties.

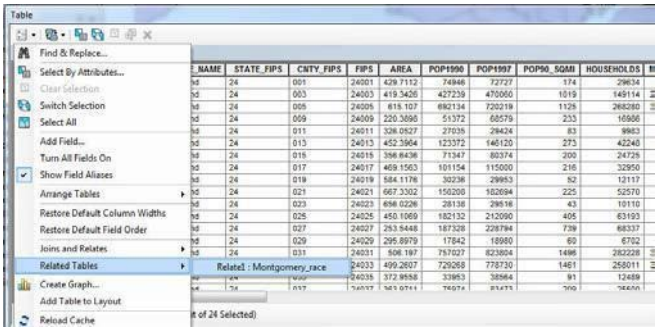
4. **In the next drop down box, select 'Montgomery_race'.** This is our table that we are relating.

5. **In the last drop down box, choose 'COUNTY'.** This tells ArcMap which field in the 'Montgomery_race' table should be related to the 'NAME' field in the 'mdcounties' layer.

6. **Lastly, name the file "Montgomery multicultural resources" and click 'OK.'**

Let's check if the relate was correctly completed.

1. **Right-click on 'mdcounties' to open the context menu.**
2. **Scroll down to 'Open Attribute Table.'**
3. **Click on the 'Table Options' icon located at the top left of the attribute table window.**
4. **Scroll to 'Related Tables.'**
5. **Click on 'Montgomery multicultural resources: Montgomery_race'.**



This opens the table we just related. Minimize the attribute table to view the new table.

By relating tables we associate the information in one table with another but do not physically join the information into one table. You can view the association between tables by selecting a row in the attribute table of a layer file and then from the attribute table > Options icon > Related tables. The rows that are related will also be selected (in bright blue).

To see this:

1. **Right click on 'mdcounties'.**
2. **Open the attribute table.**
3. **Click on the small box located to the left of Montgomery.** The row should turn blue.
4. **Click on the 'Related Tables' icon in the upper left corner.**
5. **Click on 'Montgomery multicultural resources:Montgomery_race'.** The related table should appear with the resources in Montgomery County highlighted in blue.

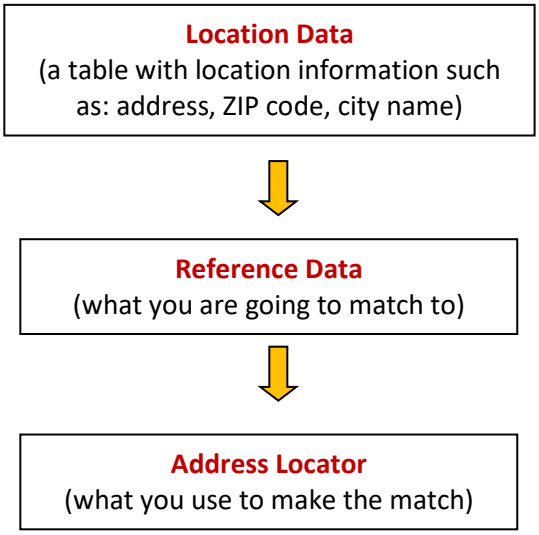
Exercise: Geocoding

Geocoding is a process that allows you to match location data that has no coordinates to an established reference database, and thereby create point features and make the original data mappable. It is commonly used for data containing addresses, and is a powerful tool in the GIS arsenal.

Or

Geocoding is the process of converting addresses (like a street address) into geographic coordinates (like latitude and longitude), which you can use to place markers on a map, or position the map.

What you need in order to geocode



Where do I get Reference Data?

- With ArcGIS 10.5, you may not need reference data—the incorporated basemap layer can provide this streets data.
- A common source is TIGER files, published by the U.S. Census Bureau.
- Reference data may also be called an address dictionary. Its attribute table will break down an address into individual components. You will often use a streets layer for reference data. The table might look something like this:

L_F_ADD	L_T_ADD	R_F_ADD	R_T_ADD	PREFIX	NAME	TYPE	SUFFIX	ZIPL	ZIPR
4300	4398	4301	4399	E	Graham	Way	N	20742	20740

Where do I get an Address Locator?

- ArcGIS has address locators incorporated directly into the software.

- ESRI has some address locators available for free to subscribers, and they cover the world and the U.S. This help page gives you a little more detail on geocoding vocabulary and address locators: http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/Essential_geocoding_vocabulary/002500000004000000/

- You can create your own.

- Look on the Internet. Here's a useful list compiled by Texas A&M University: https://geoservices.tamu.edu/Services/Geocode/About/GeocoderList.aspx

What is happening when I geocode?

- ArcMap looks at a specified field in your Location Data. For example, you may have a field "Address" with the value "4315 East Graham Way North". The program will ***parse*** the data so that it matches the format found in the Reference Data. Using the example provided above, the address would be parsed into:
  House number – 4315
  Prefix – E
  Name – Graham
  Type – Way
  Suffix – N
- Next, the program compares the Location Data to the Reference Data, and when matches are found an ***interpolation*** is performed to locate and assign real-world x,y coordinates (latitude and longitude) to the address.
- ArcMap assigns each address match a score depending on the exactness, then creates a geocoded layer with the newly assigned coordinates, and the information about those points that was stored in the Location Data now appearing in the geocoded layer's attribute table.

Exercise: Mapping Lincoln, Nebraska Places

For this exercise, we have a table with a number of locations in Lincoln, Nebraska. For each location we have a name and address. We'd like to map these out.

Adding Data

Open ArcMap and a new, blank map.

Click on Add Data  and add the following four layers from the Geocoding_data folder:

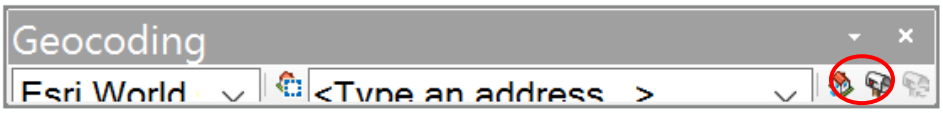
1) CustomerInfo.dbf (this is your location data)
2) Lincoln.shp and Lincoln_Downtown.shp (this is your reference data)
3) Streets.shp (this is the streets on which our addresses will be located)

Geocoding

Right click on the CustomerInfo table in ArcMap, and click open. This allows you to see all of the information stored in this table. If you scroll all the way to the right, you can see that the entire address is stored in the last column.

On the top menu bar, go to Customize > Toolbars > Geocoding to activate the Geocoding toolbar.

Click on the Geocode Addresses button 



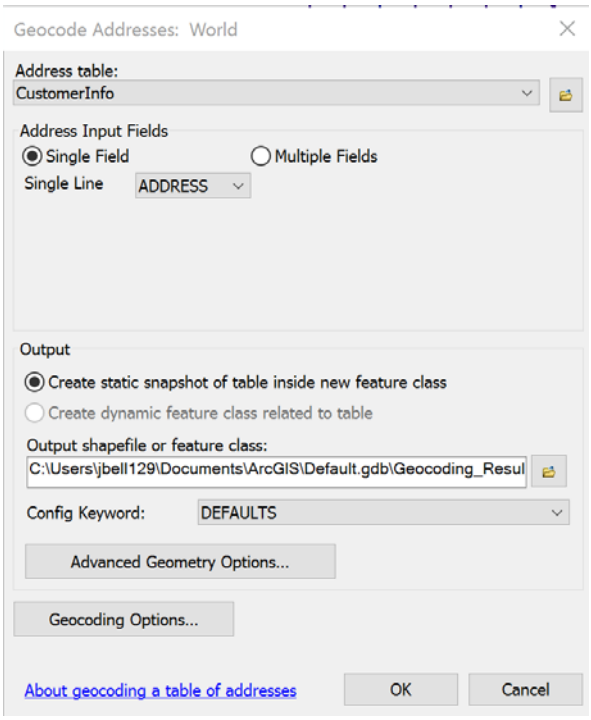
Choose “ESRI World Geocoder” – this is the address locator provided by ESRI.

You will need to login to ArcGIS online in order to use this geocoder. Use these credentials below:
Username:geocoder4
Password:GISintro2018

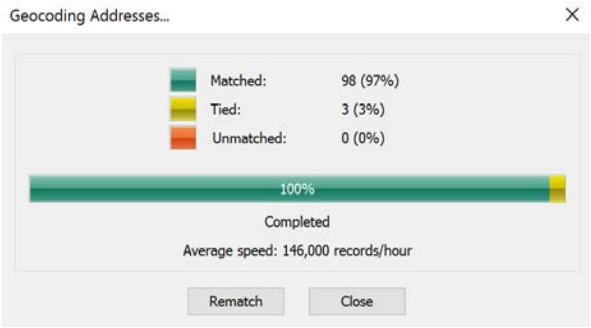
Click sign in

A Geocode Addresses: World window pops up. Because the address is stored in a singular column, we must change to Address Input Field to “Single Field”. Select “ADDRESS” as the single line field from the dropdown menu. This is letting you know what fields from the address locator will map to which field from the table with your addresses when the comparison is made.

When you geocode, the output will be a new shapefile – you should name it and save it to the GIS_TEMP folder. You may need to specify that it be saved as a shapefile, not a File and Personal Geodatabase feature class.

