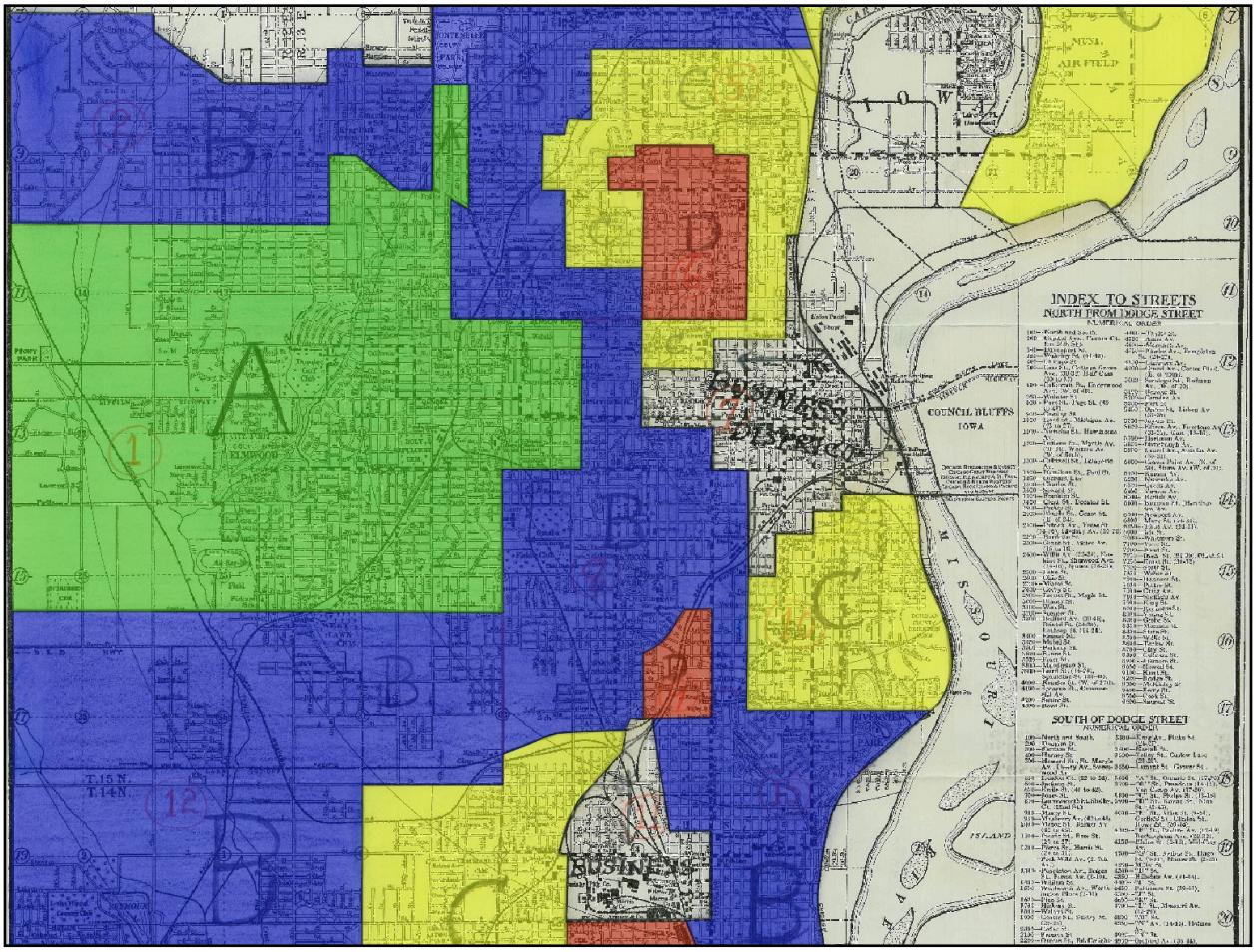
# Building Vector Layers

*in QGIS*

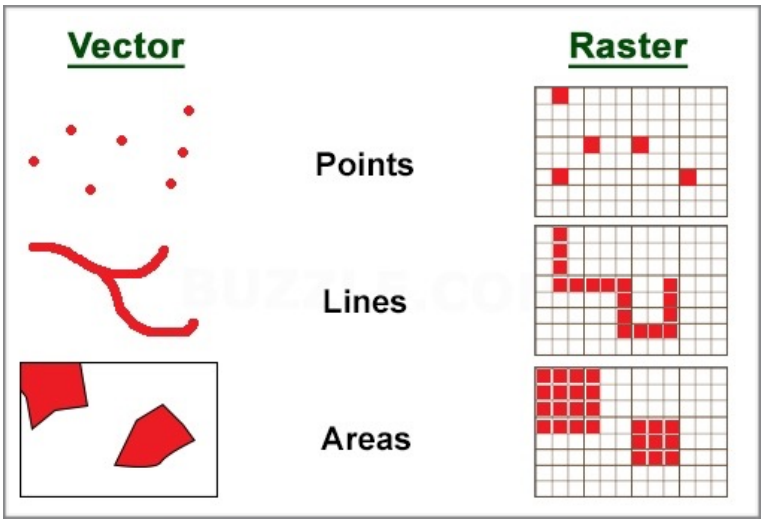



Introduction: Spatially referenced data can be separated into two categories, raster and vector data. This week, we focus on the building of vector features. Vector shapefiles are one of the primary building blocks of any GIS, particularly web-based services that do not support storage of large raster datasets. Learning how to build, edit, and interpret vector data will help you organize and visualize your geographic information. Vector datasets facilitate powerful spatial analysis techniques (which we will explore later in the semester), and just as importantly, assign geographic form and location to the data you wish to associate with those locations (called attribute data). This exercise will introduce you to the core methods of creating, editing, and interpreting vector data.

## *Definition:*

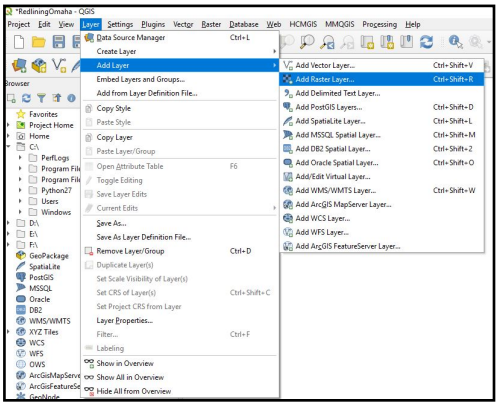
Vector: "A coordinate-based data model that represents geographic features as points, lines, and polygons. Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices. Attributes are associated with each vector feature, as opposed to a raster data model, which associates attributes with grid cells." ESRI GIS dictionary

- translation - Whereas "raster" data is visualized as cells (think of pixels on your computer screen) and do not inherently store location data, vector data are tied to coordinates on a projection and contain additional information (called attributes) tied to those same coordinates. Vector layers can be displayed as point data (i.e. one discrete place on the earth/one coordinate pair), line data, or polygon data.



