Getting Started with (Q)GIS

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UNC School of Government
Philip McDaniel, GIS Librarian (philip_mcdaniel@unc.edu)

OVERVIEW & PURPOSE

The goal of this workshop is to give a gentle introduction to geographic information systems (GIS), providing both a theoretical background on GIS, and hands-on instructor-led tutorials that focus on urban planning applications. Today, we'll walk through a set of exercises that will culminate in the creation of a sample map showing proposed future land use for Chapel Hill, NC.

OBJECTIVES

1. By the end of the today, attendees will be able to:
    a. Identify appropriate spatial datasets for planning applications
    b. Identify appropriate tools within GIS for the preparation of planning data
    c. Use desktop GIS software to perform basic processing and analysis of spatial data
    d. Use desktop GIS software to design and create maps
    e. **Note that *italicized* exercises are optional, and won't be covered in detail today

MATERIALS NEEDED

1. QGIS 3.16 (or later: https://qgis.org/en/site/forusers/download.html)
2. Sample spatial datasets (this will be provided via Sakai)

GENERAL OVERVIEW

Below are a few tips and pointers for getting oriented and acclimated to QGIS.

1. Projects (.qgz)
    a. What are they?
    b. Why/how should you use them?
2. Navigation
    a. Zoom, pan, select features, identify, previous extent, etc.
3. Panels
    a. Docked shortcuts for common activities
        i. Layers, Processing, Identify, etc.
    b. Right-click to access
4. Tools
    a. Add toolbars along the top (right-click to access)
        i. Recommended toolbars: Manage Layers, Attributes, Map Navigation, Selection, Digitizing, Snapping
    b. Add Processing Toolbox as a panel
        i. Deeper set of tools
        ii. GDAL, OGR, GRASS
        iii. Recommended panels: Identify, Layers, Processing Toolbox
5. Add-in functionality
    a. Plugins for specialized tasks
        i. Plugins -- Manage and Install Plugins…)
    b. QuickMapServices (QMS)
        i. Stamen, Open Street Map, Esri World Topo
6. Map Composer (more on this later)
7. Accessing data- vector, raster, tables, web resources
    a. When adding files, note the projection- Neighborhoods.shp
8. Layering
    a. QGIS doesn't automatically stack layers (i.e. points over polys)
    b. Features can get hidden
9. Accessing attributes
    a. Click the "Identify Features" icon
    b. Open the attribute table for a dataset

DISPLAYING SPATIAL DATA

Once you're comfortable with the QGIS interface, you're ready to start viewing, visualizing, and interacting with your data! There are several ways to do this, ranging from very simple to complex (we'll stick to the more basic techniques today). Below are a few tips and pointers for getting oriented and acclimated to QGIS.

1. In the table of contents, Right-click a layer -- Properties… -- Symbology
2. Single Symbol
    a. Features aren't differentiated
    b. Example: Streets_Orange_County.shp
3. Categories
    a. Add categories, then customize individual symbols
    b. Categorized -- Value (dropdown) -- Classify (toward the bottom)
    c. Example: Stream types (**Streams_Chapel_Hill.shp**)
        i. FeatureTyp, TownFlowTy
    d. Example: Zoning categories (**Zoning_Districts.shp**)
        i. ZONING, ZONING_AGG
    e. Example: Street types (**Streets_Orange_County.shp**)
        i. Symbology
            1. Arterial, Collector, HWY Ramp, Interstate Ramp, Local, Major, NC HWY, US HWY
    f. Can turn off classes from the Symbology menu or the table of contents
4. Categories by Expression
    a. Categorized -- Sigma Icon -- Classify (toward the bottom)
    b. Example: Flood zones (Flood_Hazard_Areas_Orange_County.shp)
        i. concat(ZONE_LID_V,'_',ZONESUB_LI)
    c. Allows for more complex categorization
    d. Can adjust the opacity from the bottom of the Symbology menu
        i. Layer Rendering -- Opacity slider
5. Graduated
    a. Style continuous variables using color gradients
    b. Graduated -- Value (dropdown) -- Color ramp -- Mode (dropdown) -- Classify
    c. Example: Parcels_Corporate.shp
        i. YEARBUILT
    d. Can turn off classes from the Symbology menu or the table of contents
6. Fill textures and outlines
    a. Highlight/differentiate based on style

    b. Example: Zoning_Overlays.shp
        i. Single symbol -- All Symbols -- Choose a style -- Diagonal hash (hashed black /)
    c. Example: Corporate_Limits.shp
        i. Single symbol -- Simple Fill -- choose Fill color, Stroke color, Stroke width, and Stroke style
        ii. Thick (dashed) outline
7. Grouping Features
    a. Give the same color/texture to different classes
    b. Edit the legend values
        i. Clean up the names (e.g. R-1 == Light Residential)
    c. Example: Zoning categories (Zoning_Districts.shp)
        i. ZONING
        ii. Ctrl/Shift to select similar classes -- right-click -- Change color…

