



Digitizing Precinct Maps

A How-To Guide

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Before We Begin

This guide is written for QGIS 3.2.3, an open-source desktop GIS software. You can download it for free at <https://www.qgis.org/en/site/>.



I assume minimal knowledge of geographic information science (GISc). I have written this guide in an accessible and fun way so that anyone can learn to digitize maps! Throughout the guide I will **highlight** important concepts and provide **links** to more resources.



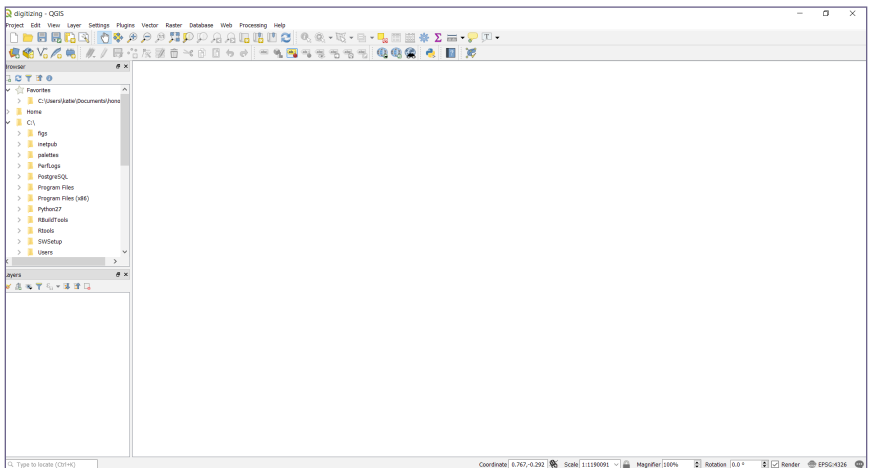
§ Georeferencing

Georeferencing is the process of associating a location with an image.

Starting a QGIS Project

¶ In this part you will set up your workspace for digitizing.

1. Open QGIS
2. Under the **Project** tab, click **New**
3. To save your project, under the **Project** tab again, click **Save As...**
4. Create a folder where you want to save this work and name your project (with no spaces), then click **Save** (keep the default filetype ***.qgz**)



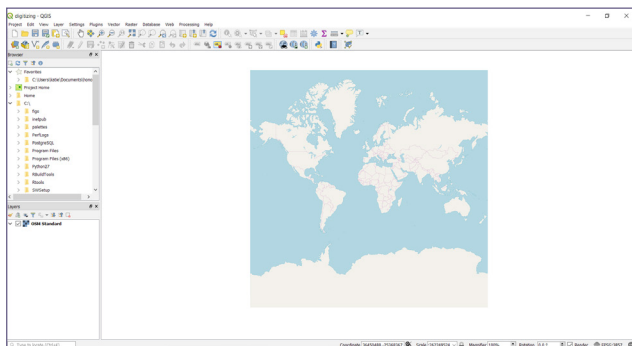
Your project will look something like this. If it's saved properly, the name will appear in the top left corner

Basemap

¶ In this part you will add a basemap to your project.

Your basemap will serve as a reference map for assigning the location to your image. We will use OpenStreetMap, a popular free wiki world map.

1. To add the *QuickMapServices* QGIS plugin, under the **Plugins** tab, click **Manage and Install Plugins**
2. Click on **All** in the side menu and type **QuickMapServices** into the search bar at the top of the window
3. Make sure there is a ☒ in the box, then click **Close**
4. In the **Web** tab, hover your mouse on the **QuickMapServices** item, move your mouse over to **OSM**, then click the **OSM Standard** option (this loads just the generic OpenStreetMap, as opposed to a specific one)
5. Save your project!



Your project will look something like this

Highlight: Projection.....

Projection is how we take 3-D data from the earth and put it on a 2-D map. Think about peeling an orange: is there a way to draw something on the orange, lay the peel flat on a table, and preserve the original design?

No way to project data is flawless, but we can strategically pick projections to minimize distortion. There is a lot about projection that I am not able to cover in this guide, but I would recommend reading about it on your own.