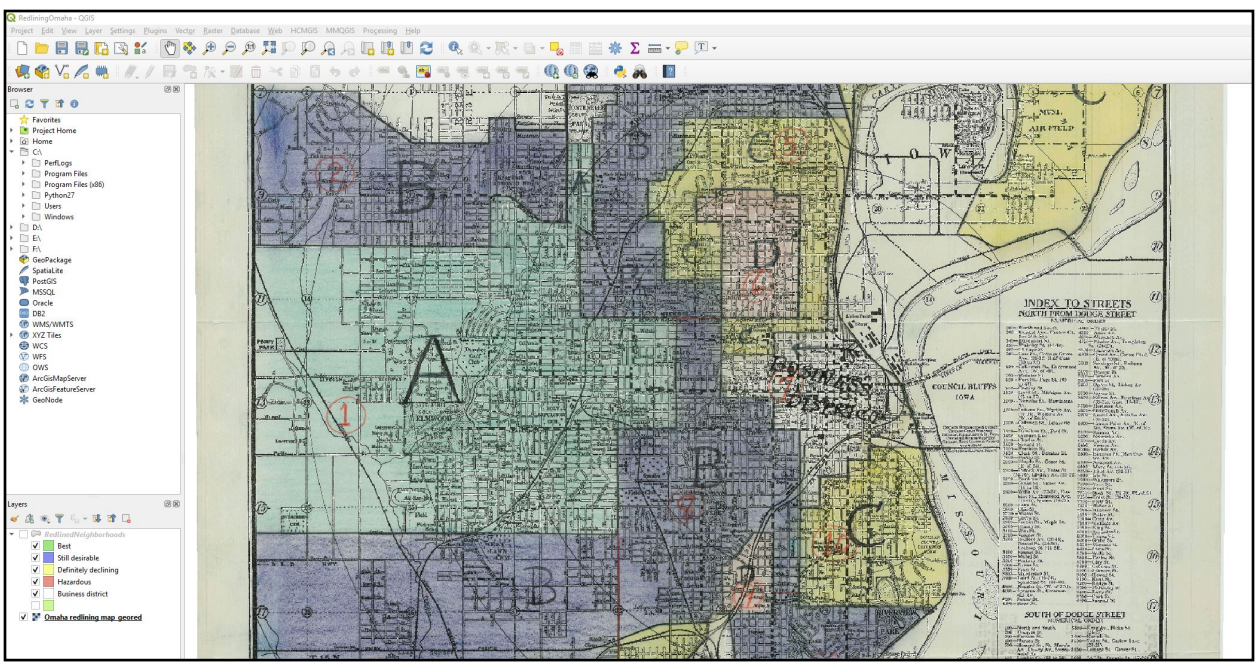

## *Instructions:*

1. Begin with the raster image you georeferenced last week. If you saved the map, simply open it. Otherwise, click "Layer" on the top toolbar, then "add layer", then "add raster layer. It will have the "add raster layer" button beside it. Next, click the ellipses to the right of the "raster datasets" bar. Navigate to the "georeferenced" raster file (your warped historical map file) and click "add. Q(GIS) may ask which projection you would like to



import the raster into. For today's lesson, choose the same reference system as last week. Pseudo Mercator. EPSG 3857. Q should store this information.

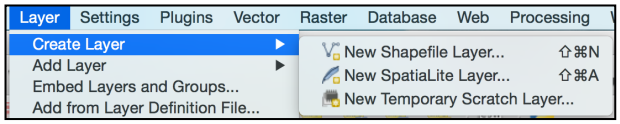
2. Create a new directory in your class folder. You may name this folder "Week 5" or "Vector Mapping" or something similar. All of the files you create in this exercise should be stored here. Save your map project layer to that folder. Click "project" on the top tab, then "save as" then give your project a name like "vectorized_map".
3. You can think about historical maps in the same way you think about modern GIS maps. All maps are compositions that incorporate points (i.e. cities, buildings, points of interest), lines (roads, political boundaries), and polygons (political units). These **features** very likely exist on your georeferenced map as well. Take a broad look at your map. Where do you see features that you can convert to digital vector representations? Pick three features (not the whole map) that you can convert. We will create three different **layers** to transcribe this historic information into the GIS. We will start with point data.
4. I georeferenced an mid-20th century map of Omaha.



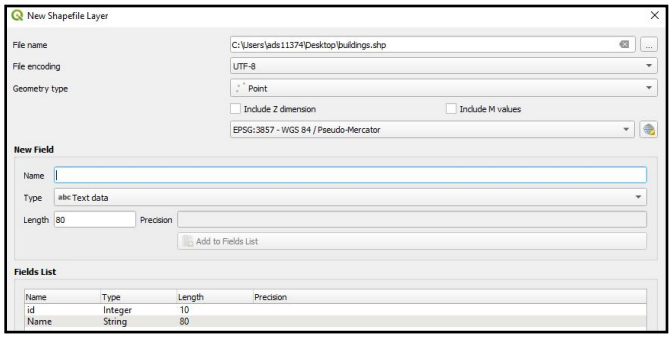

*This is an HOLC "redlining" map of Omaha. It shows areas of eastern Omaha which the federal government deemed "best" (bluish green), "still desirable" (purple), "definitely declining" (yellow) or "hazardous" (red) for investment. These categorizes were partly informed by*

