

11.205 – Intro to Spatial Analysis – Fall 2019

Week 2 – Spatial Data, Types, and Structures

ArcMap Exercise

[OCW Users: The following document refers to online resources (Stellar and CRON) that are not available to users outside MIT.]

Week 2 Objectives – Metadata, Categorical Data, Land Use Mapping, and Queries

Objectives

- I. Learn more about metadata
- II. Join tabular tax database to parcel file
- III. Make a map using categorical data
- IV. Query to extract a specific subset of land use
- V. Add a field and calculate some basic summary statistics
- VI. Perform grouping

Lab Data

Download the class files from Stellar and load them onto your external hard drive.

The unzipped file consists of the following folders:

1. DOCUMENTS: This folder includes Word documents for this week's in-class and take-home exercise(s).
2. DATA: This folder contains all the data needed for this week's in-class and take-home exercise(s).

In the first part of the in-class exercise, we are going to create a land use map of Cambridge. The Bronx River Alliance wants a similar map for the Bronx that you are going to make for your take-home exercise, but let's see how we can do it in Cambridge first.

OBJECTIVE 1: LEARN MORE ABOUT METADATA

Information on housing, parcels, land use, assessed values, and other attributes have been maintained for centuries by tax assessors for the purpose of land appraisal and tax collection. Historically, these records have been referred to as a city's cadaster. The tax assessor makes databases based on parcels that include a number of attributes, including land use type, so that they can appraise property. In the past few decades, much of this data has been digitized and made available, in some form, to the public.

Most municipalities maintain large parcel datasets for the areas over which they have jurisdiction. Each parcel has a **unique identifier** that can be used to join Tax Assessor data to the geographic parcel data. This allows us to make maps of most anything in the assessor's database by using the unique identifier of the Parcel ID to perform a join with the Assessors data to the geometry file of the parcels.

Assessor's data is highly detailed and contains a very large amount of information. The attributes for each listing in the Assessor's data are wide ranging and the field names are often simplified. For example, a field heading might be "LAND_CODE" and the data in the fields are numbers. Each number usually represents a Land use, such as 1= residential, 2 = commercial and so on. How than can one find the code values? You use what is called **metadata**. Metadata can also be called a **lookup table** or a **data dictionary**.

Metadata exists in two primary forms: 1) file metadata, and 2) separate lookup tables. File metadata can be used in GIS software and contains information on the file, ranging from author and date, to the meaning of each field. Lookup tables are usually separate documents that contain a list of attributes, their definitions, and the meanings of their values. In the first part of this exercise, we are going to make a land use map by joining spatial parcel datasets and tabular data containing a land use attribute.

Assessor's Data and Lookup Tables

The data we are going to use is assessors' data from Fiscal Year 2018 downloaded from the City of Cambridge GIS website (<http://www.cambridgema.gov/GIS/>).

We have downloaded the data for you and modified it by adding a few notes and a generalized land use field for illustration purposes, but it is freely available data. Let's explore the file.

1. Open Microsoft Excel, go to File > Open, and navigate to the **Cambridge** folder within **Data** in this week's materials. In the dropdown box at the bottom right, **set the dialog to show All Files**.



Locate **cam_assessor_fy18.dbf**. (Note: if you try to open this file through Windows Explorer, the CRON computers need to have their default program specified. Make sure you open this in Excel. The best way to do this is to right click on the file, then choose Open With > Excel.)

BOUNDARY_POLY.dbf	4/10/2014 10:24 A	DBF File
BOUNDARY_POLY.prj	4/10/2014 10:24 A	PRJ File
BOUNDARY_POLY.sbn	4/10/2014 10:24 A	SBN File
BOUNDARY_POLY.sbx	4/10/2014 10:24 A	SBX File
BOUNDARY_POLY.shp	4/10/2014 10:24 A	SHP File
BOUNDARY_POLY.shp.xml	7/16/2014 5:35 AM	XML Document
BOUNDARY_POLY.shx	4/10/2014 10:24 A	SHX File
cam_assessor_fy18.dbf	8/13/2018 12:56 PM	DBF File
cam_parcel_fy18.cpg	8/7/2018 10:55 AM	CPG File
cam_parcel_fy18.dbf	8/7/2018 10:55 AM	DBF File
cam_parcel_fy18.prj	8/7/2018 10:55 AM	PRJ File
cam_parcel_fy18.sbn	8/7/2018 10:55 AM	SBN File
cam_parcel_fy18.sbx	8/7/2018 10:55 AM	SBX File
cam_parcel_fy18.shp	8/7/2018 10:55 AM	SHP File
cam_parcel_fy18.shx	8/7/2018 10:55 AM	SHX File
cam_parcel_fy18.xml	8/7/2018 10:55 AM	XML Document
Cambridge_CityLimit.cpg	7/24/2014 7:17 AM	CPG File
Cambridge_CityLimit.dbf	7/24/2014 7:17 AM	DBF File
Cambridge_CityLimit.prj	7/24/2014 7:17 AM	PRJ File

Locate and open *cam_assessor_fy18.dbf*.

Below is a screenshot of the Assessors dataset. Some of the field names are abbreviated so it might be hard to tell what data is held within them. When you download the data from the site, it comes with a Lookup table. This Lookup table will let us know what each field means.

(Note: If your column widths are stretched out, you can Select All, go to the Home Tab, click Format in the Cells sub-palette, and click AutoFit Column Width.)

GISID	ADDRESS	PROPERTYCL	ZONING	LANDAREA	BUILDINGVA	LANDVALUE	ASSESSEDVA	SALEPRICE	BOOK_PAGE	SALEDATE	EXTERIOR_
94-144	21 Decatur St Cambridge, MA (42.36079198200008, -71.10492754799998)	CONDOMINIUM		0	1025800	0	1025800	875000	64500/ 55	11/13/14	
17-91	220-226 Hurley St Cambridge, MA (42.36841261600006, -71.08168516299997)	CONDOMINIUM		0	1002800	0	1002800	780000	62513/ 586	8/23/13	
159-4	1501 Massachusetts Ave Cambridge, MA (42.37511474200005, -71.11849905499997)	RETAIL-STORE		0	22500	0	22500	0	159/ 4	1/1/14	RETAIL-STC
154-68	5 Exeter Pk Cambridge, MA (42.38479245700006, -71.11849088799994)	CONDOMINIUM		0	674500	0	674500	1	67309/ 510	5/25/16	
204-33	9-11 Sheridan St Cambridge, MA (42.388421626000024, -71.12837923099994)	CONDOMINIUM		0	654600	0	654600	599999	64114/ 101	8/21/14	
95-58	100 Pacific St Cambridge, MA (42.36044774100003, -71.10269469799994)	CONDOMINIUM		0	1017600	0	1017600	770000	62829/ 352	10/24/13	

cam_assessor_fy18.dbf

- Go to Windows Explorer and open the Lookup Table called *cam_assessor_README.txt* using any text editor. It is in our weekly materials in the **Cambridge** folder within **Data**.

Note: you want the file type to be Text Document (.txt). There is another file with the extension .txt that is actually an XML document) This file contains the information on what each field in the assessor's database contains It will look like the following.

```
## Property Database Metadata ##
```

```
The following fields are contained in the property database table.
```

```
This version has been modified for 11.205 Fall 2018 by Lily Bui.
```

```
Link the field ML in the corresponding cam_parcels_fy18.shp file to field ML in the DBF file.
```

```
|Field Name | Description |
|-----|-----|
|GISID | Link to ML in GIS Parcels layer |
|Address | Parcel Address |
|PropertyCl | Classification Code description |
|LandArea | Land area in square feet |
|BuildingVa | Assessed value of building improvements on the parcel |
|LandVa | Assessed value of land on the parcel |
|AssessedVa | Total assessed value |
|SalePrice | Price listed for last deed transfer for the parcel |
|Exterior_S | Building style description |
|Exterior_o | Building occupany, or use, type description |
|PCC | State Classification Code |
|USE_GEN | Generalized land use (see USE_GEN_Codes.xls) |
```

This is a 'metadata' file, or in other words, data about data. In particular, it is a lookup table (or data dictionary). This file tells us what is in the Assessor's database.

Note that the field **GISID** can be used to link this data to the corresponding Parcel GIS file and display this information in the map. Also note the descriptions. We can find more detailed information on the **State Land Use Code (state_use_code.xls)** and **Generalized Land Use Code (Use_gen_codes.xls)** by looking in these supplement files. Open them now and take a look.

Land Use Data and Lookup Tables

Land Use Codes represent the type of land use that has been designated for each parcel in the municipal parcel database. They usually fall into a handful of common categories that represent the current usage of each parcel, such as residential, commercial, industrial, and institutional, among others. We saw, in the Lookup Table above, that our file contains Land Use Codes (**PCC and USE_GEN**).

The Commonwealth of Massachusetts and City of Cambridge use very detailed land use codes, which can be found in the lookup file called *State_Use_Codes.xls*. There are also generalized land use codes, which are recorded in the USE_GEN field in the *cam_assessor_fy18.dbf* file. The lookup table for *USE_GEN* is *USE_GEN_Codes.xls* is in your weekly materials. Let's take a look.

	A	B	C	D	E
1	Use Code	Definition			
2		13 Mixed Res & Com			
3		14 Mixed Res & Ind			
4		21 Mixed OpenSp & Res			
5		31 Mixed Com & Res			
6		34 Mixed Com & Ind			
7		41 Mixed Ind & Res			
8		100 RESIDENTIAL			

1. Go ahead and open the **/Data/Cambridge/State_Use_Codes.xls** file if you haven't opened it already. This contains the Data Dictionary that shows what each of the State Use Codes mean. It will look like the following.

Note that the value of STATE USE CODE corresponds to the values found in the USECODE

field in the Assessors database.

Open State_Use_Codes.xls.

2. The Lookup Table for USE_GEN in the Assessors data is called **USE_GEN_Codes.xls**. In **.../Data/Cambridge** open **USE_GEN_Codes.xls**. You can use this table to lookup what the values in USE_GEN correspond to. It looks like the following.

	A	B	C	D
1	USE_GEN	Description	Includes USECODE	
2	0	Other	0	
3	1	Residential	100-199, 1000-1999	
4	3	Commercial	300-399	
5	4	Industrial	400-499	
6	9	Institutional	900-999, 9000-9999	

Open USE_GEN_Codes.xls if you haven't opened it already.

Note the values. We can refer to these at any point during the exercise as needed.

USE_GEN	Description
0	Other
1	Residential
3	Commercial
4	Industrial
9	Institutional

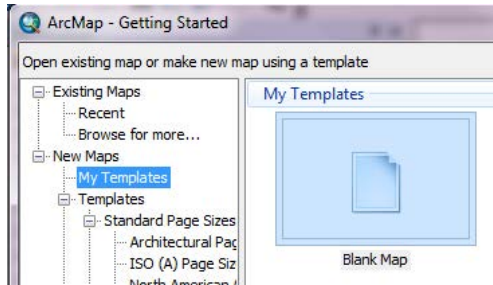
3. Close the two files. **DO NOT SAVE!** The process of opening the Lookup tables and Assessor's data is meant to educate us on what the data contains and what the fields mean.
4. Next, we will base a **join** between a parcel shape file on ArcGIS and the Tax Assessors data based on the **GISID** and **ML** fields.

OBJECTIVE 2: JOIN TABULAR TAX DATABASE TO PARCEL FILE

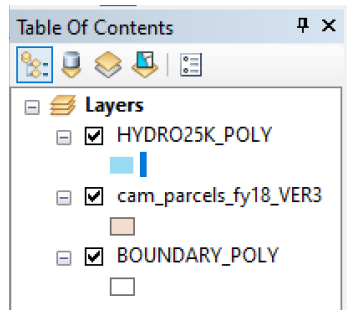
In lecture this week, we discussed spatial data, including what it is, its types, and how it is structured. In the second part of this exercise, we will utilize the concepts of the relational database model to join the tabular tax assessor dataset to the parcel shapefile, and then symbolize the tabular data on the map. Our goal will be to create a land use map of Cambridge.

1. Create a New Map and Add Data

Your home folder is the location where your Map Document will be stored and is used by default to save results, store new datasets, and access information. ArcMap's default behavior is to set your project's home directory to the location of your ArcGIS project file, so save this to the folder where you will store your work (for example, your desktop).



a. Open ArcMap, create a new Blank Map. Go to File >Map Document Properties and put a check mark next to “Store relative pathnames to data sources”. This make sure that as you move between computers ArcGIS can find your files. Name the project file anything you want – am going to call it “week2”.



b. Add the following shapefiles:

week2/data/cambridge/cam_parcels_fy18_VER3.shp

week2/data/cambridge/BOUNDARY_POLY.shp

week2/data/cambridge/HYDRO25K_POLY.shp


c. Add the following tabular Assessors dataset:

week2/data/cambridge/cam_assessors_fy18.dbf

Add data to the new ArcMap file

Note: This parcel and assessor data is from the City of Cambridge GIS Website (<http://www.cambridgema.gov/GIS/>). I added the **USE_GEN** field to the *cam_assessors_fy18* database based on values of **USECODE** to simplify the complex Massachusetts Land Use system.