SELECTING SPATIAL DATA

QGIS offers a number of ways to select data. Often the spatial data that you identify and acquire won't match your needs in terms of geographic extent and what it includes. For example, you download a layer that includes parcels for an entire county, but you only need the parcels within your municipality. Or, you have a road layer that includes a variety of road classes, but you're only interested in major roads. In these situations, you may want to simply filter the data in QGIS and only show features of interest, or you may want to derive new datasets that you can reuse. Using the tools and techniques below you'll learn how to make data more appropriate for your purposes.

1. By querying a layer
    a. From the layer Properties -- Source -- Query Builder
    b. Enter a SQL expression to select features that match your query
        i. Example: **Parcels_Corporate.shp**
        ii. Select parcels that are not locally owned
            1. "CITY" != 'Chapel Hill' OR "CITY" != 'CHAPEL HILL'
        iii. Example: **Streams_Chapel_Hill.shp**
            1. "FeatureTyp" IN ('CULVERT','DITCH','LAKE FLOWLINE','NO CHANNEL','STREAM','STREAM CENTERLINE','UNKNOWN')
            2. Using selection from a list is advised when you have many values to select
            3. Optionally, you can export this as a new Shapefile
                a. Right-click -- Export -- Save Features As…
                b. ESRI Shapefile -- c:\data**stream_sub.shp** (e.g.)
2. Using the selection tools
    a. From the Selection toolbar (icon with yellow box and white arrow), interactively draw shapes (boxes, polygons, freehand) to select features of interest
        i. Example: **Flood_Hazard_Areas_Orange_County_WGS84.shp**
        ii. Use Select Feature(s) to select only the flood areas within Chapel Hill's corporate limit
        iii. Drag a box- it doesn't have to be perfect!
            1. Optionally, you can export this as a new Shapefile, and specify a new projected coordinate system
                a. Right-click -- Export -- Save Selected Features As…
                b. ESRI Shapefile -- c:\data**CH_Flood.shp** (e.g.)
                c. CRS -- EPSG:2264 - NAD83 / North Carolina (ftUS)
3. By Location
    a. Select water polygons that intersect Chapel Hill's corporate limits

    b. Example: **Hydro_Polygons.shp** & **Corporate_Limits.shp**
    c. Vector -- Research Tools -- Select by location
        i. Select features from: **Hydro_Polygons.shp**
        ii. Where the features (geometric predicate): intersect
        iii. By comparing to the features from: **Corporate_Limits.shp**
        iv. Modify current selection by: creating new selection
    d. Optionally, you can save the selected polygons as a new Shapefile
4. Interactively
    a. You can also select interactively from the attribute table by selecting a single row or multiple rows
    b. Select, then hold Ctrl for single selections or Shift for a range of records
    c. Example: **Neighborhoods.shp**
        i. Select Deerwoods, Ridgefield, Briarcliff, and Colony Woods (these four compose my greater neighborhood!)
        ii. Optionally, you can export this as a new Shapefile

ADDING ATTRIBUTES & CREATING SPATIAL DATA

While it can be relatively easy to find existing spatial data layers that meet your needs, data that someone else created won't necessarily have the attributes (aka fields or variables) that you need. For example, if you need to keep track of when edits were made to a parcel layer, or if you need to add a field to simplify zoning categories. To do this, you will need to add and populate these new fields.

Similarly, it's often the case that the layer you need isn't available or doesn't exist. For example, a proposed new road, or the boundaries for a proposed new development. In these instances, it will be necessary to create the new features so that you can integrate them with your other datasets.

Fortunately, QGIS includes tools and functionality that allows for the creation of attributes, as well as for the creation of new point, line, and polygon features. In addition, QGIS can also be used to edit and modify existing features. The following exercises will demonstrate some of the core functionality.