*race. We will return to these maps consistently in the second half of the course as we learn how these maps reinforced Omaha segregation and continue to impact the city today. Looking at this map, I see a number of buildings (on Creighton's campus) I want to convert to point data.*

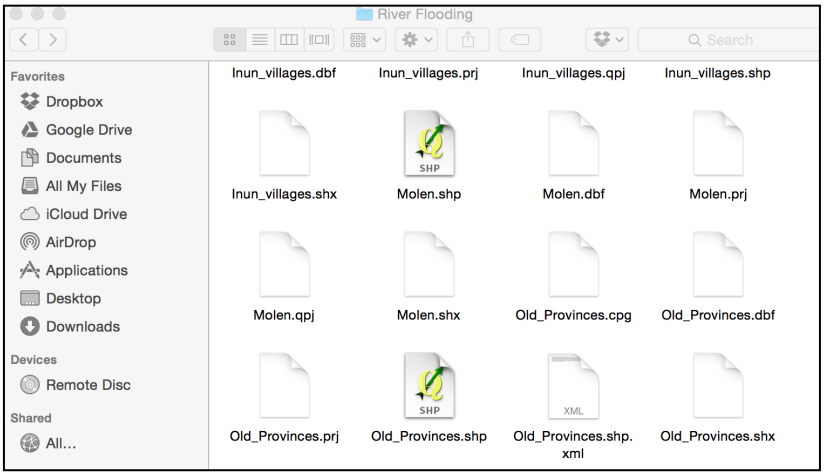
5. To begin, select "layer" from the top toolbar, "create layer," "create new shape file layer." Note - there are also keyboard shortcuts for many of these functions.
6. A "new vector" window will appear. In this window, input the CRS (coordinate reference system) and make sure the "geometry type" is point data. All data that you add in a vector layer will have associated **attribute** data. Attributes define the vector features you are creating. There are a number of different kinds of attributes you can select, including "text" or various forms of numerical data. We will discuss attribute data more fully later in the course. For now, we will simply assign names to our points. None of the buildings on Creighton's campus that I am digitizing have names on my map, but since I know what they are already, I can assign those names as an attribute category to my new vector files. To add this as a category, type "name" into the name of the new attribute box and make sure "type" is "text." Click "add to Fields list." Your vector layer is almost created. You now simply need to give the **shapefile** layer a name. Input this into the box beside "file name" at the top. I am calling the layer "buildings". Save this layer file by clicking the ellipses to the right of the box, the save to the same folder you created in step 2.



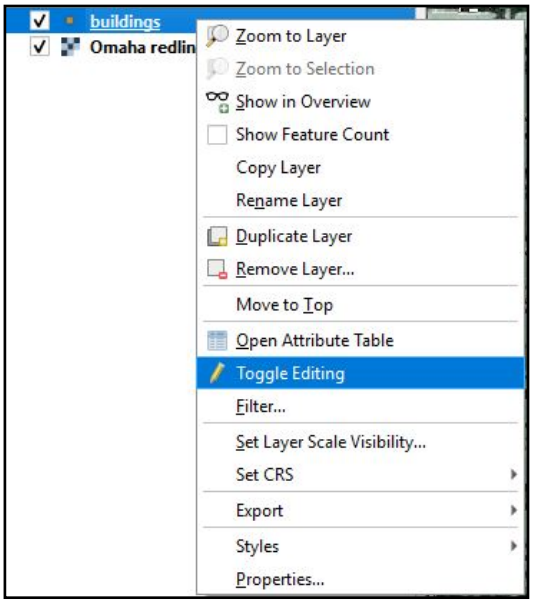

7. Your new shapefile layer should appear in your "layers" panel on the left or right of your screen.
8. Lets take a brief detour to see what exactly you've created. Open the folder your saved this file into. When you make a vector shapefile, the GIS stores it as several individual files, all with the same name (that you just assigned, "buildings") but with different file type extensions. All shapefiles have three mandatory extensions: The .shp file stores the shape