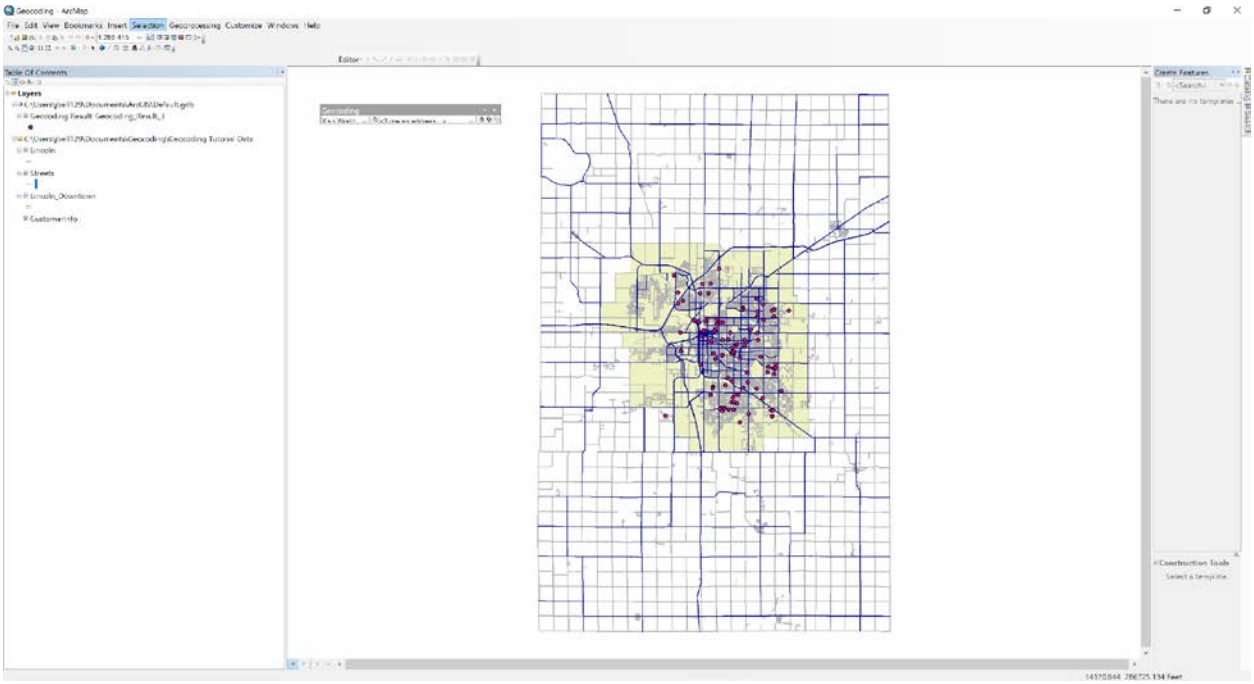


Click OK to complete the geocoding process. You will see a process window and then a result box letting you know how successful the matching process was.



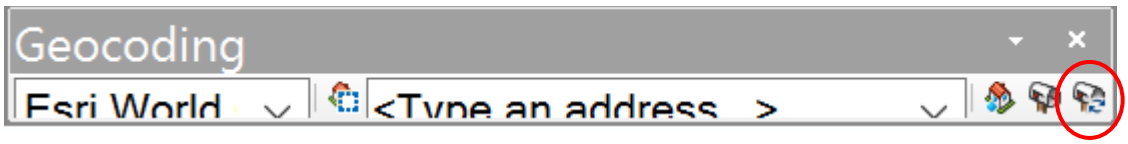
Click Close. You will see that there is a new point layer called Geocoding Result in your map, with a point for each entry in the spreadsheet. Do they seem to be in the right places?

Also, take a look at the attribute table of your new geocoded results point layer. You will see that there are some new fields such as STATUS (with M, T, or U for matched, tied, or unmatched) and SCORE (how accurate was the match?).

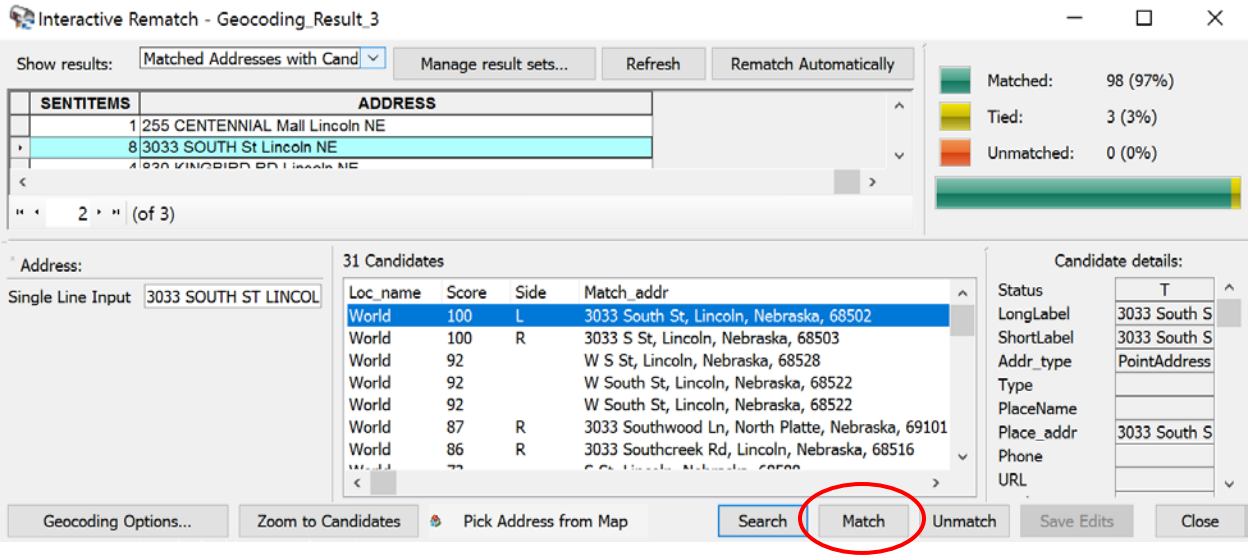


Reviewing / Rematching

What about those few results that were tied or unmatched? We'd like to clean everything up. We may need to review / rematch. To do that, click on your geocoding result point layer in the table of contents. A new button should become active on the Geocoding toolbar – Review/Rematch Addresses. Click on that.



You will get the Interactive Rematch window. This shows you both your table and the candidates from the reference data. You can right click on STATUS and sort ascending in order to group together all the Ms, Ts, and Us. In this case, we have no unmatched addresses, only Tied. Then scroll down to take a look at the T entries. There is one T, for 3033 South St Lincoln NE. Click on that entry to highlight it. Now look at the three candidates, all with varying match scores that appear in the lower part of the window. The top two matches have the same score of 100, and seem to be the same place—probably the address locator had multiple entries. Pick one of them, highlight it, and click Match.



Note:
In some cases, you will have unmatched addresses—they simply appear as blank records in the geocoding result layer. For example:

1101 Fourth Street SW
37th and O Streets NW
2121 Eye St NW

You would see that although your reference data did find another intersection, it may not have this intersection. The other addresses look fairly standard, but again there may be discrepancies in the reference data. You have a couple of options in this case.

1) Use the Geocoding Options to reduce the level of accuracy required for spelling or match scores.
2) Use the Pick Address from Map button – only use this if you know right where the address is, since you are manually putting the point on the map.
3) Edit your table to fix spelling errors or other problems in the original addresses.
4) Try a new geocode with a different address locator. You may find that if you use the 10.0 North America Geocode Service, you get a 100% match. However, if you look carefully, you will see that the three problem addresses were matched only to zip codes, not exact street addresses.

Geocoding is a great tool, but as always, you are responsible for the ultimate accuracy and quality of the data produced!

Self-Directed Exercises: Crime, Census, Food Atlas

In the next portion of the workshop, you will independently download data in both shapefile and table formats, then join the table to the shapefile. Finally, you will make a color map with the resulting joined data.

You may choose to do one exercise based on the topic that interests you the most, or you may try all three!

If you want to try to do the exercise entirely on your own, go right ahead. If you get stuck, there are cheat sheets on the following pages for reference.

General hints – READ BEFORE BEGINNING!

- When downloading shapefiles, they will generally consist of a zip file (remember how a shapefile is composed of multiple files?). You will need to download the zip file, then unzip it and extract the files to the DATA folder in your DOWNLOADS, or to your own storage device.
- You will need a field in the shapefile that can match up to a field in the table you download in order for them to join properly.
- You will need a one-to-one or many-to-one relationship to make a join. 1-1 is best.
- When you are looking at an outside table and considering if you can bring it into ArcGIS, remember that you may have to do a lot of cleaning up of formatting and you may need to transpose rows and columns for the outside table and the shapefile's attribute table to match. This can be labor intensive and time consuming!
- ArcGIS will usually not accept spaces in field names for standalone tables.
- Remember to be very careful about where you save things that you download—it is easy to lose track of them. Please save everything you download to the DATA folder in the DOWNLOADS folder.
- When you've downloaded an Excel spreadsheet, ArcGIS may present you with a list when you try to add the table. This reflects the various workbooks in an Excel spreadsheet—just choose the first one in the list.
- You may need to format the cells in an Excel spreadsheet to "general".
- Sometimes the metadata for downloaded data is not along with it, but in a separate file or on a website.

- NOTE: These instructions are for downloads using the Firefox web browser. The process may be slightly different if using Internet Explorer. Use Firefox to avoid confusion.

If you want to keep going or try something else on your own, this guide to GIS Data and Websites may help you find some data to experiment with:
http://lib.guides.umd.edu/gisdata

Crime

- Download a shapefile containing boundaries for all U.S. states from the following website:
    - https://www.census.gov/geo/maps-data/data/tiger-line.html (go to the 2017 TIGER/Line shapefiles main page, then click on "Download" select Web Interfaces and pick "States (and equivalent)" from dropdown menu and submit.)

- Download a table from the FBI's Uniform Crime Reports Data Tool: https://ucr.fbi.gov/. Clean it up so that it can match the attribute table of your U.S. states shapefile and identify a common field.
    - Hint: does your table contain one row per state, and are the states rows or columns? They should match the attribute table you want to join to. Is the first row of the table the fields that you want to be the column headings?
    - Hint #2: One Year of Data – choose all states – choose a variable should give you a workable table.

- Join the crime table to the U.S. states shapefile.

- Once the tables are joined, make a color map showing some crime numbers mapped for the entire U.S.

Census

- Download a shapefile containing boundaries for all U.S. states from the following website:
    - https://www.census.gov/geo/maps-data/data/tiger-line.html (go to the 2015 TIGER/Line shapefiles main page, then click on "Download" select Web Interfaces and pick "States (and equivalent)" from dropdown menu and submit.)

- Download a table from American Factfinder: http://factfinder2.census.gov/. Use the Advanced Search. Clean it up so that it can match the attribute table of your U.S. states shapefile and identify a common field.
    - Hint: choose your geography first (all U.S. states)
    - Hint: The "Housing Units" (H1) table from the 2010 SF1 summary file might be a good table to try out…you want a table that has one row per state, and for the states to be rows, not columns.

- If you need to, use “modify table” to transpose rows and columns.

- Join the census table to the U.S. states shapefile.

- Once the tables are joined, make a color map showing some one of the number fields from the newly added table mapped for the entire U.S.