A Tale of Three Ohios

Map 1



Mercator

Map 2



North American
Equidistant Conic

Map 3



Universal Transverse
Mercator Zone 17N

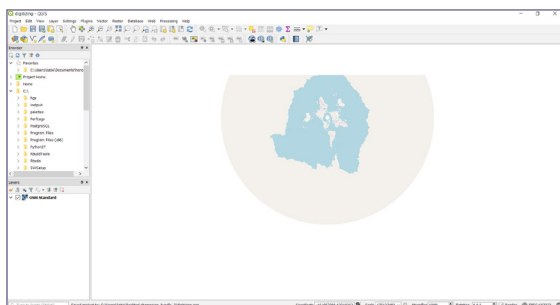
Each of these maps looks slightly different, even though they're all of the same place. Map 1 shows the left border as an almost vertical line, Map 2 looks tilted and narrow, and Map 3 looks almost like a combination of the first two. The difference is the projection (labeled below each map).

Set a Projection

¶ In this part you will set the projection for your project. Before doing anything, you need to pick a good projection. For the Ohio Project (see Appendix A), we use State Plane. Another option is UTM. You'll need to do some research to find your State Plane/UTM zone. I'm doing Champaign County, OH, which is in Ohio State Plane South.

State Plane Coordinate System: <http://desktop.arcgis.com/en/arcmap/10.3/guide-books/map-projections/state-plane-coordinate-system.htm>


1. Under the **Project** tab, click on **Properties**
2. Click on **CRS** (for "coordinate reference system")
3. In the search bar, type **stateplane ohio**, which should narrow down the options. I'm choosing **NAD_1983_HARN_StatePlane_Ohio_South_FIPS_3402** (make a note of the EPSG code)
4. Once the projection name is highlighted, click **OK**
5. Your basemap should reload and look different
6. Save your project!

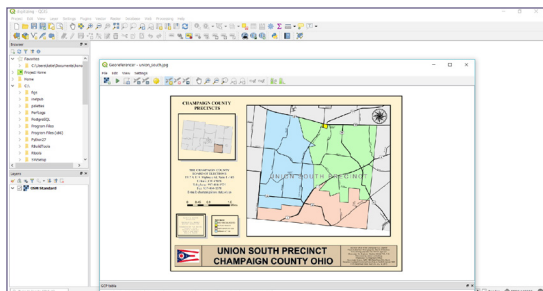


Your project should look something like this. If you projected it properly, the EPSG code in the bottom right corner will be your new one

Adding an Image

¶ In this part you will add an image that you want to georeference. I'm assuming you already have a particular image you want to digitize. If not, you can download the Champaign County images from Dropbox at <https://tinyurl.com/champaign-images>.

1. Add your image(s) to your project folder. Each map must be an individual jpeg file, not a pdf
2. Under the **Plugins** tab, click **Manage and Install Plugins**
3. With **All** selected in the side menu, type **georeferencer** into the search bar
4. Make sure there is a ✓ in the box next to **Georeferencer GDAL** and click **Close**
5. Under the **Raster** tab, click **Georeferencer...**
6. Select  (**Open Raster**)
7. Choose an image and click **Open** (I chose union_south)
8. Select the same projection as you selected for your project. You can search by name or EPSG code. When you've highlighted your projection, click OK

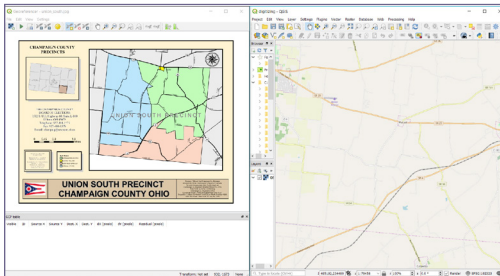


Choosing Points

¶ In this part you will match points on your image to points on the basemap.

This is the part when you actually assign the location to your image. We do this by matching coordinates. It's important to try to match coordinates as close to the four corners as possible for maximum accuracy.

1. Minimize your **Georeferencer** window while you try to find your location on the map. I recommend using Google Maps to cross-reference. Try to zoom in as close to your image's location as possible. You can search specific county and road names to try to narrow it down.