format (line/polygon etc) or its geometry; .shx is a shape index format that stores relational information; and .dbf stores the attribute format in a database (like an excel spreadsheet). QGIS also creates a few other kinds of file extensions such as .prj (stores your projection) and .qpj (a QGIS-specific extension that stores, for instance, the EPSG projection data). **Why is all of this important?** If you ever export your data out of QGIS (for instance to a webGIS, you need to select which of your files to include. Additionally, other desktop GIS software creates their own proprietary files that may, or may not, play well with Q. It's good to know what exactly is happening behind the scenes. Finally, if you need to move your data from one folder to another, make sure to include **all of these files**, since they store different parts of what you are visualizing in the GIS.



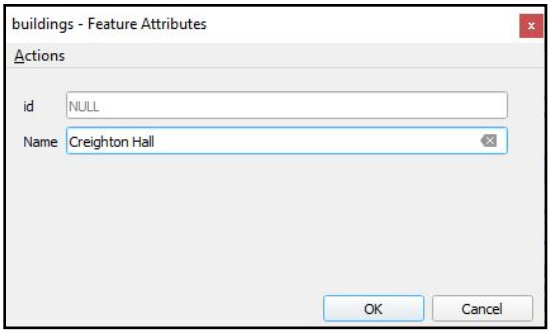

9. You've created your point layer files, but you have not assigned any coordinates or attributes to them. Now you will edit the file. Look to your "layers" window on the left. This widow displays all of the layers you are visualizing in the main window. You should have two. The name of your historic map and your point shapefile layer. You may also have a basemap if you desire. First, you need to toggle editing. You can do this in two ways. Click on the point layer to highlight it. Right-click the layer and select "toggle editing" from the menu. It has a yellow pencil symbol beside it. On



the top toolbar you'll find another pencil symbol (this is another way to toggle editing).

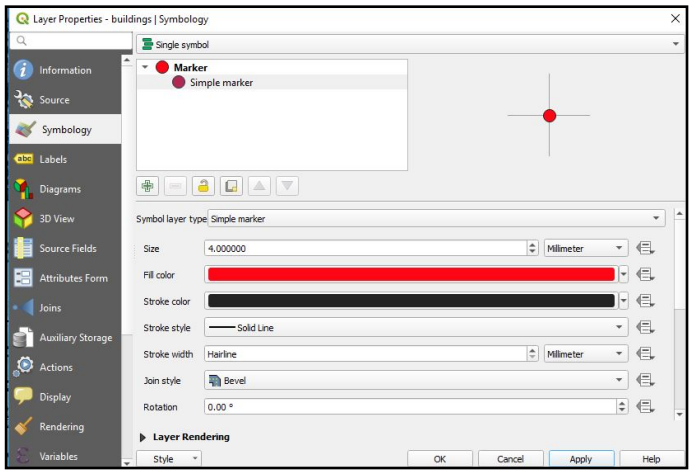
10. Now that you're in editing mode, lets explore the options available for creating and manipulating your point data. On the top toolbar, symbols that were previously unavailable are now highlighted. The double pencil symbol lets you save or "rollback" changes you've made to one or several layers. Since you will be dealing with one layer for now, let's move on. To the right is the shortcut to toggle edits. Beside that is the "save edits" button which will be available to you once you add points. To the right of that you have "add feature," "move feature," and "node tool." The add feature button allow you to create new points, the move feature tool allows you to move selected points around your map (for instance, if you click in the wrong place to add a point), and the "node" tool allows you to manipulate points in a variety of ways (this will be more significant once we create lines and polygons. You can also delete (once you create points) or "cut" your features using the tools to the right of that.
11. Add at least 10 points to your map, by click the "add feature button" and clicking on the area of the map you want visualized as a point. Make sure to input the "name" of your point when the pop up window prompt you to. Remember, you can pan around the image using the white hand button, zoom in/out to the "full extent" of the layer you are digitizing. If you get lost, use the "zoom last" button to go back to your previous extent. Explore these functions at your leisure. You can also "refresh" the screen if it goes black or does not resolve. **Do not forget to save your project once you've made some significant changes.**

