

Data**politan**

Data Solutions for the Modern Metropolis



Introduction to GIS Fundamentals

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Follow along: http://bit.ly/dot_intro_gis2

Goals for the class

- Describe the foundational concepts of spatial analysis and mapmaking
- Describe the general structure and purpose of Geographic Information Systems (GIS)
- Describe spatial data formats and sources of spatial data
- Apply concepts of spatial analysis using NYC Open Data to answer an NYC-related problem
- Discuss resources for further information and instruction on QGIS and other spatial analysis tools

Outcomes

- You will be familiar with the foundational concepts in spatial analysis and mapmaking
- You will understand the structure and purpose of GIS
- You will be practiced in applying spatial concepts to real-world problems
- You will be familiar with the differences between open source and proprietary software applications
- You will be familiar with resources for further information on how to use QGIS for spatial analysis and mapmaking

Goals for this morning

- Review basic geospatial principles and GIS tools
- Discuss spatial data formats
- Demonstrate and practice how to load, filter, and select data in QGIS
- Demonstrate and practice how to style spatial data
- Demonstrate and practice how to export data from QGIS

Types of Maps

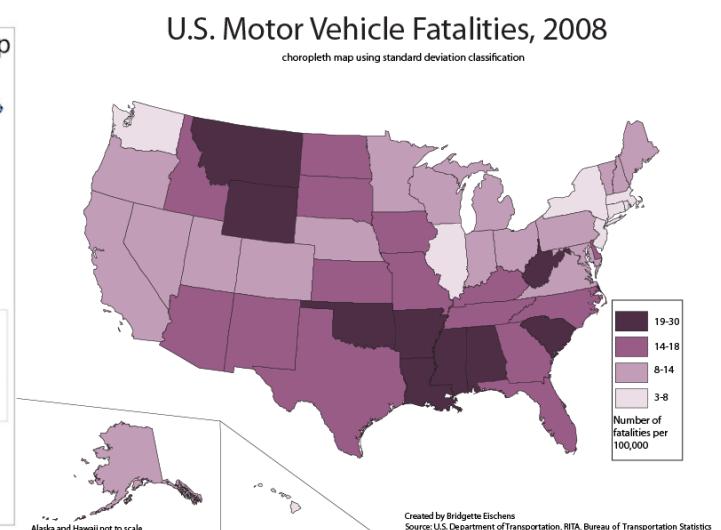
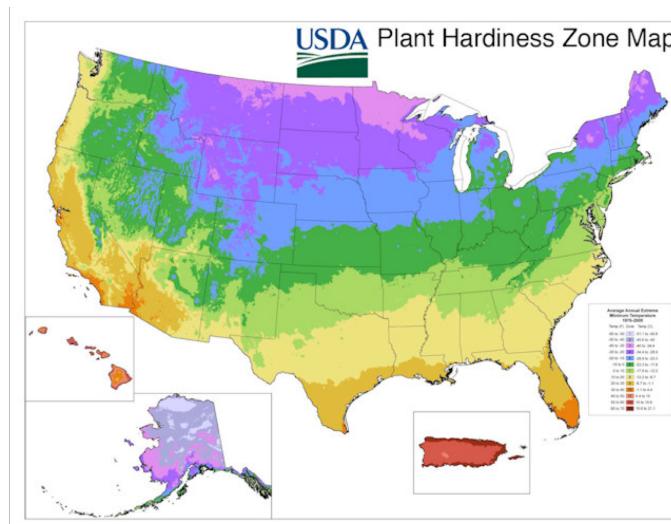
General Reference Maps

- Show important physical features of an area
- Include natural and man-made features
- Usually meant to help aid in the navigation or discovery of locations
- Usually fairly simple
- Can be stylized based on the intended audience (tourists vs locals)



Thematic Maps

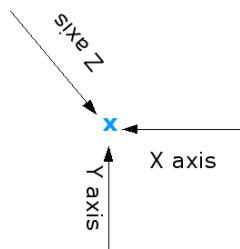
- Focuses on a specific theme or subject area
- Features on the map represent the phenomenon being mapped
- Spatial features used for reference



Basic Map Elements

Vector Point Feature

Point Geometry (indicates the x,y and z position of the feature)



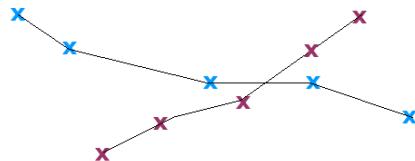
Point attributes (describe the feature)

Id, Name, Description

- 1, Tree, Outside our classroom
- 2, Light post, At the school entrance

Vector Polyline Feature

Polyline Geometry (a series of connected vertices that do not form an enclosed shape)



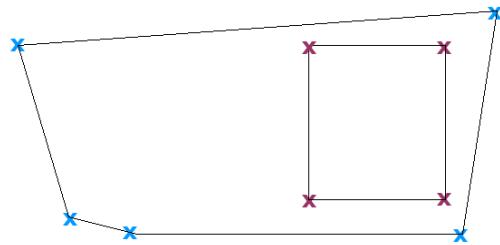
Polyline attributes (describe the feature)

Id, Name, Description

- 1, Footpath 1, From class to the playground
- 2, Footpath 2, From the school gate to the hall

Vector Polygon Feature

Polygon Geometry (a series of connected vertices that do form an enclosed shape)



Polygon attributes (describe the feature)

Id, Name, Description

- 1, School Boundary, Fenceline for the school
- 2, Sports Field, We play soccer here

Source: http://docs.qgis.org/2.8/en/docs/gentle_gis_introduction/vector_data.html#overview

Geographic Information System (GIS)

- Create interactive queries (user-created searches)
- Analyze spatial information
- Edit data in maps
- Present the results of all these operations

“Any system for capturing, storing, checking, and displaying data related to positions on the Earth's surface”

- National Geographic Education Encyclopedia
- “In a GIS, you connect data with geography.”
- GISgeography.com

QGIS - The Good

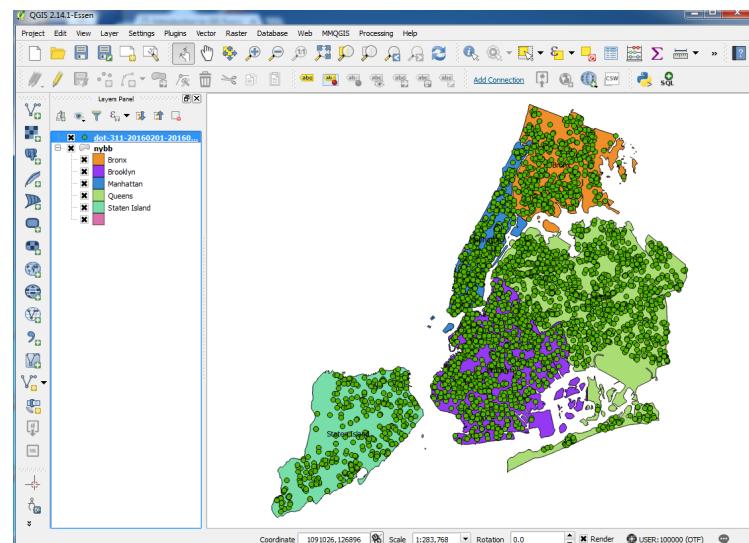
- Freely available desktop application
- Lots of features
- Works with different data types
- A strong community developing new features and plug-ins

QGIS - The Bad

- A bit bug-y sometimes
- Visual style is a little clunky
- Features change between versions
- It will crash (but so will ArcGIS)

QGIS - The Bug-y

- Sometimes things get jumbled -> zoom out then zoom back in
- Things don't work properly -> close and restart
- Other problems that we'll find in class



Let's Get Started

1. Click the link (http://www.datapolitan.com/DOT_GIS/20160428_Introduction_to_GIS_Fundamentals/data/boros/boros.zip) and download the file to your desktop
2. Unzip the file
3. Open QGIS

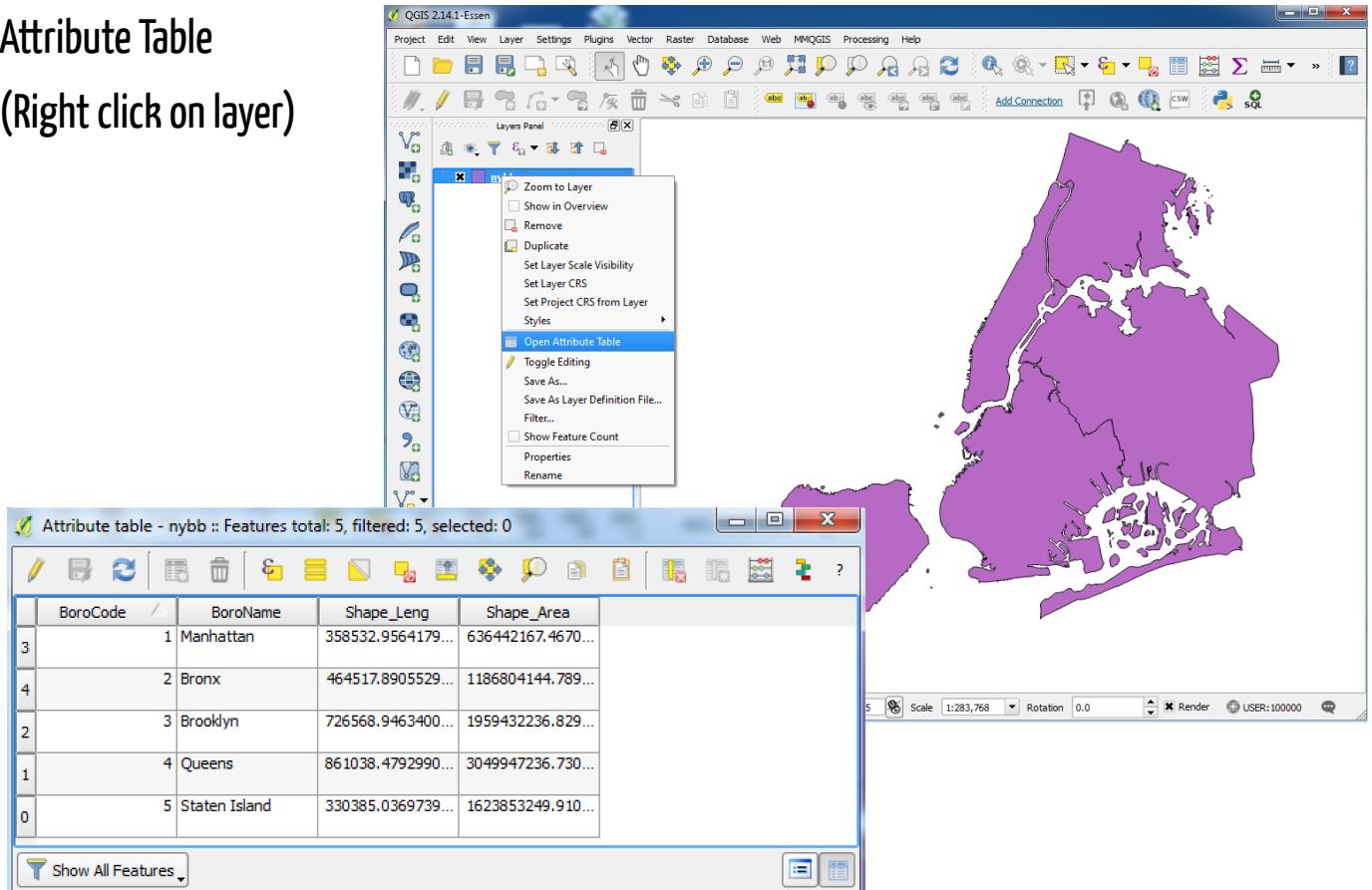
A screenshot of the QGIS application interface. The menu bar is visible at the top, showing options like Layer, Settings, Plugins, Vector, Raster, Database, Web, MMQGIS, Processing, and Help. A blue arrow points from the 'Layer' menu down to the 'Add Layer' submenu, which is open. The 'Add Vector Layer...' option is highlighted with a blue box and has a keyboard shortcut 'Ctrl+Shift+V' next to it. To the right of the menu, a 'Add vector layer' dialog box is open. It has sections for 'Source type' (radio buttons for File, Directory, Database, and Protocol, with 'File' selected), 'Encoding' (set to 'System'), and 'Source'. A 'Dataset' input field contains 'boros' and has a 'Browse' button to its right, which is also highlighted with a red box. At the bottom of the dialog are 'Open', 'Cancel', and 'Help' buttons.

