GEOSPATIAL INNOVATION FACILITY
Cutting-Edge Mapping Technology at UC Berkeley

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INTRODUCTION TO QGIS

This exercise is designed to familiarize you with some basic concepts and capabilities of QGIS. You will explore the abilities of QGIS to visualize, navigate, manipulate, and analyze geographic datasets. To download the application, visit http://qgis.org.

Specifically, you will learn how to:

- Create a map project
- Add layers to your project
- Display data to your specifications (e.g. colors, symbols, line weights)
- Navigate the data using the zoom, pan, and full extent tools
- Identify features and their attribute data
- Query the map based on your criteria
- Create Buffers around points
- Create a map layout

In order to explore these concepts, we will use the datasets listed below to select the best locations for community sponsored produce stands. In our imagined scenario, the City of Berkeley has assigned you with the task of identifying lower income communities with limited access to fresh fruits and vegetables. The City would like to identify five civic buildings that are in close proximity to these neighborhoods and place weekly produce stands on their property. Therefore, your final product will be a map depicting the location of these potential sites and their service areas.

Dataset

You will be working with several data layers from different sources. Note that a layer is comprised of several different files with the same name and different extensions. All these files of the same name must be in a folder together for the software to read them. The data you will be using for this exercise can be found in **https://github.com/nethomas-geo/QGIS-Training/data.zip.** Please download the data to your laptop and save your work as you proceed through the exercise.

Berkeley_dem.tif – a raster "digital elevation model" displaying elevation for the City of Berkeley and surrounding areas.
Berkeley_shd.tif – a raster grid file displaying shaded relief based on elevation.
BerkeleyBlockGroups.shp – polygons containing demographic information for census block groups
Fruit_Vegetable_and_FarmersMarkets.shp – shows point locations for fruit and vegetable markets, as well as Farmers Markets
BerkeleyLimits.shp – polygon of city boundary
County.shp – polygon of Alameda and Contra Costa Boundaries.
PublicSites.shp – point locations of public buildings, institutions, and churches. This layer was created by combining three shapefiles and removing buildings on the Cal campus.

*** Note that all data layers are in the following projection:**
Projection: Universal Transverse Mercator (UTM)

Datum: North American Datum 1983 (NAD83), Zone: 10 North

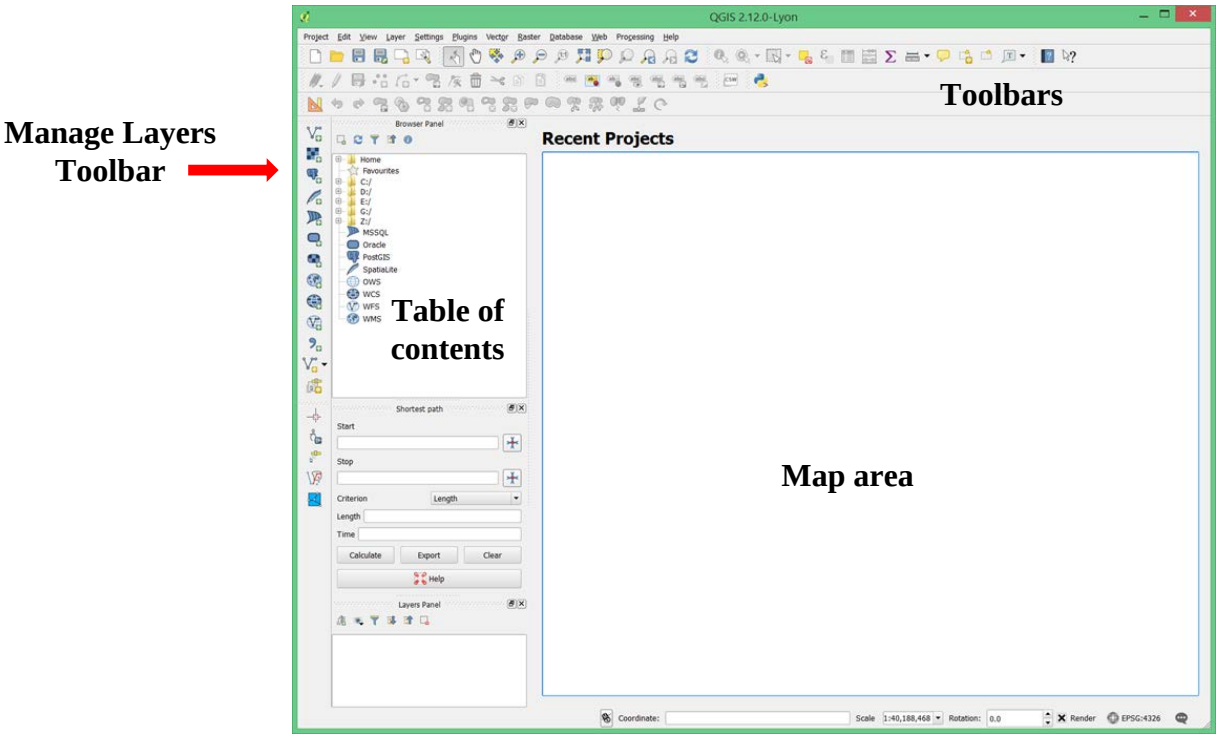
Display Data

In this section you will add layers to your map project and change their display properties.

Add Data

1. Open QGIS by going to ***Start > All Programs > QGIS > QGIS Desktop***

   When the program opens, you can see that much like ArcGIS/ArcMap, there is a Map area, Table of contents, Overview map area, and Toolbars.



Find the "Manage Layers" toolbar on the left side of the project window (see above). This is where you add data. There is a separate button for VECTOR, RASTER, GEODATABASE, and WEB MAPPING SERVICE data. You can also access each of these tools under the "Layer" menu.

2. Go to *Layer > Add Vector Layer* or Click on the *Add Data* button: 

3. Click the *Browse* button, then navigate to the folder where you saved the data. The folder's many contents should appear in the window.

4. Click on the bottom right of the window and change the File Type to ESRI Shapefile and then add all of the shapefiles to QGIS. You can select multiple files at once by holding the *Ctrl* or *Shift* keys.

5. Next, go to Layer > Add Raster Layer or Click on the *Add Data* button: 

6. Navigate to the folder where you saved the data. Set the "Files of Type" to *GeoTIFF* (at the bottom right of the pop up window) and add **Berkeley_dem.tif** and **Berkeley_shd.tif** to the map.