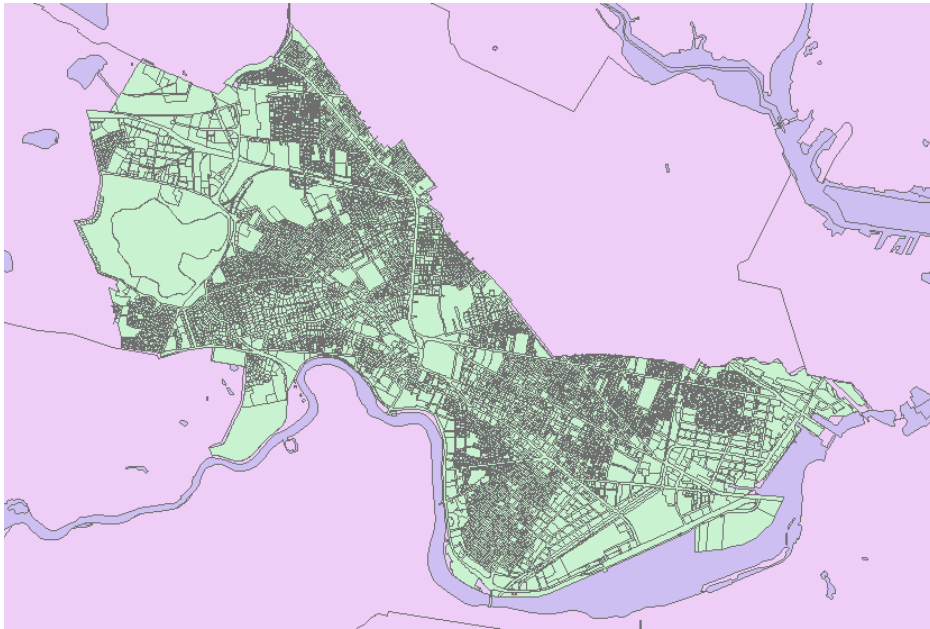
d. In the Table of Contents (TOC), arrange your files so that the hydrology layer is on top, followed by the parcels and city boundaries. Make sure you have your TOC set to ‘List by Drawing Order’ by clicking

on the first icon, from left to right . When you bring in tabular data, ArcGIS automatically switches to 'List by Source', and you will be unable to reorder your layers.

At this point, none of your data is symbolized. All you should see are the unclassed polygons and unsymbolized data.

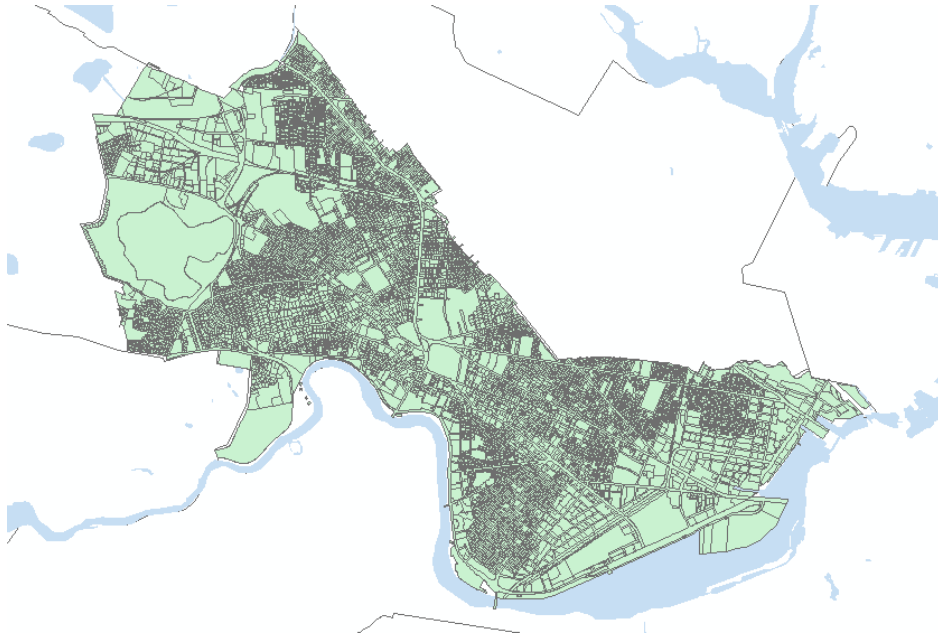
2. Symbolize the Base Data

Your map should look something like the following. If you don't see what is below, you can right-click on the *cam_parcels_fy18_VER3.shp* file in the Table of Contents and click *Zoom to Layer*.



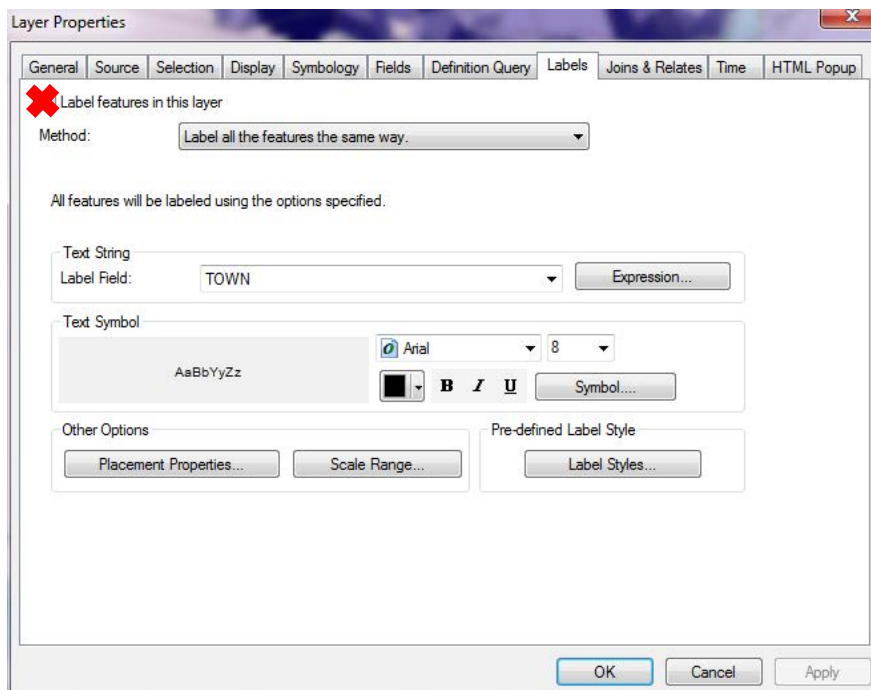
Zoom to layer cam_parcels_fy18.shp

Layer colors are selected by ArcMap randomly. Purple water and pink land (your colors may vary) will be highly unintuitive to our readers. We have to change the symbolization. Using the symbolization skills you learned in week 1, symbolize your base layers. Make the water blue and the land (BOUNDARY_POLY) a neutral grey or white fill with a thin, simple outline in dark grey or black.



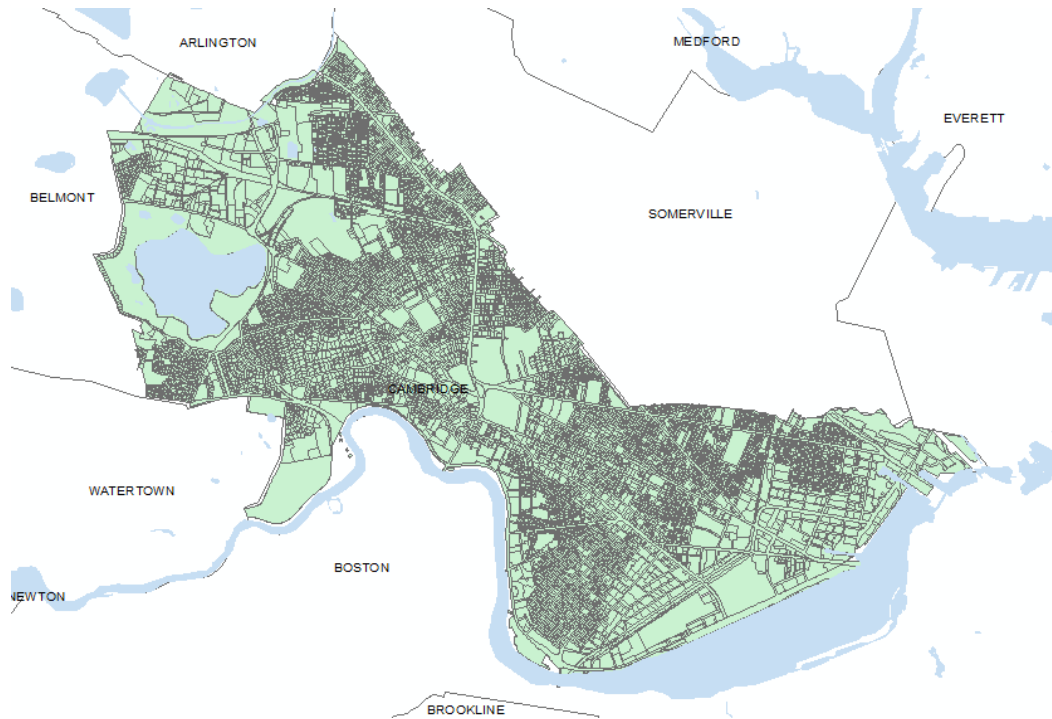
Symbolize your base layers

Label your Map. At this point our map has no labels to give us greater context. Right click on the BOUNDARY_POLY layer, which contains our town boundaries. In the Layer Properties, select the Labels tab, and label the layer's features based on the field TOWN.



Label the town boundaries based on the field TOWN.

Your map will appear something like the following.



3. Join the Files

We have gained familiarity with the data by using the lookup tables and created a map document with the data. Now the next step is to join the tax assessor database table to our geographic parcel file. Our shapefile and tabular data file each need to have a **unique field (primary key)** that can be used to link the files together. In spatial data, this unique ID will represent the same geographic area. We are using parcel data from the City of Cambridge. Each parcel has a fully unique ID assigned to it. This is the primary key we will use to join the tax database to the parcel file. The primary key can be found in our tabular data, connecting the tabular data to a specific parcel; and in our shapefile, uniquely identifying each parcel. Let's begin.

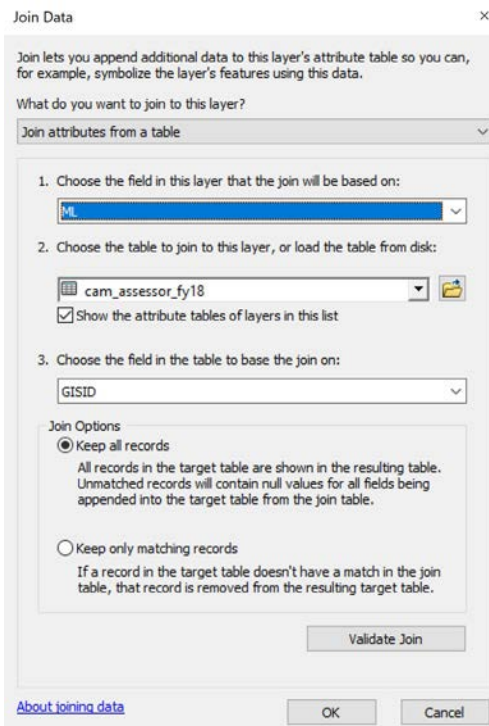
1. Right click on the parcel file (*cam_parcels_fy18_VER3.shp*) and open the attribute table. As we learned above, there is a field in our attribute table called 'ML'; this is the unique identifier for each parcel in the City of Cambridge and we will use this field to join our tabular Tax Assessor file (*cam_assessor_fy18.dbf*) to the parcel file.
2. Open the attribute table of the Tax Assessor data and look at it alongside the Parcel data. You will have to switch your TOC to 'List by Source'. As we saw in the DBF file's metadata, this file contains a 'GISID' field which can be joined to the spatial parcel data's 'ML' field.

FID	Shape *	OBJECTID	ML	MAP	LOT	U	OID	GISID	Address	StateClass
3885	Polygon	3927	10-30	10	30		188	10-30	12 Charles St	424 PU
2851	Polygon	2876	10-31	10	31		189	10-31	121 First St	316 W
557	Polygon	563	10-32	10	32		190	10-32	106-108 Second St	112 >8
5240	Polygon	5293	10-33	10	33		191	10-33	29 Charles St	130 RE
11653	Polygon	11766	10-34	10	34		192	10-34	18 Hurley St	340 GE
12857	Polygon	12973	10-35	10	35		193	10-35	21 Charles St	325 RE
2947	Polygon	2977	10-37	10	37		194	10-37	107 First St	345 RE
1477	Polygon	1490	10-38	10	38		195	10-37	107 First St	345 RE
5212	Polygon	5265	10-39	10	39		196	10-38	131-137 First St	390 CC
2431	Polygon	2450	10-44	10	44		197	10-39	139 First St	337 PA
5202	Polygon	5255	10-65	10	65		198	10-44	31R Commercial Ave	930 V
4923	Polygon	4974	100-10	100	10		200	10-65	1 Charles Pk	346 IN
2076	Polygon	2094	100-11	100	11		5802	100-10	6 Gordon Pl	101 SN
3829	Polygon	3871	100-12	100	12		5803	100-11	7 Gordon Pl	101 SN
3782	Polygon	3823	100-13	100	13		5804	100-12	5 Gordon Pl	1014 SN
1608	Polygon	1621	100-14	100	14		5805	100-13	3 Gordon Pl	104 TV
6007	Polygon	6007	100-15	100	15		5806	100-14	1 Gordon Pl	101 SN
							5807	100-15	6 Florence St	101 SN

Locate the key field

3. Now that we have identified the unique keys, close the attribute tables, so that we can join the two tables together.

4. To join both tables, right-click on the Parcels layer in your table of contents and select **Joins and Relates -> Join...** (Note: We are right-clicking on the shapefile layer that we want to join the data TO.) This will open up a Join Data dialog that will allow you to set parameters and options for the table join. In this dialog, select "Join attributes from a table". Choose 'ML' as the field in this layer to join the table on. Choose *cam_assessor_fy18* as the table to join to this layer. Choose 'GISID' as the field in the table to base the join on to the layer. Under Join Options, leave "Keep all records" selected.