A screenshot of a Windows file explorer window titled 'Open an OGR Supported Vector Layer'. The path 'boros' is selected in the navigation bar. The main area shows a list of files:

Name	Date modified	Type	Size
__MACOSX	4/6/16 2:47 PM	File folder	
nybb.dbf	4/4/16 5:35 PM	DBF File	1 KB
nybb.prj	4/4/16 5:35 PM	PRJ File	1 KB
nybb	4/4/16 5:35 PM	SHP File	1,074 KB
nybb.shp	4/4/16 5:35 PM	XML Document	16 KB
nybb.shx	4/4/16 5:35 PM	SHX File	1 KB

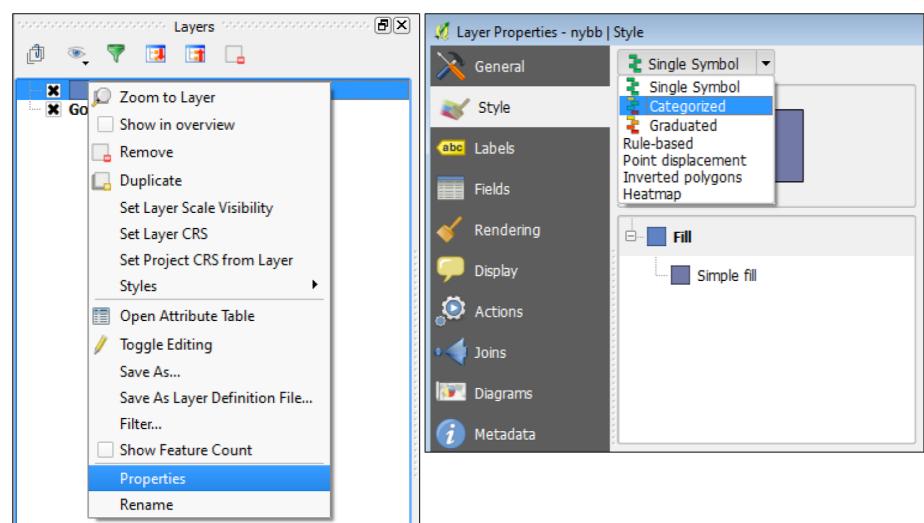
A large blue arrow points from the 'Open' button in the 'Add vector layer' dialog down to the 'Open' button in the file explorer window. Both the 'Open' button in the dialog and the 'Open' button in the file explorer are highlighted with red boxes.

Attribute Table (Right click on layer)

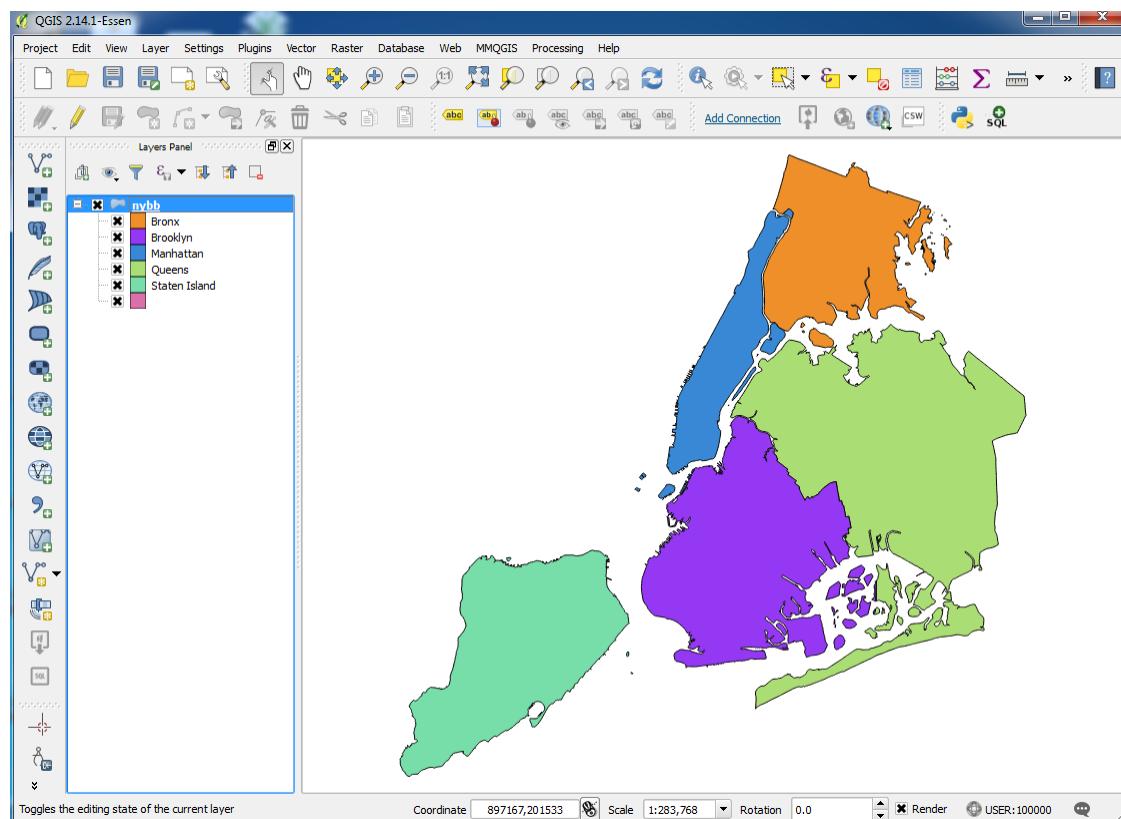
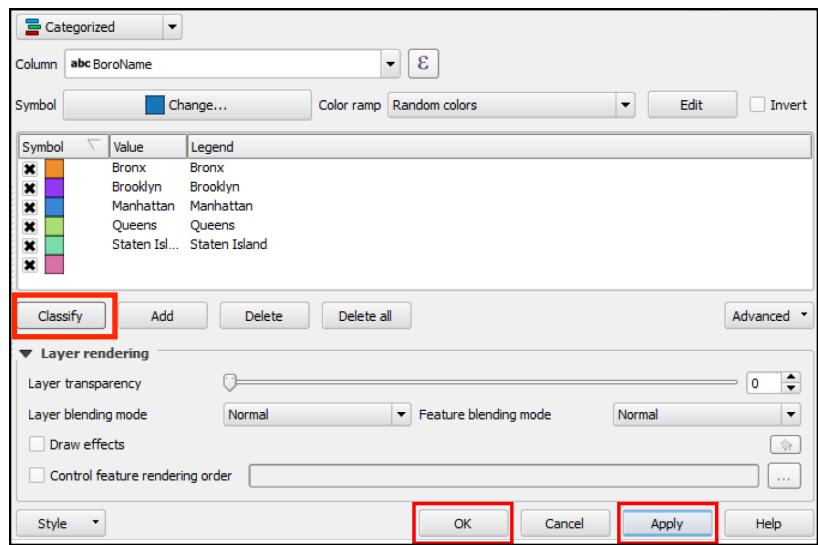
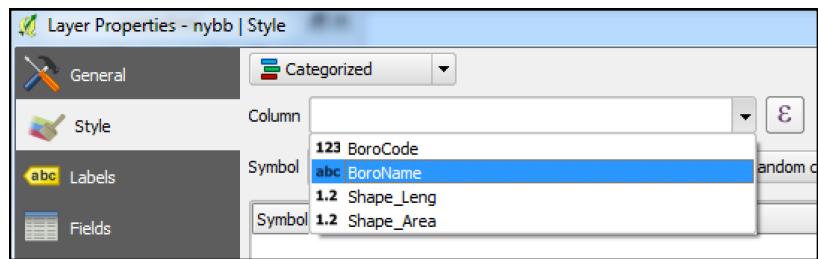