1. Adding Fields
    a. What type of data are you trying to store? Numeric or String?
        i. Numeric: Integer (whole) and Decimal
            1. The level of precision you need will determine the choice: decimal numbers include decimal precision (e.g. 50.25), while integers/whole numbers do not (e.g. 50)
        ii. Text: Strings
            1. E.g. Names, Descriptions, Land Use
    b. Example: **Zoning_Districts.shp**
        i. For this example, we will add a field to test out a hypothetical scenario where we increase the areas zoned for Commercial in Chapel Hill.
        ii. Open the attribute table for the zoning districts, and **Create a new field** (text, with a length of 10) called **Scenario_A** to hold the zoning categories for our scenario.
            1. In the expression window to the left, enter ZONING_AGG. This will copy the values from the **ZONING_AGG** field to our new field so that we can modify the existing values (rather than keying in new values from scratch).
        iii. Click the **Select features using an expression button** (icon with the sigma over a yellow box)
            1. In the dialog that pops up, enter the following:
                a. scenarioA = 'CU RES'
        iv. Click the abacus icon to open the field calculator
            1. Notice that the **Only update selected features** box in the

upper left is checked.
2. Check Update existing field and choose **Scenario_A**
3. Enter 'Commercial' in the expression window to the left

v. Once the values for the 'CU RES' are reassigned to 'Commercial', you can style this layer using **Scenario_A** as the value to see what the town would look like if this change were to be made.

c. Example: **Streets.shp**

i. Open the attribute table for the streets, and click the abacus icon to **Create a new field** (text field, with a length of 10) called **Type_Agg** to hold the collapsed/simplified categories for the streets ('Other', 'Highway', 'Major', and 'Minor'). In the expression window to the left, enter two single quotes (' ').

ii. Select the groups as follows, and update the existing field **Type_Agg**

1. Right-click -- Properties… -- Source -- Query Builder
    a. "Symbology" IN ('Alley','Arterial','Gravel Path','Trail')
    b. These are the categories for 'Other' roads
2. Open the attribute table and click the abacus icon to open the field calculator
    a. Check Update existing field and choose **Type_Agg**
    b. Enter 'Other' in the expression window to the left
3. *Follow these steps again for each of the other three categories*
    a. 'Highway': "Symbology" IN ('Interstate','Interstate Ramp')
    b. 'Major': "Symbology" IN ('Major','NC HWY','US HWY','HWY Ramp')
    c. 'Minor': "Symbology" IN ('Local','Private','PRIVATE','Collector','Minor Collector')

iii. Once the new field is added, we can more easily style the roads with varying line thicknesses and colors

2. Creating features - Polygons

a. For the first exercise, we'll create **polygons** showing hypothetical land use categories in Chapel Hill.

b. Layer -- Create Layer -- New Shapefile Layer…

i. File Name: c:\data**Land_Uses.shp**

ii. Geometry type: Polygon

iii. CRS: EPSG: 2264 - NAD83 / North Carolina (ftUS)

iv. Fields List:

1. **LandUse** -- Text Data -- 20 length -- Add to Fields List
    a. This will be the field that is used to hold the name for the land use categories
2. **Area** -- Decimal Number -- 20 length -- Add to Fields List
    a. Note that decimal numbers decimal precision (e.g. 50.25), while whole numbers do not (e.g. 50)
3. **Perimeter** -- Decimal Number -- 20 length -- Add to Fields List
4. Note that you can add fields now, or when you start digitizing

c. Right-click the new layer -- Toggle Editing
d. From the Snapping toolbar, click the magnet icon to enable snapping. This will allow your digitized features to fit together in a more organized/cleaner way.
e. From the Digitizing toolbar, click the pencil icon to start digitizing
    i. Left click to add nodes
    ii. Right click to stop digitizing
    iii. From the popup window, fill in the name of the feature
    iv. Repeat this process for as many polygons as you'd like. For this exercise, let's plan on adding at least 10-15, including at least one for each land use category.
f. Now we will update the area and perimeter fields so that we have a better sense of the size of the new development
    i. Right-click to open the attribute table of the new polygon
    ii. Click the abacus icon
        1. Check Update Existing Field -- Area
        2. In the expression window to the left:
            a. Enter **$area*10.764** to calculate the area in square feet
            b. Enter **$area** to calculate the area in square meters
            c. Enter **$area/4047** to calculate the area in acres
        3. Repeat this to calculate the perimeter (Update Existing Field -- Perimeter)
        4. In the expression window to the left:
            a. Enter **$perimeter*3.281** to calculate the perimeter in feet
            b. Enter **$perimeter** to calculate the perimeter in meters
g. ****As a general rule, any time you get data from someone else, or when you're manipulating data, it's highly recommended that you add a new field to recalculate the geometry fields (area and perimeter). GIS data**

can get messy/cluttered with extraneous attributes, and it's not always clear what units they're using, or if the geometry fields are accurate.