7. You should see the file names we added at the bottom left corner of the window under 'Layers Panel". You expand this panel by dragging it so that you can better see the file names.

8. Check the boxes to the left of the layer name off and on. As you can see, this makes the layer visible or not visible in the data frame.

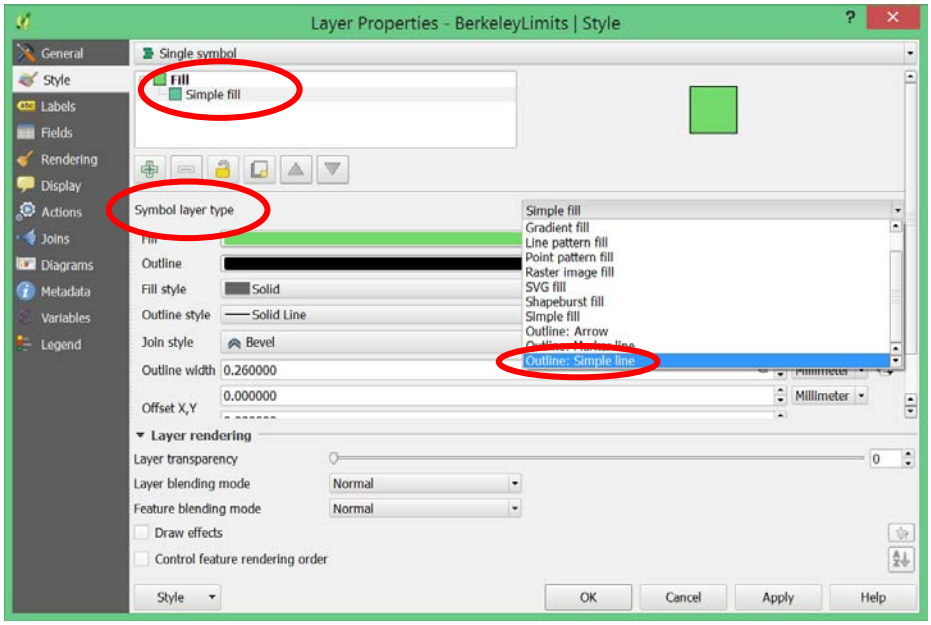
9. Click and drag the layers in the table of contents to rearrange their order. Arrange the layers in this order, from top to bottom:

    a. **PublicSites**
    b. **Fruit_Vegetable_and_FarmersMarkets**
    c. **BerkeleyLimits**
    d. **BerkeleyBlockGroups**
    e. **County**
    f. **Berkeley_shd**
    g. **Berkeley_dem**

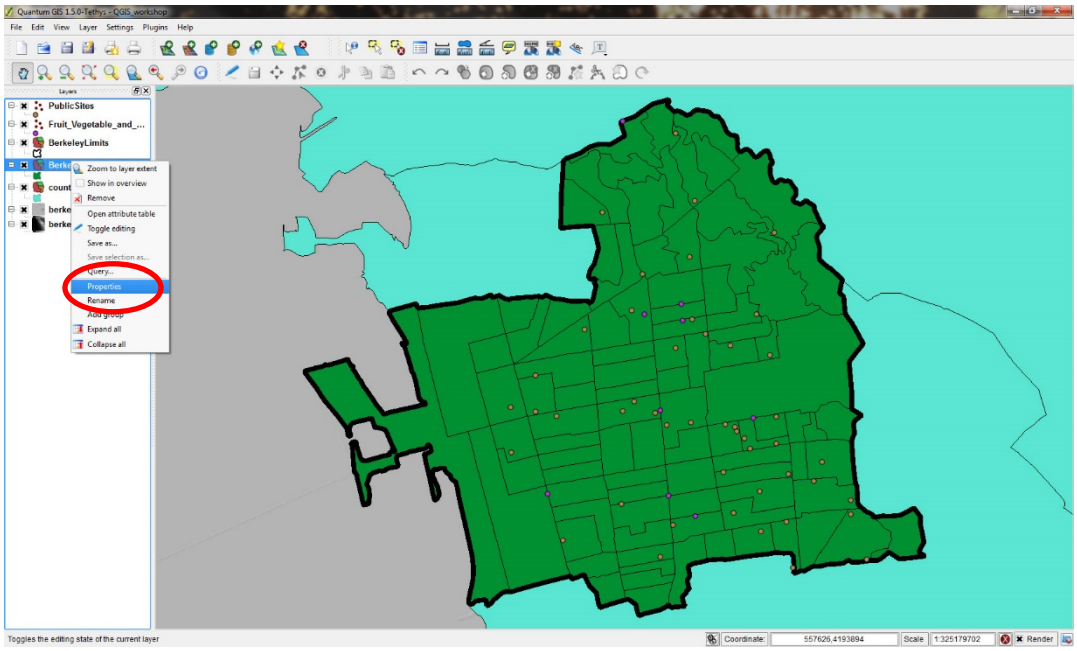
10. Click the *Save* Button , navigate to your working directory (the same directory that your data is in), and name the file as **'*LASTNAME*_QGIS_workshop'**. Save your work repeatedly throughout this project. A project file (.qgs) will save your display and layers, however it only points to the selected data files. Data files are maintained separately from the project file.

Layer properties

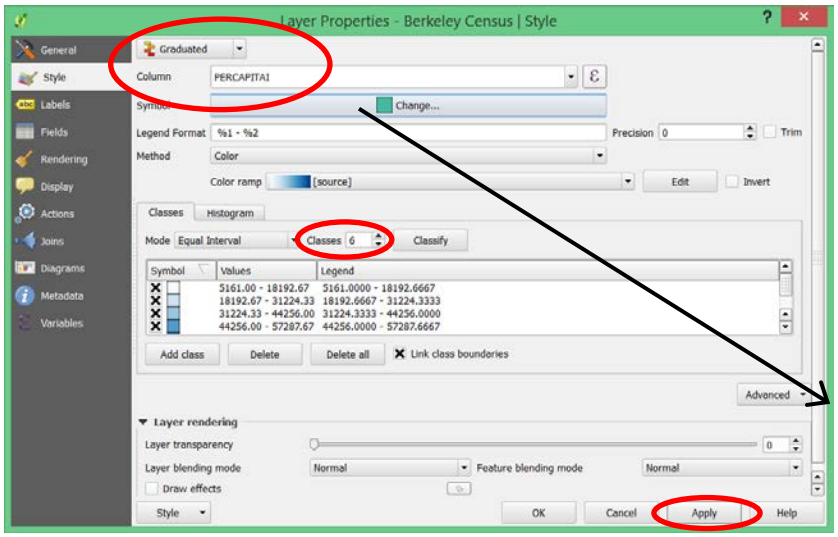
1. Change the **BerkeleyLimits** polygon to an outline by double clicking its name in the table of contents. Go to the "Style" tab, and click on "Simple fill". Click on the "Symbol layer type" drop down arrow and select "Outline: Simple line".