» Zoomed in on
Union South
precinct

2. Zoom into your image to find a recognizable intersection and then find that same intersection on your basemap (my first choice is Buck Creek and Route 54 in the bottom left corner of the image)

3. To choose points, click  (**Add Point**)

§ Georeferencing

4. With the **+**, click on your intersection on the image
5. It will prompt you to enter coordinates, but instead click the **From map canvas** option
6. On your basemap, locate the same intersection and select it with the **+**
7. Click **OK** in the **Enter Map Coordinates** box
8. In the table at the bottom of your **Georeferencer** window you should see your new coordinate listed as well as a small red point on both your image and the basemap
9. For my second coordinate, I'm choosing Mechanicsburg Catawba Road and Route 56
10. Repeat the process of zooming and selecting for this coordinate
11. Aim for five to six points total with four at the corners
12. Save your project!

Buck Creek
and Route 54

Buck Creek
and Route 54

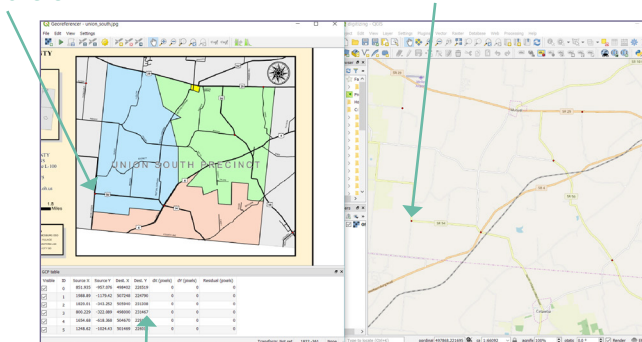



Table of Selected Points

Generating a Final Image

¶ In this part you will use the points you've marked to interpolate a location for the image. Exciting!

1. In your **Georeferencer** window, click  (**Transformation Settings**) from the bar at the top

Input the following options:

Transformation type = Linear

Resampling method = Nearest neighbor

Target SRS = same projection as your project (Ohio State Plane South for me)

Output raster = (within your project folder) georeferenced/
precinctname_projection.tif

Compression = None

Load in QGIS when done = ✓

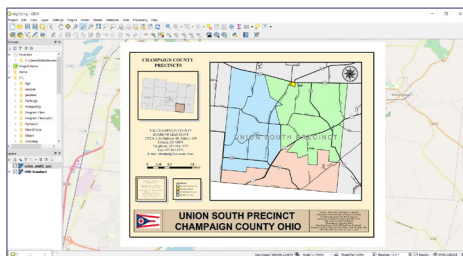
2. After you fill these in, click **OK**

3. Click  (**Start Georeferencing**)

4. In a second or two you should see your image show up on your basemap

5. Save your project!

Image overlaid
on basemap

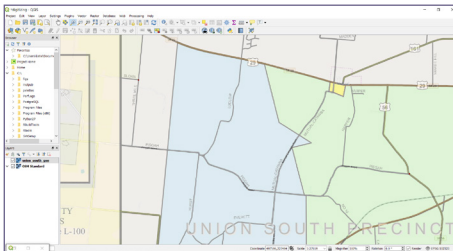


Checking Your Work

¶ In this part you will check to make sure your image is in the right location on the basemap.

We can get a better view of where our image is by setting the transparency.

1. Back in your main QGIS window, go to the **Layers** panel where your image and basemap should be listed
2. Right click on your georeferenced image layer
3. Select **Properties...**
4. Select **Transparency** from the menu
5. Type in a value for **Global opacity** (40 to 60% tends to be good) and click **Apply** until you find one you like (then click **OK**)
6. Zoom into your image: Are the intersections lining up? Does the placement of the map seem like a good fit?
7. If your answer to either of these is *no*, you may want to redo the georeferencing process. Otherwise you're good to go!



» Checking image placement

Before you move on, georeference all of your images! It is not advised to vectorize an incomplete area. In this case, we would not vectorize a county until all of the precincts are georeferenced.



§ Vectorizing

Vectorizing is the process of converting an image to a shapefile.

Getting Data

¶ In this part you will get the data that you will use to create your precinct areas.

Typical vectorizing involves manually drawing an outline around your georeferenced features. That isn't feasible with such difficult lines to follow in many of our precinct maps. Instead we use census blocks to approximate the area covered by each of the precincts.

** If you are digitizing a state other than Ohio, these same instructions apply from here on, just substitute your state name!