3. Creating features - Lines
    a. For the next exercise, we'll create a **line** showing the location of a hypothetical proposed new street Chapel Hill.
    b. Layer -- Create Layer -- New Shapefile Layer…
        i. File Name: c:\data**New_Road.shp**
        ii. Geometry type: Line
        iii. CRS: EPSG: 2264 - NAD83 / North Carolina (ftUS)
        iv. Fields List:
            1. **Name** -- Text Data -- 20 length -- Add to Fields List
            2. **Length** -- Decimal Number -- 20 length -- Add to Fields List
            3. **Speed** -- Whole Number -- 5 length -- Add to Fields List
    c. Right-click the new layer -- Toggle Editing
    d. From the Digitizing toolbar, click the pencil icon to start digitizing
        i. Left click to add nodes
        ii. Right click to stop digitizing
        iii. From the popup window, fill in the name of the feature
    e. Now we will update the length field so that we know how long the new corridor will be.
        i. Right-click to open the attribute table of the newly digitized line
        ii. Click the abacus icon
            1. Check Update Existing Field -- **Length**
            2. In the expression window to the left:
                a. Enter **$length*3.281** to calculate the length in feet
                b. Enter **$length** to calculate the length in meters
                c. Enter **$length/1609** to calculate the length in miles
        iii. Click the abacus icon again to add a value for the **Speed**
            1. Check Update Existing Field -- **Speed**
            2. In the expression window to the left:
                a. Enter 35 (for example)

GEOPROCESSING GRAB BAG

After you've gotten familiar with the basics of QGIS, you'll be ready to start using some of the more sophisticated functionality that GIS provides to derive new layers from existing datasets. In the following exercises, we'll look at a few common geoprocessing tools in QGIS: buffer, clip, intersection, and dissolve. The techniques are conceptually fairly simple, but quite powerful in terms of the insight and information that they can add to your analyses. Keep in mind that these are but a few of the dozens of tools that are included in QGIS.

To start, we will very quickly cover Clip, Buffer, and Dissolve. However, in the exercises that follow the quick introduction to these three tools, you will be given a more in-depth look at some of the core geoprocessing tools in GIS.

1. Clip -- Buffer -- Dissolve
    a. In this exercise, we'll run three tools in sequence to create an output dataset that shows the areas within 50 feet of a stream in Chapel Hill. We'll start with a stream layer that includes features outside of Chapel Hill's municipal boundaries, clip this to the extent of Chapel hill, buffer those features to 50 feet, and then dissolve the buffered stream to end up with a polygon layer containing a single feature- areas in the 50 foot riparian buffer.
    b. Example: **Streams.shp** & **Corporate_Limits.shp**
    c. Vector -- Geoprocessing Tools -- Clip…
        i. Clip **Streams** by **Corporate Limits**, and save the output as a temporary layer (it will be called **Clipped**)
    d. Vector -- Geoprocessing Tools -- Buffer…
        i. Buffer the **Clipped** streams to a distance of 50 feet, and save the output as a temporary layer (it will be called **Buffered**)
    e. Vector -- Geoprocessing Tools -- Dissolve…
        i. Dissolve the interior boundaries of the **Buffered** streams, and save the output as a temporary layer (it will be called **Dissolved**)
2. *Buffer*
    a. *The Buffer tool allows you to create polygons of a defined radius around the features of an input dataset. This tool can be particularly useful in planning applications. In this example, we'll generate buffers of 50 feet around the streams in Chapel Hill.*
    b. *Example:* ***Streams_Chapel_Hill.shp***
    c. *Vector -- Geoprocessing Tools -- Buffer…*
        i. *Input:* ***Streams_Chapel_Hill.shp***

ii. *Distance: 50 feet*
iii. *Dissolve result: Check this (more on dissolve soon!)*
iv. *Buffered: c:\data**Streams_50ft.shp***