Styling Features

1. Right-click the layer and select the Properties option
2. Select "Style," and finally, choose "Categorized"

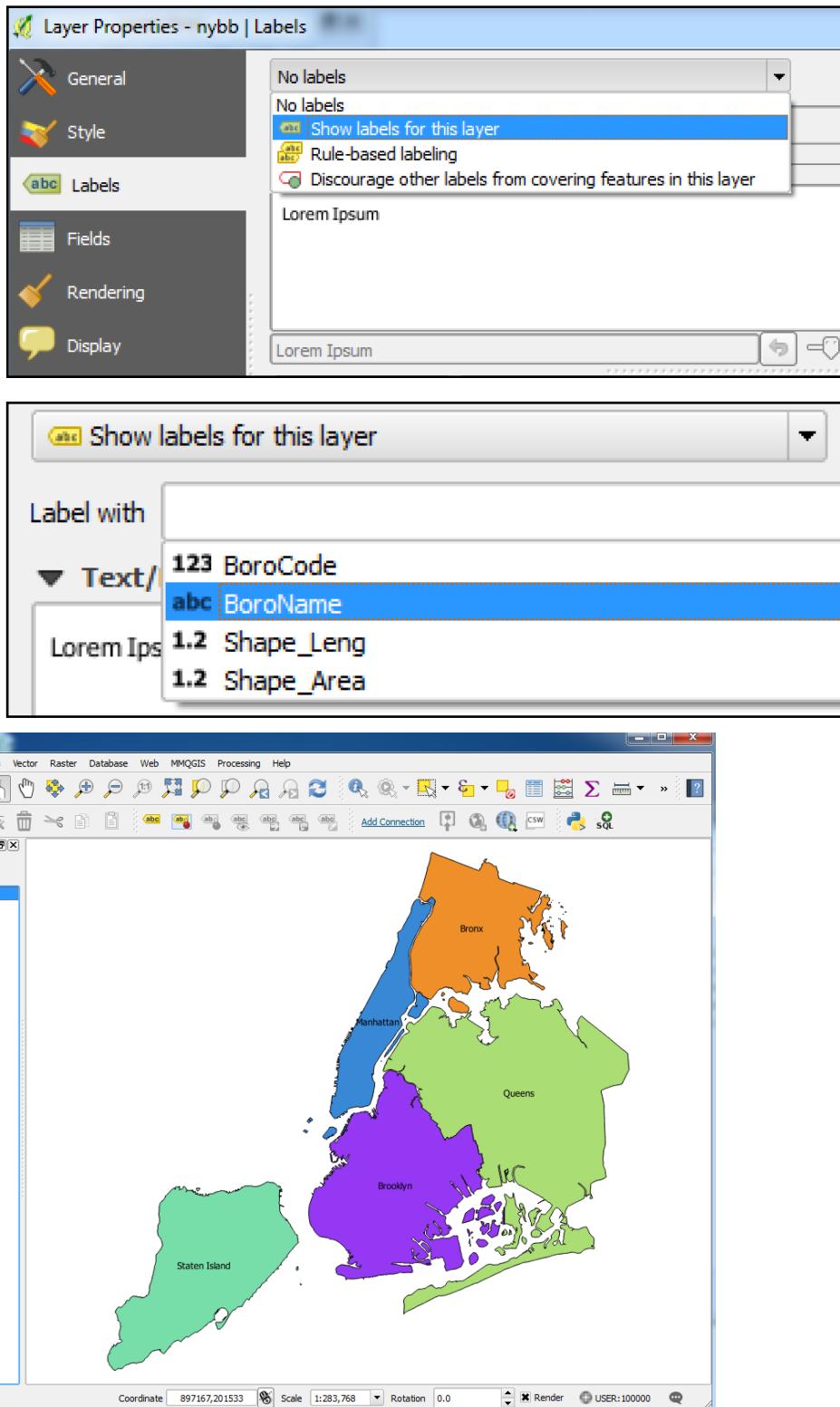


3. Select the column that has the data you want to style
4. Select “Classify”
5. Click “Apply” and “Ok”

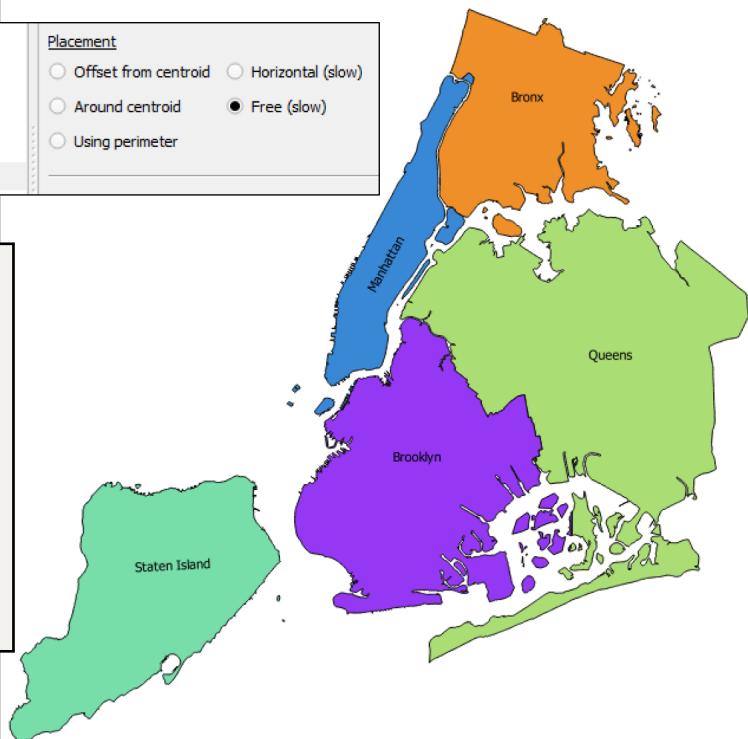
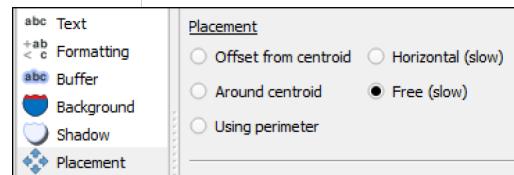
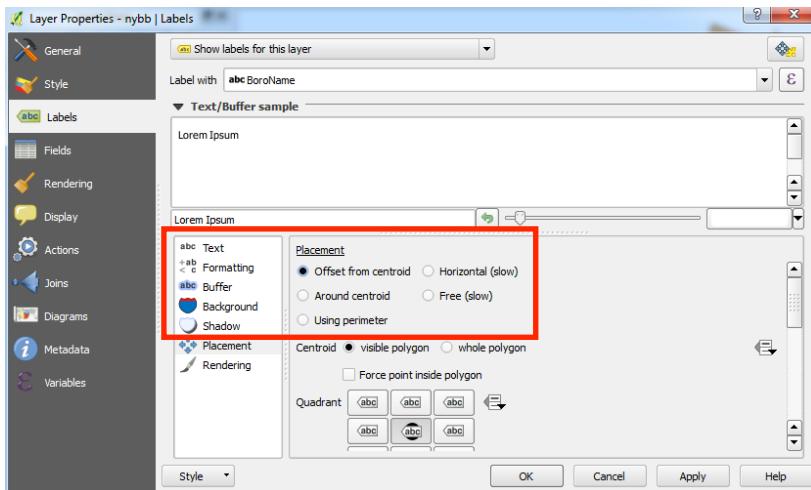


Add labels to data

- From Properties, select "Labels", "Show labels for this layer"
- Select the column that has the data you want to use for labels
- Click "Apply", "Ok"



Styling Labels



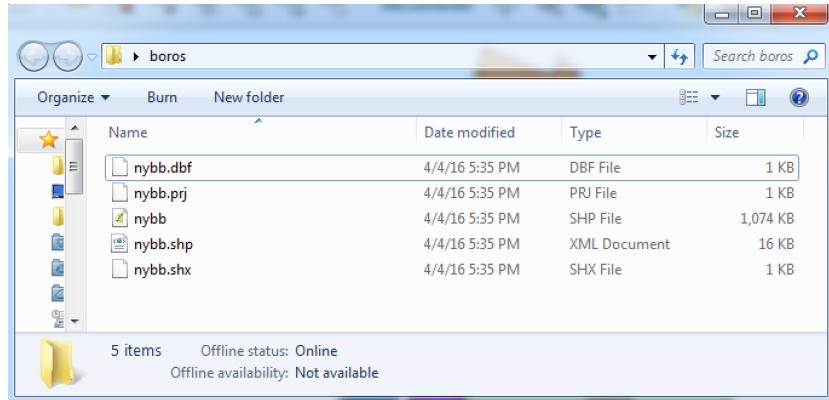
Your turn

- Style the polygons however you'd like
- Change the outline color or add a pattern
- Style the labels
- Change the font, the font size, or other attributes

Shapefile Format

Shapefiles

- Basic file for storing map elements
- Stores spatial data, like points, lines, and polygons
- Multiple files comprise a “shapefile”
- Have a few limitations
- One geometry type (Point, Line, Polygon) per shapefile
- So sometimes you end up with multiple shapefiles
- Column names can only be letters, numbers, and underscores “_”
- Column names can only be ten characters long



Shapefile file components:

- .shp — The main file that stores the feature geometry
- .dbf — The dBASE table storing attribute information of features
- .prj — The file that stores the coordinate system information
- .shx — The index file that stores the index of the feature geometry
- .cpg — Identifies the character set to be used
- .sbn and .sbx — The files storing spatial index of the features

Adding Layers

1. Download the data to your desktop (http://www.datapolitan.com/DOT_GIS/20160428_Introduction_to_GIS_Fundamentals/data/dot-311/20160201_20160207_DOT_311_ServiceRequests.zip)
2. Unzip the file
3. Open in QGIS

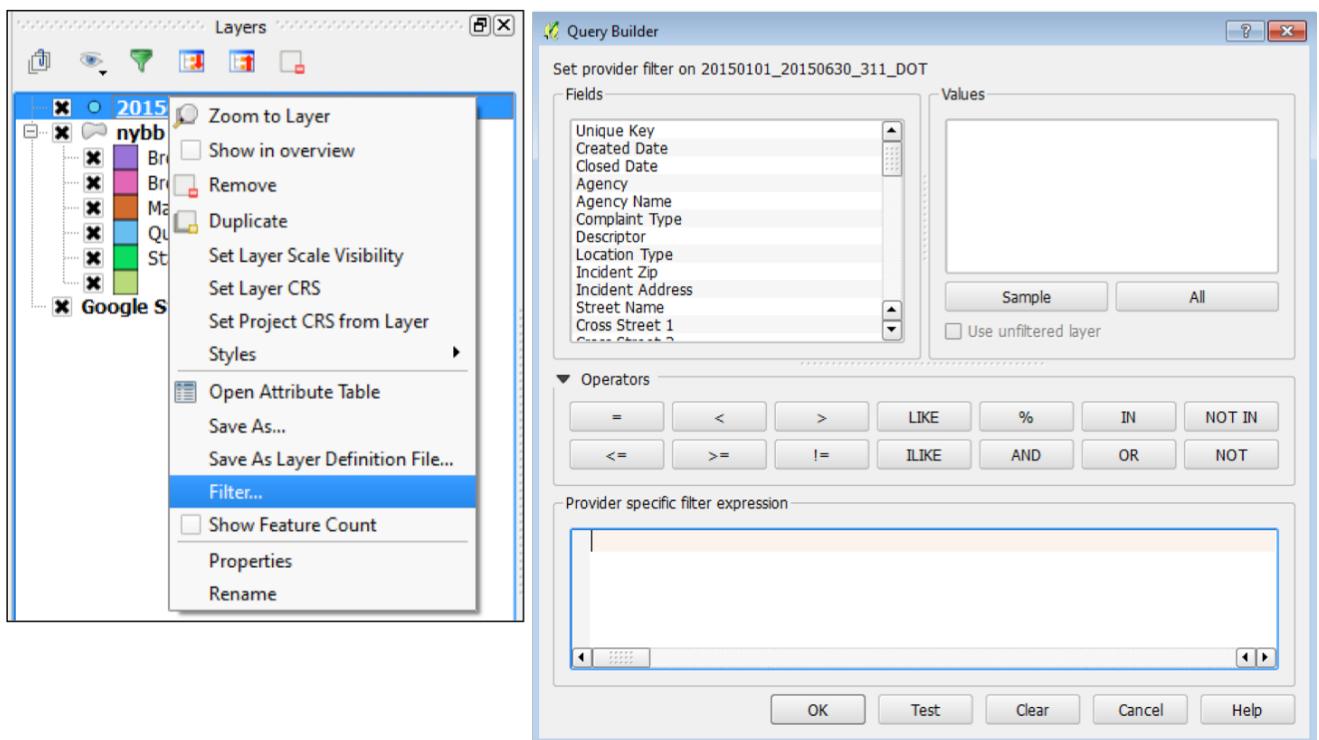
Layer Ordering

- Layers on top are drawn on top
- Just drag and drop within the Layers Panel to change order

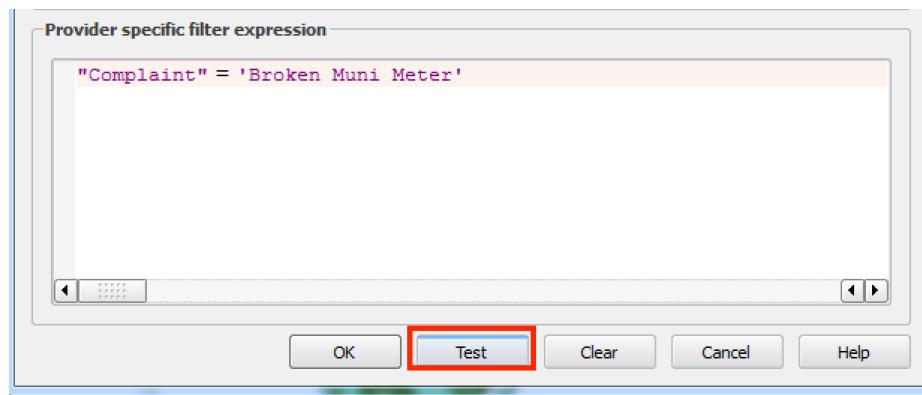
Filter and Query

Filter

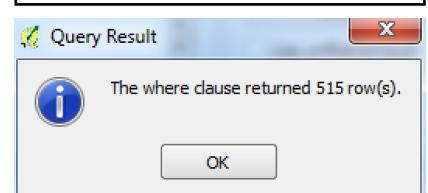
- We can filter the points based on the values in the attribute table
- Right-click on the layer and select "Filter" to open the Query Builder