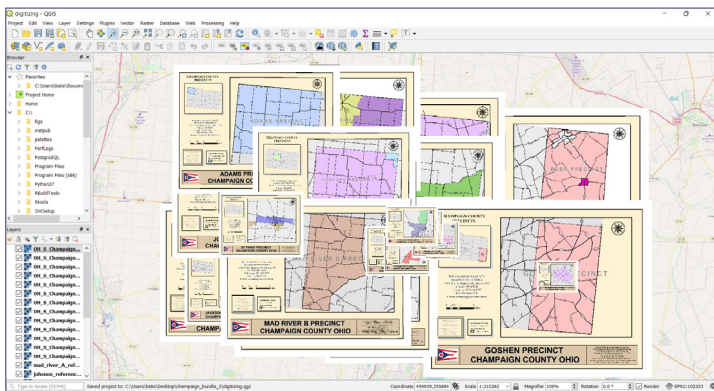
1. Go to <https://www.census.gov/cgi-bin/geo/shapefiles2010/main>
2. Select **Blocks** as your layer type and click **Submit**
3. Select **Ohio** in the **Block (2010)** drop-down menu and click **Submit**
4. Select **All counties in one state-based file** from the drop-down menu and click **Submit**
5. Unzip the folder into a subfolder called **data** in your project folder so that your folder structure looks like this:

```
- project
  - QGIS map
  - images
  - data
    - tl_2010_39_tabbblock10.shp
    - ...
```

Adding Images to Your Project

¶ In this part you will set up your workspace for vectorizing. Follow the instructions below if all of your images are **not** already loaded into your QGIS project.

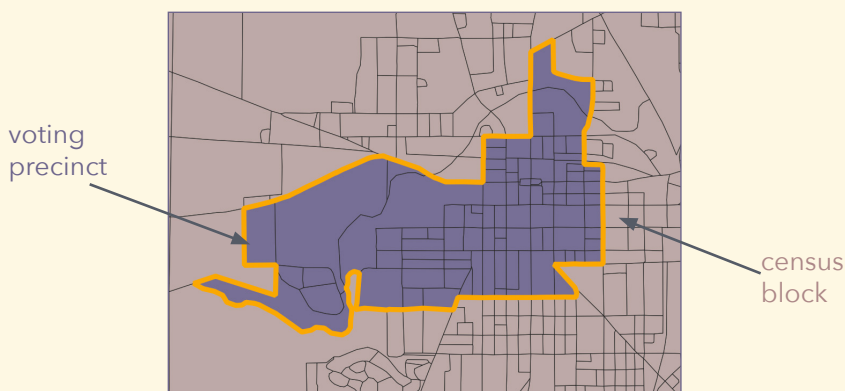
1. Under the **Layer** tab mouse over **Add Layer** and select **Add Raster Layer...**
2. In the **Data Source Manager** window, click the ... button to select the files you want to add
3. Select all of your georeferenced images (the ones you created that end in .tif) by selecting the first image and then holding down **shift** when you click the last
4. Once they are all selected, click **Open**, then click **Add**
5. Save your project!



This is what my project looks like with all of my images loaded

Highlight: Census Blocks






Census blocks are the building block for all census designated geographies. They can be bounded by physical features, such as roads or rivers, or invisible features like city or school district lines. In urban areas, census blocks tend to align with city blocks bounded on all four sides by streets. Rural census blocks can be up to hundreds of square miles. Census blocks are the smallest unit at which most demographic data from the decennial census and American Community Survey are available. In many states, including Ohio, it is mandated that precincts must follow census block boundaries unless a specific reason not to is given. This regulation validates our method of building up precincts from census blocks.




Adding Census Block Data

¶ In this part you will add your census block data.

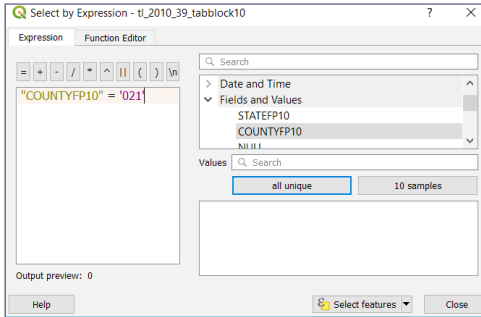
1. Under the **Layer** tab, mouse over **Add Layer** and select **Add Vector Layer...**
2. In the **Data Source Manager** window, click the ... button to select the file you want to add
3. Navigate to the **data** folder that we put the census blocks in and select the SHP file (confusingly, two files end in **.shp** so be careful to not choose the XML Document)