d. *We can now see the riparian areas in Chapel Hill that are in close proximity to streams, which may indicate places where development isn't allowed. In order to get a more accurate sense of the total size that the 50 foot buffer covers, we can calculate the area.*
e. *Click the abacus icon*
   i. *Check Create a new field*
      1. *Output field name: areaAcres*
      2. *Output field type: Decimal number (real)*
   ii. *In the expression window to the left:*
      1. *Enter **$area/4047** to calculate the area in acres*
f. *Optionally, if we want to determine the percentage of Chapel Hill's corporate limits that falls in the 50 foot riparian buffer, we can add an area field to the **Corporate_Limits.shp** file to calculate the acreage.*
   i. *Click **Corporate_Limits.shp** in the table of contents*
   ii. *Click the abacus icon*
      1. *Check Create a new field*
         a. *Output field name: areaAcres*
         b. *Output field type: Decimal number (real)*
      2. *In the expression window to the left:*
         a. *Enter **$area/4047** to calculate the area in acres*
g. *Now, if you divide the riparian acreage by the corporate acreage, then multiply by 100, you'll know the percent of Chapel Hill's area that is in the riparian buffer:*
   i. *(2156.95/13918.50)*100 = 15.49%*

3. *Clip*
   a. *The Clip tool works like a cookie cutter, clipping out the features (points, lines, or polygons) from one layer by the polygon features from another layer. In this example, we'll use the Chapel Hill corporate limits file to clip out the flood hazard areas within town limits.*
   b. *Example: **Corporate_Limits.shp & Flood_Hazard_Areas_Orange_County.shp***
   c. *Vector -- Geoprocessing Tools -- Clip…*
      i. *Input layer: **Flood_Hazard_Areas_Orange_County.shp***
      ii. *Overlay layer: **Corporate_Limits.shp***

iii. *Clipped: c:\data**Flood_Hazard_Areas_Chapel_Hill.shp***

d. *We now have a dataset that shows only the flood hazard areas in Chapel Hill. As above, it's always a good idea to update the polygon areas since many of the input polygons will have been split by the overlay layer.*

i. *Click **Flood_Hazard_Areas_Chapel_Hill.shp** in the table of contents*

ii. *Click the abacus icon*

1. *Check Create a new field*

a. *Output field name: areaAcres*

b. *Output field type: Decimal number (real)*

2. *In the expression window to the left:*

a. *Enter **$area/4047** to calculate the area in acres*

4. *Intersection*

a. *The Intersection tool (also known as Intersect) is an overlay tool that operates like a Venn Diagram, returning the area of intersection between two layers. In this example, we will intersect the building footprints in Orange County and the zoning districts in Chapel Hill. The result will allow us to get an estimate of the square footage of buildings within each zoning category.*

b. *Example: **Building_Footprints_New.shp & Zoning_Districts_Corporate.shp***

c. *Vector -- Geoprocessing Tools -- Intersection…*

i. *Input layer: **Building_Footprints_New .shp***

ii. *Overlay layer: **Zoning_Districts_Corporate.shp***

iii. *Intersection: c:\data**Buildings_per_Zone.shp***

d. *The output for this will contain all of the building footprints that fall within the zoning districts in Chapel Hill, with separate records for the portions of buildings that fall within multiple zoning categories. For example, if a building straddles low density and medium density residential zoning types, a separate polygon will exist in the output intersection file for the low density and the medium density portion. Since some of the buildings were split, as above, it's a good idea to update the polygon areas.*