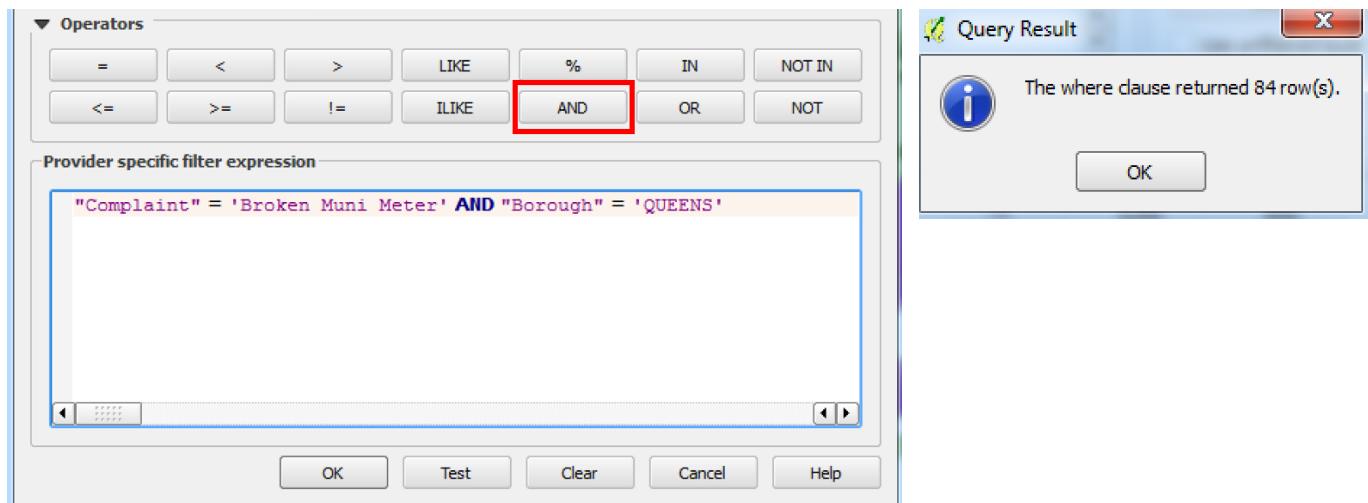
To Filter for Broken Muni Meter complaints:



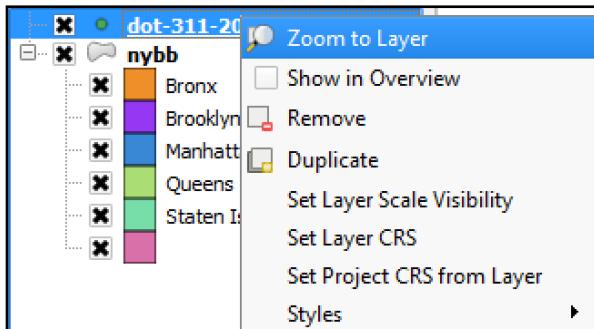
TIP: Always test your queries to make sure they return resulting rows



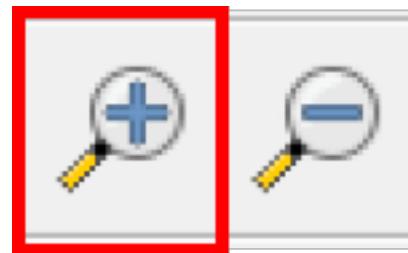
To filter by multiple conditions



Zoom to Layer



Zoom Selection (Select and draw box)



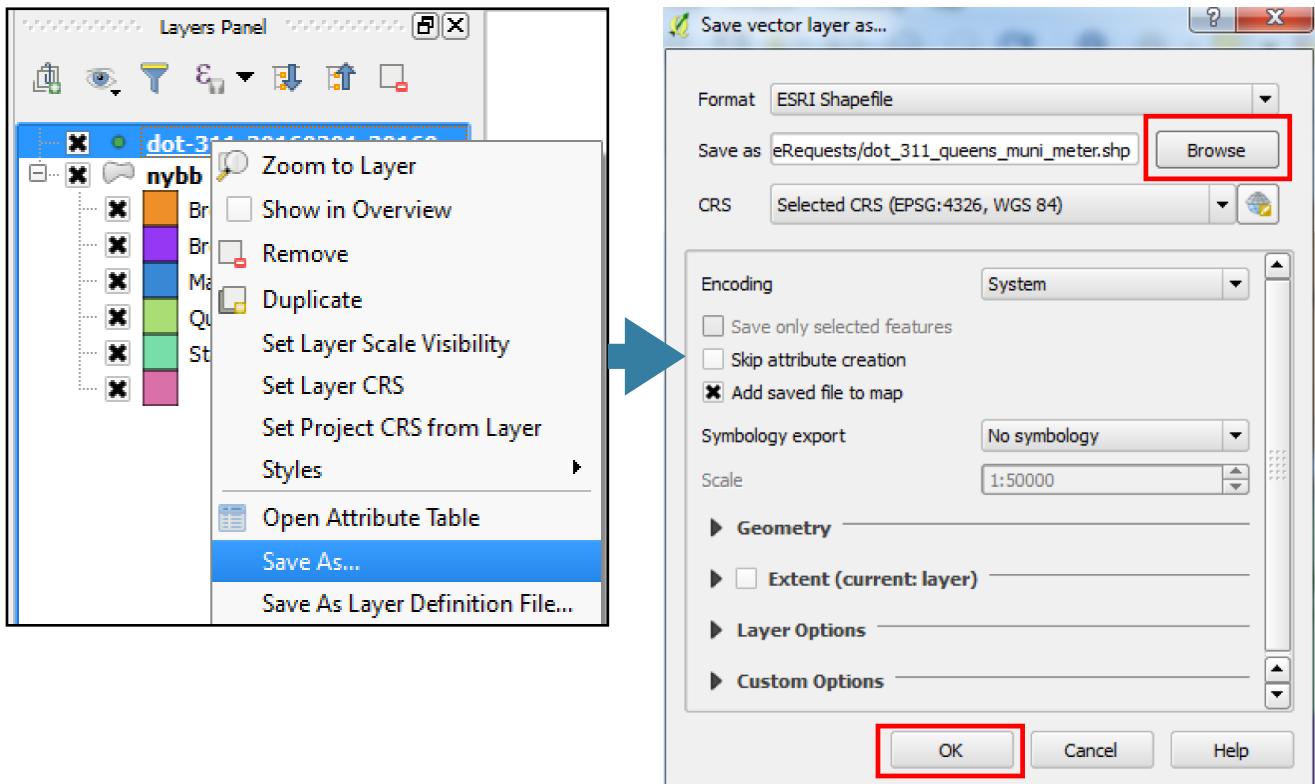
Pan Map (Select and pan map)



Return to Previous Map Extent



Exporting Data



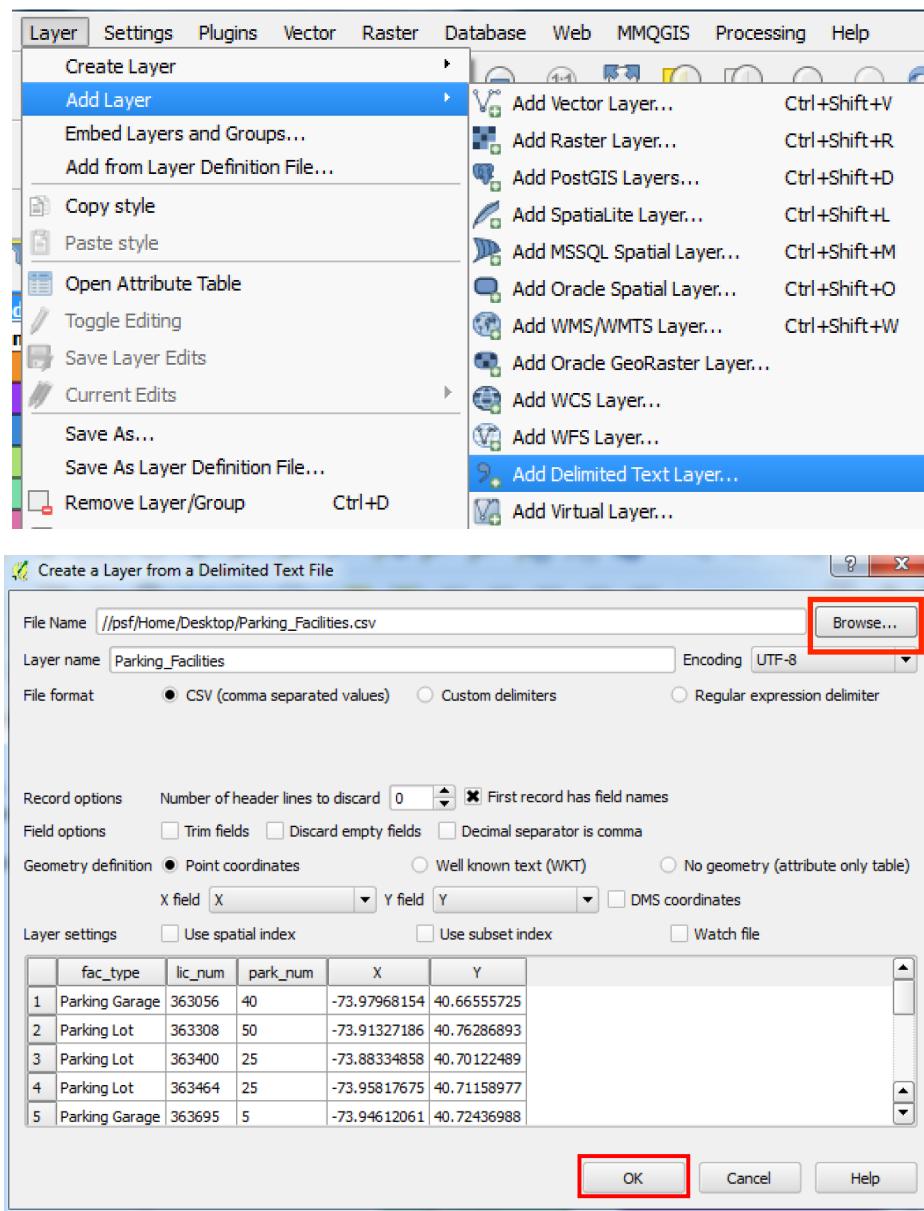
Your Turn

- Filter for service requests in your borough
- Try and find something interesting
- Change the style of the point, either to a different shape, color, or icon
- Export your selection as a new shapefile

Adding CSV Data

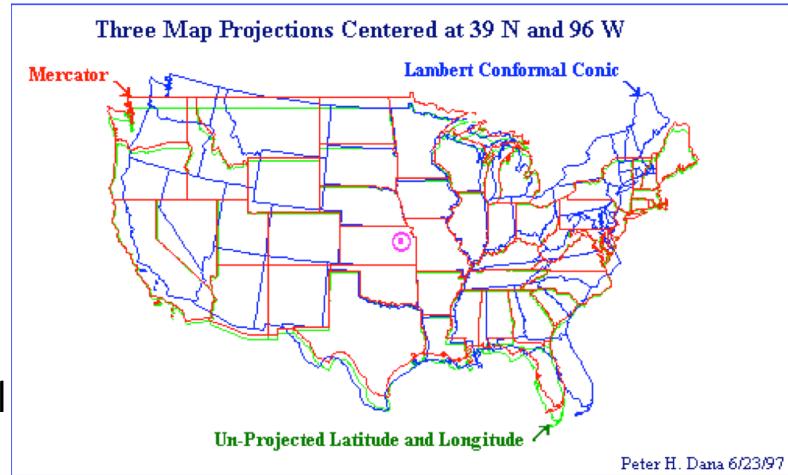
Adding Parking Facilities

- Save this file to your desktop http://www.datapolitan.com/DOT_GIS/20160428_Introduction_to_GIS_Fundamentals/data/Parking_Facilities.csv



Projections

- No one's favorite part of GIS
- But a necessary part of it nonetheless
- Convert points on the 3-dimensional Earth (latitude and longitude) to x and y coordinates on a 2-dimensional map
- Every projection distorts some part of your map
- For the most part we will work in WGS 84 (latitude and longitude)
- In NYC, we use a more accurate projection NY State Plane/Long Island Zone
- Identified by unique IDs that make it easier to talk about them
- WGS 84 is referred to as EPSG:4326
- State Plane Long Island is referred to as EPSG:2263



Remember these two
and you should be set

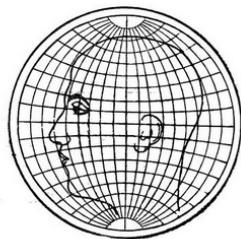


FIG. 42.—Man's head drawn on globular projection.

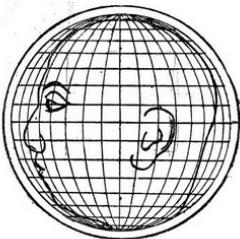


FIG. 43.—Man's head plotted on orthographic projection.