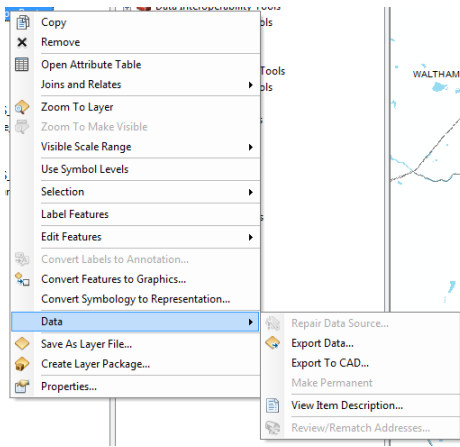


To see if the parameters you set are valid, and to check how many matches you have in your join, you can click "Validate Join." Note: you will get a notice indicating that only 12,863 out of 12,963 observations have matched. This happens because some parcels in the shapefile are not present in the assessor's database. It's fine for the purpose of this exercise.

To complete the join, click OK. A window may popup asking if you want to index your data. Say yes. Your tables should now be joined.

5. Make sure the join worked. Open the Parcel layer attribute table and scroll to the right. If our data was joined correctly, you will see all of the Tax Assessors data appended to the Parcel file fields.

Export a shapefile with the joined data

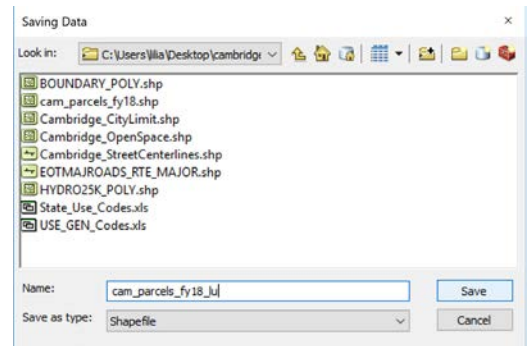


5. To preserve our join, we can export a copy of the data to create a new Parcel file that contains the appended tabular data. To export the data, right-click on the Parcel layer in the table of contents and navigate to **Data -> Export Data**. Exporting data that is joined will combine all the joined files so this is a great way to make database joins permanent. When data is not permanently joined it can cause problems for keeping files organized.

Make sure you are exporting the layer's source data, to ensure you get all features, and then select your Week2 materials working space as the location to save your file. Save your file as a Shapefile. Name your file *cam_parcel_fy18_lu.shp*.

Click Save. Click OK.

When the new data file is created, add it to your map document. Place the new layer above the old one on which you performed the join, and toggle off the old layer. To make sure everything worked properly, view the attribute table of the new layer.



By now, you should have a map that resembles the one on the left.

OBJECTIVE 3: MAKE A MAP USING CATEGORICAL DATA

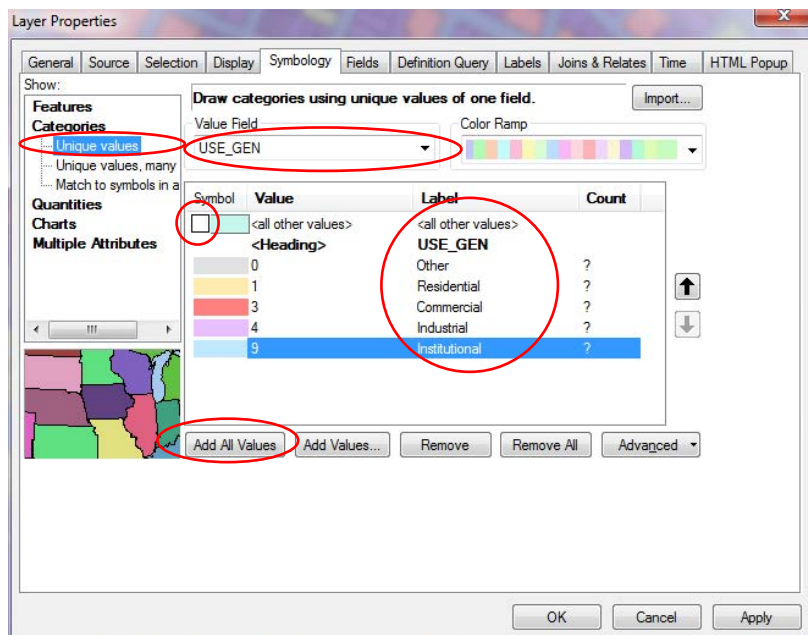
With the data joined, we can begin to visualize the land use layers for the city. As we have discussed at length, the land use data is included in our Tax Assessor’s data. We found while looking at the Data Dictionaries, that there are two fields containing information on Land Use, a detailed land use field called USECODE (created by the City of Cambridge), and a generalized land use field called USE_GEN (created by us based on PCC to simplify the task). We are going to use USE_GEN, and classify our map into five basic categories: Residential, Commercial, Industrial, Institutional, and Other. You can refer to these data dictionaries at any point you need to.

Broad Future Land Use	Detailed Future Land Use
Residential	Rural Residential
	Low Density Residential
	Medium Density Residential
	High Density Residential
Commercial	Neighborhood Commercial
	Community Commercial
	Regional Commercial
Industrial	Light Industrial
	Heavy Industrial
	Port / Aviation Industrial
Mixed Use	
Military	
Institutional	
Agriculture	
Parks, Openspace, & Greenways	Parks and Recreation
	Resource Conservation
	Historic /Cultural

Land use categories and standard colors

Color schemes for land use maps have become loosely standardized over time, with many municipalities using similar colors to represent the various land use types. A guide above can help assign your colors (Source: <http://www.hrtpo.org/uploads/images/broad.png>).

1. Open the Layer Properties of our joined Parcel layer and navigate to the Symbology tab. (Remember that you find the layer Properties by right-clicking in the Table of Contents and selecting Properties) We are using Categorical data this time instead of Quantities as we did last time with the census data. Select **Categories with Unique Values** in the left window of the dialog. Choose **USE_GEN** as our value field for the classification, and **Add All Values** to the window. See below for the number and land use code lookup table.



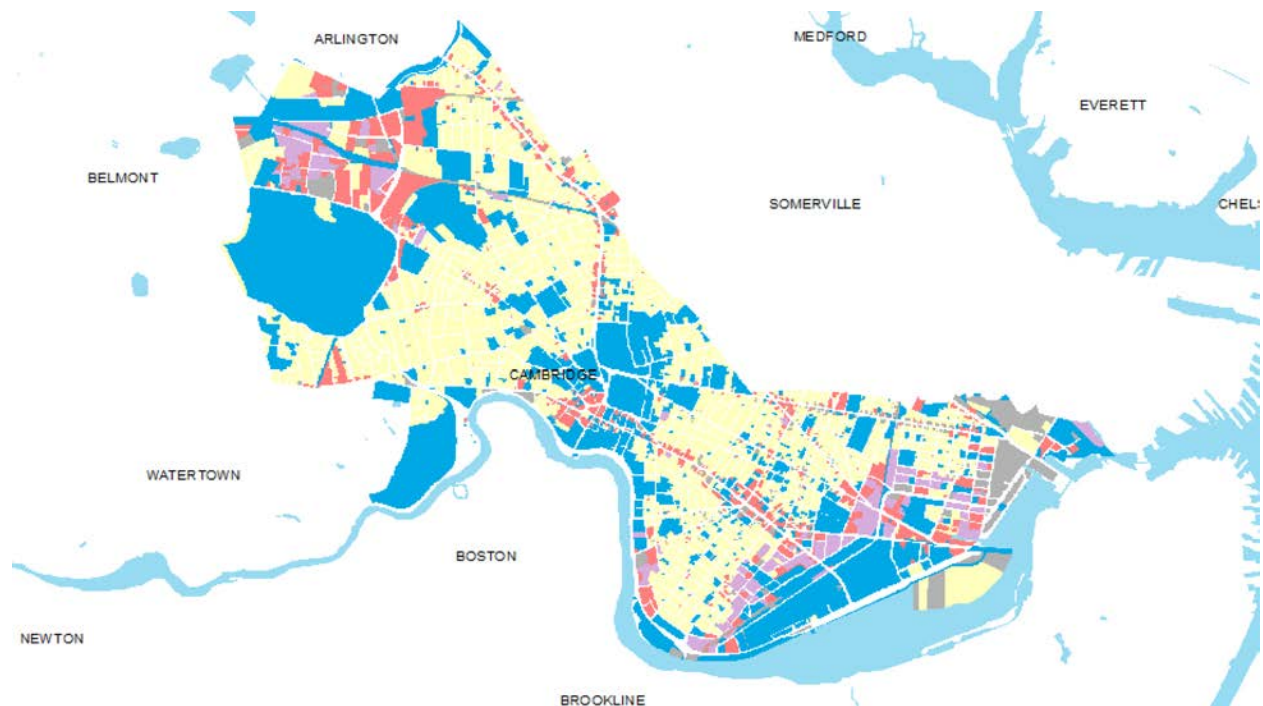
Use USE_GEN as value field and Add All Values

Symbolize each category according to the land use codes by double clicking on the swatch next to the label. The Cambridge Land Use Codes, taken from the lookup table for this exercise, are as follows.

- 1 – Residential – yellow
- 3 – Commercial – red
- 4 – Industrial – purple
- 9 – Institutional – light blue
- 0 – Other – grey

Deselect the check mark in the <all other values> box, and click on the Symbol column header to change the outlines for all of the symbols (Properties for All Symbols...) Right now, it is set as a dark grey line at 0.4 point stroke. Change this to a 0.2 point white stroke. Click OK and apply all of our settings.

You should have started to create a Land use map that looks something like the one below.



Symbolized land use map

3. Zoom in and Create a More Detailed Map

Make a more detailed map of the zoning just in the Central Square area. Zoom into the area around Central Square, which is just to the upper left of the MIT campus area along Massachusetts Avenue.

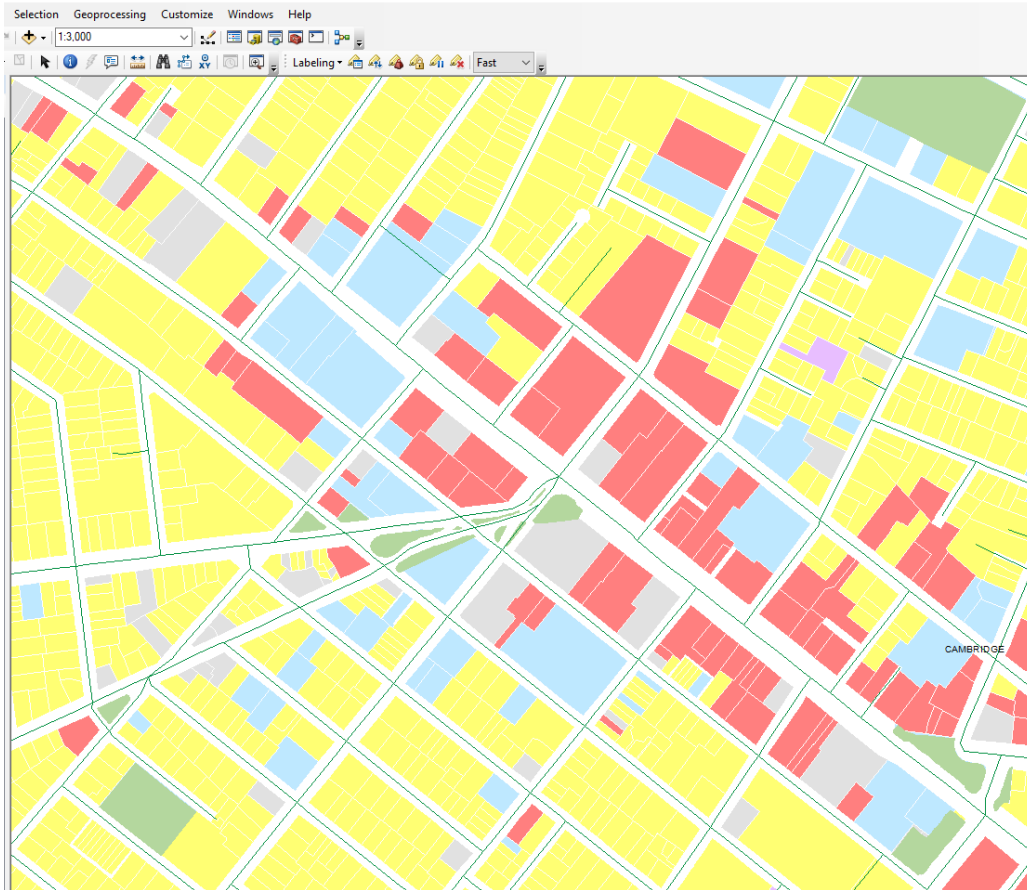
1. Add the Open Space layer (`\\week2\data\cambridge\Cambridge_OpenSpace.shp`). Change the symbology to be green to represent parks.