2. Increase the "Pen width" to 1.0 Millimeter, and click *OK*
3. Right-click **BerkeleyLimits** and select *Zoom to Layer*.
4. Right-click on the layer: **BerkeleyBlockGroups**. A context menu appears – Stop for a minute and look at the options in this context menu. This menu contains several important options.
5. Choose *Properties* to open the *Layer Properties* (same as double-clicking). The *Layer Properties* dialog appears. You can access the properties for the other layers in the same manner.

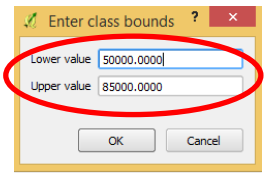


6. In the Layer Properties window of the **BerkeleyBlockGroups**, click on the *General* tab. You can change the "Layer Name" of layer here. This only changes how the name is displayed, it does not change the name of the actual file. Type **Berkeley Census**.
7. Click on the *Style* tab and change the symbol type from "*Single Symbol*" to "*Graduated Symbol*" (at the top left of the Layer Properties window). In the drop-down menu for "Column", Select *PERCAPITAI* (Per Capita Income). These settings will assign color to each polygon based on their per capita income. Set the number of classes to "6", and click the *Apply* button.

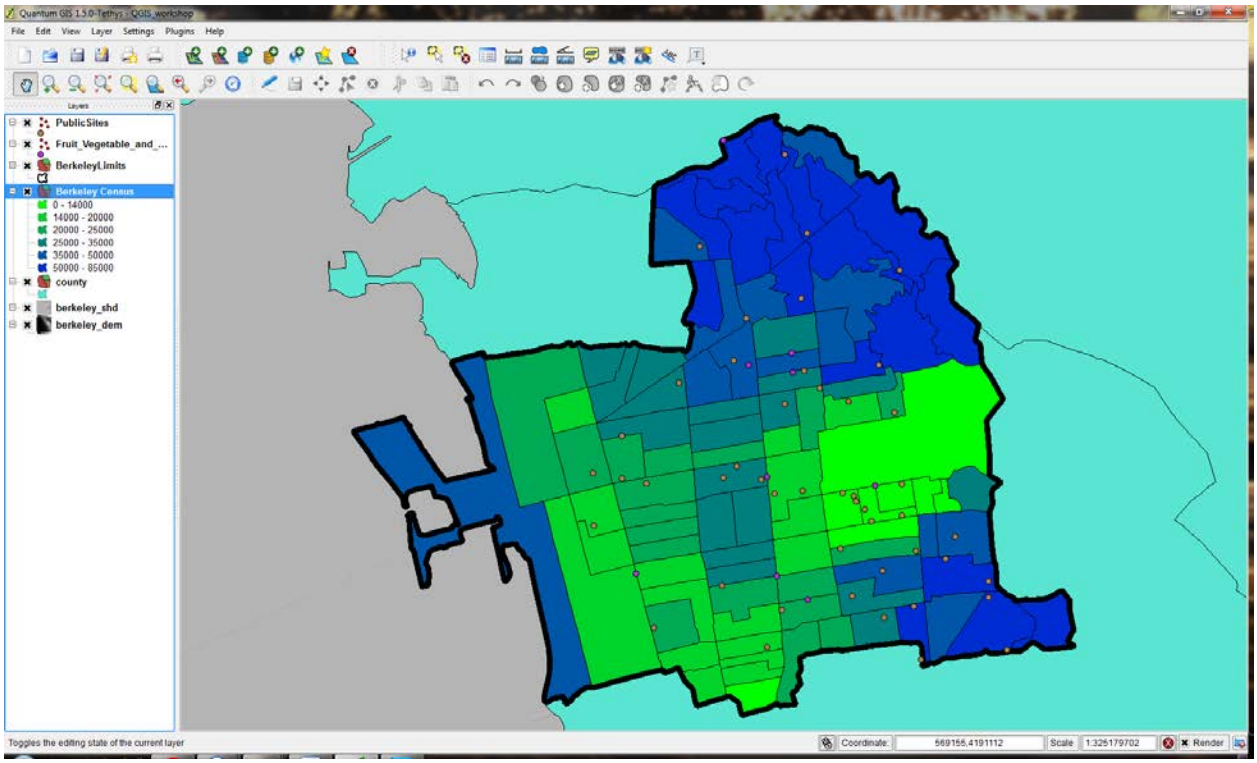


8. Redefine the bins for each class by double clicking the number range for each bin and manually entering the lower and upper values as follow:

0-14000
14000-20000
20000-25000
25000-35000
35000-50000
50000-85000



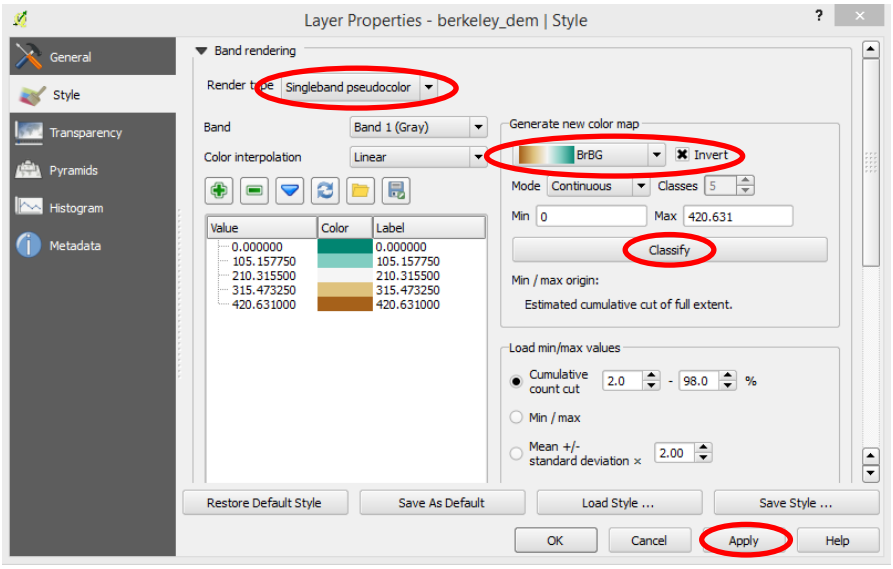
Click **OK**, and you will see the census blocks vary in color according to Per Capita Income. Feel free to experiment with the "Color ramp" to find something that you like.