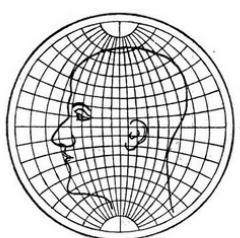


FIG. 44.—Man's head plotted on stereographic projection.

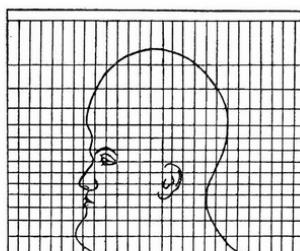
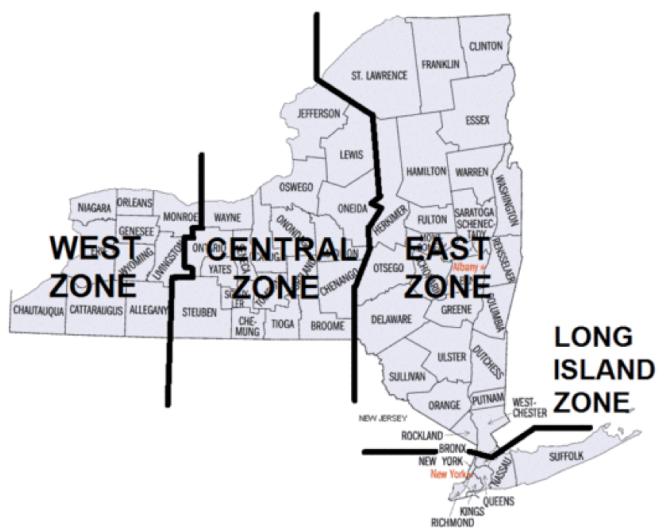
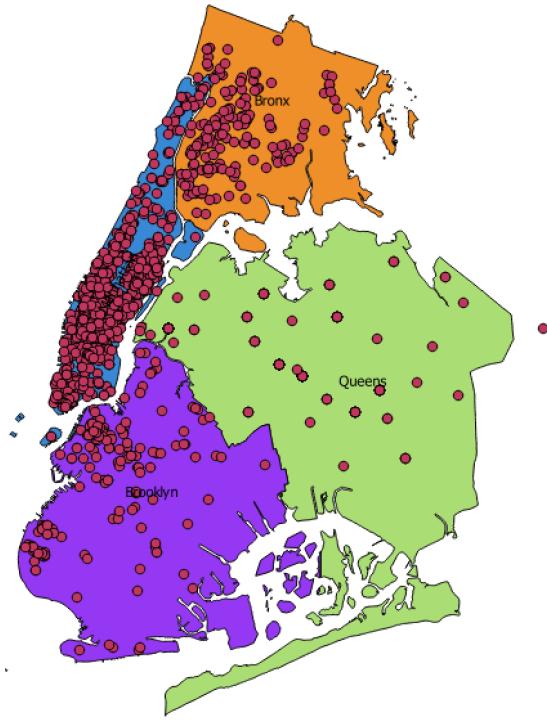
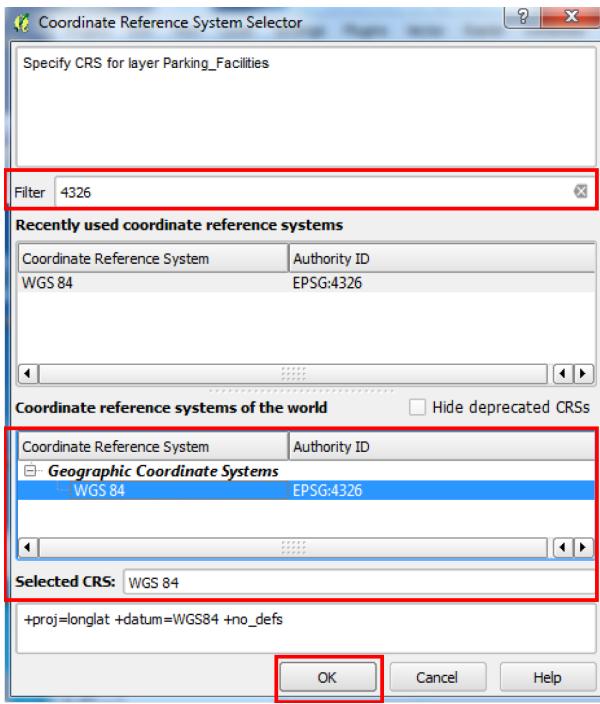


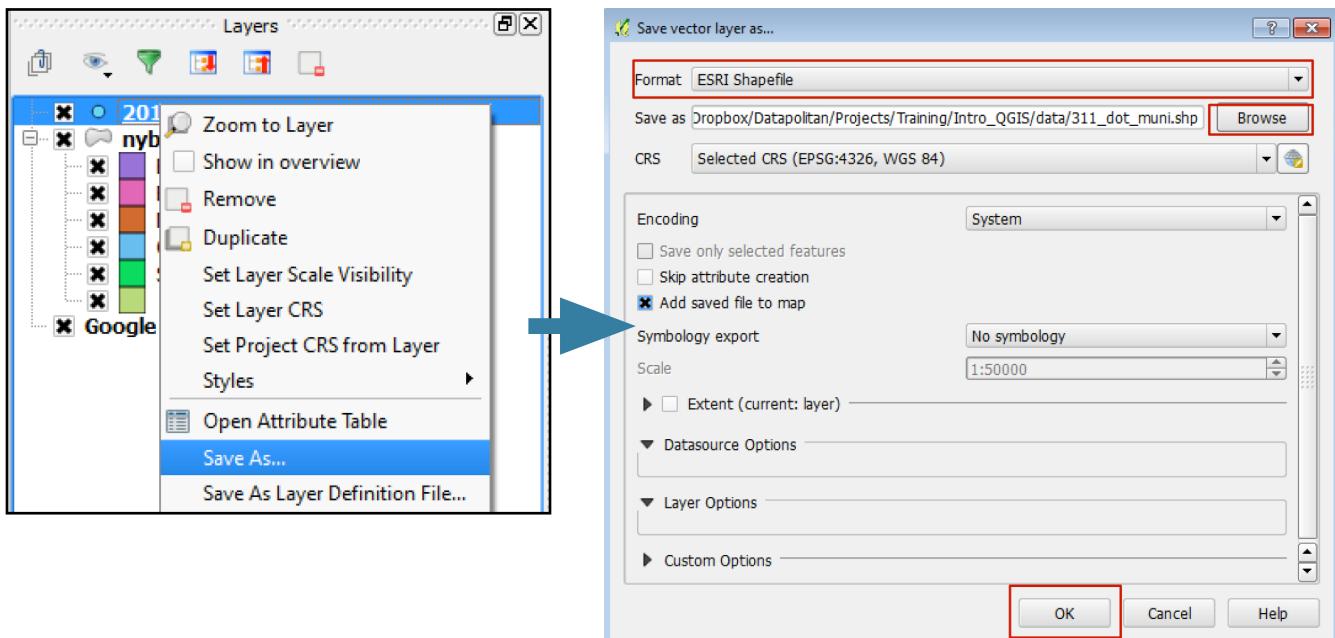
FIG. 45.—Man's head plotted on Mercator projection.



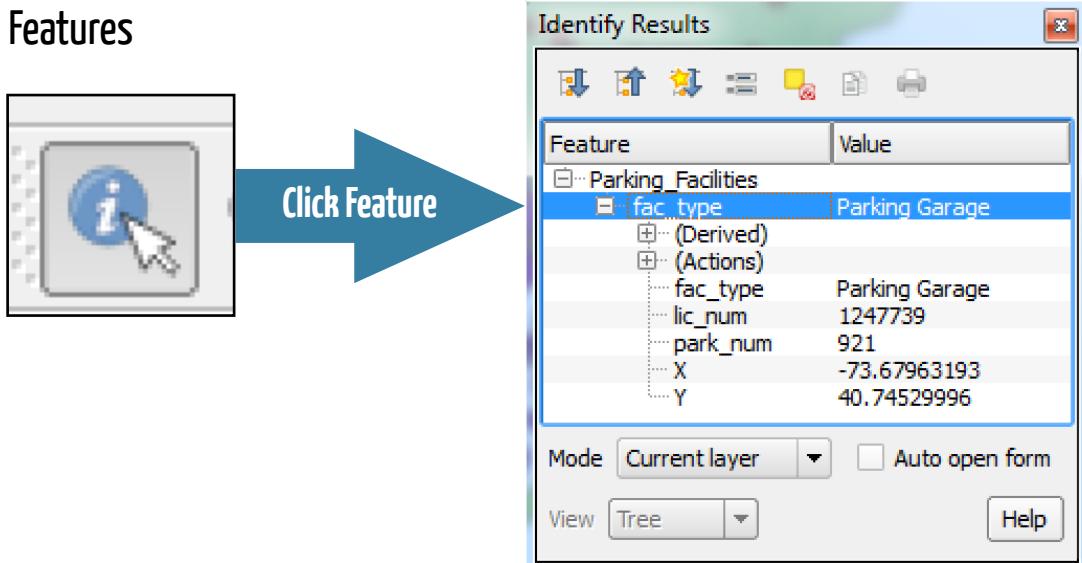
Adding CSV Data



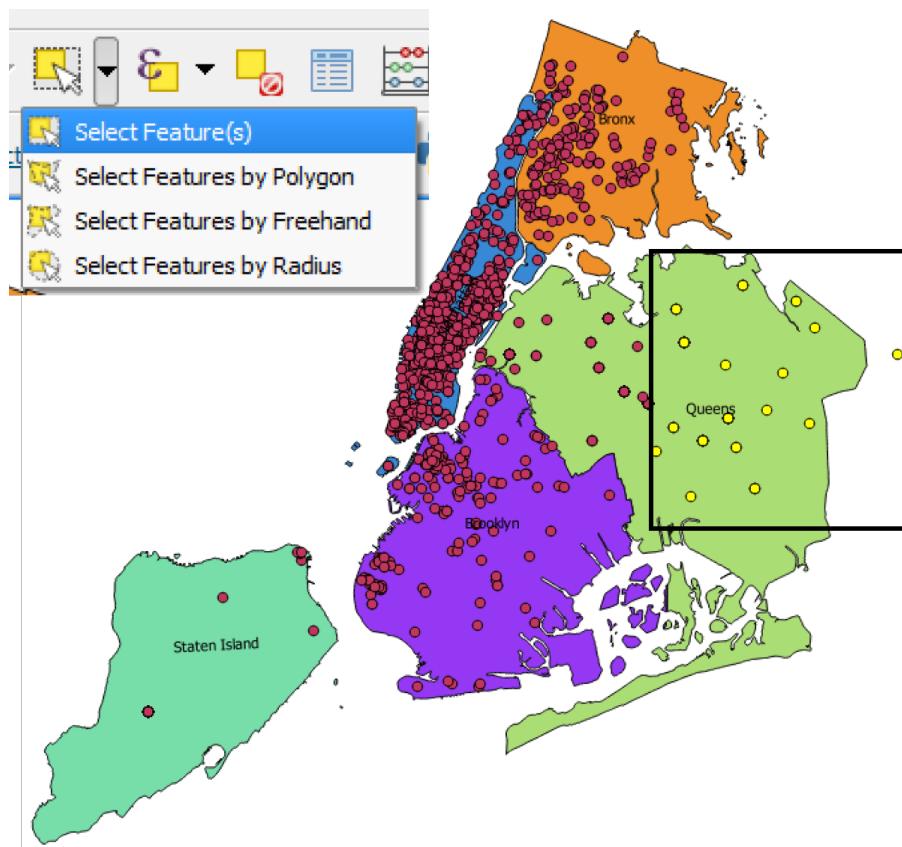
Saving CSV Data as Shapefile



Inspect Features



Select Features



Show Selected Features in Attribute Table

The screenshot shows two instances of the ArcGIS Attribute Table window. The top window displays 1407 total features, 51 selected, and has a filter dropdown menu open. The bottom window shows 46 selected features from a total of 1407.