i. *Click **Buildings_per_Zone.shp** in the table of contents*

ii. *Click the abacus icon*

1. *Check Create a new field*

a. *Output field name: areaSqFt*

b. *Output field type: Decimal number (real)*

2. *In the expression window to the left:*

a. *Enter **$area*10.764** to calculate the area in square feet*

5. *Dissolve*
    a. *The Dissolve tool simplifies an input dataset by removing internal boundaries between features that have common attributes. In addition, Dissolve is often used to combine all features from an input dataset, as we saw above when we dissolved the 50 foot stream buffers. For this exercise, we'll run Dissolve twice- once to remove the boundaries between identical flood hazard areas, and once to remove the boundaries between identical zoning categories.*
    b. *Example:* ***Flood_Hazard_Areas_Chapel_Hill.shp***
    c. *Vector -- Geoprocessing Tools -- Dissolve…*
        i. *Input layer:* ***Flood_Hazard_Areas_Chapel_Hill.shp***
        ii. *Dissolve field(s) [optional]:* ***Zone_LID_V*** *&* ***ZONESUB_LI***
        iii. *Dissolved: c:\data****Flood_Areas_Dissolved.shp***
    d. *We now have a layer showing the flood areas and subareas in Chapel Hill, with all of the internal panel boundaries removed. This layer can be styled following the instructions above (#4 in the first set of exercises).*
    e. *Example:* ***Zoning_Districts_Corporate.shp***
    f. *Vector -- Geoprocessing Tools -- Dissolve…*
        i. *Input layer:* ***Zoning_Districts_Corporate.shp***
        ii. *Dissolve field(s) [optional]:* ***ZONING_AGG***
        iii. *Dissolved: c:\data****Zoning_Dissolved.shp***
    g. *We now have a more simplified version of the zoning categories in Chapel Hill. Rather than having the boundaries between common zoning categories in contiguous areas being shown, we see these similar areas as a single region (e.g. central eastern Chapel Hill). Moreover, regions with the same zoning category are treated as the same record in the dissolved output, making the dataset easier to work with.*
    h. *Another step that is advised is to recalculate the areas for the dissolved zoning categories so that we can determine more precisely the acreage per zone in Chapel Hill.*
        i. *Click* ***Zoning_Dissolved.shp*** *in the table of contents*
        ii. *Click the abacus icon*
            1. *Check Create a new field*
                a. *Output field name: areaAcrNew*
                b. *Output field type: Decimal number (real)*
            2. *In the expression window to the left:*
                a. *Enter* ***$area/4047*** *to calculate the area in acres*
    i. *Lastly, in order to make the categories more intuitive, we can use the*

guidelines in this file to assign appropriate colors to the zoning categories: https://planning-org-uploaded-media.s3.amazonaws.com/document/LBCS.pdf (page 4, also pasted below). Generally speaking, we will use

i. *Yellows and oranges for residential*
ii. *Reds for commercial*
iii. *Blues for office/institutional*
iv. *Purple for industrial*
v. *See this link for an example map from Chapel Hill: https://tinyurl.com/4y6r72s2*

Land-Based Classification Standards 01-Apr-2001

LBCS Color Codes for 1-Digit Level Coding

Activity

Red, Green, Blue Values	Color*	LBCS Code	
RGB(255,255,0) RGBHex(FF00FF)	yellow	1000	Residential activities
RGB(255,0,0) RGBHex(FF0000)	red	2000	Shopping, business, or trade activities
RGB(160,32,240) RGBHex(A0F020)	purple	3000	Industrial, manufacturing, and waste-related activities
RGB(0,0,255) RGBHex(00FF00)	blue	4000	Social, institutional, or infrastructure-related activities
RGB(190,190,190) RGBHex(BEBEBE)	gray	5000	Travel or movement activities
RGB(47,79,79) RGBHex(2F4F4F)	dark slate gray	6000	Mass assembly of people
RGB(144,238,144) RGBHex(9090EE)	light green	7000	Leisure activities
RGB(34,139,34) RGBHex(22228B)	forest green	8000	Natural resources-related activities
RGB(255,255,255) RGBHex(FFFFFF)	white	9000	No human activity or unclassifiable activity

SUMMARIZING YOUR DATA

Once you've processed your data somewhat, it can be useful to summarize the results. For example, what's the total parcel area in your town? What percentage of the town's area is dedicated to commercial activities? What percentage of each zoning type is in a high flood risk zone? QGIS offers several tools that allow you to easily calculate aggregate statistics, as well as statistics for different categories.

1. *In the first example, we'll use **Show statistical summary** to determine the total parcel area and the mean parcel size in Chapel Hill.*
2. *Example: **Parcels_Corporate.shp***
3. *Click the Sigma symbol in the Attributes toolbar. Alternatively, you can activate the Statistics Panel.*
    a. *Select **Parcels_Corporate.shp** as the input*
    b. *Choose **SQFT** as the field to summarize*
    c. *You can optionally choose the statistics to include from the dropdown menu to the lower right, and copy the result to a clipboard (to paste into Excel, e.g.) from the clipboard icon at the bottom.*
4. *In the next example, we'll use **Statistics by categories** to calculate the total building footprint area per zoning category in Chapel Hill.*
5. *Example: **Buildings_per_Zone.shp***
6. *Activate the **Processing Toolbox Panel** and enter "Statistics by categories" in the search window, then double click to open the tool*
    a. *Input vector layer: **Buildings_per_Zone.shp***
    b. *Field to calculate statistics on (if empty, only count is calculated)[optional]: areaSqFt*
    c. *Field(s) with categories: ZONING_AGG*
    d. *Statistics by category: **Buildings_per_Zone_Summary_Stats.csv***
7. *The output text file shows you various statistics about the buildings per zoning type, including the count of buildings, the mean size of buildings, and the aggregate size of buildings, among others.*