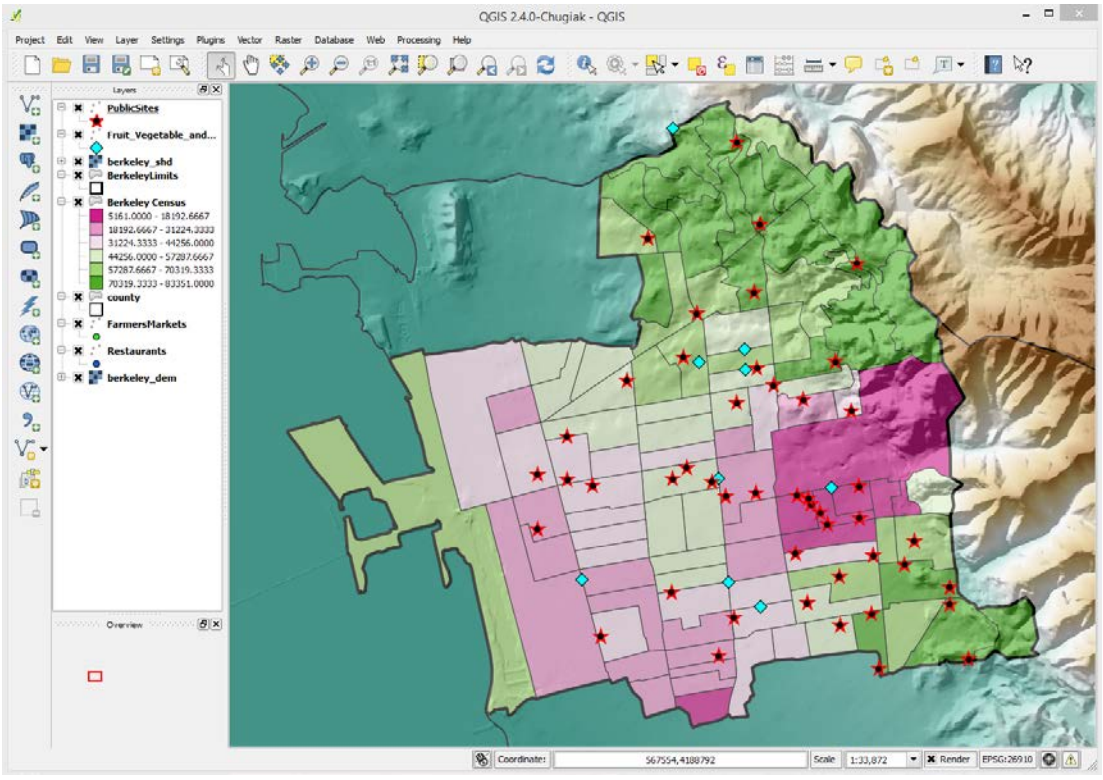
9. Change the symbols for the other **vector layers** so that they are easily distinguishable from the **Berkley Census**. You can change the symbols for layers by clicking on their symbol (colored rectangle under the layer name) as described in step 1 of this section. Be sure to make your symbols colors that will stand out and are large enough to see.

10. Set the County layer's Fill from *Simple Fill* to *Outline: Simple line* so that you can see the topography beneath.

11. To adjust the symbology for the **raster layers**, access the *Layer Properties* menu for **berkeley_dem** and go to the *Style* tab. Set the *Band rendering* > *Render type* to be *Singleband pseudocolor*. Select a color scheme for the color map, click Classify, click Apply, and click OK. The example shown here is basic earth tones with "Invert" selected. Note, you may need to temporarily turn off (unclick) the **berkeley_shd** layer in the TOC to be able to see the **berkeley_dem** layer beneath it.

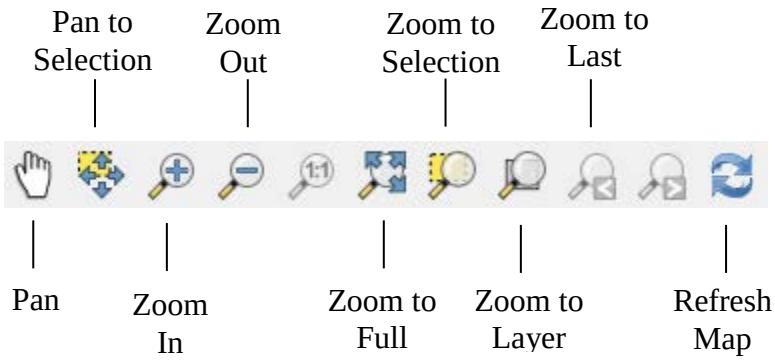


12. Lastly, open the *Layer Properties* for **Berkeley_shd** and go to the *Transparency* tab. Set the *Global Transparency* to **60%**, which will create a 3D effect with the DEM. You can adjust transparency on any layer to maximize viewing. Also try moving the semi-transparent **Berkeley_shd** layer above the polygon layers.