Top Window (Initial State):

- Attribute table - Parking_Facilities :: Features total: 1407, filtered: 1407, selected: 51
- Filter dropdown menu:
 - Show All Features
 - Show All Features
 - Show Selected Features** (highlighted in blue)
 - Show Features Visible On Map
 - Show Edited and New Features
 - Field Filter
 - Advanced Filter (Expression) Ctrl+F
- Show All Features button (red box)

Bottom Window (After Applying Filter):

- Attribute table - Parking_Facilities :: Features total: 1407, filtered: 46, selected: 46
- Show Selected Features button

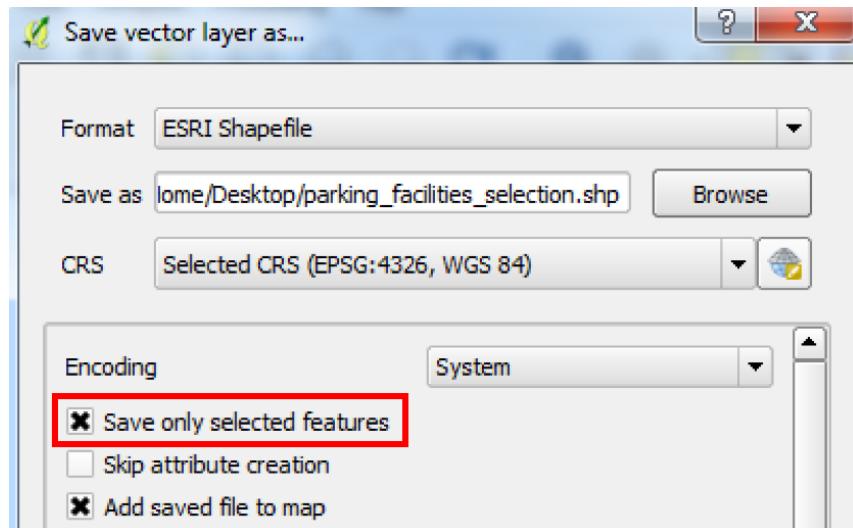
Data from Top Window:

	fac_type	lic_num	park_num	X	Y
0	Parking Garage	363056	40	-73.97968154	40.66555725
1	Parking Lot	363308	50	-73.91327186	40.76286893
2	Parking Lot	363400	25	-73.88334858	40.70122489
3	Parking Lot	363464	25	-73.95817675	40.71158977
4	Parking Garage	363695	5	-73.94612061	40.72436988
5	Parking Lot	363732	75	-73.96946773	40.69110093
6	Parking Garage	363740	165	-73.97968154	40.66555725
7	Parking Garage	363809	200	-73.93339948	40.68366871
8	Parking Garage	363881	85	-73.96807185	40.6941565
9	Parking Garage	363961	90	-73.99836234	40.69206331
10	Parking Garage	364407	25	-73.98705379	40.68702658
11	Parking Lot	364804	15	-73.92715985	40.68438847
12	Parking Lot	365110	75	-73.73864032	40.70991312
13	Parking Lot	365142	40	-73.97956719	40.6823121
14	Parking Lot	365547	300	-73.92054135	40.74489337

Data from Bottom Window:

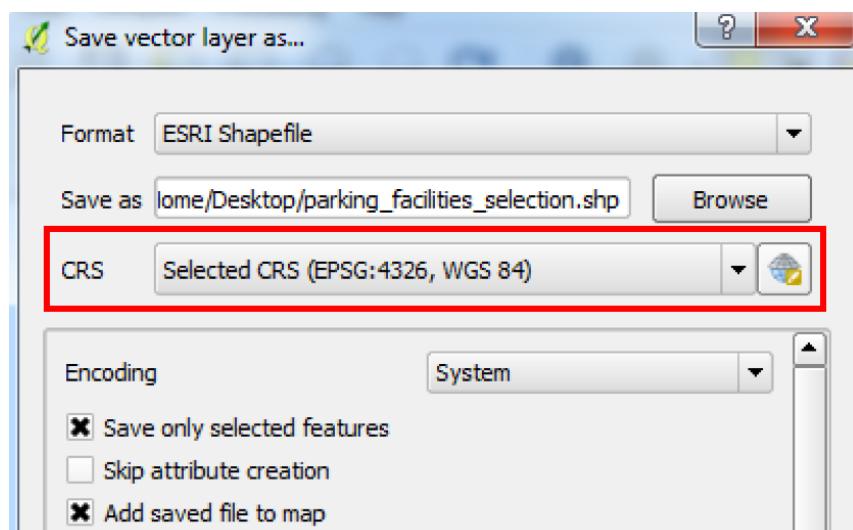
	fac_type	lic_num	park_num	X	Y
12	Parking Lot	365110	75	-73.73864032	40.70991312
75	Parking Garage	368602	33	-73.82147855	40.7512998
101	Parking Lot	369838	263	-73.79462154	40.73987184
239	Parking Lot	767674	56	-73.80979666	40.70119265
273	Parking Garage	835198	49	-73.792821	40.71311535
307	Parking Garage	889309	178	-73.82719028	40.76862022
430	Parking Lot	927659	125	-73.74679789	40.77239842
444	Parking Garage	942550	94	-73.82855612	40.70828608
500	Parking Garage	965328	900	-73.78226734	40.78070133
501	Garage - Parking ...	965331	900	-73.78226734	40.78070133
507	Parking Lot	972208	22	-73.792821	40.71311535
524	Parking Garage	976779	148	-73.792821	40.71311535
525	Parking Garage	976815	204	-73.792821	40.71311535
526	Parking Lot	976816	65	-73.792821	40.71311535
547	Parking Lot	994343	33	-73.80979666	40.70119265

Save Selected Features as a Shapefile



Reproject Features into Different CRS

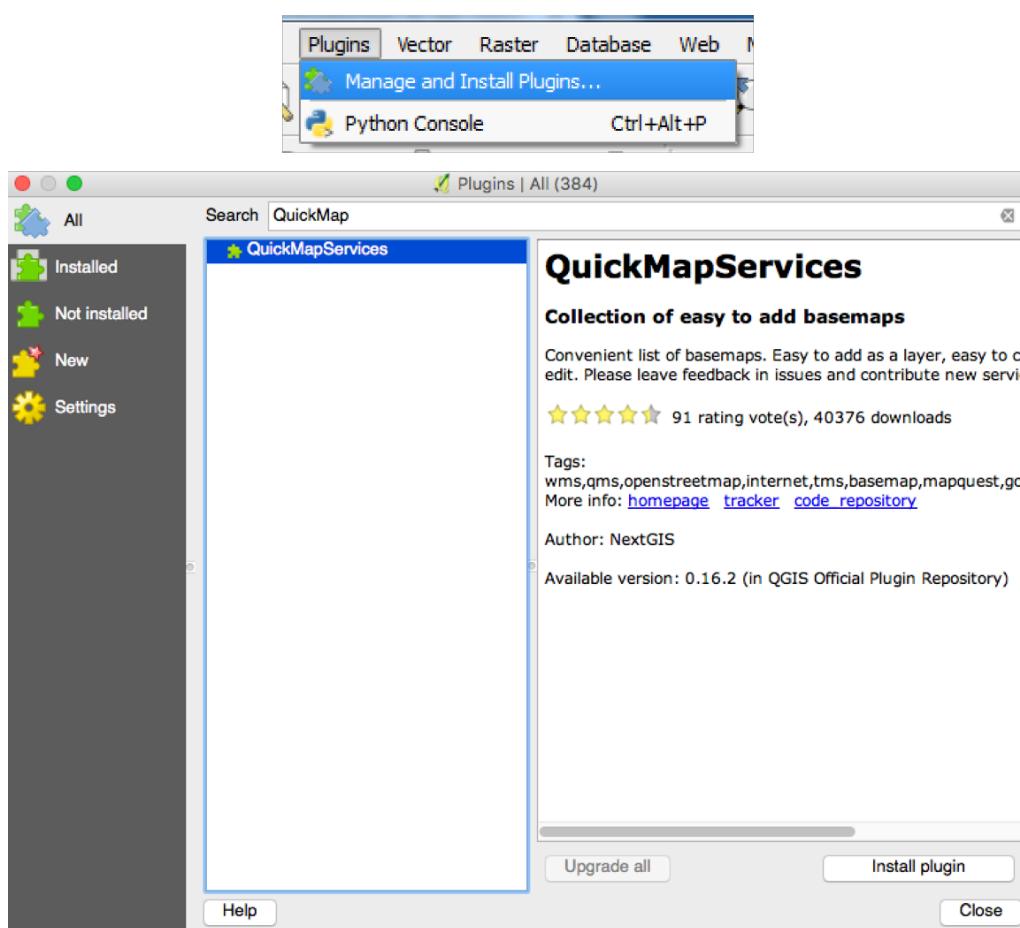
- If we wanted to reproject the data into a different CRS, we could do that here
- Pick the new projection in the CRS field (like when we imported the CSV)



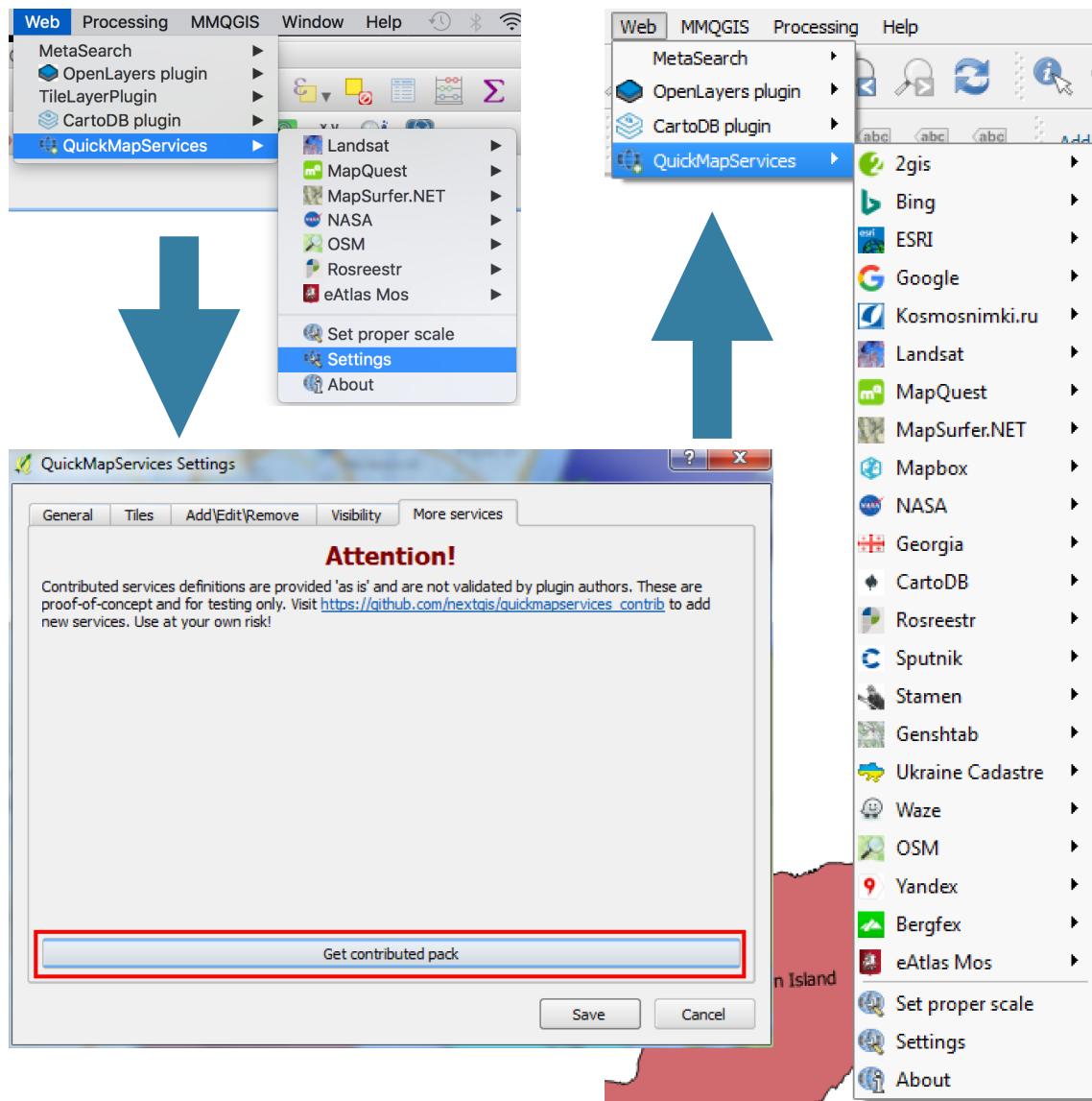
Goals for the Afternoon

- Add reference data to our maps
- Learn how to join features in QGIS
- Create printable maps in QGIS
- Share resources for further learning