CREATING MAPS

The final set of exercises today deal with making maps. QGIS offers robust, if initially somewhat confusing, functionality for creating digital and hardcopy maps. Maps can include a range of content, including styled data layers, core map elements (north arrow, scale bar, legend), graphs and tables, images, and text and graphic annotation. Maps can be exported to numerous raster (.png, .jpg, .tif, etc.) and vector (.pdf, .svg) formats.

1. From the main menu, Project -- New Print Layout… -- My_First_Map (e.g.)
2. You can adjust the settings for the layout from Layout -- Layout Properties…
    a. From the Layout tab to the right
        i. Adjust the output image specifications (e.g. dpi)
    b. Right-click -- Page Properties…, then from the Item Properties tab to the right
        i. Adjust the page size, including both standard page sizes (letter, A4), larger poster sizes (ANSI C, ARCH D), and custom sizes.
            1. Note: if you're planning to plot your map as a larger format (e.g. a poster), it is recommended that you set your page size to one of the poster sizes (ANSI E, e.g.) since it will look better when plotted. If you create a map as a smaller format (letter), then plot the map as a poster, the elements on the map will appear blurry/fuzzy.
    c. From the Guides tab to the right
        i. Insert horizontal and vertical guides to assist in aligning map elements
3. Items are added to layouts by dragging boxes, and then specifying the source for the content you want to add. To the left, you'll see icons for the most commonly added features, including maps (Add Map), images (Add Picture), legends (Add Legend), among others.
4. First, we'll add the map that we've been working on today.
    a. Add Item -- Add Map, and drag a box that covers roughly the ⅔ of the page.
    b. If the map isn't oriented on your content the way you'd like, you can click the **Move item content** icon from the left (it looks like a piece of paper with arrows pointing in the cardinal directions), then either pan around in the map or roll the mouse wheel to zoom in and out.
    c. Note that there is a dynamic link between the features on your map and the way that they are displayed on the layout. For example, if you go to the map and turn off a layer, the layer will also be turned off in the layout

d. Let's display the potential future land use categories from the polygon layer **Land_Uses.shp** that we created above. Take a few minutes to add appropriate colors for the land uses you created, keeping in mind that you can always change these later.
    i. Labels can be added to the layer, as well. From the QGIS map, double-click the zoning districts -- Properties… -- Labels, and choose **LandUse** as the Value. You can adjust the size, color, opacity, and other styles from the Text menu.
    ii. Other settings pertaining to the placement can also be set from the Placement menu. Settings include placement location, overlapping labels, orientation, buffering/offsets, as well as others.
    iii. Keep in mind that label placement can be a major headache, and you may never be satisfied with how the labels are placed. An alternative to bulk adding labels in this way is to be more intentional about labelling, and instead add labels to a more targeted set of features as text annotation (discussed below).

*e. Let's display the zoning categories for our hypothetical **Scenario_A** from the **Zoning_Districts.shp** layer. Take a few minutes to add appropriate colors to the zoning categories, keeping in mind that you can always change these later!*
    i. Labels can be added to the layer, as well. From the QGIS map, double-click the zoning districts -- Properties… -- Labels, and choose ZONING_AGG as the Value. You can adjust the size, color, opacity, and other styles from the Text menu.
    ii. Other settings pertaining to the placement can also be set from the Placement menu. Settings include placement location, overlapping labels, orientation, buffering/offsets, as well as others.
    iii. Keep in mind that label placement can be a major headache, and you may never be satisfied with how the labels are placed. An alternative to bulk adding labels in this way is to be more intentional about labelling, and instead add labels to a more targeted set of features as text annotation (discussed below).