 tl_2010_39_tabblock10.dbf	12/7/2018 9:20 PM	DBF File	37,463 KB
 tl_2010_39_tabblock10	12/7/2018 9:20 PM	PRJ File	1 KB
 tl_2010_39_tabblock10.shp	12/7/2018 9:20 PM	SHP File	266,371 KB
 tl_2010_39_tabblock10.shp	12/7/2018 9:20 PM	XML Document	22 KB
 tl_2010_39_tabblock10.shx	12/7/2018 9:20 PM	SHX File	2,855 KB

4. Click **Open**, then click **OK**. Your screen should soon be covered in little census blocks!
5. This is a huge file and will slow down your QGIS, so let's filter out just our county of interest. Right click on **tl_2010_39_tabblock10** in your layers panel and click on **Open Attribute Table**
6. On Google, look up the 3-digit FIPS code of your county of interest. These can usually be found on Wikipedia pages
7. In the top bar, click  (**Select features using an expression**)

§ Vectorizing

8. In the **Expression** text box, type **"COUNTYFP10" = 'your county FIPS code'** (I used '021' for Champaign County), then click **Select features**



» Expression to select Champaign County

9. The census blocks in your county should be yellow

10. Right click on **tl_2010_39_tabblock10**, mouse over **Export**, then click **Save Features As...**

11. Keep the **Format** as **ESRI Shapefile**, then click the ... next to **File name**. Navigate to your **data** folder and write **filtered_county** as the **File name** and click **Save**

12. Change the **CRS** to your projection and check the box next to **Save only selected features** and **Add saved file to map** (keep other defaults) and click **OK**

13. Make sure the new layer is only your county, then in the **Layers** panel right click **tl_2010_39_tabblock10** and click **Remove layer...**

14. Click on the **filtered_county** layer and drag it to the bottom on the list of image layers but above **OSM Standard**

15. Save your project!

Building a Precinct from Census Blocks

¶ In this part you will select the census blocks that make up a precinct. A warning in advance: to me this is the most tedious process when digitizing and is prone to mistakes, sometimes ones that take a lot of time to fix. Try not to get too frustrated, it's difficult for everyone!

1. Pick one precinct to vectorize. I chose **Union South**
2. Click on the image name in the **Layers** panel and click and drag it to the top of the layers list
3. Right click on your image name and click **Zoom to Layer**
4. Click and drag the **filtered_county** layer so that it is right under your image layer
5. Change the transparency (so you can see the census blocks underneath) by right clicking on the layer then clicking **Properties...**
6. In the **Layer Properties** window, click **Transparency** in the menu and set the **Global Opacity** to something you like, I chose 30%
7. You can also change the color of the census block layer. Right click on the layer name and click **Properties...** then

§ Vectorizing

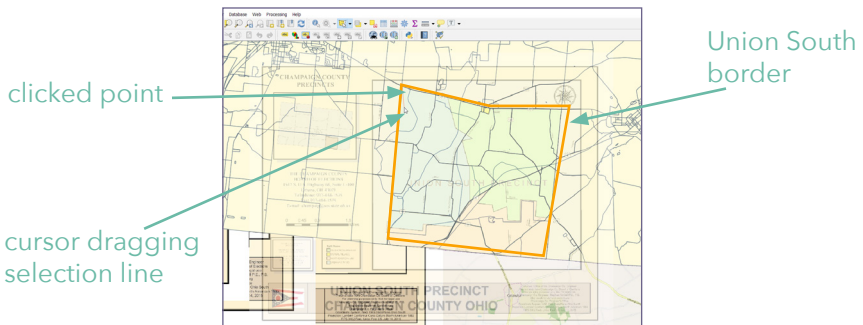
click **Symbology** from the menu

8. Click the **Simple fill** option then change your **Fill color** and **Stroke color** (I recommend light colors for the fill and dark colors for the stroke)

9. Now we are ready to start selecting! Click on the **filtered_county** layer in the **Layers** panel so that the name is highlighted (this tells QGIS which layer we want to select features from)

10. From the toolbar at the top, click **(Select Features by Polygon)**. If there's a similar select tool, like **Select Features by Freehand/Radius/...**, click the drop-down menu to change it to the correct tool