Adding Base Maps (QuickMapServices Plugin)



Adding Base Maps (QuickMapServices Plugin)

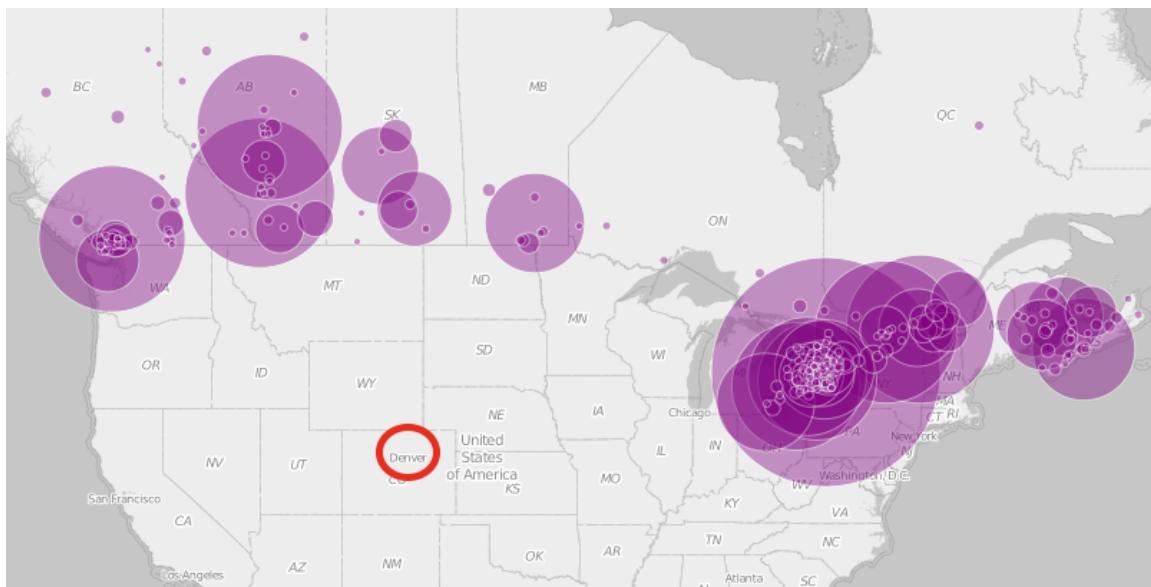


Choosing a Base Map

- Think about what someone reading your map needs to see for context
- Think about how the base map interacts with the data on your map

Base Maps

- If your data is the most important part of the map, make sure it looks more important than the base map
- Avoid base maps that strongly emphasize features that aren't relevant on your map
- Choose base maps with colors that complement your map's colors
- The contrast between your map's colors and the base map's colors should be enough to make your layers clearly visible
- Base maps show different levels of detail at different scales
- Make sure the level of detail is appropriate to your map

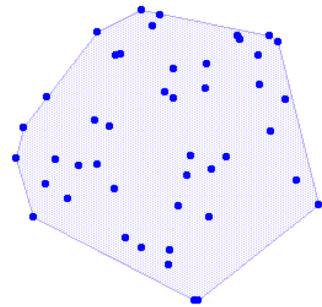


Your Turn

- Find a good base map for your data
- Think about hierarchy, color, and scale
- Don't be afraid to play around

Basic Spatial Joins

- Point to Polygon -> Relate points inside a polygon to that polygon (ex. count the number of points)
- Polygon to Point -> Points can take on value of enclosing polygon



Exercise: Calculate the number of parking facilities by borough

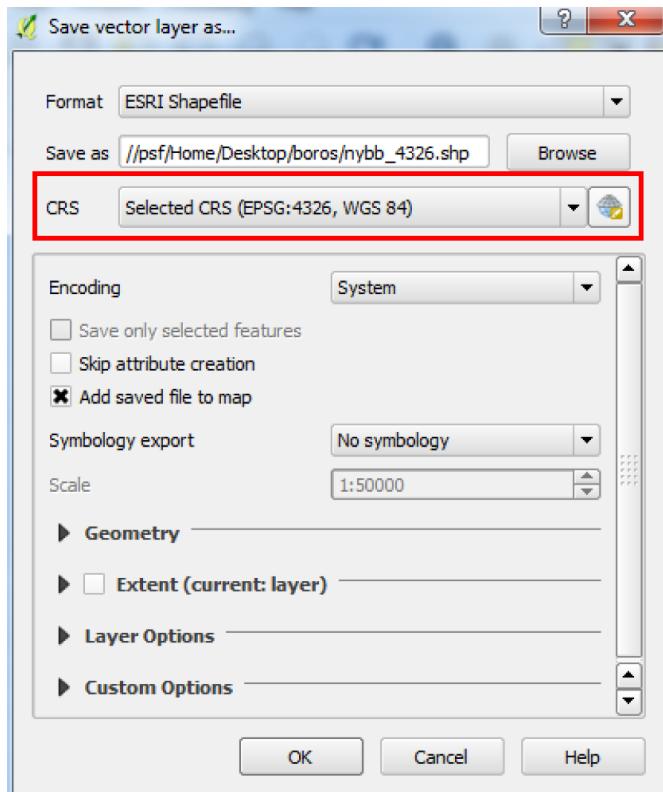
The 'Join attributes by location' dialog box is open, showing the following settings:

- Target vector layer: nybb
- Join vector layer: Parking_Facilities
- Attribute Summary:
 - Take attributes of first located feature
 - Take summary of intersecting features
 - Mean
 - Min
 - Max
 - Sum
 - Median
- Output Shapefile: C:/Users/richarddunks/Desktop/nybb_sum_parking_facilities.shp
- Output table
- Only keep matching records
- Keep all records (including non-matching target records)

The resulting attribute table shows the following data:

BoroCode	BoroName	Shape_Leng	Shape_Area	SUMlic_num	SUMPark_nu	SUMX	SUMY	COUNT
0	5 Staten Island	330385.0369739...	1623853249.910...	NULL	NULL	NULL	NULL	NULL
1	4 Queens	861038.4792990...	3049947236.730...	NULL	NULL	NULL	NULL	NULL
2	3 Brooklyn	726568.9463400...	1959432236.829...	NULL	NULL	NULL	NULL	NULL
3	1 Manhattan	358532.9564179...	636442167.4670...	NULL	NULL	NULL	NULL	NULL
4	2 Bronx	464517.8905529...	1186804144.789...	NULL	NULL	NULL	NULL	NULL

Reproject Data



Redo Join

Top Dialog (Target vector layer):

- Target vector layer: nybb_4326
- Join attributes of first located feature (radio button selected)
- Mean, Min, Max, Sum, Median checkboxes (Sum is checked)

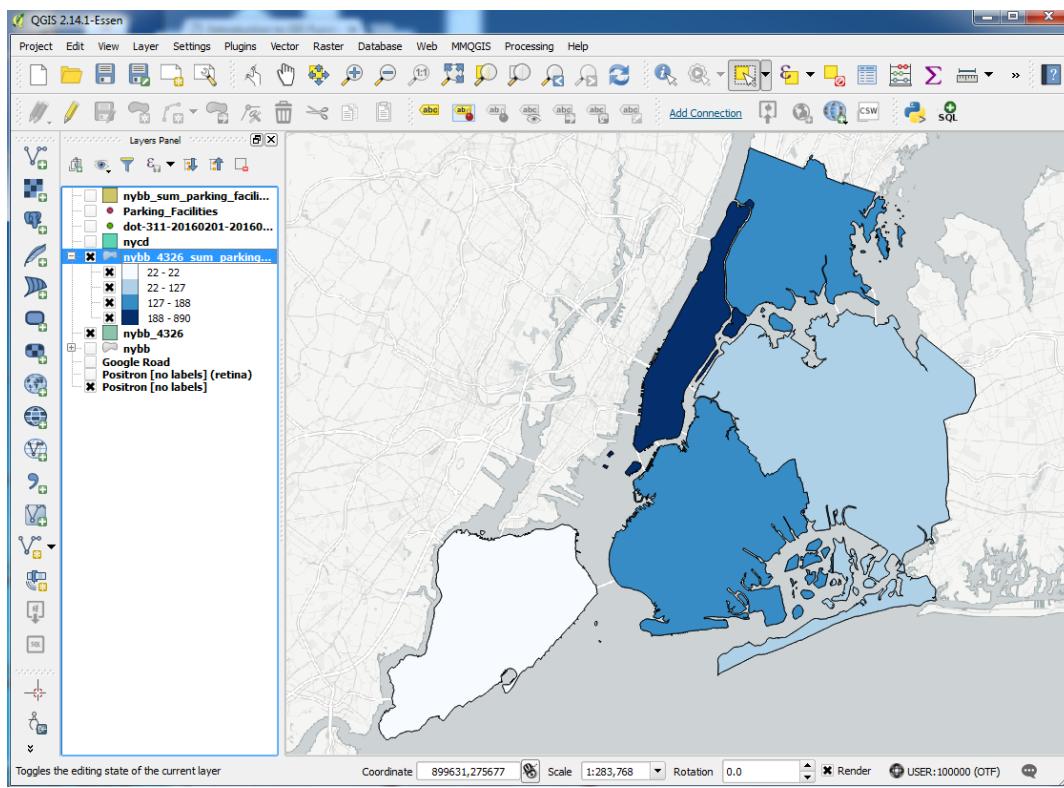
Bottom Dialog (Join vector layer):

- Target vector layer: nybb_4326
- Join vector layer: Parking_Facilities
- Take summary of intersecting features (radio button selected)
- Mean, Min, Max, Sum, Median checkboxes (Sum is checked)
- Output Shapefile: Users/richarddunks/Desktop/nybb_4326_sum_parking_facilities.shp
- Output table: Keep all records (radio button selected)

Attribute table - nybb_4326_sum_parking_facilities :: Features total: 5, filtered: 5, selected: 0

	BoroCode	BoroName	Shape_Leng	Shape_Area	SUMlic_num	SUMpark_nu	SUMX	SUMY	COUNT
0	5	Staten Island	330385.0369739...	1623853249.910...	20209343.00000...	4173.000000000...	-1631.36844026...	892.8162593399...	22.00000000000...
1	4	Queens	861038.4792990...	3049947236.730...	128132534.00000...	25812.000000000...	-9379.17638096...	5172.962901719...	127.00000000000...
2	3	Brooklyn	726568.9463400...	1959432236.829...	180288128.00000...	23003.000000000...	-13908.6854484...	7645.405119449...	188.00000000000...
3	1	Manhattan	358532.9564179...	636442167.4670...	869916485.00000...	121414.0000000...	-65840.2460817...	36275.91160290...	890.00000000000...
4	2	Bronx	464517.8905529...	1186804144.789...	178923195.00000...	31758.000000000...	-13079.3330419...	7230.148146460...	177.00000000000...