Note: Many times, in zoning datasets, land owned by the public domain is considered institutional. For that reason parks will appear blue, because they have the institutional land use code but they are really

parcs and we want them to appear that way on the map. Cambridge has developed a separate open space GIS layer so it is clear which institutional parcels are parks.

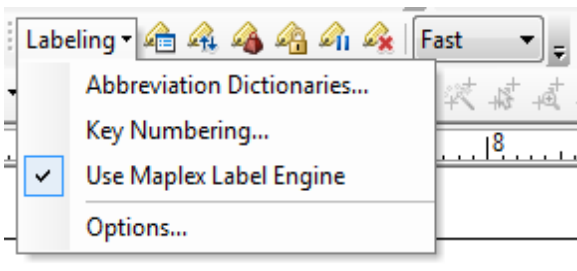
2. Add the Street Centerlines (`\\week2\data\cambridge\Cambridge_StreetCenterlines.shp`)

Roads and streets are not parcels so they are often classified as “other” in the land use code. This is the case in Cambridge – we made these grey so they appear as grey streets on the land use map. Adding the street centerlines allows us to label the map.



Add street centerlines

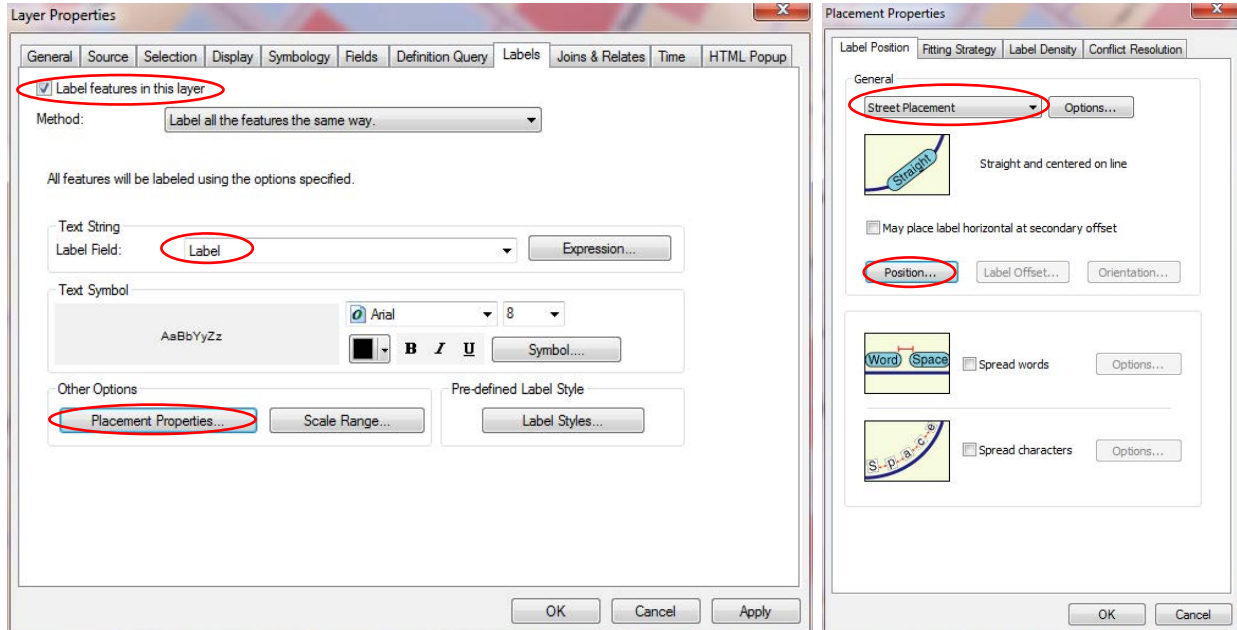
3. Use the ArcMap labeling tools to label the streets in our Central Square area map. To complete this, turn on the Label window by going to Customize -> Toolbars -> Labeling.



The ArcMap Labeling toolbar will appear. ArcMap has a ton of options for labels. We are going to use what is called the Maplex Label Engine. Click on the Labeling dropdown in the Labeling toolbar, and **make sure there is a check next to Use Maplex Label Engine**. If not, click Use Maplex Label Engine to turn on the labeling features. The check will show if enabled.

Turn on the label window

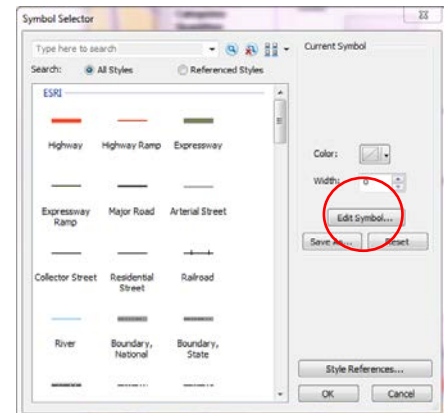
Navigate to the Layer Properties of the *Cambridge_StreetCenterlines.shp* file and click on the Labels tab. In the Labels tab, set the Label Field to be Label. Click on Placement properties and, under General, use 'Street Placement'. Select 'position' and choose 'Centered Straight.'



Set the placement properties parameters and click OK

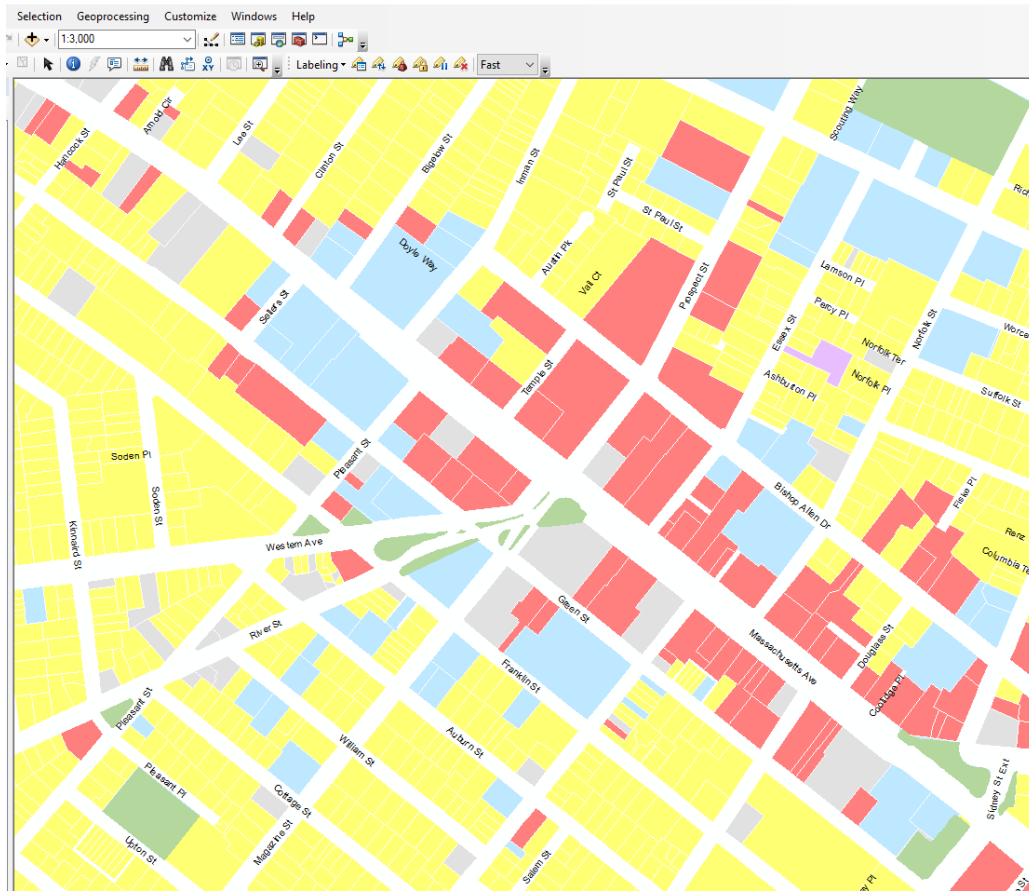
Click OK to apply your label settings. Right click on the Layer and make sure Label Features is turned on. Your map should update to include road labels.

We can still see the street centerline however, and at this scale it does not make sense. Change the symbology of the street to have no stroke width and no color. This way, the street line will still be there, but it will be invisible. Doing this, we can retain our labels without having the feature visible on the map. Click on the Symbology tab in the Layer properties. In the Symbology tab, click on the Edit Symbol button. Set the color to be No Color, and the Width to be zero. Click OK.

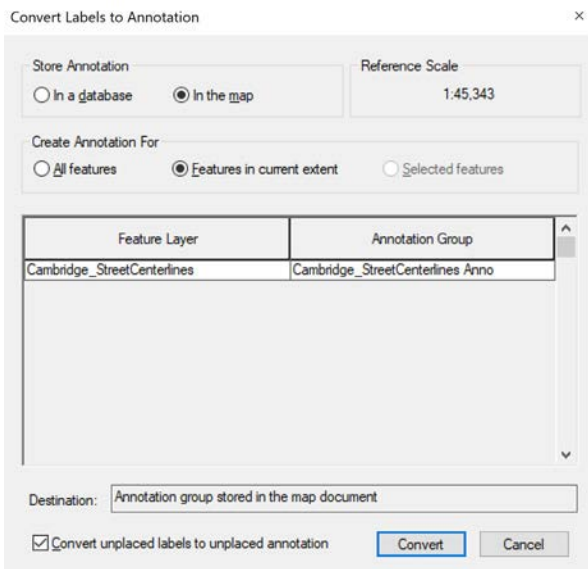


Click on Edit Symbol

Click OK again and return to your map. The land use map for Central Square should now look like the following.



Updated symbology for land use map



Hint for the take-home exercise: once you have automatically labeled your map using the ArcMap labeling tools, you can move labels yourself by converting them to 'Annotation'. Right-click on the layer you want to label, select 'Convert Labels to Annotation'.

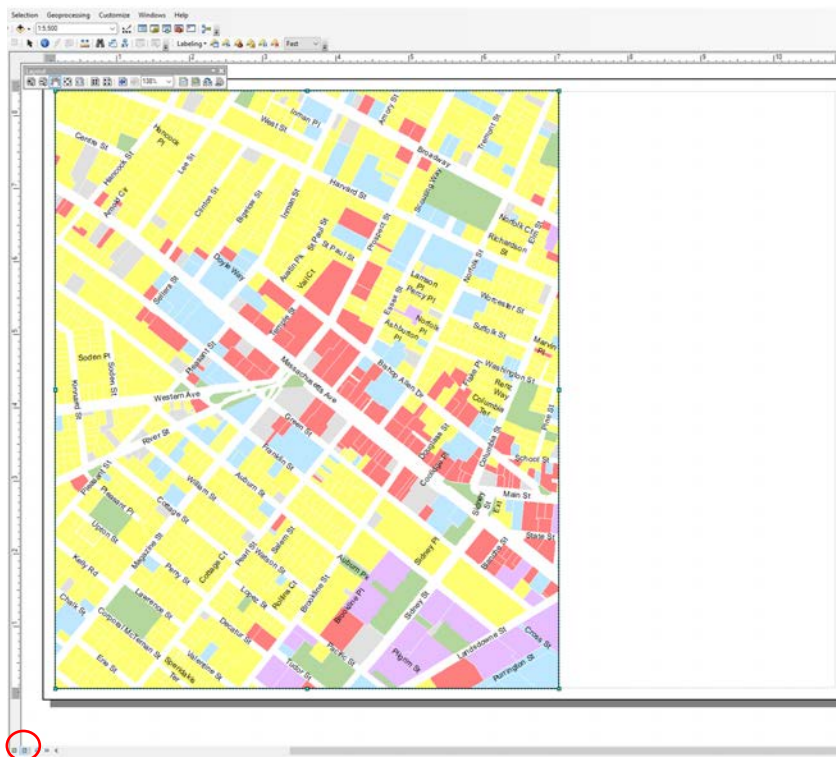
Store Annotation in the map, and create Annotation for Features in the current extent. Click Convert.

4. Create a Map Layout

In Week 1, we showed the two main map views in ArcMap, 'Data View' and 'Layout View'. To create our map layout and add a legend, we need to move from 'Data View' to 'Layout View', and set up the layout for our output map.

1. Toggle your Map to Layout View

Below your main map window, you see two small icons. The one on the left represents 'Data View' the one on the right represents 'Layout View'. Click to move to Layout View. Your map document window will change to a page layout.



Click on 'Layout View'

Depending on your starting template, your default view may be landscape or portrait. Make it landscape, by going to File> Page and Print Set-up and select Landscape.