11. Visually figure out where your precinct is (you can toggle transparency and layers to help with this), then with your blocks layer highlighted and selection tool activated, click in one corner of your precinct, as close to the border as you can get

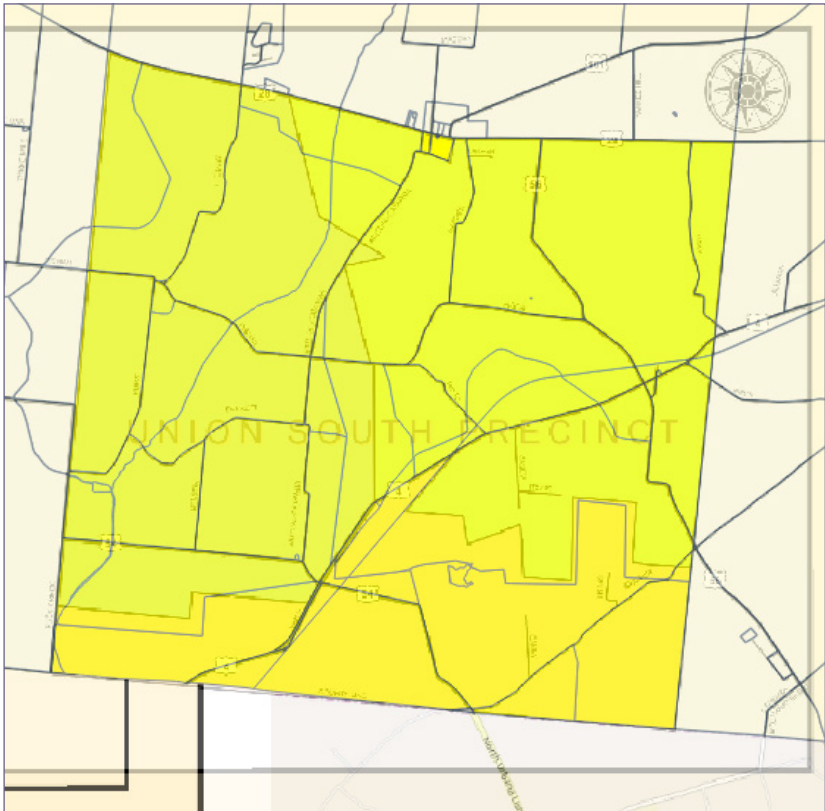


12. Repeat the process of clicking at the angles to draw a polygon just inside the border of the precinct

§ Vectorizing

13.Right click when you have drawn the complete polygon



14.Your selected blocks should be highlighted at this point, take a moment to admire your work!

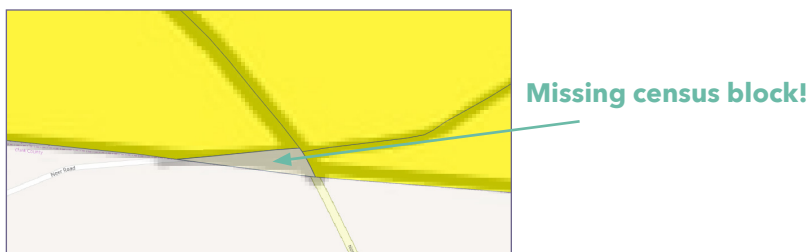


Union South selected from census blocks

Double-Checking and Exporting Your Selection

¶ In this part you will finalize your census block selection.

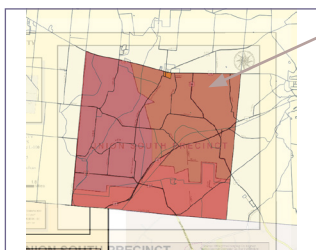
1. **Without accidentally clicking on your map with the selection tool activated** (this will undo your selection), click  (**Zoom In**) then draw a box around one corner of your precinct to magnify it
2. From there, click on  (**Pan Map**) to search along the border of the precinct for any missing census blocks (they can be quite small, so look carefully!)