Food Environment Atlas

- Download a shapefile with U.S. counties from the census website:
  - https://www.census.gov/geo/maps-data/data/tiger-line.html (go to the 2015 TIGER/Line shapefiles main page, then click on “Download” select Web Interfaces and pick “Counties (and equivalent)“ from dropdown menu and submit.)

- Download the spreadsheet containing compiled data from the Food Environment Atlas:

  http://www.ers.usda.gov/data-products/food-environment-atlas.aspx (Go to “Data Access and Documentation Downloads” and download the Excel data file for the current version)

- Join one of the worksheets from the spreadsheet to the attribute table of your counties shapefile.
  - Hint: You need to read the Variable List worksheet to identify the fields in the rest of the spreadsheet.
  - Hint #2: The common attribute for the join is not a name, but a number…

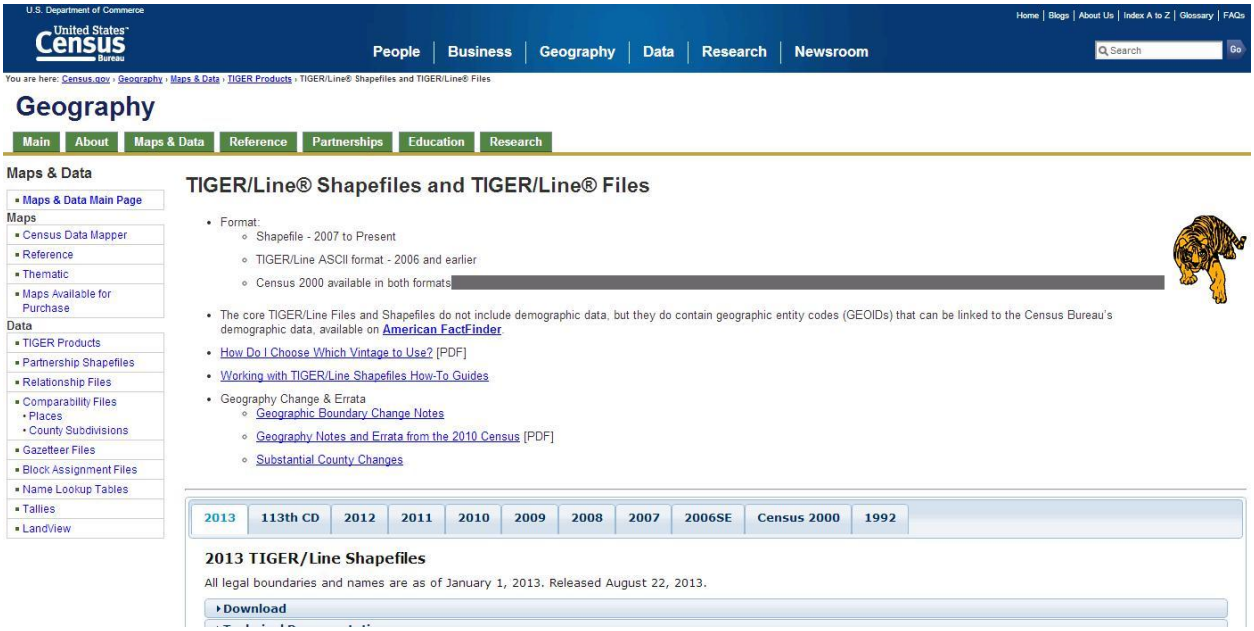
- Once the tables are joined, make a color map showing a new variable from the Food Environment Atlas data.

SPOILER ALERT – DON'T LOOK AT THESE CHEAT SHEETS AHEAD OF TIME

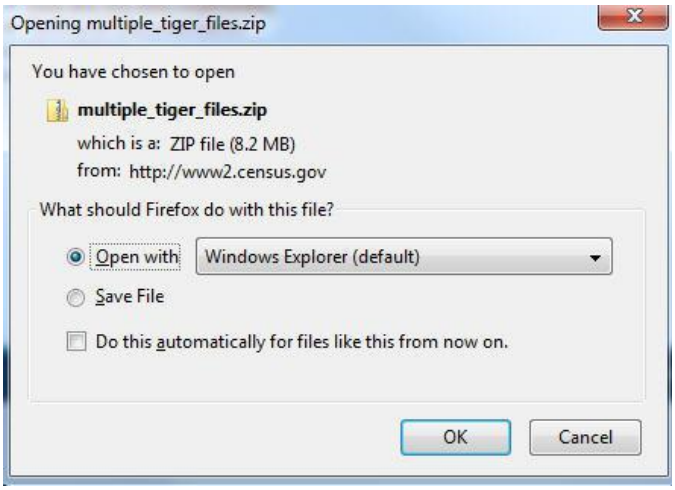
Crime Exercise – Cheat Sheet

To download a shapefile containing all U.S. States:

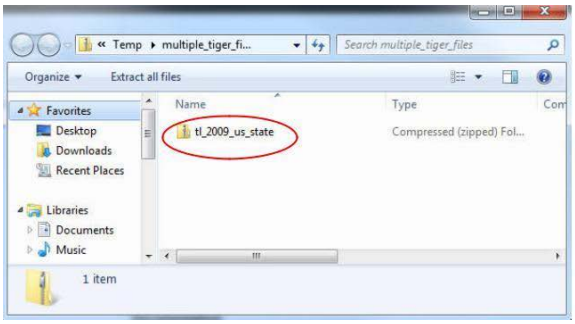
1. Go to the following link to download a shapefile with boundaries for all U.S. states: https://www.census.gov/geo/maps-data/data/tiger-line.html
2. Click on 2009 TIGER/Line Shapefiles Main page, then click on "Download Shapefiles". Check off the box for "State and Equivalent (Current) and click on "Download Selected Files"

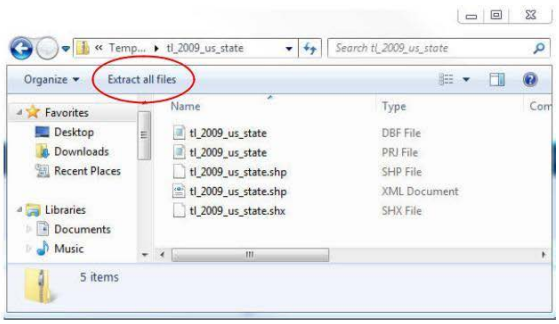


1. When a downloading window opens, choose to open the zip file using Windows Explorer.



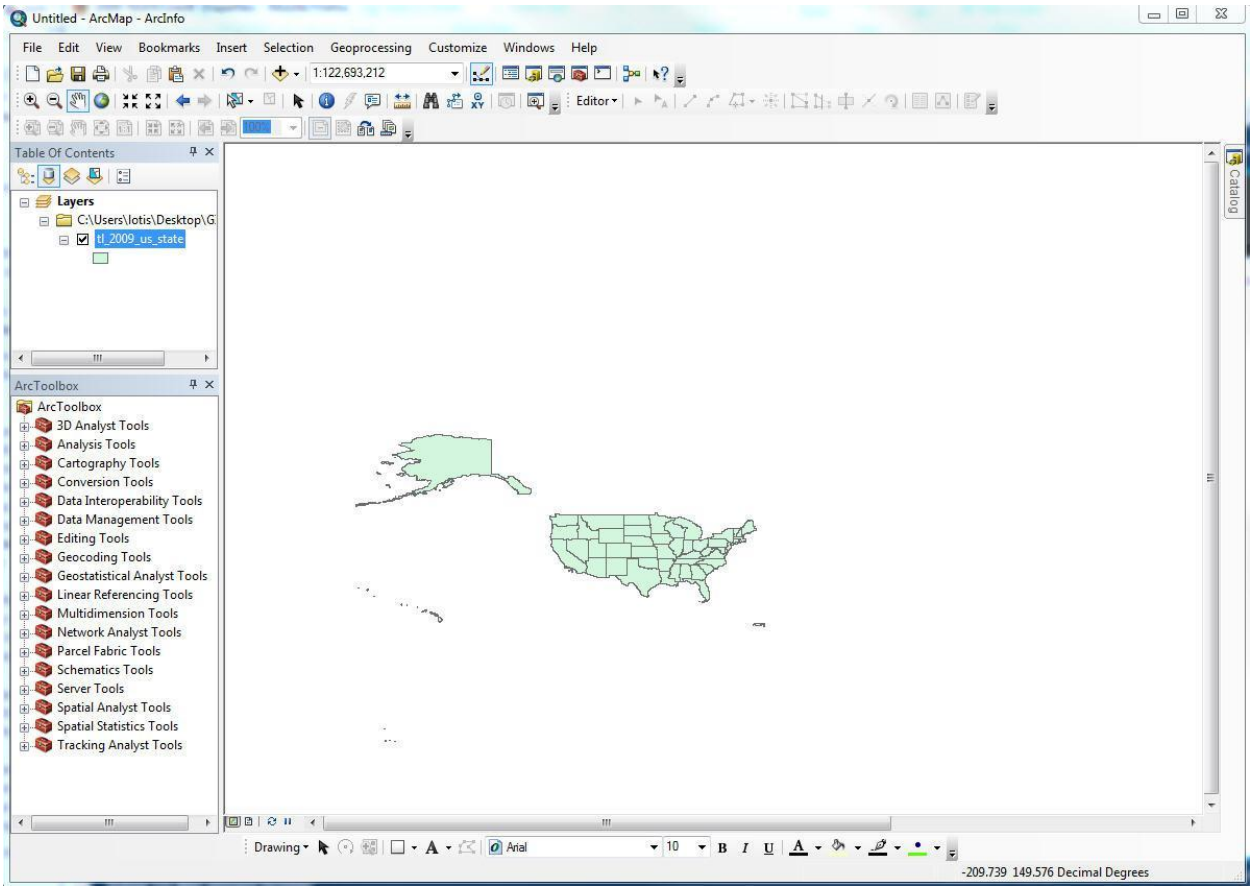
2. Double click on the zipped file in Windows Explorer. Click on “Extract all files” (this is important! If you don’t get them all, the shapefile will not work). **Be sure to extract the**





files to the DATA folder in the DOWNLOADS folder.