f. Also add the following layers:
    i. **Streets.shp**, styling them based on the simplified **Type_Agg** field that we added earlier. Generally speaking, make the more major roads thicker and the minor roads thinner.
    ii. **Buffered** streams, the polygon that represents our 50 foot riparian

buffers, styling this layer with a thick outline and hashing.

iii. Add any other layers that you'd like to see, as well, such as:
    1. building footprints (**Building_Footprints_New.shp**), with ~50% opacity set so that they don't dominante the map
    2. *flood risk areas (**Flood_Areas_Dissolved.shp**), also with a 50% opacity set*

5. Next, we'll add the legend
    a. Add Item -- Add Legend…, and drag a box in part of the empty area on the layout
    b. Once added, you can click the legend to adjust the settings under Item Properties (to the right):
        i. Check **Auto update**
        ii. Check **Only show items inside the linked map** (this will remove items in your table of contents that aren't visible on the map
        iii. Under **Columns**, change the **Count** to 2, and check **Split layers**. This will prevent your legend from getting too long vertically, since it will split the land use categories across 2 columns
        iv. Under **Fonts and Text Formatting -- Item Labels**, you can change the font size and color
        v. Under **Spacing**, you can adjust spacing among your various elements (e.g. the spacing between symbols and their labels)
        vi. Check **Frame** and **Background** if you'd like to specify a wireframe and background color for your map
6. Other elements to add include a scale bar, a north arrow, a title, and any credits (date, creator or department's name, etc.) that you'd like to include:
    a. Add Item -- Add Scale Bar, and drag a short and wide box. Under Item Properties, you can:
        i. Adjust the Style (boxes, tick marks, etc.)
        ii. Adjust the Scalebar units
        iii. Adjust the number of segments and the width
            1. Warning: this may be the most frustrating thing that you'll do in QGIS. My general advice is:
                a. Set the units (miles, e.g)
                b. Choose a **Fixed width**, or scalebar interval, that works well for your map (.5 is half a mile)
                c. Adjust the number of segments to the left and/or right so that the scalebar fills the space you want to fill. If

you specify 1 for the left and 2 for the right, your scalebar will have three .5 mile segments.

   b. Add Item -- Add North Arrow, and drag a small box for the arrow. The included options are limited for the style, but you can see the handful to choose from under Item Properties to the right (**SVG image -- SVG Groups -- App Symbols -- arrows**)
   c. Add Items -- Add Label, and drag a large box at the top of the map, and then a short and wide box toward the bottom of the map. Under Item Properties, you can:
      i. Add descriptive text ("LAND USE MAP FOR CHAPEL HILL", "This map was made by Philip McDaniel for a workshop")
      ii. Adjust the font size and color
      iii. Add a wire frame and background color
7. Adding photos and other graphics to your map can make it a more compelling visual, turning it into more of an informational poster than just a basic map.
   a. Add Item -- Add Picture, and drag a smallish box in some of the remaining empty space
   b. Under Item Properties -- Picture -- Raster Image, navigate to the folder containing today's materials, and choose the low density residential picture (**Low_Density_Residential.png**).
   c. Repeat this step for the high density residential picture (**High_Density_Residential.png**)
   d. If you'd like to add captions under the photos, you can do this with Add Items -- Add labels
8. You may also want to highlight a specific area on your map/poster to include as an inset. To do this, you must first lock the first map you created so that any changes to the content and extent that you make for your second map don't override the settings for the first map.
   a. In the upper right under **Items**, check the box to the left of Map 1 under the padlock icon.
   b. In addition, under Item Properties for Map 1, check the box to the left of **Lock layers** under **Layers.** This will prevent this map from being altered once we add the inset map.
   c. Add Item -- Add Map, and drag a small-medium box in the remaining empty space
   d. Click **Move item content** to the left and click the inset map you just added. Roll the mouse wheel to zoom into the proposed **New_Development.shp**

layer.

e. If you want to exclude any layers that are on your larger map, or include any layers that weren't on your larger map, you can do this now by going back to the map in QGIS. For example, you may want to include parcel outlines (from **Parcels_Corporate.shp**) on the inset map to get a better sense of how the development may affect existing properties.

9. Finally, you're ready to export your map! You can export maps as raster or vector files. When exporting as a PDF (Layout -- Export as PDF…), you can leave the defaults. For raster formats, you have a few options:
    a. Layout -- Export as image… -- give the file a name and output location
    b. Specify a resolution of at least 500 dpi, and click **Save**