12. When you are done adding your 10 points, toggle the editing off and save your data when the pop up window appears. Don't forget, you can also retoggle the editing back on if you would like to add more point data or move the

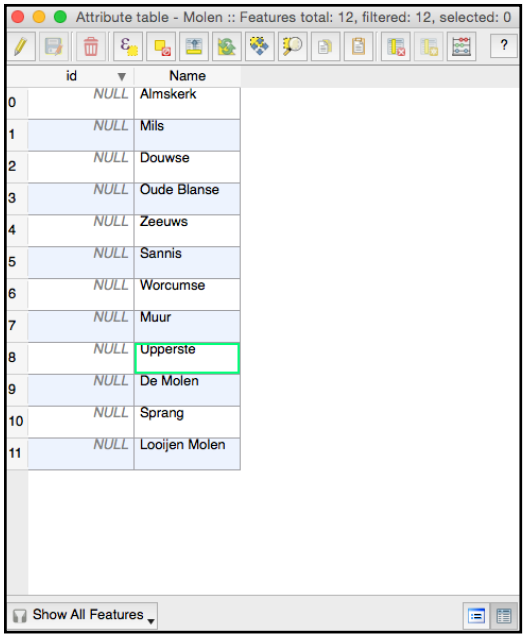


points around.

13. Now let change the symbology of your point data. Perhaps you have the same trouble I have in seeing the points that you have already added. Lets enlarge the points and change the color to make them more visible.
14. Right click on the point layer file again, this time selecting "properties." Under properties, you will see a variety of options in the left hand toolbar. To change the symbology of your points, click "symbology." There are a variety of options to alter your symbology, even creating your own symbol. Explore these and choose a symbol, color, and size that give the point greater visibility. (we will have a lesson on cartographic symbology and aesthetics later in the course). Click "ok" when content. Don't forget to periodically save your map project.

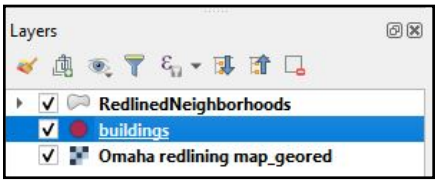


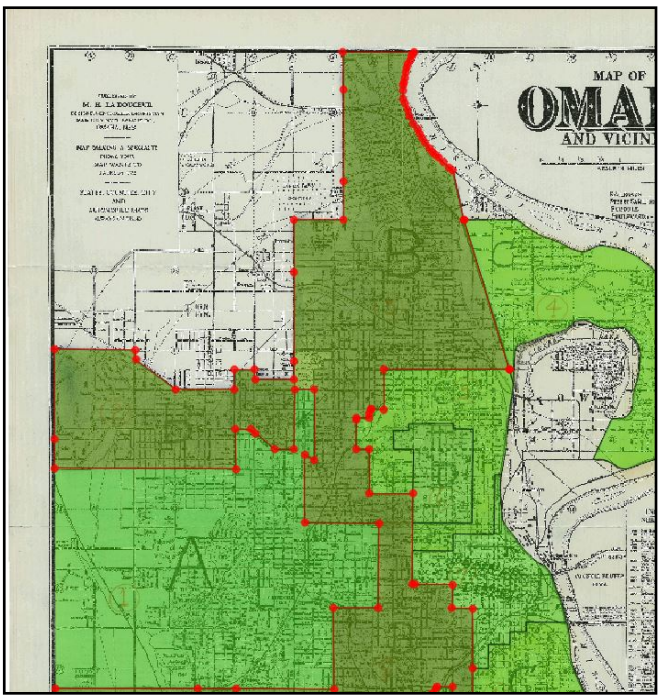

15. Before moving on to lines and polygons, let's take a look at the attribute data you have been adding. Right click your point layer file again and click "open attribute table." A spreadsheet will appear. If you have an attribute category that you did not add data to (for instance, the default "id" category, it will appear as null). The information you added under "name" should appear as well. You can edit this spreadsheet using the same pencil icon as before if you misspelled or forgot to add data. You can also add other attribute information and even compute the geometry (area/length/etc) or tabulate



the sum of your data. We will be exploring this more in future lessons. Close your attribute table.