3. Preview your extracted shapefile in ArcMap to see if everything looks correct. It will probably be called tl_2009_us_state.shp (it looks small within the display because it includes the Northern Mariana Islands in their actual location – you can zoom in to just the contiguous U.S. or to include Alaska and Hawaii.)



4. Go to the FBI's Uniform Crime Reports website: http://www.fbi.gov/about-us/cjis/ucr/ucr

5. Under Crime in the United States, go to the link for the new online UCR Data Tool: www.ucrdatatool.gov

6. Under Find Data, click on "Go to the table-building tool"

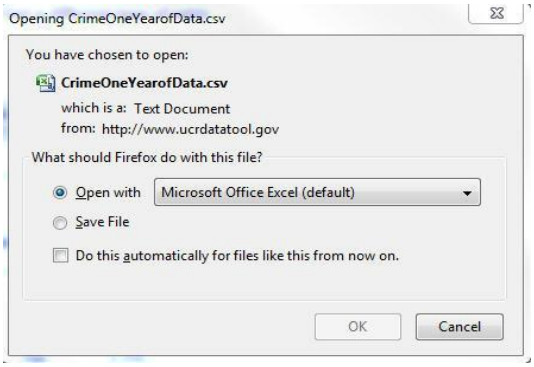
7. We will build a table that contains some crime data for all the U.S. states, because that is the equivalent shapefile we have and would like to join this data to. We want a table with one row of numerical information for each state so it will easily join with our attribute table for U.S. states, which also has one row per state. This will be a one-to-one join.

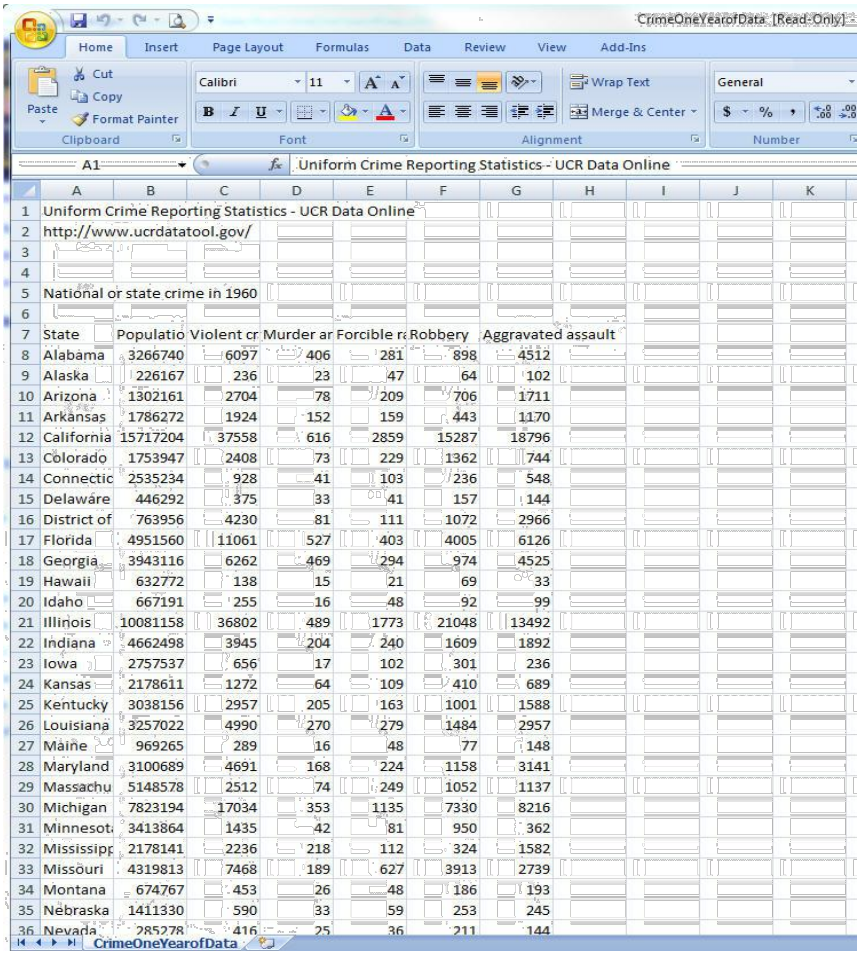
    - Click on All States and U.S. Total
    - Click on One year of data
    - Select all of the states by clicking on Alabama, then scrolling down to the end of the list, holding down the shift key, and clicking on Wyoming.

- Choose a variable group – we will use “Number of violent crimes”
- Choose a year (for example, 2009 because our shapefile dates to that time)
- Click the “Get Table” button

8. Download the resulting table.

    - Click on the “Spreadsheet of this table” link near the top of the page (.csv file) When prompted, use Microsoft Excel to open this comma-separated table.





CrimeOneYearofData [Read-Only]

Home | Insert | Page Layout | Formulas | Data | Review | View | Add-Ins

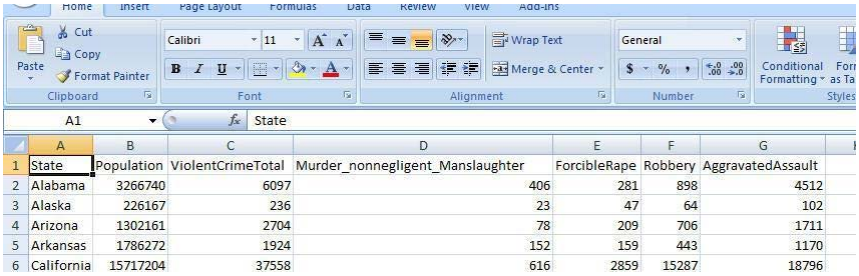
Cut, Copy, Format Painter, Paste — Clipboard
Calibri, 11 — Font
Wrap Text, Merge & Center — Alignment
General — Number

A1: Uniform Crime Reporting Statistics - UCR Data Online

	A	B	C	D	E	F	G	H	I	J	K
1	Uniform Crime Reporting Statistics - UCR Data Online										
2	http://www.ucrdatatool.gov/										
3											
4											
5	National or state crime in 1960										
6											
7	State	Populatio	Violent cr	Murder ar	Forcible r	Robbery	Aggravated assault				
8	Alabama	3266740	6097	406	281	898	4512				
9	Alaska	226167	236	23	47	64	102				
10	Arizona	1302161	2704	78	209	706	1711				
11	Arkansas	1786272	1924	152	159	443	1170				
12	California	15717204	37558	616	2859	15287	18796				
13	Colorado	1753947	2408	73	229	1362	744				
14	Connectic	2535234	928	41	103	236	548				
15	Delaware	446292	375	33	41	157	144				
16	District of	763956	4230	81	111	1072	2966				
17	Florida	4951560	11061	527	403	4005	6126				
18	Georgia	3943116	6262	469	294	974	4525				
19	Hawaii	632772	138	15	21	69	33				
20	Idaho	667191	255	16	48	92	99				
21	Illinois	10081158	36802	489	1773	21048	13492				
22	Indiana	4662498	3945	204	240	1609	1892				
23	Iowa	2757537	656	17	102	301	236				
24	Kansas	2178611	1272	64	109	410	689				
25	Kentucky	3038156	2957	205	163	1001	1588				
26	Louisiana	3257022	4990	270	279	1484	2957				
27	Maine	969265	289	16	48	77	148				
28	Maryland	3100689	4691	168	224	1158	3141				
29	Massachu	5148578	2512	74	249	1052	1137				
30	Michigan	7823194	17034	353	1135	7330	8216				
31	Minnesot	3413864	1435	42	81	950	362				
32	Mississipp	2178141	2236	218	112	324	1582				
33	Missouri	4319813	7468	189	627	3913	2739				
34	Montana	674767	453	26	48	186	193				
35	Nebraska	1411330	590	33	59	253	245				
36	Nevada	285278	416	25	36	211	144				

CrimeOneYearofData

9. This table now needs to be cleaned up a bit so that ArcGIS can read it easily. We don't need the information in the first six rows – we want the first row (which will become the header row in an ArcGIS attribute table) to be the one telling us what the fields are—what is currently Row 6 in this table. We also need the field names not to have any spaces, so we will edit cells in what is now Row 7 to remove spaces from field names (or replace spaces with underscores). The final thing we'll do is take away the descriptive information at the bottom of the table. The row for Wyoming should be the end of the table.

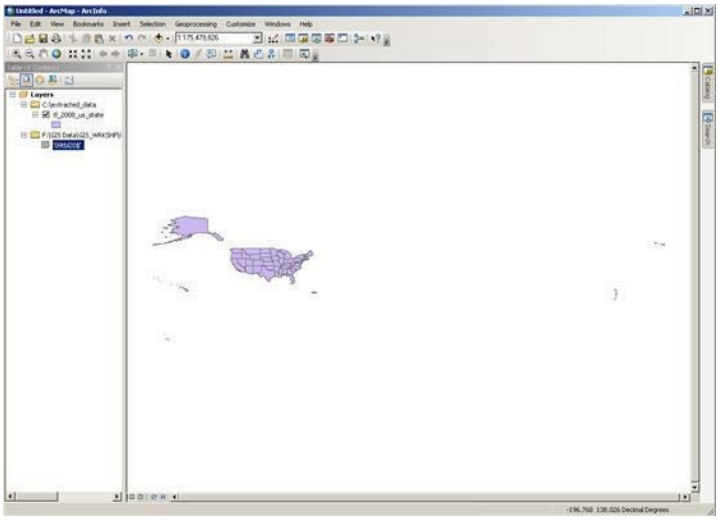


	A	B	C	D	E	F	G
1	State	Population	ViolentCrimeTotal	Murder_nonnegligent_Manslaughter	ForcibleRape	Robbery	AggravatedAssault
2	Alabama	3266740	6097	406	281	898	4512
3	Alaska	226167	236	23	47	64	102
4	Arizona	1302161	2704	78	209	706	1711
5	Arkansas	1786272	1924	152	159	443	1170
6	California	15717204	37558	616	2859	15287	18796

10. Save your cleaned-up crime table to the DATA folder in the DOWNLOADS folder.

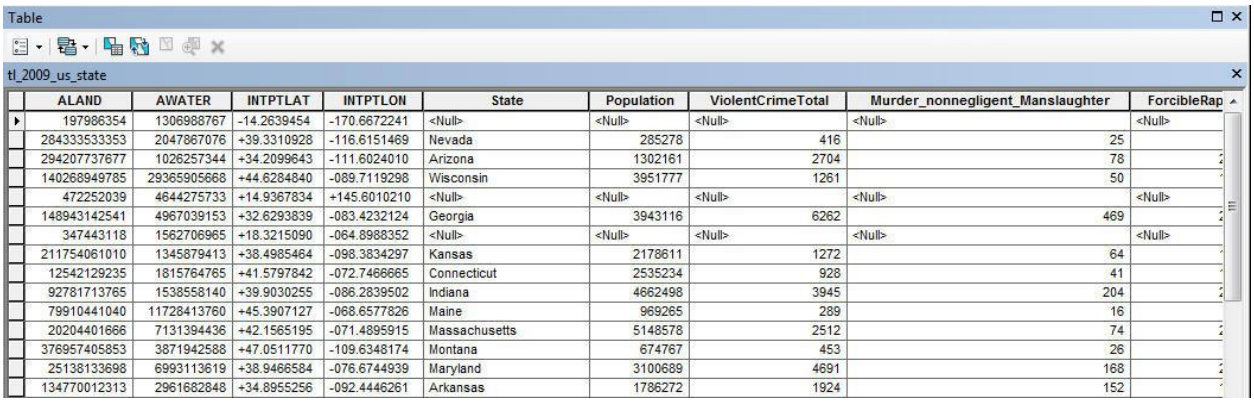
11. Open up ArcMap and a new, blank map.