Show All Features

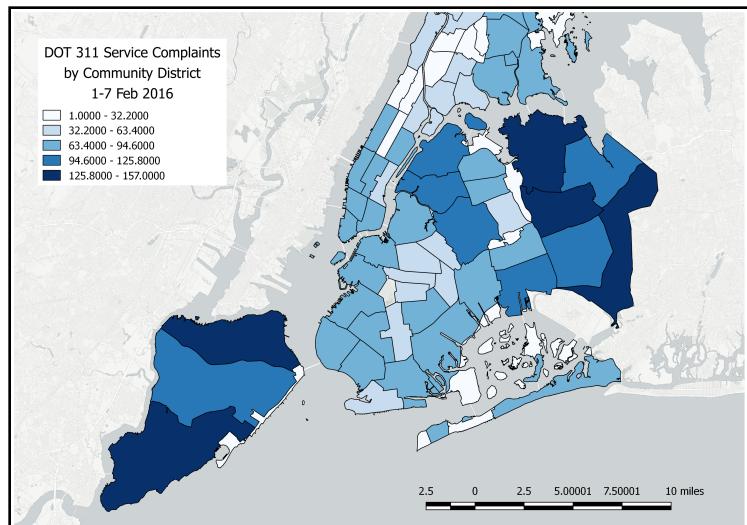


Your Turn

- Count the number of DOT 311 service requests in each community district in your borough
- Style the community districts by the number of service requests

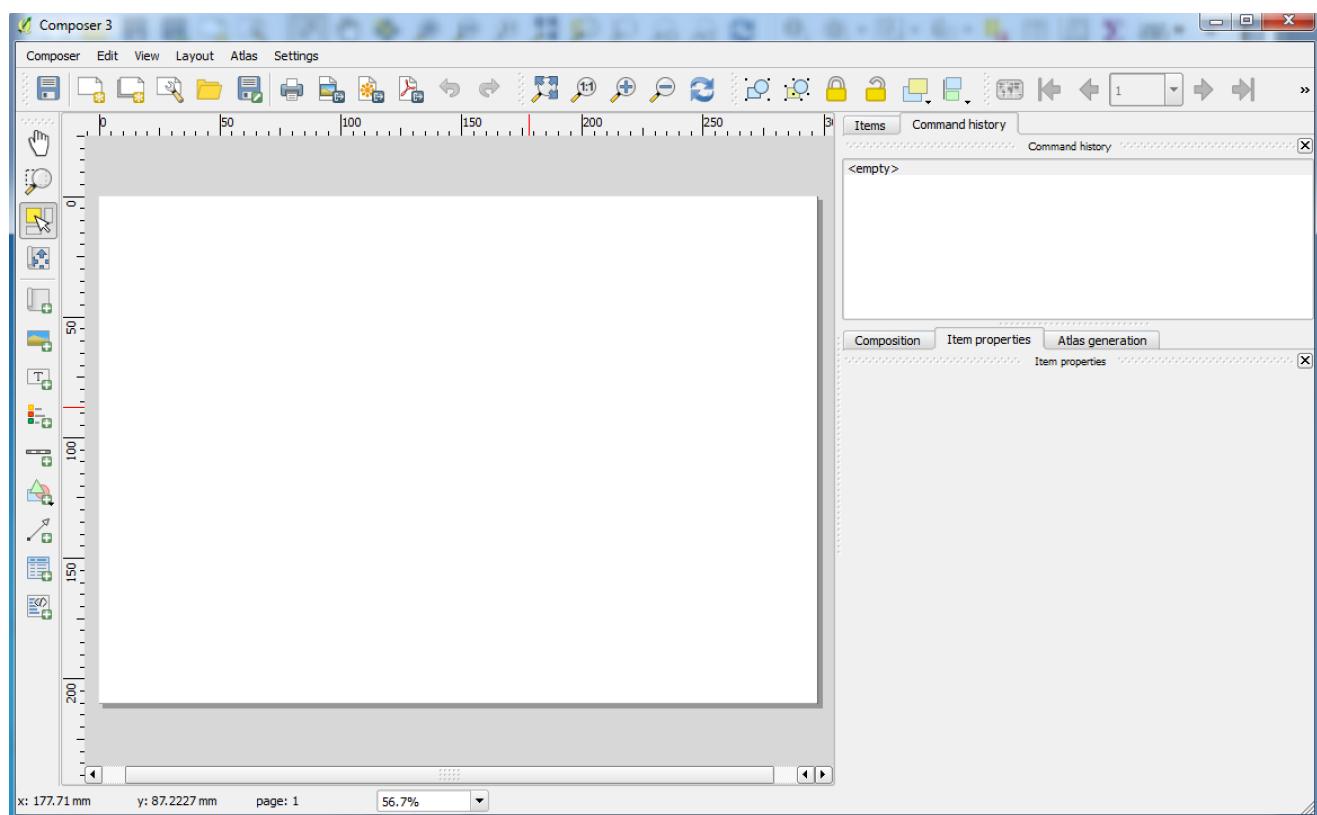
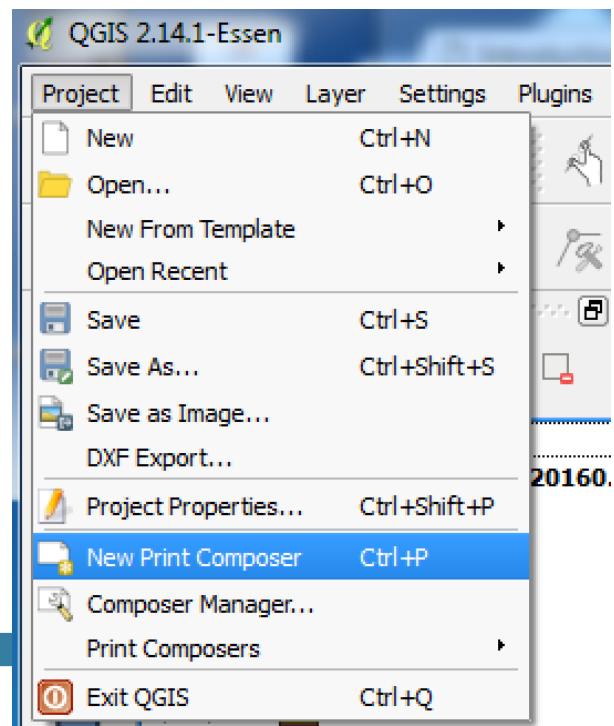
Print Composer

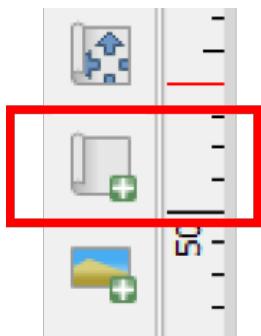
- How you make exportable and printable maps in QGIS
- Able to add map elements (legends, scales, text, etc)



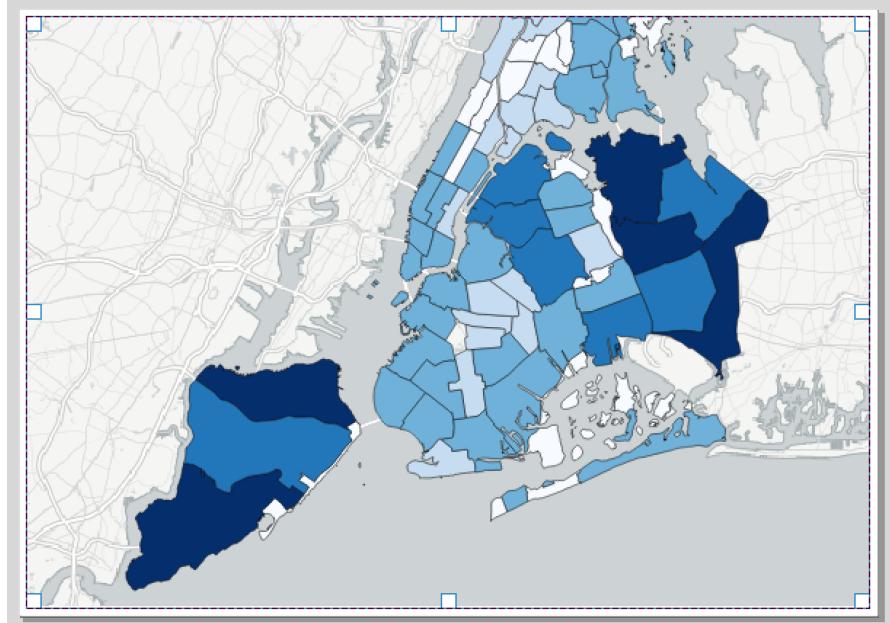
Creating a Print Composer

1. Select “New Print Composer”
2. Give it a title
3. Add elements to the blank canvas
4. Style elements





Draw Map Extent



Customize Item Properties

Main properties

Cache: Update preview
Scale: 212296
Map rotation: 0.00 °
 Draw map canvas items
 Lock layers for map item
 Lock layer styles for map item

Extents

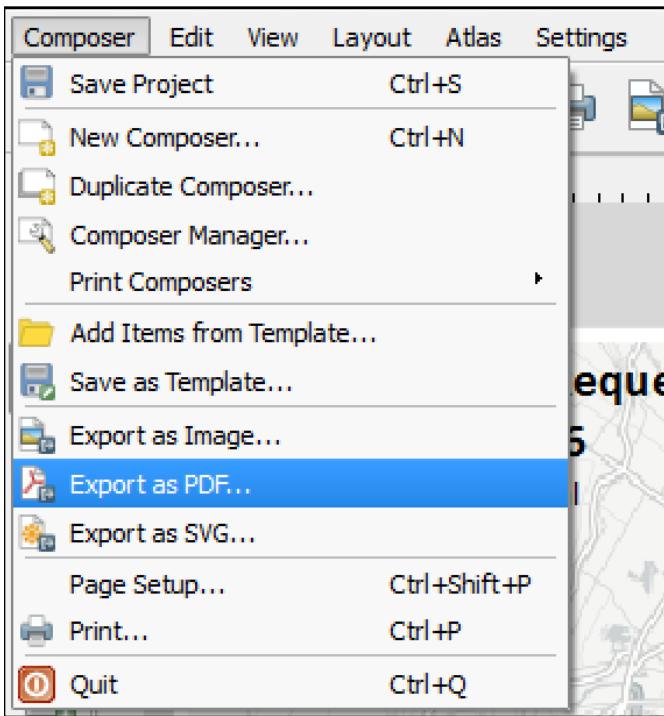
X min: 889284.955
Y min: 116303.821
X max: 1091272.662
Y max: 256998.707
Set to map canvas extent
View extent in map canvas

Add Text to Map



Print Composer Problems

- Map extent -> "Use current map extent"
- Moving map around -> Adjust with arrows
- "North" arrow -> need to manually align



A Few Things We Didn't Talk About

- Normalizing data for choropleths
- Buffering features
- Geocoding
- Spatial databases
- Other spatial data types (KML, GeoJSON, GeoTIFF)
- Editing data

Proprietary vs Open Source Software

- Proprietary software source code is owned by an individual or an organization and tightly restricted (usually for profit)
- Open source software source code is freely available to anyone for download, alteration, and republishing
- Proprietary software code is generally supported by a team of paid professionals working for the organization that owns the code
- Open source software code is generally supported by a mix of paid and volunteer professionals that contribute changes back to the community
- Proprietary software is often available only by purchasing a license
- Open source software is free to use though there generally a license that specifies the restrictions (if any) on its use and reuse
- Companies using open source software may charge for the use of the software through their proprietary implementations or via their infrastructure

Reminders

- Know your layer CRS
- When in doubt, zoom in and then zoom out
- If you're working with a CSV file and run into an error, export as a shapefile and try it again
- Save your project often
- Choose good file names

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Bernardo Loureiro, TA

Resources

- QGIS Map Design
- Learning QGIS 2.0
- <http://gis.stackexchange.com/>
- http://docs.qgis.org/2.8/en/docs/gentle_gis_introduction
- <http://www.qgistutorials.com/en/index.html>

Final Thoughts

- Maps are a great way to visualize and explore spatial data
- Some data is only intelligible when mapped
- QGIS is a cheap (as in free) way to get started
- There are many resources online for how to use QGIS and other GIS applications
- Share what you know with others -> Data wants to be mapped