Navigation

1. Explore the data using some of the navigation tools in the Toolbar:



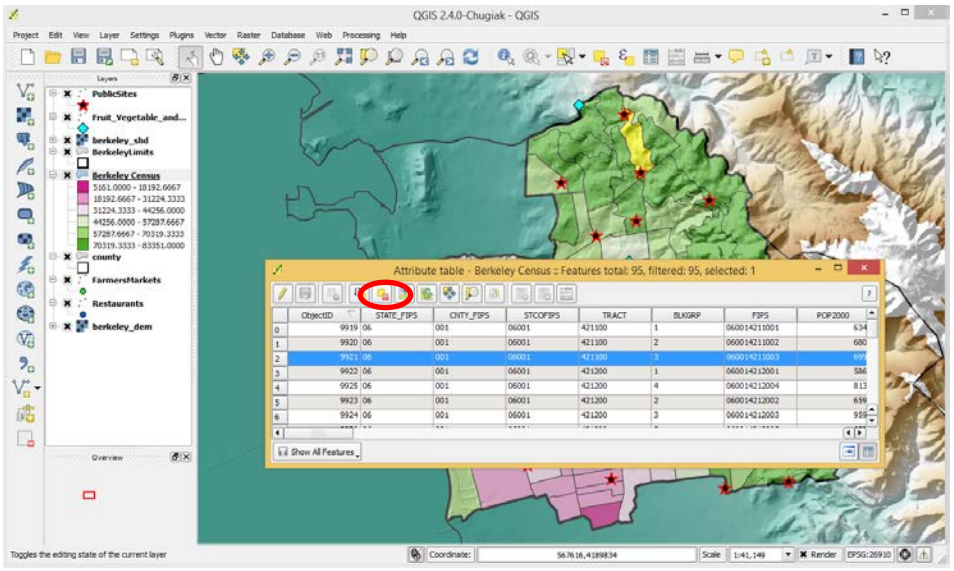
2. Use the magnifying glass tools to draw a rectangle around an area to zoom in or to zoom out. With the zoom in/out tools, you can either draw a box around the area you want to zoom in/out on, or you can click once.
3. Click on the full extent button  to see your entire dataset.
4. The identify tool  can be a good way to browse the attribute information behind the geospatial data. Attributes are data that correspond to a spatial location, whether it is a point, line, or polygon shape. To explore this tool, first click on the Berkeley Census layer in your TOC to select it in the layer list. Then use the identify tool to select an individual census block to examine the results.
5. Experiment with the other navigation tools to see what they do.

Working with Attribute Data

Every spatial unit, such as a polygon, point, or pixel may be assigned several values that are associated with relevant attributes. These values are stored in the database file (.dbf) and may be viewed in an attribute table or using the identify tool. This section explores attribute tables and some tools to query them.

Attribute Tables

1. Right-click on **Berkeley Census** and select "Open Attribute Table."
2. Explore the table. Each row corresponds to a spatial feature and each column represents an attribute.
3. Click on the grey box at the beginning of a row, and the corresponding feature is highlighted in yellow on the map. Click the  button, and the map zooms in to the selected feature.
4. Click the *Unselect all* button  at the top of the attribute table's window to clear selection.

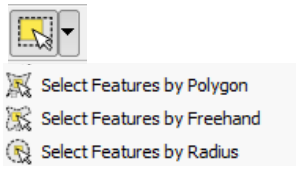


Select Features

1. In the previous section, we selected features from the attributes table. You can also select them directly on the map. Re-adjust your zoom level to display the full Berkeley Census layer and then choose the *Select Feature(s)* button from the *Tools* toolbar. 

2. Click inside of a polygon. Hold the *Ctrl* key to make multiple selections, or drag over a large area while holding the *shift* key. You will notice that features are highlighted both on the map and in the attribute table.

3. Click on the Select Features drop-down button, and you will see several additional selection options:

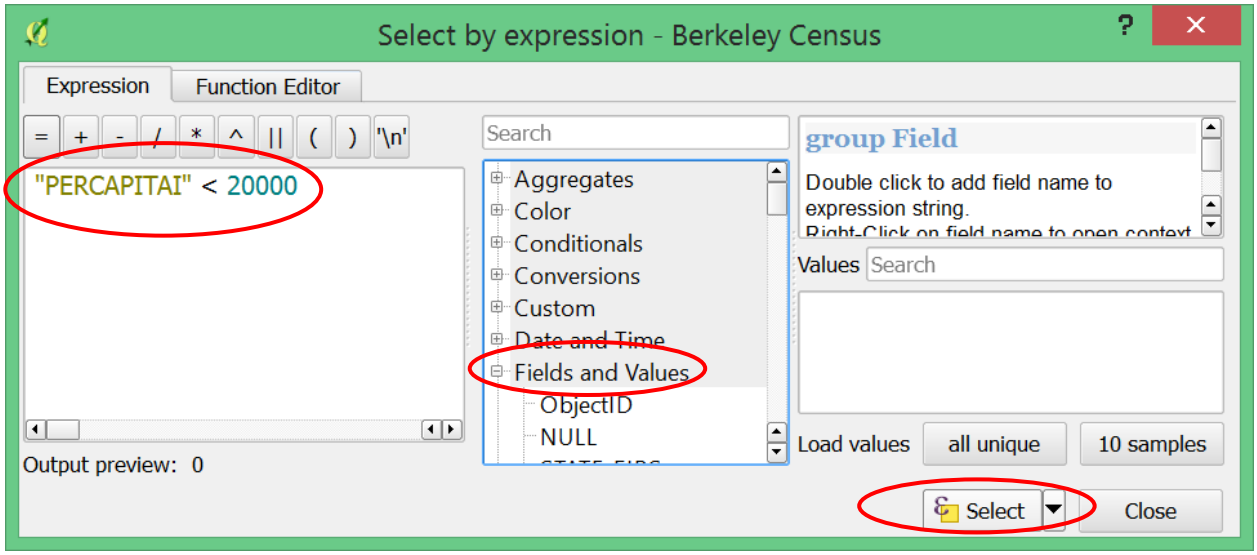


4. Alternatively, you can also select features based on their attribute values. Clear the selected features  and return to the **Berkeley Census** attribute table. Click on the Select by Expression  button.