12. Add the two files you've downloaded to the map from the DATA folder in the DOWNLOADS folder.



13. Right click on the states shapefile and choose Join. Join the shapefile to the spreadsheet using state names as the common field (this is the NAME field in the states shapefile). See pp. 15-16 for a reminder on joining if needed.

14. Check the attribute table of the states shapefile to see if the join worked. You should be able to see the homicide data appended to the attribute table. You may have null values where data is missing, such as for the U.S. territories – that is fine. We selected "keep all records" when making the join – if we had selected "Keep only matching records," the territories would have been eliminated.



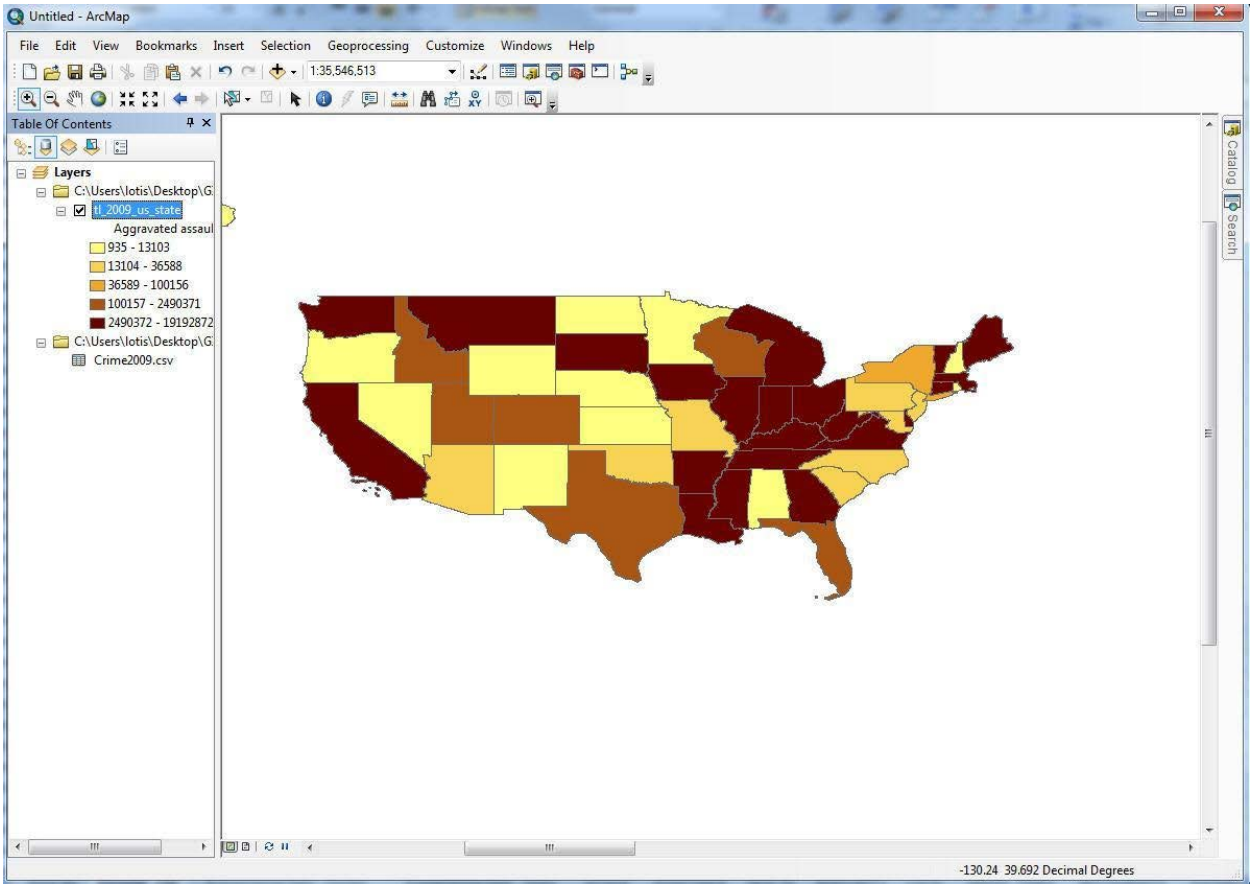
Table

tl_2009_us_state

ALAND	AWATER	INTPTLAT	INTPTLON	State	Population	ViolentCrimeTotal	Murder_nonnegligent_Manslaughter	ForcibleRap
197986354	1306988767	-14.2639454	-170.6672241	<Null>	<Null>	<Null>	<Null>	<Null>
284333533353	2047867076	+39.3310928	-116.6151469	Nevada	285278	416	25	
294207737677	1026257344	+34.2099643	-111.6024010	Arizona	1302161	2704	78	
140268949785	29365905668	+44.6284840	-089.7119298	Wisconsin	3951777	1261	50	
472252039	4644275733	+14.9367834	+145.6010210	<Null>	<Null>	<Null>	<Null>	<Null>
148943142541	4967039153	+32.6293839	-083.4232124	Georgia	3943116	6262	469	
347443118	1562706965	+18.3215090	-064.8988352	<Null>	<Null>	<Null>	<Null>	<Null>
211754061010	1345879413	+38.4985464	-098.3834297	Kansas	2178611	1272	64	
12542129235	1815764765	+41.5797842	-072.7466665	Connecticut	2535234	928	41	
92781713765	1538558140	+39.9030255	-086.2839502	Indiana	4662498	3945	204	
79910441040	11728413760	+45.3907127	-068.6577826	Maine	969265	289	16	
20204401666	7131394436	+42.1565195	-071.4895915	Massachusetts	5148578	2512	74	
376957405853	3871942588	+47.0511770	-109.6348174	Montana	674767	453	26	
25138133698	6993113619	+38.9466584	-076.6744939	Maryland	3100689	4691	168	
134770012313	2961682848	+34.8955256	-092.4446261	Arkansas	1786272	1924	152	

15. Make a color map of aggravated assault for all states.
    Hint: Right click states shapefile – Properties – Symbology tab – Quantities