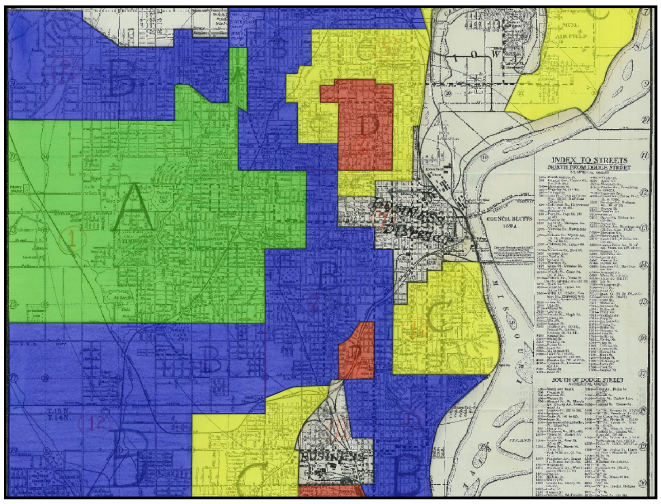
16. Now it is time to add your polygon layer. On my map, geographic space is organized primarily according to large colored polygons that show loan hazard. I will trace these region and add them as polygons to the GIS. Select a similar category of analysis on your own map.
17. To add a polygon layer, use the same steps as before, this time selecting "polygon" when the "new vector layer" window appears. Remember to save this with a file name in your file folder that corresponds to the type of information you are digitizing (I am called my file "RedlinedNeighborhoods")
18. When you are finished, look to the left "layers" panel. You now have three layers. The symbol to the left of the name corresponds to the type of shapefile you created (a colored polygon). Toggle the editing for this layer. You'll notice that the symbol for "add feature" has likewise changed. (its now a green amorphous polygon with a pencil over it).




19. Select "add feature" and trace a polygon you have identified on your historical map. Zoom in a closely as you can to keep your digitization exact. Click repeatedly along the border until you have completely traced the polygon, then right click to end the operation. The window will appear that asks you to name the polygon. Do so. Click ok.
20. Create three polygons using this process.
21. When you are finished, do not toggle the editing off. Use the "select node" tool to manipulate your polygon. Each time you click along the polygon, you

created a new node to your polygon. Click on one of the nodes to highlight them all in red. With one highlighted in blue after you click it, you can use the node tool to move the node around and reshape your polygon, delete nodes (with delete key), or add new nodes by double click a line on your polygon that has no node. You can also move the entire polygon around use the "move feature" tool. Explore these tools.




22. Feel free to change the symbology of your polygon layer as well. You can simply change the color, change its transparency, alter its borders, etc. I will change the polygon colors to correspond to my underlying historical redlining map.
23. Your last step will be to add a line shapefile layer. Follow the same process as before, this time selecting "line" instead of point or polygon in the "new vector layer" window. For this layer, I will digitize major roads. Oftentimes, roads and rivers are visualized as lines.
24. When you are finished, toggle the editing off and save your map.

**Consider - Many features in historical and modern maps can be represented by these three types of "vector data" (in fact, many digital maps exclusively employ these tools. If you repeat these operations for every since line, point, and shape on a map, each time changing its color, saturation, texture, size etc, how close to the original map would you come? How complex would you map be?**

## *Questions for Consideration:*

1. Are there any features on your historical map that would have been difficult to assign a vector categorization (point, line, polygon)? Why?

2. What other attributes (aside from name) do you think would have been appropriate to add to your vector dataset?

3. Did you detect any spatial relationships when digitizing your map that you would not have otherwise? Did you see your historical map in a new way? If so, how?