5. We want QGIS to select features from **Berkeley Census** where Per Capita Income (**PERCAPITAI**) is less than 20,000 dollars. The Select by Expression pop up window is similar to a calculator. Double-click on listed terms to insert them into a formula and click on the mathematical buttons to insert these. Write the statement as seen below:

    a. Select **Fields and Values** and scroll down to double-click on **PERCAPITAI**.
    b. You can select the **<** sign either on your keyboard or by clicking on **Operators**, scrolling down and double click **<**
    c. Type in 20000

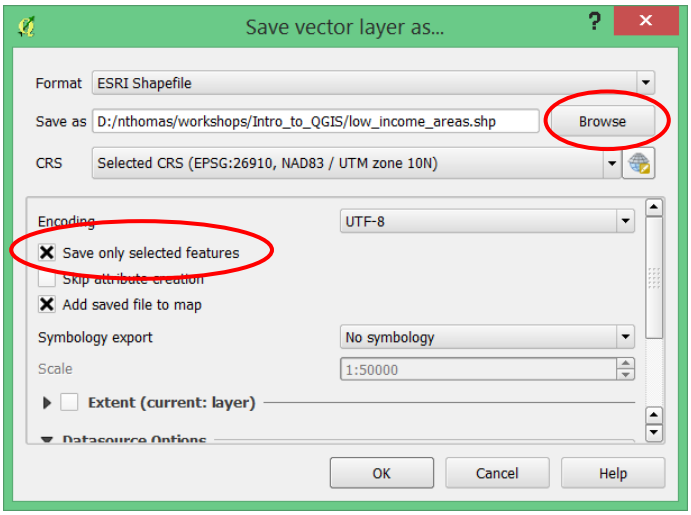
    "PERCAPITAI" < 20000



6. Click on *Select*. Notice the polygons that are now highlighted in your map.

7. To export the selected areas, and create a new shapefile with only these areas, Right-click **Berkeley Census** in the table of contents, and click *Save as*... Under *Format*, select ESRI Shapefile. *Browse* to the folder where your data is kept and name the new shapefile **low_income_areas.shp**,

8. Click "*Save only selected features*" and accept the default projection. Click OK. You can now add this new file to your map.



Exploring Plugins

In QGIS, many spatial analysis tools can be found as Plugins. This allows users to only add in additional functionality that is needed.

1. Open the Plugin Manager by selecting *Plugins* > *Manage and Install Plugins*. Here you will find many additional tools that extend the capabilities of QGIS. Plugins that are already activated are marked with a check. Take a look at the various different Plugins available.

2. One great plugin that I always recommend is **OpenLayers**. This plugin allows yout to add a number of different images or map baselayers such as Google Maps and OpenStreetMap to your QGIS project. If it's not already activated, click on the check mark or install this on your computer and then close the *Plugins* window.

3. In the main QGIS window, go to *Web* > *OpenLayersPlugin* and select an image you'd like to view. Explore a few of the different options to see what you like. This feature is especially valuable when you are working with your own datasets and don't want to download all of these baselayers yourself.

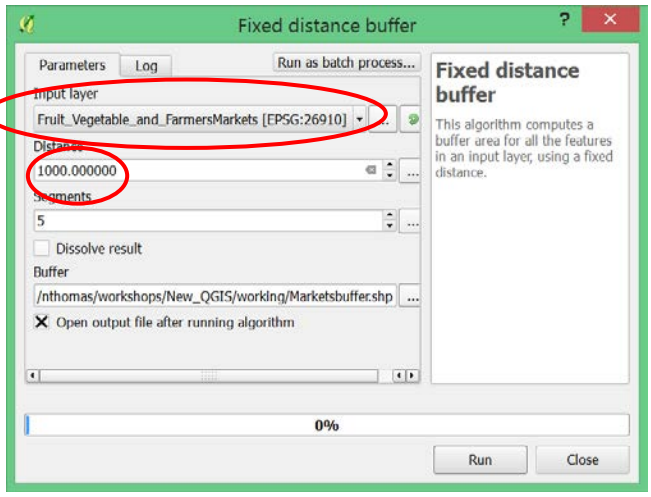
4. You can turn the new layers on and off in your TOC just like other layers. They might slow down your QGIS session, so I recommend only including 1 or 2 layers at a time.

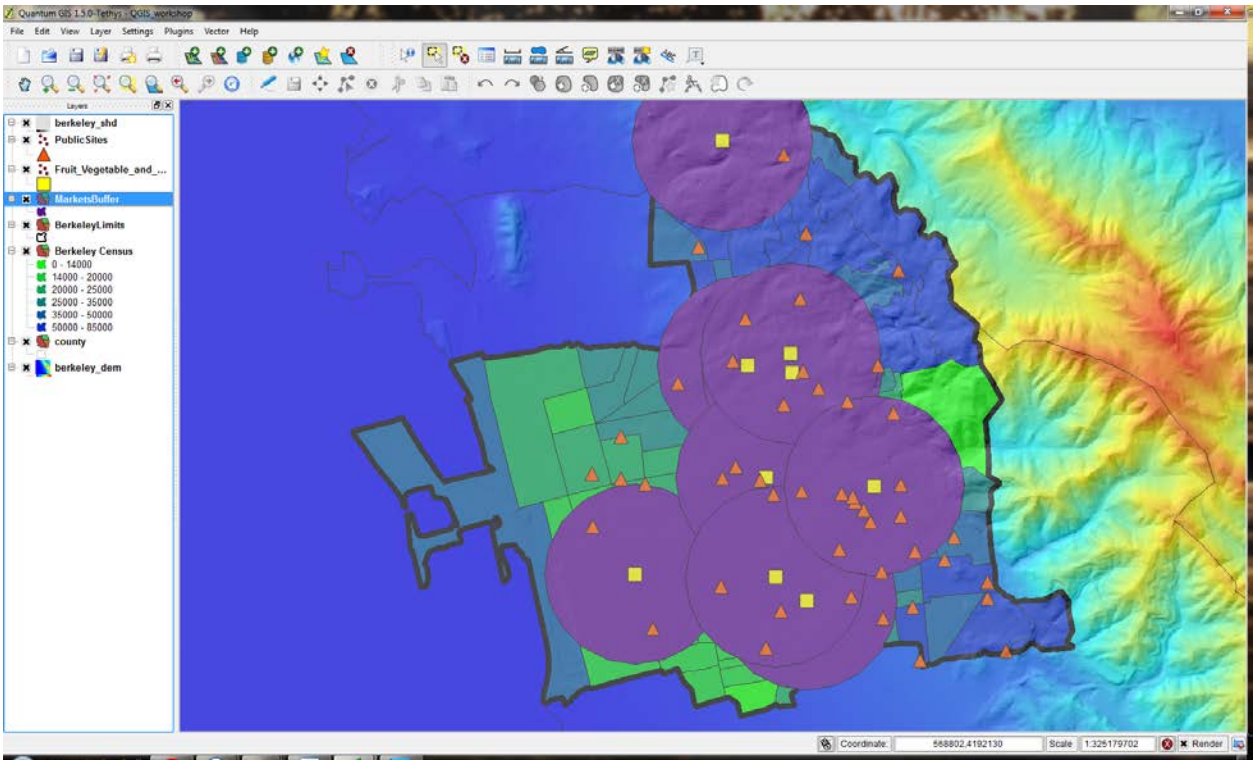
Basic Spatial Analyses

This section introduces simple spatial analysis tools.