16. Here's the end map!

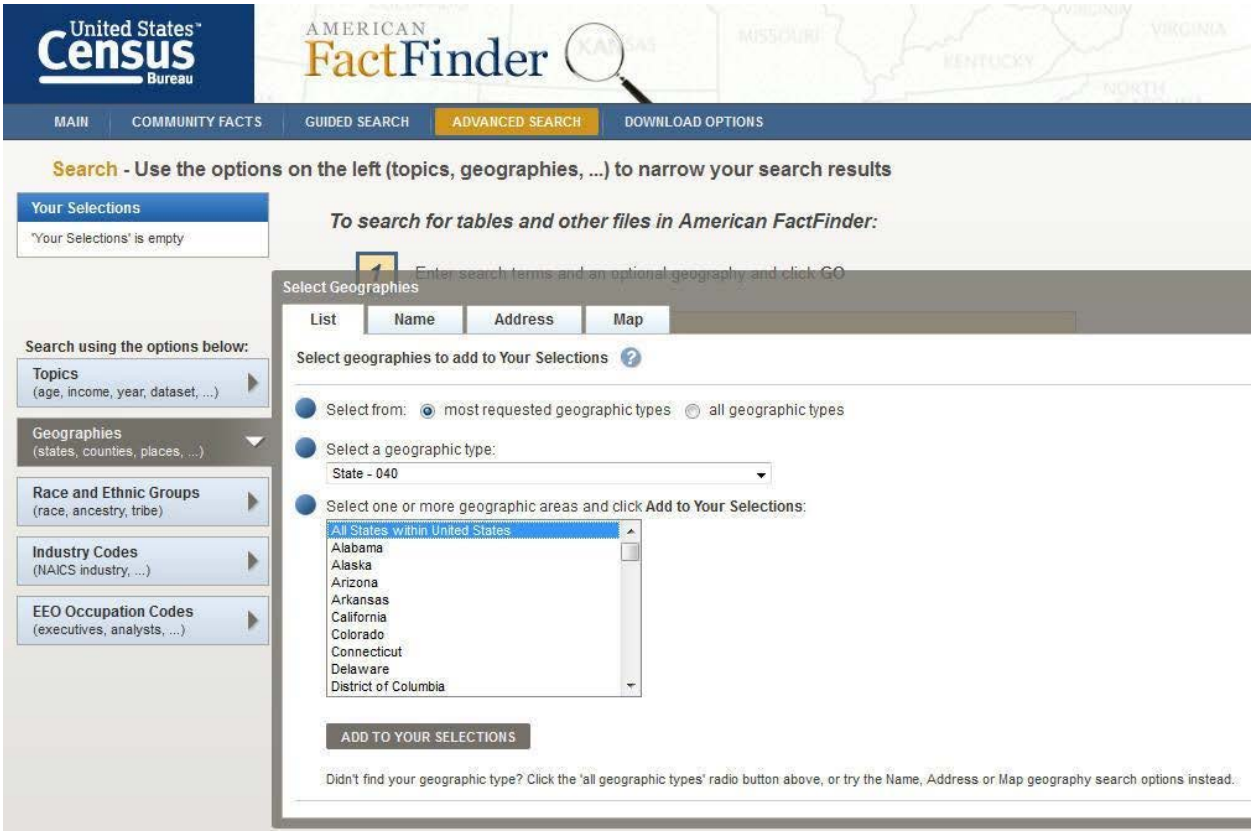


Census Exercise – Cheat Sheet

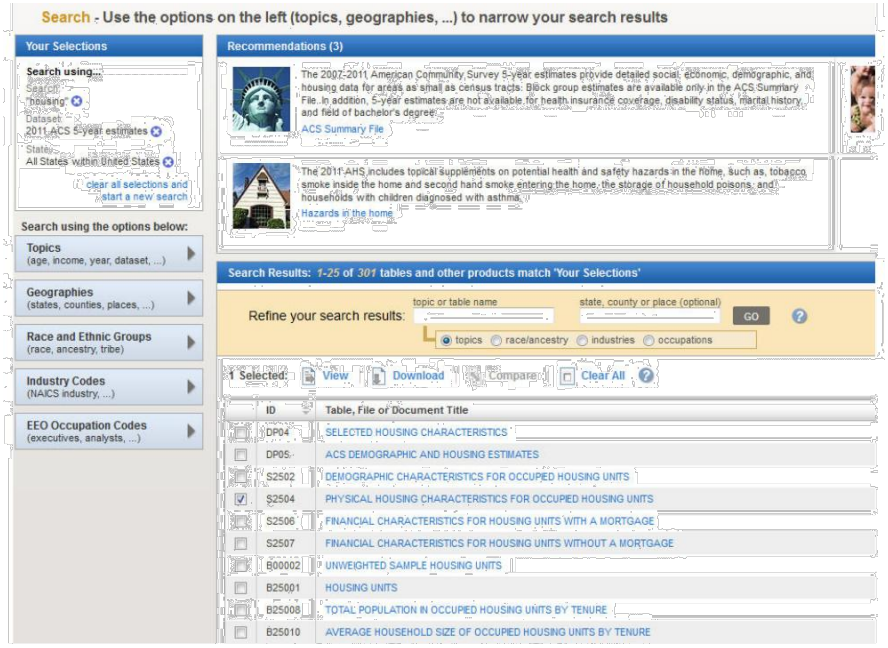
1. Download a shapefile containing all U.S. States – follow steps 1-5 as seen on pp. 24-25 of this workbook.

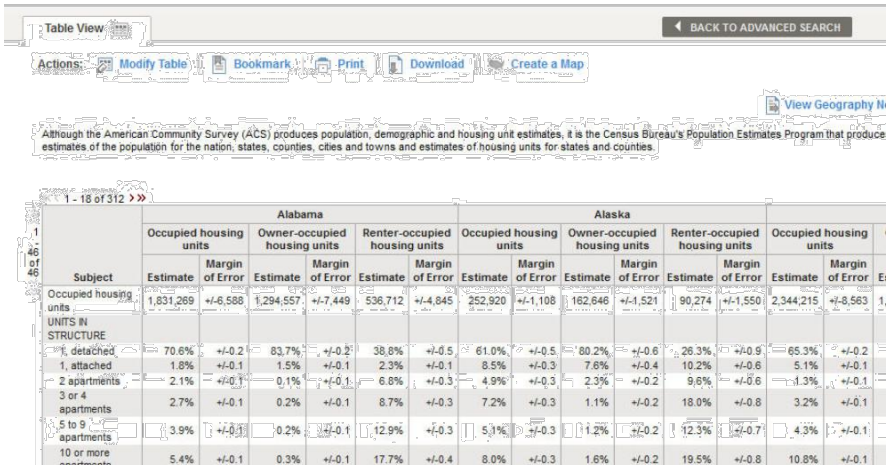
2. Look at the attribute table of your U.S. States shapefile. When you're looking for census data, you will need to keep in mind that it will have to have a common field in order to be able to be joined to this shapefile. It looks like the state name field will be the easiest one to use for a join.

3. Go the U.S. Census American Factfinder webpage: http://factfinder2.census.gov
4. Go to the Advanced Search and click "Show Me All". We want to download some data for the entire U.S. by state, so we'll click on the "Geographies" tab, and use the "Select a geographic type" drop-down menu to choose "State" and "All States within United States" and click on "Add to Your Selections". Close the "Select Geographies pop-up box.

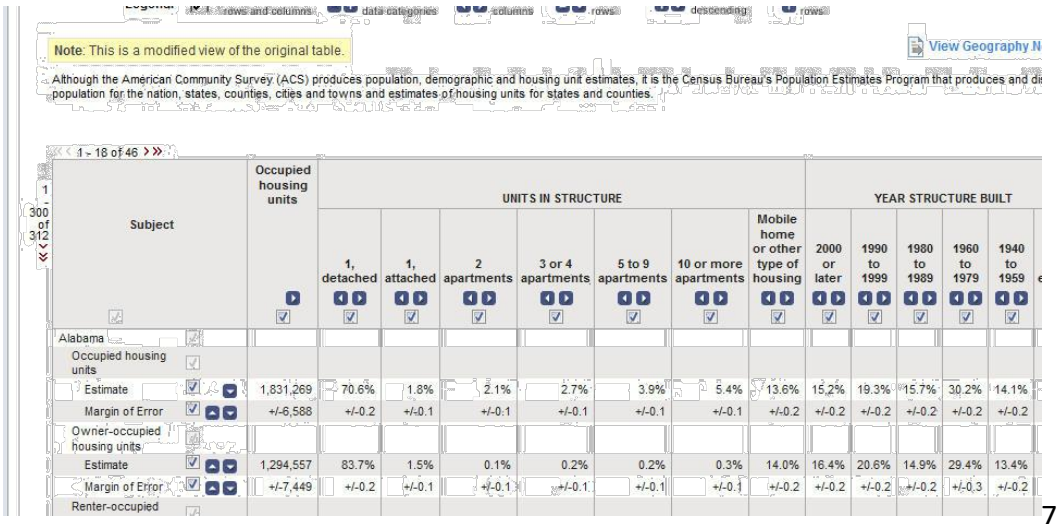


5. Next we'll click on the sideways-facing arrow in the "Topics" tab to expand the category and see some options for data. Click on the plus sign to expand the "Dataset" group, then click on "2011 ACS 5-year estimates". Close the "Select Topics" pop-up box. We now have over 1,000 tables to consider. Let's use the "Refine your search results" box to search for "housing". Click on Table S2504, Physical Housing Characteristics for Occupied Housing Units.

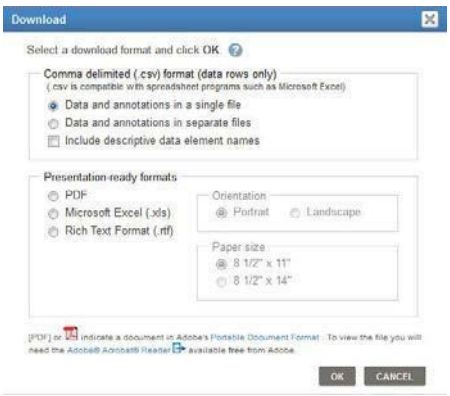




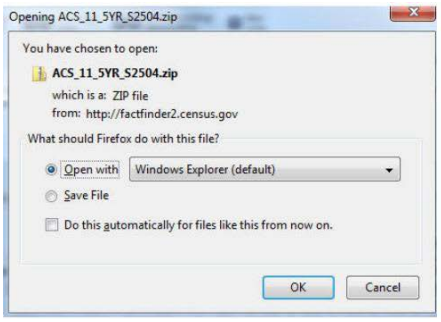
6. This is a nice-looking table with lots of good data, but will it match the attribute table for U.S. states that we have? We do have fields for each state name, but in this table they are the columns, while in the U.S. state shapefile, the state names are the rows. They will need to match. Luckily, you can modify this table. Click on "Modify Table" and then on "Transpose Rows/Columns". We want the state names to be vertical on the left, not horizontal along the top of the table. This is how it should look:

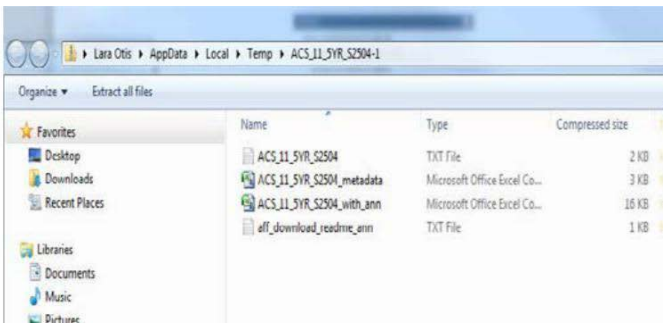


7. Now we are ready to download the table. Click on the "Download" link at the top and choose the "Data and annotations in a single file" option under the Comma delimited format. This is usually a cleaner, better option than choosing to download a Microsoft Excel table. Also, there are size limitations on Excel table downloads.