2. Add the Map Elements

In Layout View, you can add all the elements you need to complete your map layout. This includes a north arrow, scale bar, title, source information, author, and legend, along with any other text you might want to use to supplement your map. To add these elements, use the 'Insert Menu' from the bar at the top of your screen.

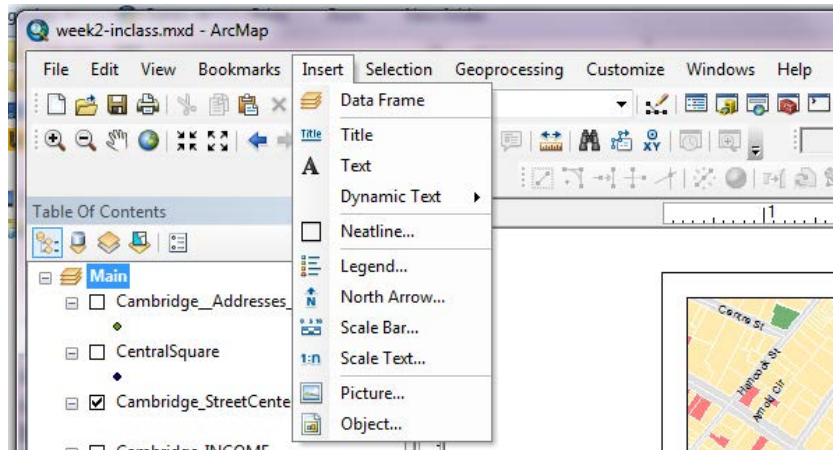
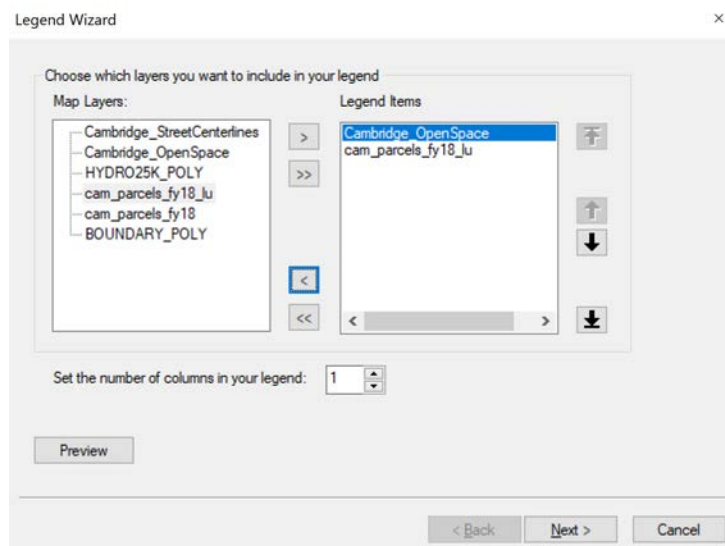


Figure 28. Use the 'Insert Menu' to add map elements

- a. Click *North Arrow...* to add a north arrow to your map.
- b. Click *Scale Bar...* to add a scale bar. In the *Scale Bar* dialog, click *Properties...* And set the scale bar units to *Feet*.
- c. Click *Text* to add a title to your map and add it to the layout. Name it '*Land Use in the Vicinity of Central Square*'
- d. Click *Text* to add supplemental text such data sources, author, and date.
- e. Click *Legend* to add a Legend to your map, this will open the legend dialog, detailed in the following step.

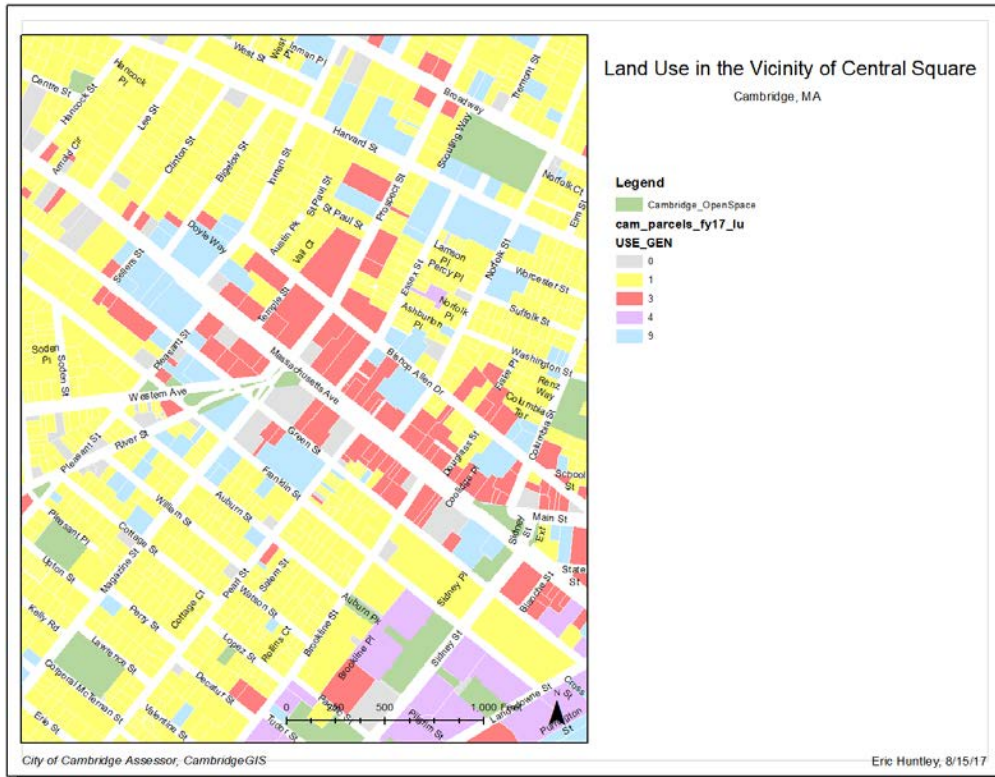
3. Create a Categorical Legend

Creating a legend for Categorical data is a bit different than what we did in Week 1 with normalized quantities. When you click on *Insert -> Legend*, the Legend Wizard will open that will allow you to place the legend on your map and step you through the initial settings. The wizard looks like the following.



Declare layers to include in the legend

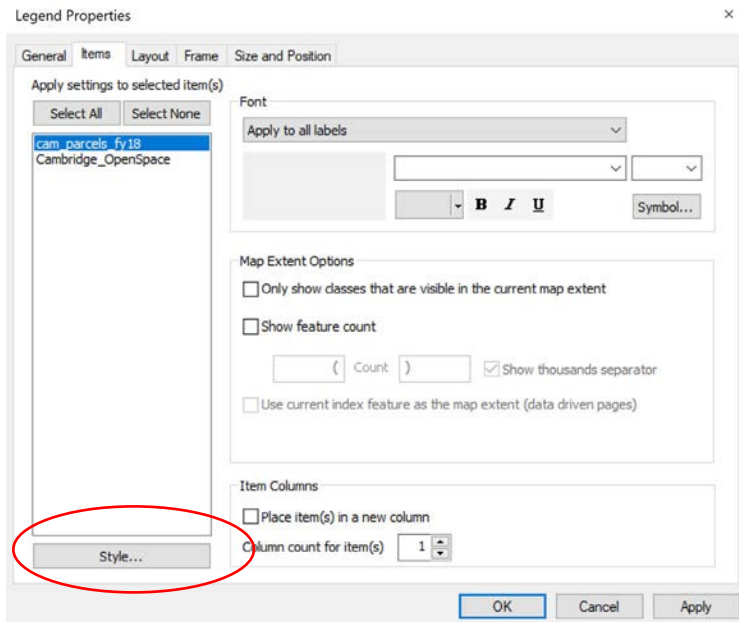
In the first window of the wizard, declare which layers you want to include in your legend. The layers in your map are on the left, and the layers to be included in your legend are on the right. Include the layers that will properly communicate the map to your reader, in this case, the ones containing land use information. We should show open space (parks) and the land use parcel. There is no water in our current extent, so we can remove it from the Legend Items. Click through the defaults on the next screens, and add your legend to the map. Place it in your layout. Your map will look something like the following:



Preliminary map elements (title, legend, north arrow, scale bar, sources, and author/date).

Right now, our legend is a bit confusing. To style our legend, right click on the legend and go to the Legend Properties. Here we have the ability to fully style our legend. Look at the legend to see what we need to change. Note that the parks layer is called *Cambridge_OpenSpace* – this is the layer name. Leave this as is in the properties, and change the name of the layer to Open Space in the TOC. Similarly, open the properties of *cam_parcels_fy18_lu* and edit the labels for each value (e.g., change ‘1’ to ‘Residential’ by clicking on it).

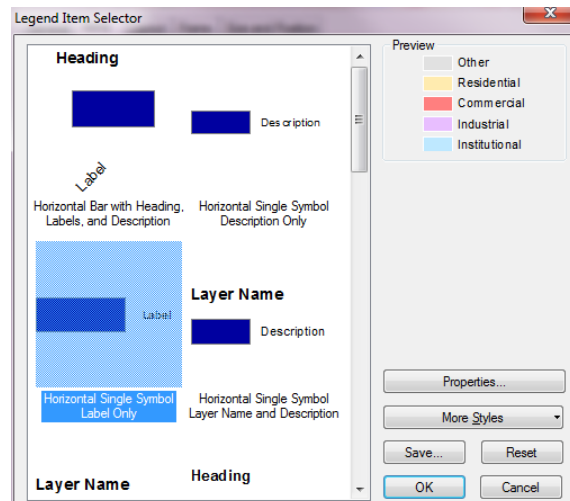
It’s a bit more complicated to change the name of the LandUse layer because we have it symbolized. We want to remove the layer name and the field name, currently shown, from the design of our legend.



To complete this, use the Style feature in the Legend Properties. To access, click on the 'Items' tab in the Legend Properties, highlight *cam_parcel_fy18_lu*, and click Style...

Select target layer and click on Style.

The Legend Item Selector will appear. Select the option that is called "Horizontal Single Symbol Label Only". This will remove the layer name and field name from the legend.

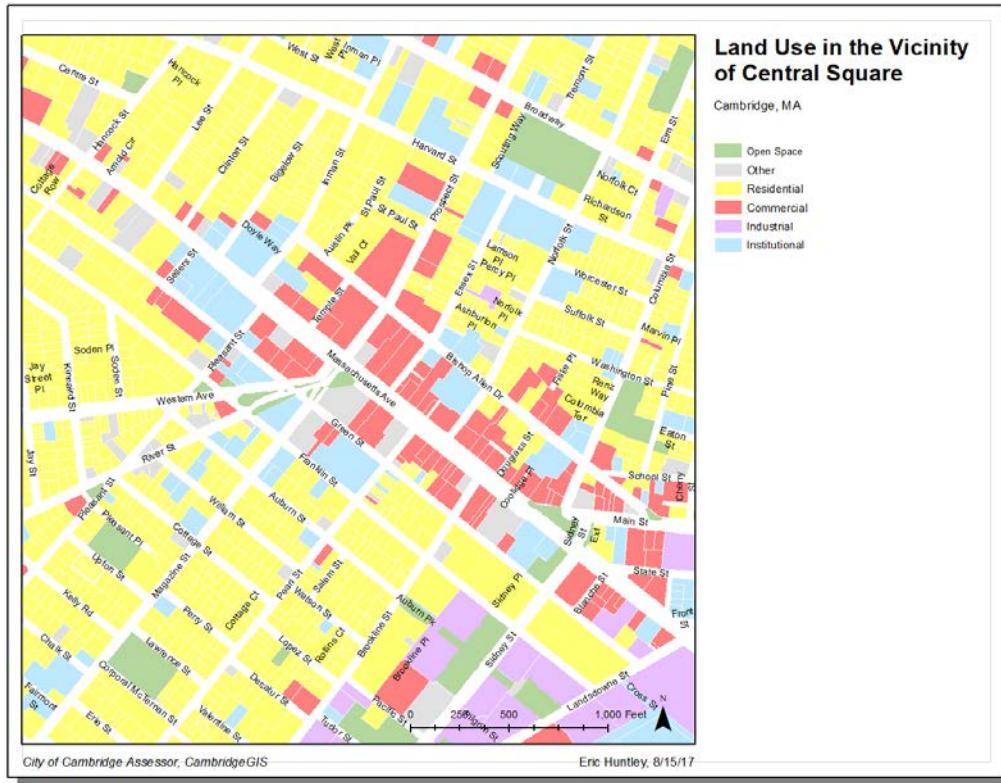


Select 'Horizontal Single Symbol Label Only'.

Click OK to return to the Legend Properties screen. Click on the General Tab, and uncheck Show in the Title section. This will remove the large LEGEND text from our map. Click OK to return to the map and save your changes. You will see the legend update.