1. In the main QGIS window, in the top menu, click *Vector* > *Geoprocessing Tools* > *Fixed Distance buffer*.

2. As seen in the figure below, use the drop-down list to select **Fruit_Vegetable_and_FarmersMarkets** as the *input vector layer*. Set a buffer distance of 1000 (units are in meters), and click browse to select a folder and name to save the new buffer polygon shapefile. Name the new file **MarketsBuffer.shp** and click **Run.**





Difference

1. Choose *Vector > Geoprocessing Tools > Difference*.

2. Using this tool, we will identify the low income areas that are greater than 1km from a fruit and vegetable or farmers market. Set **low_income_areas** as the *Input vector area*, and **MarketsBuffer** and the *Difference Layer*.

3. Save the new feature as **underserved.shp**.

4. Click *OK*, and add your new underserved vector layer to the map. Close the *Difference* tool.

5. Turn off the **Buffer** layer. Your new layer should show only low income areas that are greater than 1km from markets.

6. Clear your selected features by clicking on *View > Select > Deselect features from all layers* in the drop down menu at the top of the window.

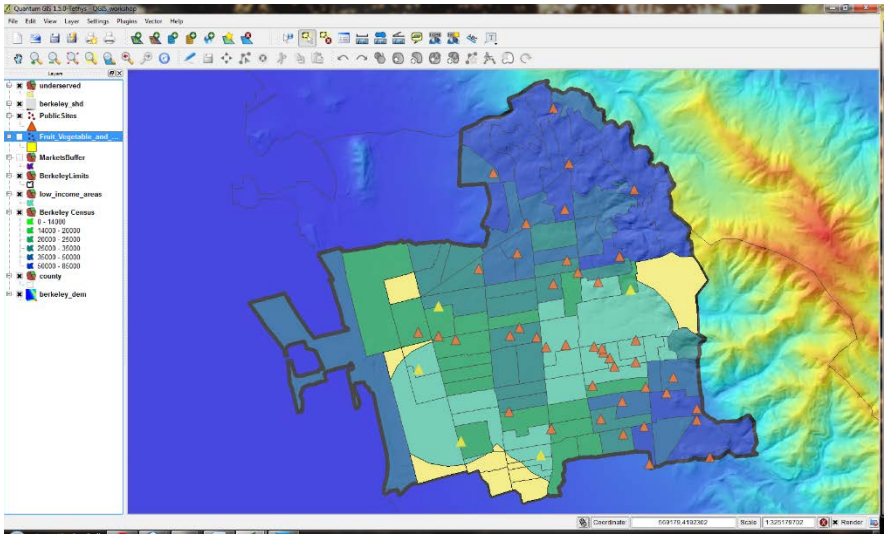
Expert Opinion

Your task is to identify buildings in the underserved areas of the city that will be targeted for new fruit and vegetable stands. Select five sites from the candidates based on their service areas and your knowledge of the area. Which sites will best serve the community?

1. Choose the *Selection* tool 

2. Make sure that **PublicSites** and **UnderservedAreas** are both visible on your map. You are selecting from Public Sites, so make sure to click on that layer to highlight it in your Table of Contents.

3. Use the *Select feature* tool and highlight five "Public Sites" that could represent good sites for community produce stands, based on their proximity to underserved areas. Hold the *shift* key to select multiple features.



4. Right click **PublicSites.shp** in the table of contents and *Save as* to create a new output of your five selected points. Make sure to check the "*Save only selected features*" box. Name the file **ProposedSites.shp**.
5. Turn off the other public sites, and create *1km* buffer around **ProposedSites** using the steps described in the previous buffer section.

Exporting Data

Many people do not have access to GIS, so we must consider how we will share our data with the rest of the world. You may want to export just the attribute data from your project and import it into Excel or use as a .csv file in some other program such as R. Or, you may want to create a map visualization of your data to include in a report, thesis, or poster. This section will teach you how to export your data to other formats.

Exporting Attribute Data

1. QGIS makes it simple to export your attribute table to .csv format. Right-click on the file you want to export in the Table of Contents and select *Save As.*

2. Click on the *Format* pull-down menu to see all the different options. If you want to save a table that you can then use within Excel or some other package such as R, select Comma Separated Value (.csv) format. Give your new file and output name and click Ok.

3. The exported table can easily be opened in Excel or used in other software or packages.

4. Notice some of the other formats you can use to export your data. For example, you can easily *Save As* Keyhole Markup Language (.kml), which you could then open up directly in Google Maps or Google Earth.