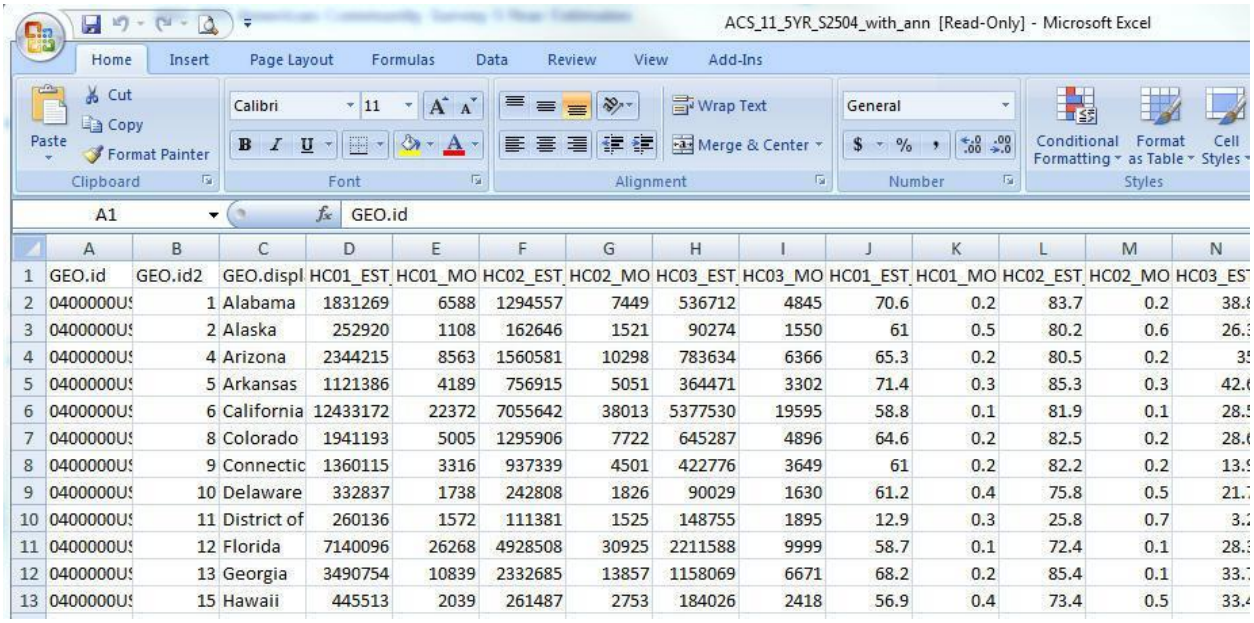


8. Choose to open the zipped file with Windows Explorer, then extract the files to the DATA folder in your DOWNLOADS folder.



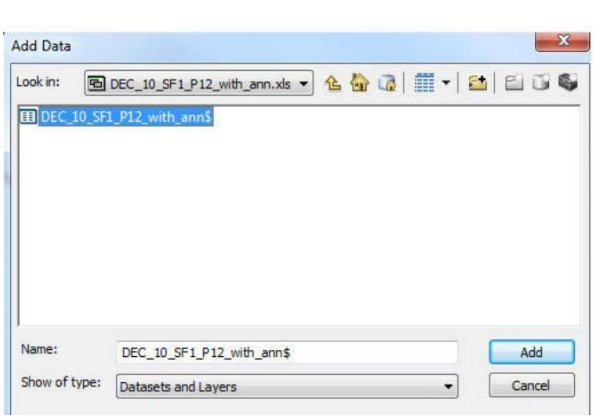


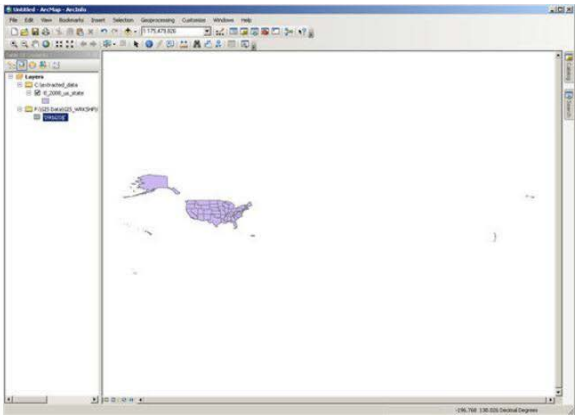
9. Open the ACS_11_5YR_S2504_with_ann file. **The first row will be the field names in the attribute table in the GIS**. That is fine here, but the field names are not obvious identifiers – you would need to look at the DEC_10_SF1_P12_metadata file to know what these codes are indicating.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	GEO.id	GEO.id2	GEO.displ	HC01_EST	HC01_MO	HC02_EST	HC02_MO	HC03_EST	HC03_MO	HC01_EST	HC01_MO	HC02_EST	HC02_MO	HC03_EST
2	0400000US	1	Alabama	1831269	6588	1294557	7449	536712	4845	70.6	0.2	83.7	0.2	38.8
3	0400000US	2	Alaska	252920	1108	162646	1521	90274	1550	61	0.5	80.2	0.6	26.3
4	0400000US	4	Arizona	2344215	8563	1560581	10298	783634	6366	65.3	0.2	80.5	0.2	35
5	0400000US	5	Arkansas	1121386	4189	756915	5051	364471	3302	71.4	0.3	85.3	0.3	42.6
6	0400000US	6	California	12433172	22372	7055642	38013	5377530	19595	58.8	0.1	81.9	0.1	28.5
7	0400000US	8	Colorado	1941193	5005	1295906	7722	645287	4896	64.6	0.2	82.5	0.2	28.6
8	0400000US	9	Connectic	1360115	3316	937339	4501	422776	3649	61	0.2	82.2	0.2	13.9
9	0400000US	10	Delaware	332837	1738	242808	1826	90029	1630	61.2	0.4	75.8	0.5	21.7
10	0400000US	11	District of	260136	1572	111381	1525	148755	1895	12.9	0.3	25.8	0.7	3.2
11	0400000US	12	Florida	7140096	26268	4928508	30925	2211588	9999	58.7	0.1	72.4	0.1	28.3
12	0400000US	13	Georgia	3490754	10839	2332685	13857	1158069	6671	68.2	0.2	85.4	0.1	33.7
13	0400000US	15	Hawaii	445513	2039	261487	2753	184026	2418	56.9	0.4	73.4	0.5	33.4

10. Open up ArcMap and a new, blank map.
11. Add the two files you've downloaded to the map from the GIS_WORKSHP folder in the DOWNLOADS folder.





12. Look at both attribute tables to see what field you will use to make the join and what it is called in each table. Right click on the states shapefile and choose Join. Join the shapefile to the spreadsheet using state names as the common field (NAME from the states shapefile and GEO.display-label from the census table). See pp. 15-16 for a reminder on joining if needed.

13. Check the attribute table of the states shapefile to see if the join worked. You should be able to see the census data appended to the attribute table. You may have null values where data is missing, such as for the U.S. territories – that is fine. You can choose "Keep only matching records" when you make the join if you want to avoid this.

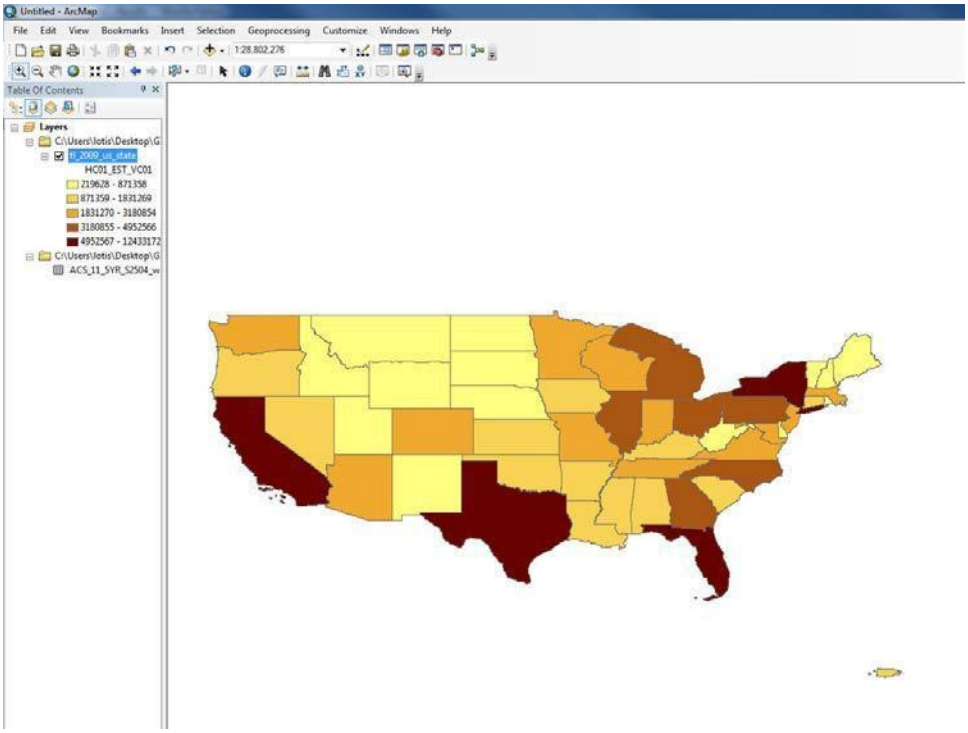
Table

tl_2009_us_state

INTPTLAT	INTPTLON	GEO.id	GEO.id2	GEO.display-label	HC01_EST_VC01	HC01_MOE_VC01	HC02_EST_VC01	HC02_MOE_VC01
-14.2639454	-170.6672241	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
+39.3310928	-116.6151469	0400000US32	32	Nevada	986741	4363	582671	5276
+34.2099643	-111.6024010	0400000US04	4	Arizona	2344215	8563	1560581	10298
+44.6284840	-089.7119298	0400000US55	55	Wisconsin	2279738	9509	1574719	9398
+14.9367834	+145.6010210	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
+32.6293839	-083.4232124	0400000US13	13	Georgia	3490754	10839	2332685	13857
+18.3215090	-064.8988352	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
+38.4985464	-098.3834297	0400000US20	20	Kansas	1104479	3939	761874	4912
+41.5797842	-072.7466665	0400000US09	9	Connecticut	1360115	3316	937339	4501
+39.9030255	-086.2839502	0400000US18	18	Indiana	2472870	7194	1758192	9218
+45.3907127	-068.6577826	0400000US23	23	Maine	551601	2170	400881	2282
+42.1565195	-071.4895915	0400000US25	25	Massachusetts	2522409	4911	1604473	7753
+47.0511770	-109.6348174	0400000US30	30	Montana	403495	1965	277913	2511
+38.9466584	-076.6744939	0400000US24	24	Maryland	2128377	5413	1461708	8215

14. Make a color map with the new housing data from the census.
    Hint: Right click states shapefile – Properties – Symbology tab – Quantities
    Remember: You will look at the metadata to decide which field to use (for example, HC01_EST_VC01 will map estimated occupied housing units)

15. Here's the end map!

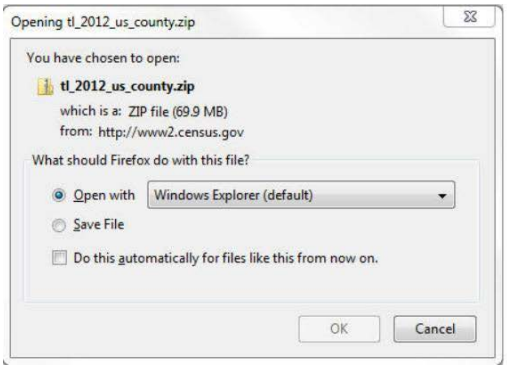


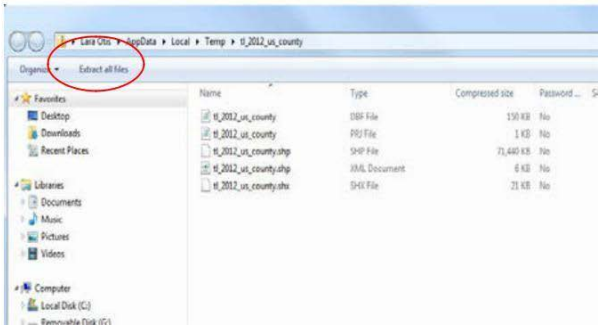
Food Atlas Exercise – Cheat Sheet

1. Go to the following link to download a shapefile with boundaries for all U.S. counties: https://www.census.gov/geo/maps-data/data/tiger-line.html (go to the 2013 TIGER/Line shapefiles main page, then click on “Download”, Select a layer type Counties and equivalent.