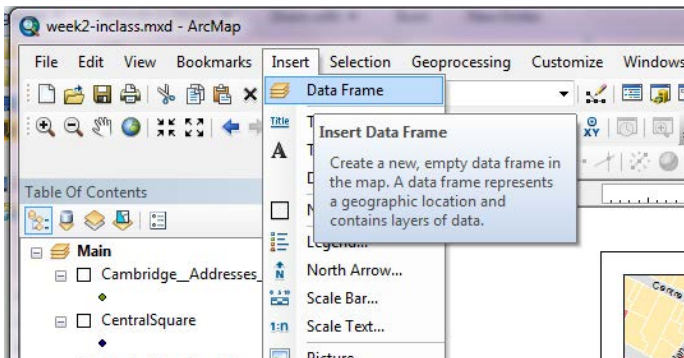
Note: the legend shows layer symbolization like we have in the land use layer according to the settings in the Symbolization tab in the Layer Properties. If you want to change the order of your land use types in the legend, move them around in the Symbolization tab in the Layer Properties. Modify the properties

until you are satisfied and have created a clean, efficient legend. Your map should look something like the following:



Draft legend with updated layer name for open space.

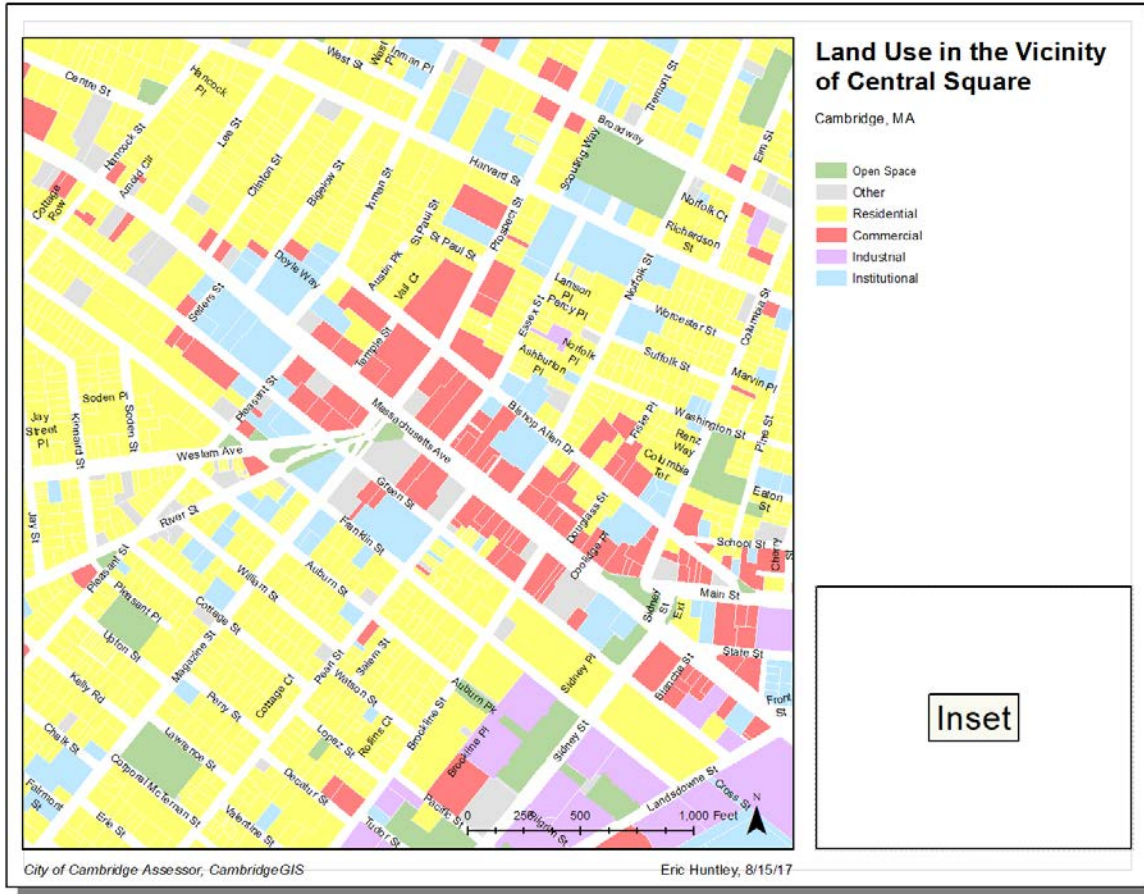
4. Add an Inset (Locator) Map



Insert a new Data Frame

As we did last week, add an inset (locator) map to our layout. In the layout in the large open space below the legend, add an inset map to give our map some greater context. To do this, add a new data frame by navigating to Insert -> Data Frame.

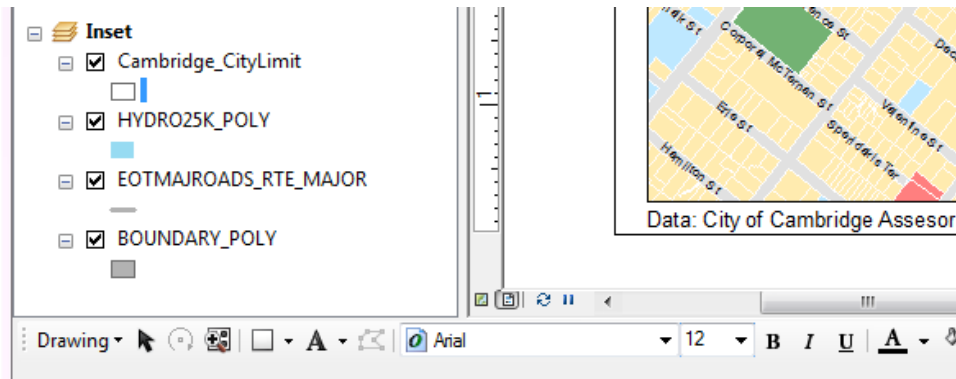
A new data frame will appear on your layout.



Locate the new data frame below the legend

In the Table of Contents, rename the data frame 'Inset'.

To get data in the Inset, click on Add Data. From the Data/Cambridge folder, add *Cambridge_CityLimit*, *HYDRO25K_POLY*. From the Data/Boston folder, add *EOTMAJROADS_RTE_MAJOR*, and *BOUNDARY_POLY*. Organize and symbolize them.



Add layers to the new data frame

Your map should look like the following.

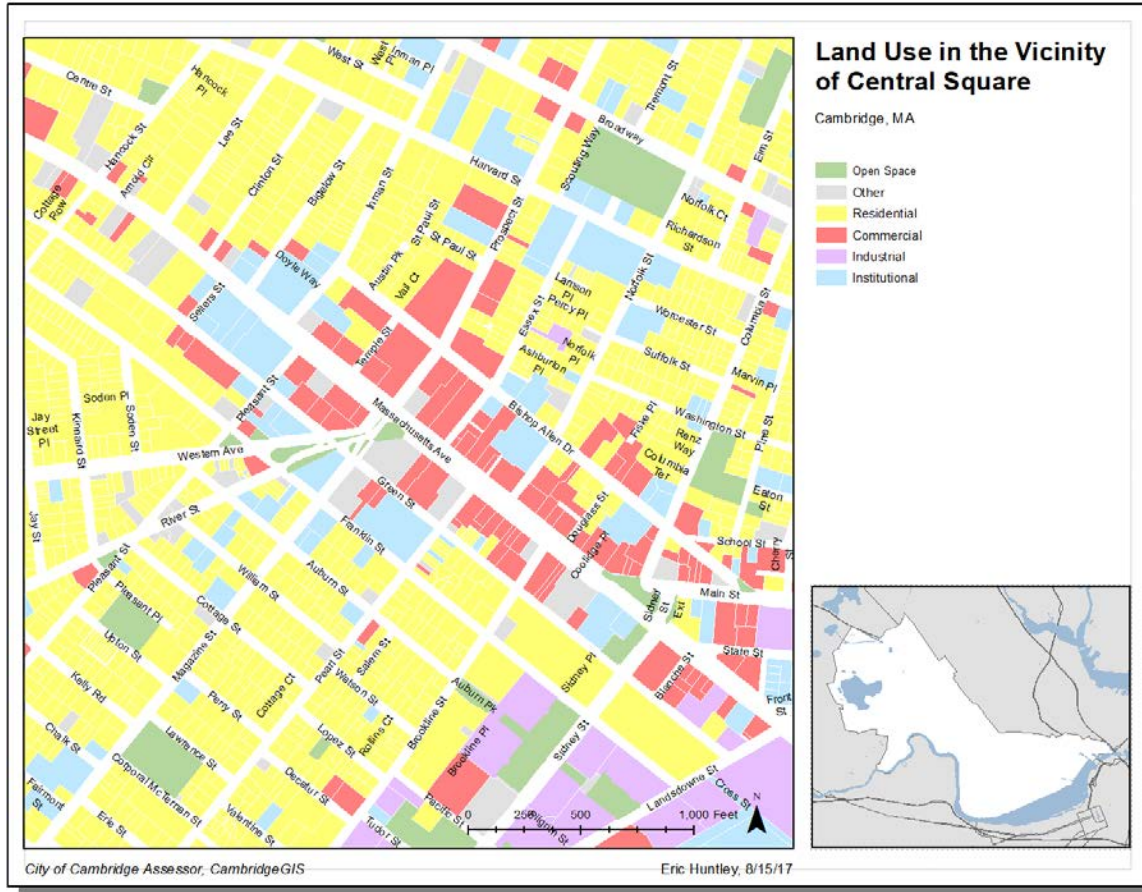
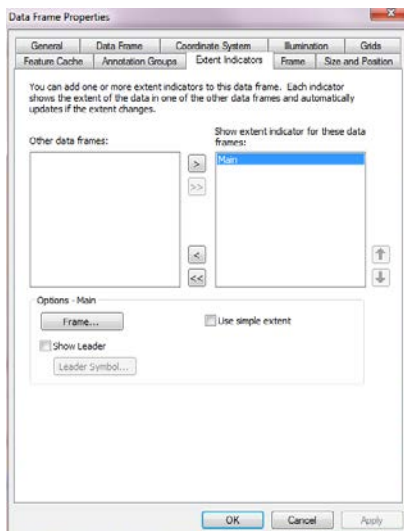


Figure 38. Updated layout with locator map.

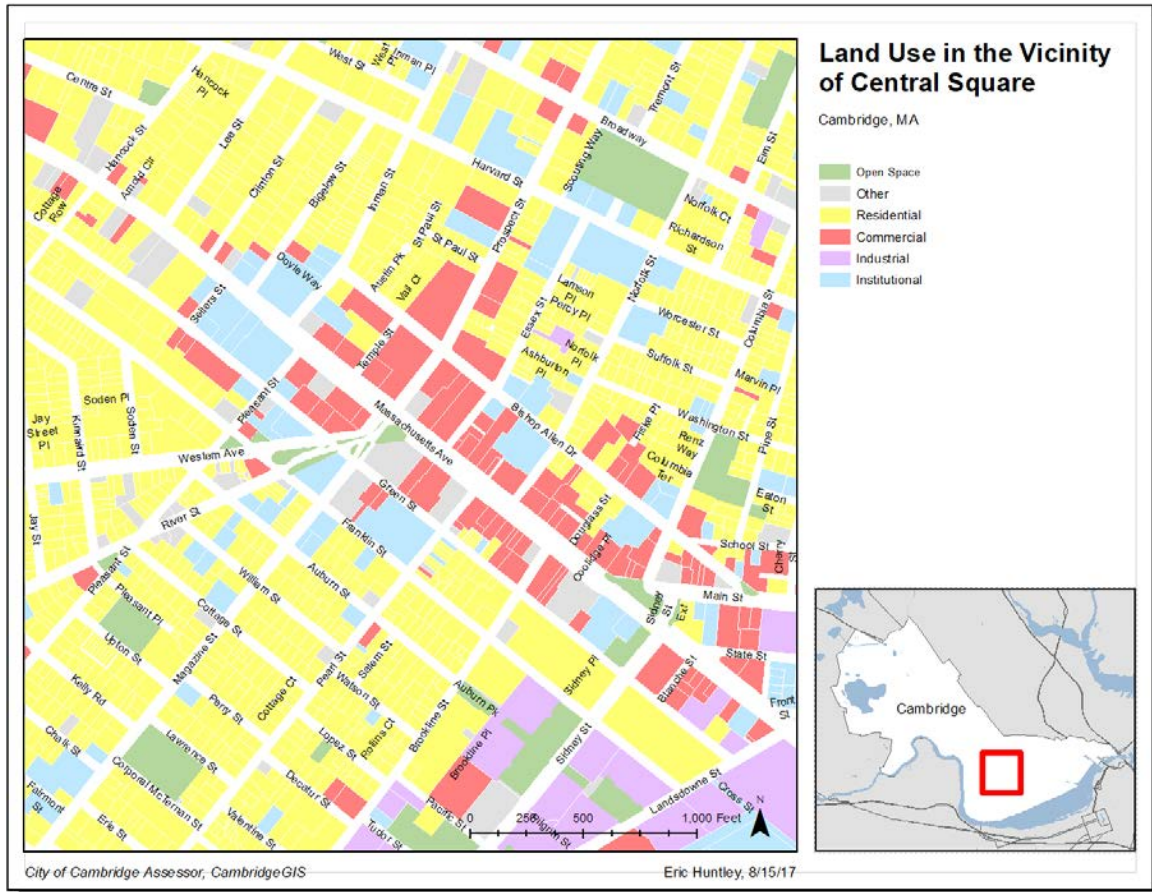
There are two more steps to complete our locator map, add an extent box showing the extent of the main map, and a couple supplemental labels.