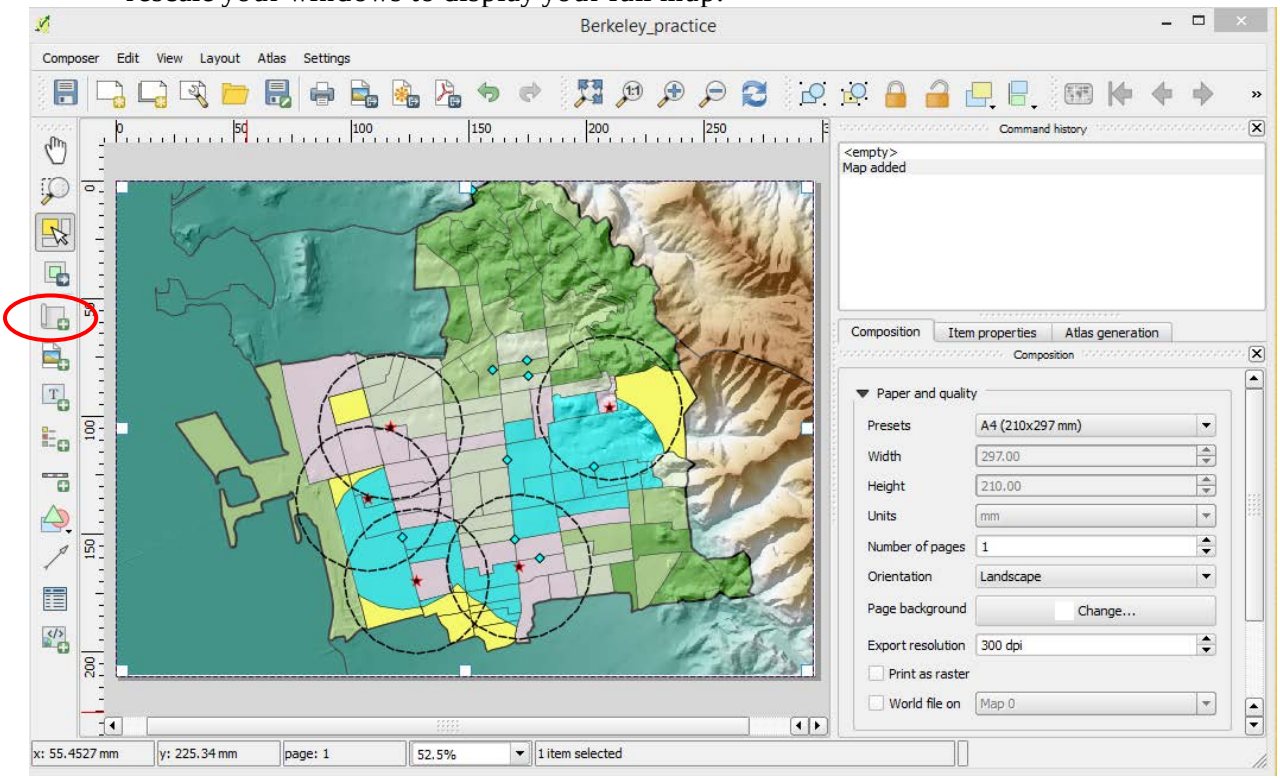
Print Layouts

This section will teach you how to export your data to other formats while emphasizing quality map design. You can follow these steps to create a map of your own data that can be included in a word document, presentation file, or as a graphic on a poster.

1. First, adjust your layers symbology to create a compelling map layout in your viewer before entering the QGIS print composer. Don't be afraid to make your map unique! Spend some time thinking about how you might want to convey information to your audience.

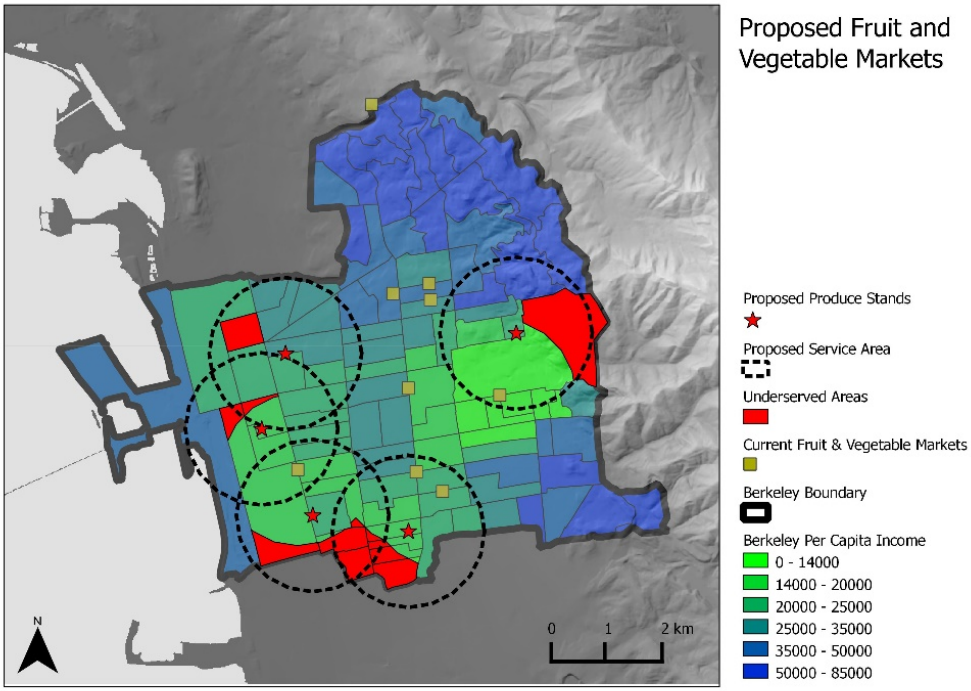
2. Enter the Print Composer by selecting *Project* > *New Print Composer* in the top left hand drop-down menu. You can enter a name, or leave it blank.

3. In the new window that opens, click the *Add new map* tool  on the left toolbar, and drag a box over the blank workspace. Notice that you may need to redraw the box or rescale your windows to display your full map.



4. Add a scale bar to the map using the *Add new scalebar* tool and clicking on the map. You can adjust the style and numbering while the scale bar is highlighted under the *Item properties* tab. Change the "*Label unit multiplier*" to *1000* to convert meters to kilometers, and add *km* to the "*Label for units*."

5. Add a legend to the map by selecting the *Add new legend* tool and click to place on the layout. Use the options under the *Item properties* tab to adjust the legend to your liking. Click the *Auto update* button off, and you will be able to delete or move items up and down and edit their names here. Spend some time with this tool so you know how to change the legend to your liking.
6. Add a title to the map using the *Add new label* tool . You can adjust the text under the item tab, and size and position by dragging the outline on the map.



Export as digital image

1. Once you are satisfied with your map composition, you can now export it to another format.

2. Under the *Composition* tab (on the right of the window), you can adjust the print quality of your map. Scroll down until you see *Export settings*. If you want to publish your map,

either in a journal or poster, make sure to export it at a high resolution of 300-600 dpi (dots per inch).

3. Click the *Composer* button (top left corner of window), choose *Export as image* to save your map layout. You can choose from several different file types to output.

4. Use the drop down menu to *save as type* .jpg. Name the map **Berkeley_map.jpg**. Find your file in Windows Explorer and open it to view!

Congratulations! You have learned how to perform basic geospatial analysis and how to create a map using a free and open source software package that you can easily download and install on you Mac, Windows, or Linux machine.