2. Click on 2012 TIGER/Line Shapefiles Main page, then click on “Download Shapefiles”. Check off the box for “Counties (and equivalent)” and click on “Submit” and then “Download national file”.

3. Open the zipped file with Windows Explorer and then extract all the files to the DATA folder in your DOWNLOADS folder.



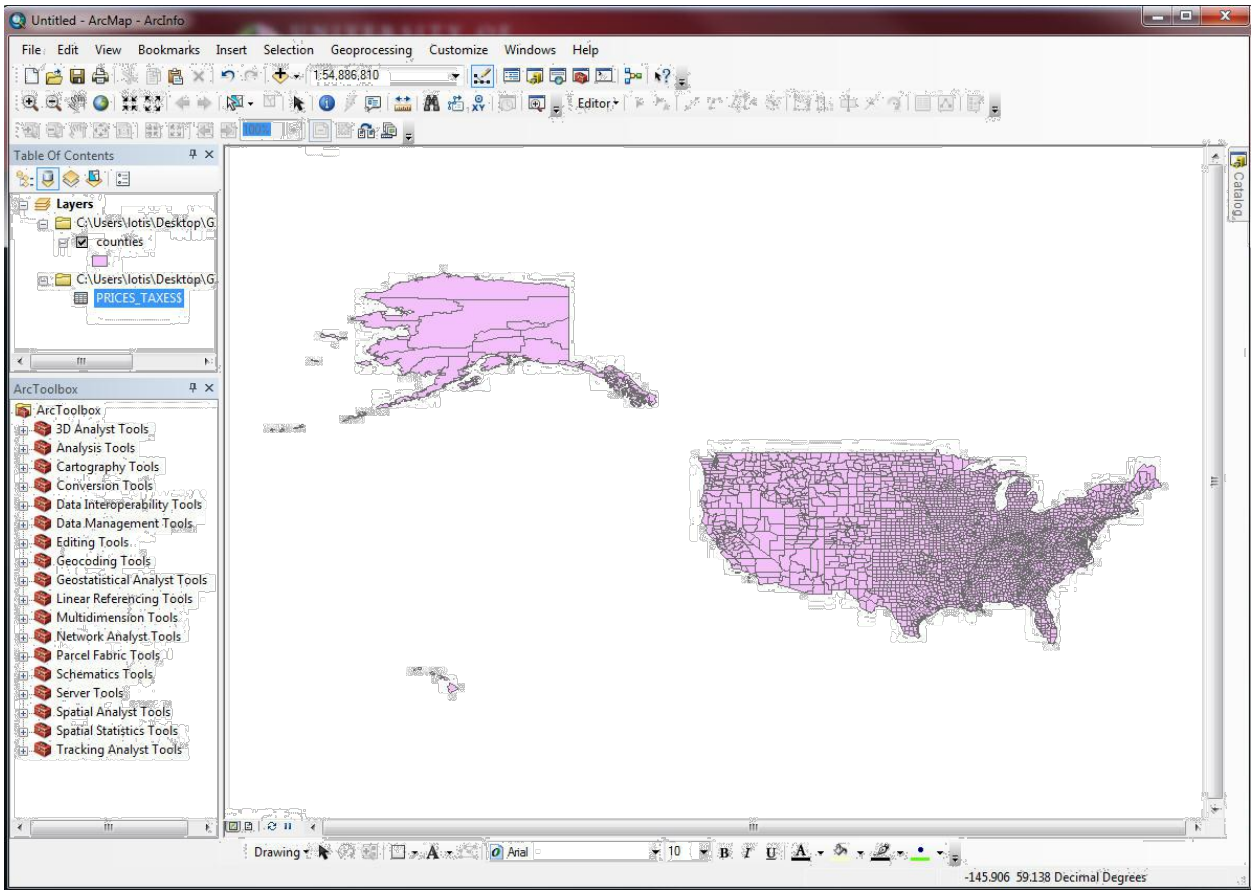


4. Next we will download a table in spreadsheet form from the Food Environment Atlas: http://www.ers.usda.gov/data-products/food-environment-atlas.aspx

5. Click on the “Data Access and Documentation Downloads” link, then download and save the current version of the “Food Environment Atlas Data File” spreadsheet to the DATA folder in your DOWNLOADS folder.

6. Investigate the Food Atlas spreadsheet. There are multiple worksheets with different kinds of data. How do you know what the field names indicate? You need to look at the Variable_List worksheet to find the metadata.

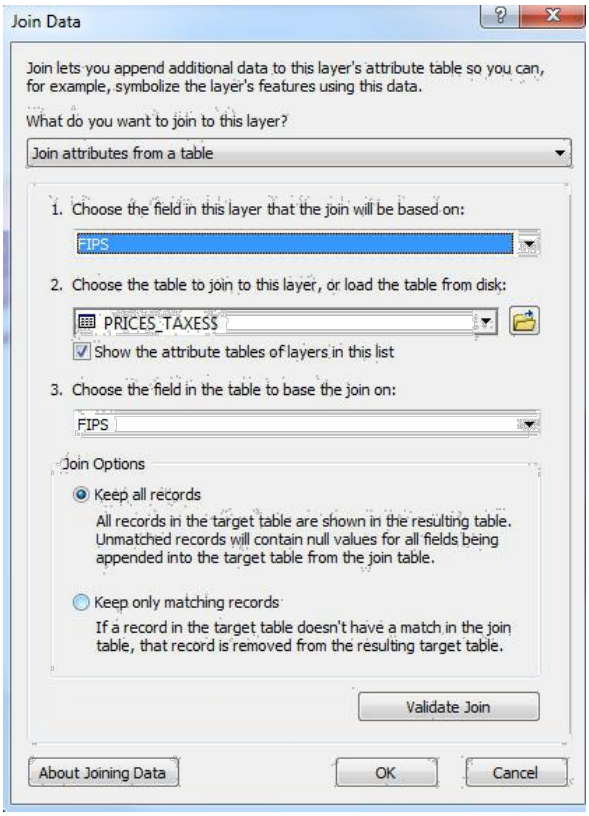
7. Open ArcMap and add both the new counties shapefile and one of the worksheets from the Food Atlas spreadsheet that contains data you are interested in.



8. Take a look at the attribute tables of both layers. How will we be able to join them? County name is an obvious possibility, but try sorting the counties alphabetically and seeing how many Washington Counties there are in the U.S. It will be easier if we can make a one-to-one relationship for our join. For that reason, we'll use a FIPS field.

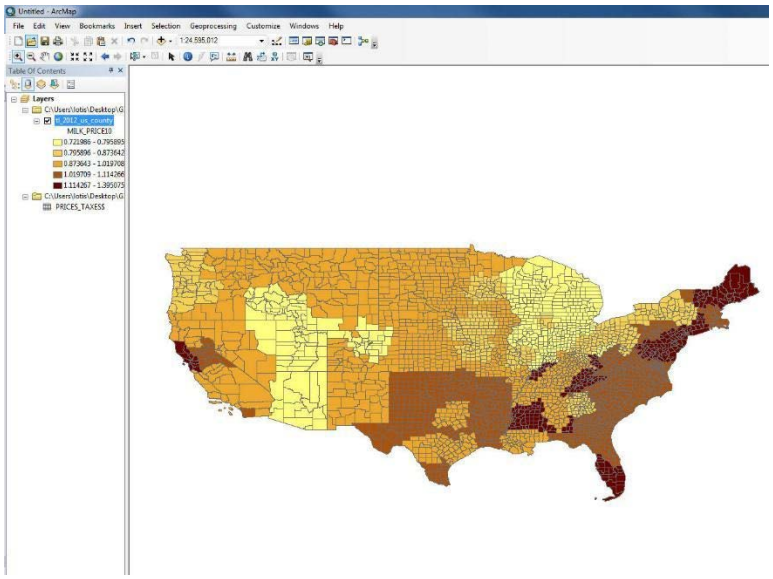
    - The counties shapefile has three fields with FIPS numbers (STATEFP, COUNTYFP, and GEOID), but the Food Atlas table has only one FIPS field, with a five-digit number. Therefore, we'll make the join using the GEOID field from one and the FIPS field from the other.

9. Right click on counties, and choose Joins and Relates > Join



10. Take a look at the attribute table of counties to see if the join worked. The food data should be added on to the end, so that the last field is FOOD_TAX11.

11. Now we'll map this new information. Right click on counties and choose Properties > Symbology tab. Choose Quantities, then pick a field from the food data to map. For example, this map used the PRICES_TAXES worksheet from the Food Atlas data and shows the price of milk in all U.S. counties.



More Training and Information

University of Maryland at College Park students, faculty, and staff have access to free online courses provided by ESRI. These cover a wide range of GIS topics and skills. To gain access to online classes, please contact *kelleyo@umd.edu* with the name of the course you are interested in and your UMD e-mail address to obtain a registration code.

Course list: https://www.esri.com/training/unlimited-esri-training/

University of Maryland Libraries' GIS and Spatial Data Services Center website: http://lib.umd.edu/gis/

University of Maryland Libraries' GIS and Spatial Data Services Center workshop series: https://www.lib.umd.edu/gis/workshops