To add the main map extent to the locator, right click on the Inset data frame to access data frame properties. Click on the Extent Indicators tab, and show the 'Main' tab. Click OK.

Add the main extent through the Extent Indicators tab in locator map's data frame properties

To add some supplemental text, go to Insert -> Text, like we did earlier, and drop in a label that says Cambridge. The map will look something like the following.



Updated layout with locator map extent and label.

For the first part of the take home exercise, The Bronx River Alliance wants a land use map of the Bronx to learn more about land uses near and in the river watershed. Use the techniques and principles of this in class exercise to work on a land use map of the Bronx.

Save your map document as 'week2_inclass_landuse.mxd' to refer to moving forward.

OBJECTIVE 4: QUERY TO EXTRACT A SPECIFIC SUBSET OF DATA

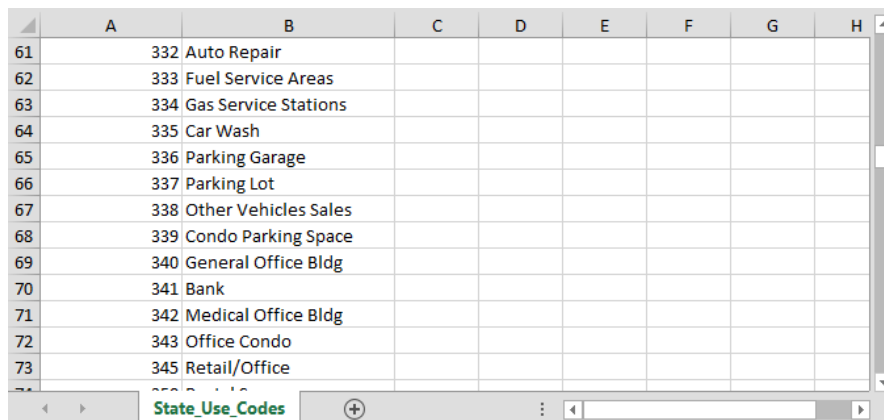
In lab so far, we have created a land use map of Cambridge. What if, for example, we wanted to dig further and only see the parcels that have one specific type of land use, such as Parking Lots. To complete this next objective, we are going to extract information from our parcel dataset using query tools to create a new dataset. Our map to this point is of **all land use in Cambridge**, specifically near Central Square, and we are going to make a map that shows **all the parking lot parcels** near Central Square. An important note, because we are using Assessors data, we are likely NOT going to get City-Owned lots on the map as those aren't taxed. Some supplemental work would need to be done to identify these.

Make a Map of Privately-Owned Parking Lots near Central Square

1. Create a copy of your map document. Open 'week2_inclass_landuse.mxd' (if not still open) and go to File -> Save As... Save the file as 'week2_inclass_query.mxd'.

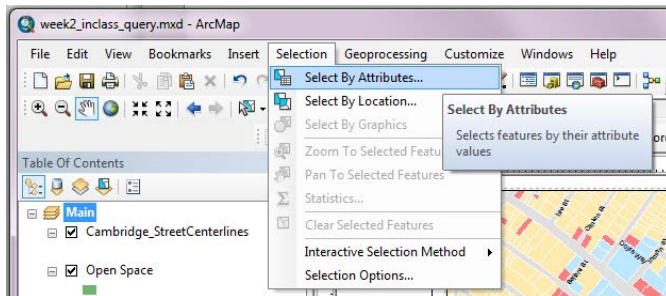
2. Get ready to query in GIS. A query is a selection of a subset of data based on whether or not that data meets specific criteria. To run a query in ArcMap, we need to know two items: **1) what layer we perform the query on, and 2) what to query out of the attribute table**. In this circumstance, we want to find parcels that contain privately owned parking lots (city owned lots are marked a city owned property), so we will query our parcel layer, and then we need to determine which value in the land use field is the value that represents privately owned parking lots. To do this, we are going to use the **detailed land use code (PCC) instead of the generalized code**.

The lookup table for this is the *State_Use_Codes.xls* file. Open this file using Excel and locate 'Parking Lot'. Note the value in the Use Code column that represents Parking Lots.



	A	B	C	D	E	F	G	H
61	332	Auto Repair						
62	333	Fuel Service Areas						
63	334	Gas Service Stations						
64	335	Car Wash						
65	336	Parking Garage						
66	337	Parking Lot						
67	338	Other Vehicles Sales						
68	339	Condo Parking Space						
69	340	General Office Bldg						
70	341	Bank						
71	342	Medical Office Bldg						
72	343	Office Condo						
73	345	Retail/Office						

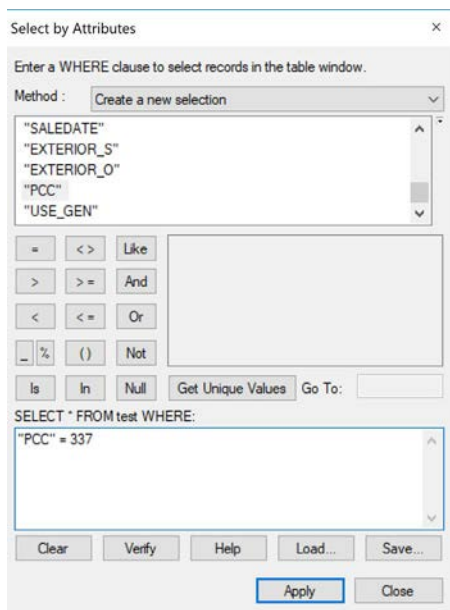
Locate 'Parking Lot' and note its Use Code.



From the Selection menu, click on 'Select by Attributes'

In the lookup table, we see that a value of 337 represents a parcel occupied by a parking lot.

3. Run the query in ArcMap, noting that the Use Code variable is called PCC. We are going to use the 'Select by Attributes' feature in ArcMap. At the top of our ArcMap screen, find the Selection menu, in the dropdown, choose 'Select by Attributes'. A query dialog for Select by Attributes will appear.



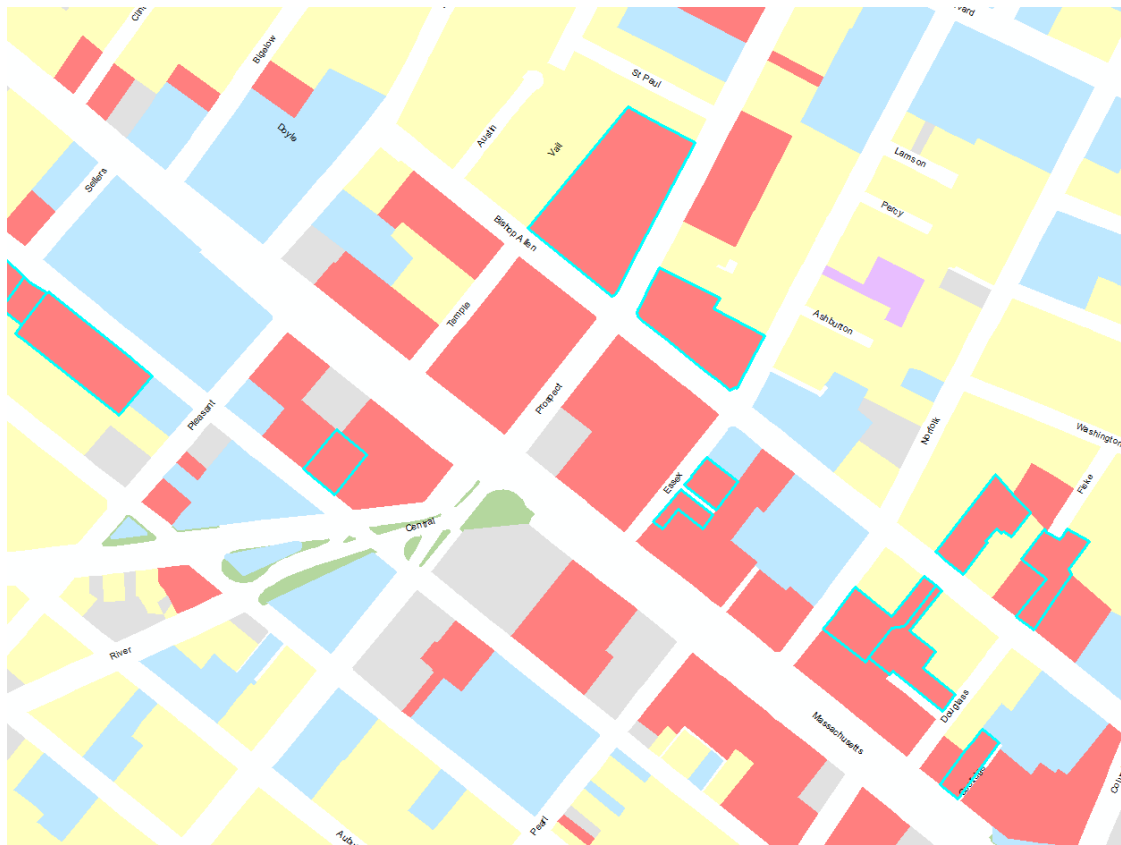
4. In the Select by Attributes dialog, set the Layer to be **cam_parcel_s_fy18_lu**, and make sure the Method is set to **Create a New Selection**. Below, you see all the names of the fields in our Parcel shapefile. Double click **PCC** in this dropdown. This will start to populate the bottom window of the dialog with the criteria for our selection. Remember, we want to select all parcels where "PCC" is equal to 337.

Click on the bottom window, type an = (equal to) sign next to "PCC", and type 337 after the equal sign. This is a basic SQL query. Once it looks good, hit apply. This will select all parcels where "PCC" is equal to 337, or in other words, where the parcel code corresponds with Parking Lot.

Use the phrase "PCC" = 337 to set your query

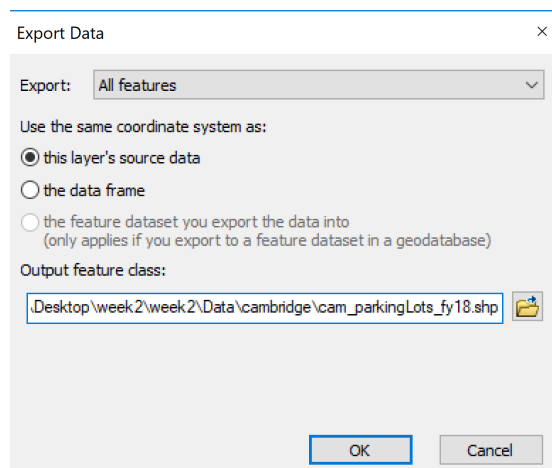
Hint: In your homework, you will be working with strings (text) so you will need single quotes on your query criteria. For example, instead of "PCC" = 337 (numeric), you'll need to set your query to "PCC" = '337'

Click OK, your screen should now look like this, with privately-owned Parking Lots selected.



Query results are displayed graphically in light blue.

5. Now that we have the parking lot parcels selected, we can create a new dataset that consists of only the parking lot parcels. Similar to how we joined data and then exported it previously, in the Table of Contents, right click on the *cam_parcels_fy18* layer (from which we made the current selection), select Data -> Export Data. **Make sure you have Selected Features as the export option**, and are exporting the source data. Name the file *cam_parkingLots_fy18.shp*, and save it as a shapefile in your working directory. Your export window should look as follows.

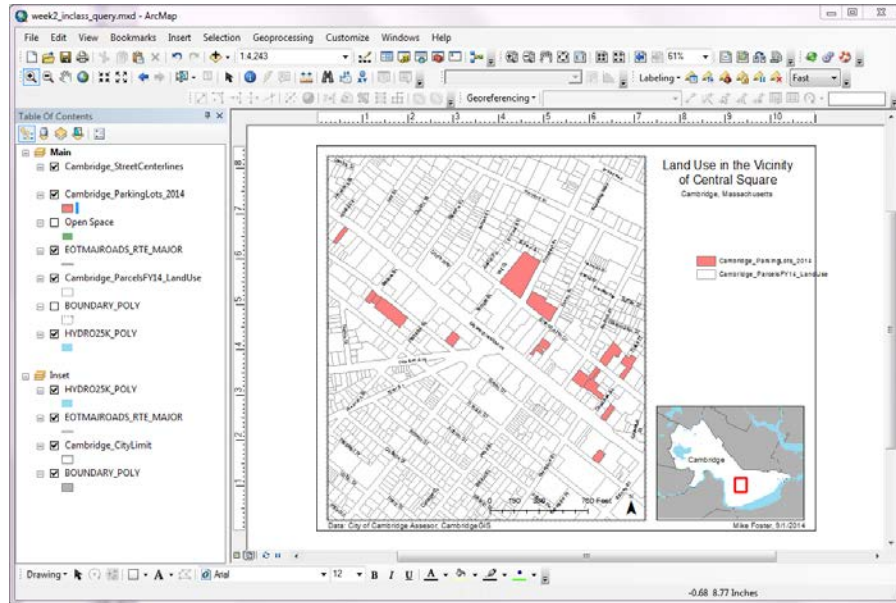


Set the parameters and export as a new shapefile (SHP).

Click OK. Add the new layer to the map.

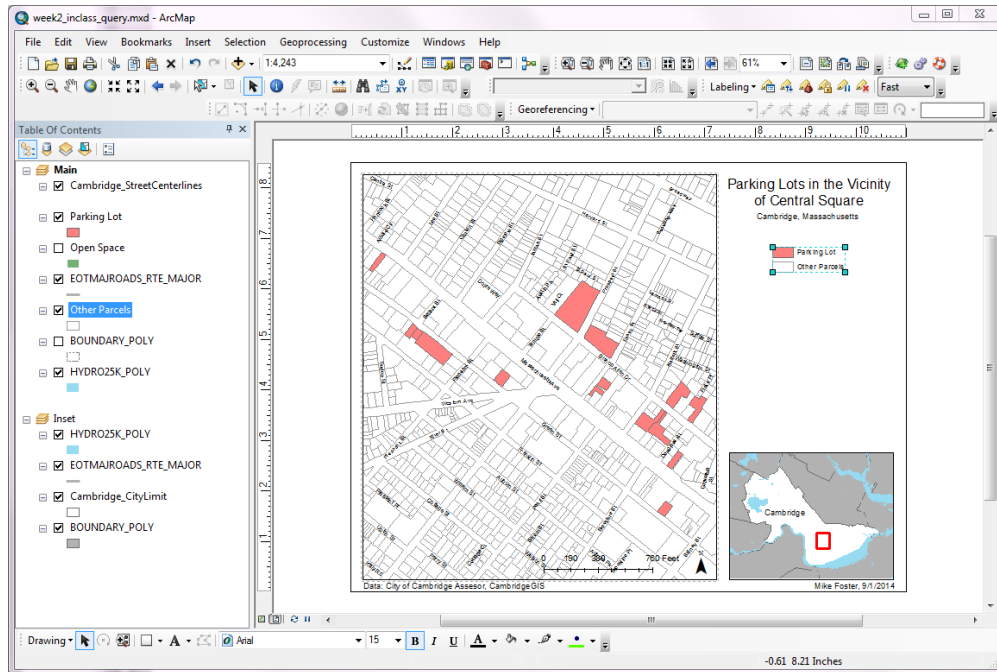
6. Clear your selection by going to Selection -> Clear Selected Features.

7. Change the Symbolization. We have a separate layer with privately owned parking lots now in our map. We want to highlight the parking lots. Change the symbolization so that parking lots are a bold color, and change the symbolization of the land use layer to a neutral color (white or no fill), still showing the parcel outlines for context. After changing symbolization, your map should look like the following:



Parking lots symbolized in bold color.

8. Change the map layout so that the title, legend, and other map components are correct. Give it a title '**Privately Owned Parking Lots in the Vicinity of Central Square**' and then change the legend labels to accurately represent what the map is showing. Your parking lot map should look like the following. Save your document.



Updated parking lots title, legend, etc.

Querying and selecting are powerful and commonly used tools in the GIS software. Try this again, and query a different variable. For example, you could select all parcels that have "PropertyCl" = ">8-UNIT-APT", which would get you all the parcels that hold apartment buildings with more than eight units, or you could do "LandValue" < 200000 AND "LandValue" > 0 to get you all parcels with land values less than \$200,000 (an endangered species). You will do something similar to this in your homework.

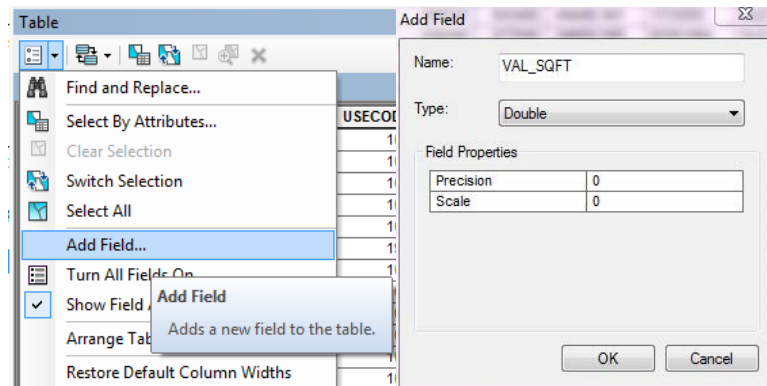
OBJECTIVE 5: NEW FIELDS AND BASIC SUMMARY STATISTICS

In the final objective for this exercise, we are going to create a derived field and calculate some basic summary statistics. In the *cam_parcel_fy18_lu.shp* file that we have been working with, we are going to add a field that will contain the value of the land in dollars per square foot.

SUMMARY STATISTICS

1. Open up the Attribute Table for *cam_parcel_fy18_lu*. This is the table to which we are going to add the new derived column.

2. In the Table Options dropdown at the upper left of the Attribute Table, select Add Field... This will add a field to our table. In the dialog that appears, name the field **VAL_SQFT**, give it the type **Double**, and accept the defaults for Precision and Scale. Hit OK.



You have just added a field to your table.

Add a field and give it the type Double.

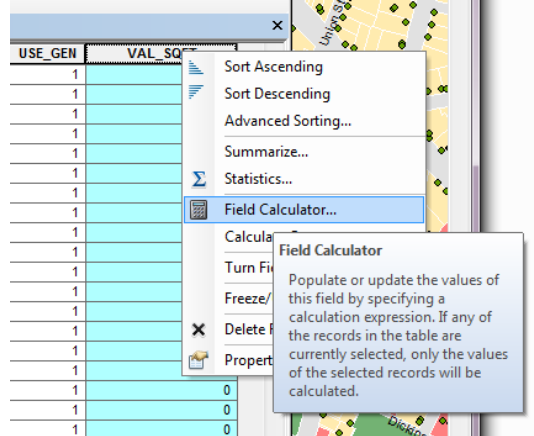
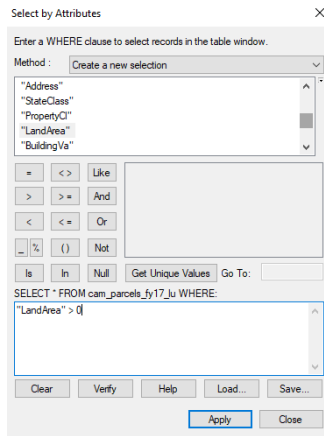
Important Note: Perform these sorts of table modifications on copies of your data, or on derived datasets, such as our LandUse file we created. Never do this on original data or shared datasets that might compromise the integrity of the original data. Once you perform a field calculation it cannot be undone.

3. Before calculating the values of the new field, we want to make sure that there are no land areas that have a value of zero. We are going to be dividing land value by land area, and if there is a value of zero in the denominator, our field calculation will stop and not fully complete filling out the field – because you cannot divide by zero. Create a query (by choosing “Select By Attribute” in the above menu) that will select all rows where

LandArea is greater than 0 (“LandArea” > 0). You will see the selected rows highlighted in light blue.

While in theory there should be no parcels with zero area, many cities code condominiums, apartments, and suites with this value as they are within a building and already counted elsewhere. Zeros might also exist in error.

Select all parcels with LANDAREA > 0.



4. Right click on the header of your new column. We are going to use the Field Calculator to write a formula to populate our new VAL_SQFT field for the selected rows. Select Field Calculator.

Click OK to perform the calculation outside of an editing session.

Click on the header then on Field Calculator

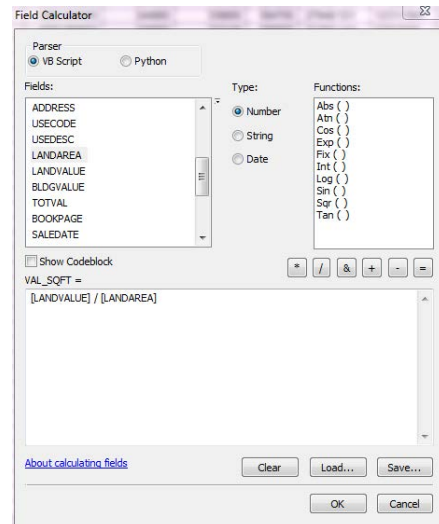
4. In the field calculator, we write our formula. Divide LandValue by LandArea – we want to populate the field with the quotient. You can select the fields by double clicking on them in the Fields window of the dialog.

$$\text{VAL_SQFT} = [\text{LandValue}] / [\text{LandArea}]$$

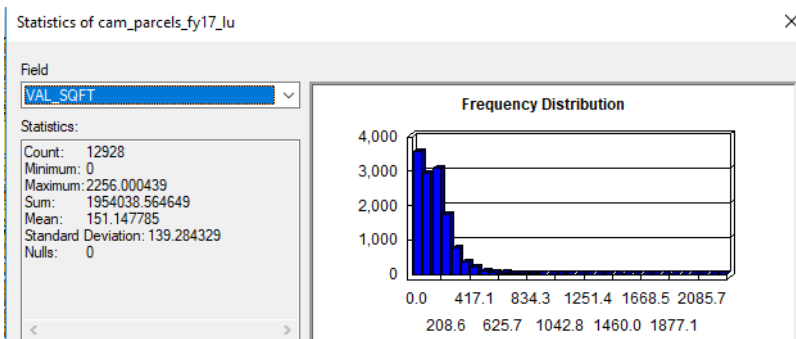
Click OK, our field will begin to populate with value of the formula we specified in our Field Calculator.

5. Clear your selection using Table Options -> Clear Selection.

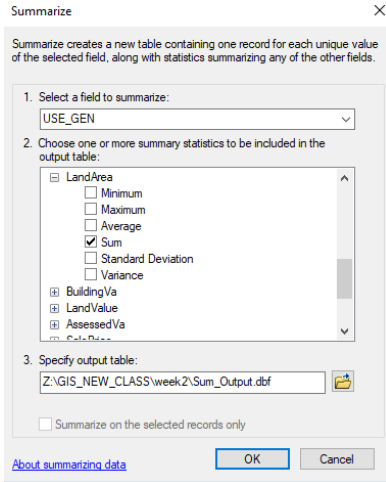
6. Right click on our newly calculated VAL_SQFT field and select **Statistics**. This will give a quick look at the summary statistics for our field. You can view the count, minimum, maximum, and mean, among other statistics, for the field.



Use the formula $\text{VAL_SQFT} = [\text{LANDVALUE}] / [\text{LANDAREA}]$



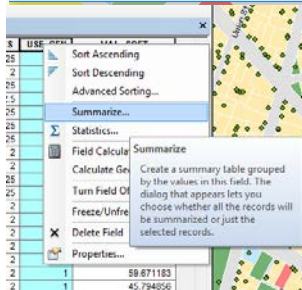
Right click to open the Statistics to review a quantitative summary of the data.



OBJECTIVE 6: GROUPING

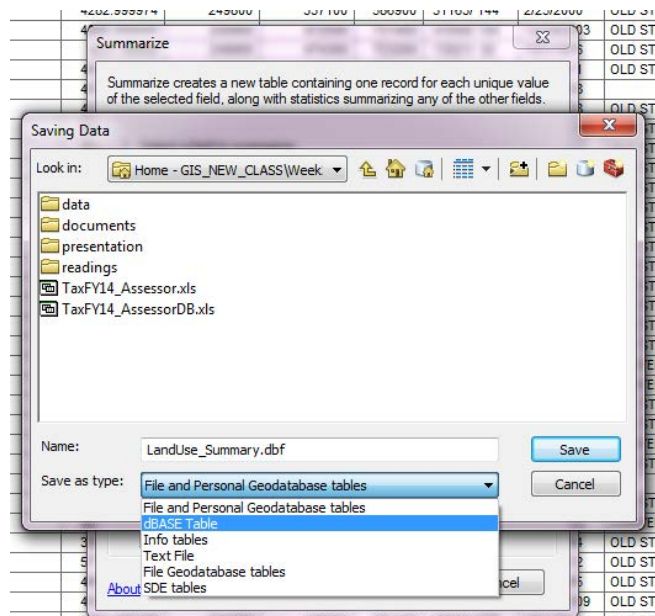
We have seen some basic summary stats, now we are going to try grouping. We want to take a look at our *cam_parcels_fy18_lu.shp* file and determine how many parcels are classified as each type. For example, how many parcels are classified as Residential? To do this, we use grouping.

1. Open up the Attribute Table again for *cam_parcels_fy18_lu*. Right click on USE_GEN, which contains our generalized land use codes. Select Summarize.



From the Attribute Table right click on the USE_GEN field and select Summarize.

2. Summarize will group our data. We want to group based on the value in USE_GEN. In the Choose one or more summary statistics section of the dialog window, navigate to LandArea and check Sum. This will include the sum of land area in our output table. In the Output Table window, name the *LandUse_Summary*, and make sure you save it as type 'dBase Table'. Save this file to your week's workspace.



Click OK to run. Add your results to your map document when complete.

Table				
LandUse_Summary				
	OID	USE_GEN	Count_USE_GEN	Sum_LandArea
▶	0	0	542	8817842
	1	1	10702	58670924
	2	3	754	15948987
	3	4	145	7444587
	4	9	785	47955557

4. Open up your resulting table we just named *LandUse_Summary*. In here you will see a summary of the parcel land uses and their area for the City of Cambridge.

What does this summary tell us?

In this in-class exercise, we performed some joins, queries, and basic calculations. You will use these principles in your take home exercise.

Review the result of the field calculations under Sum_LANDAREA.

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11.205 Introduction to Spatial Analysis
Fall 2019

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