3. To add missing blocks to your selection, switch your selection tool to **Select Feature(s)** in the drop-down menu (**be careful of any accidental clicking!**)
4. Use the **Pan Map** and **Zoom In** tools to get to problem spots, if you aren't already there

§ Vectorizing

5. With your selected tool activated and your census block layer highlighted, click on the feature **while holding down the shift key** that you want to add to your selection (if you don't hold down shift it will replace your entire selection)
6. You can deselect blocks with a similar process
7. Continue to pan and zoom until you have fixed all of the missing blocks (I recommend checking the entire border twice)
8. It's okay if your precinct borders don't line up *perfectly* with your census block boundaries, just get them to line up as closely as possible
9. When your selection is complete, give yourself a high-five! Next, right click on **filtered_county** in the **Layers** panel, mouse over **Export**, and click **Save Features As**
10. Click the ... next to **File name**
11. In your main project folder, create a new folder called **precincts**
12. Save your layer in that new folder with a descriptive name (I use precinctname_countyname)
13. Make sure that the **CRS** is the same as your project's and that **Save only selected features** and **Add saved file to map** are checked, then click **OK**
14. You should now see your new precinct layer! You can also deselect the census blocks



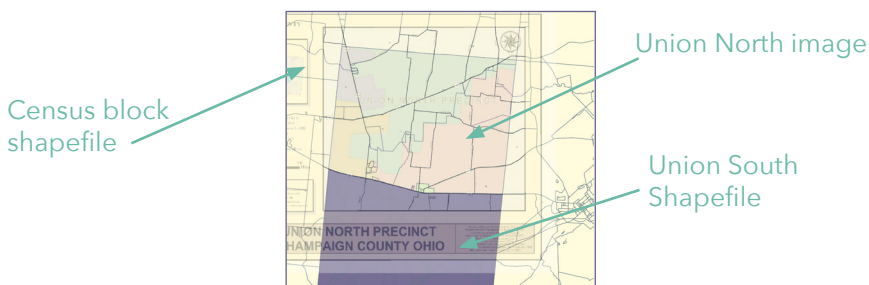
You can still see some of the georeferenced image

» Exported precinct layer

Continuing the Vectorizing

¶ In this part you will begin vectorizing the rest of the precincts and learn some good strategies.

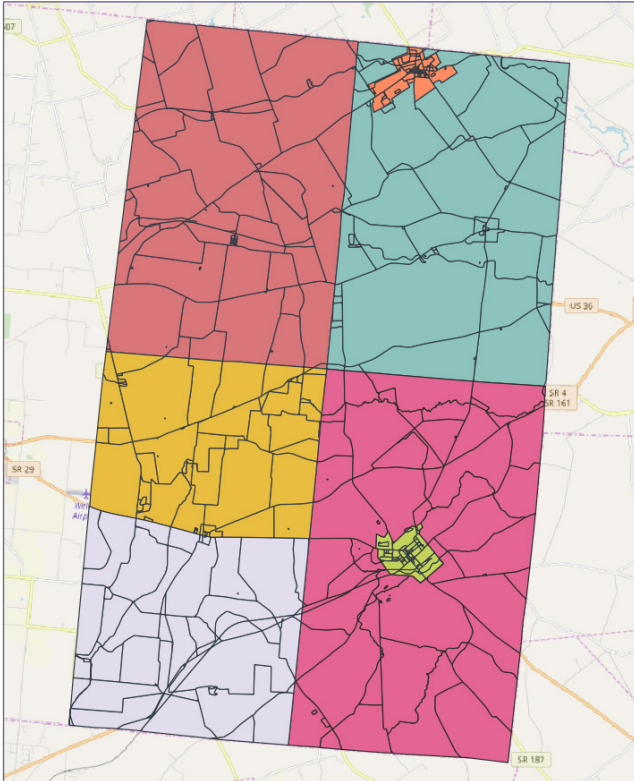
1. The next precinct you'll vectorize will be adjacent to the one you just finished (this is to make sure you aren't skipping any blocks along the boundaries that can be hard to see). I chose Union North
2. Repeat the process of dragging your layers into a better order for vectorizing (I have the Union North image at the top, then the new Union South shapefile, then the census block shapefile) and set the transparency of the next image



3. Using the same process as before, select the polygon just within the border of the precinct
4. Toggle the already-vectorized layer to make sure that the borders match up and also that you haven't accidentally selected blocks that have already been assigned a precinct

§ Vectorizing

5. Double-check all of the blocks along the boundary
6. Export this layer using the same process as before
7. Continue vectorizing by choosing adjacent precincts until you have each image done



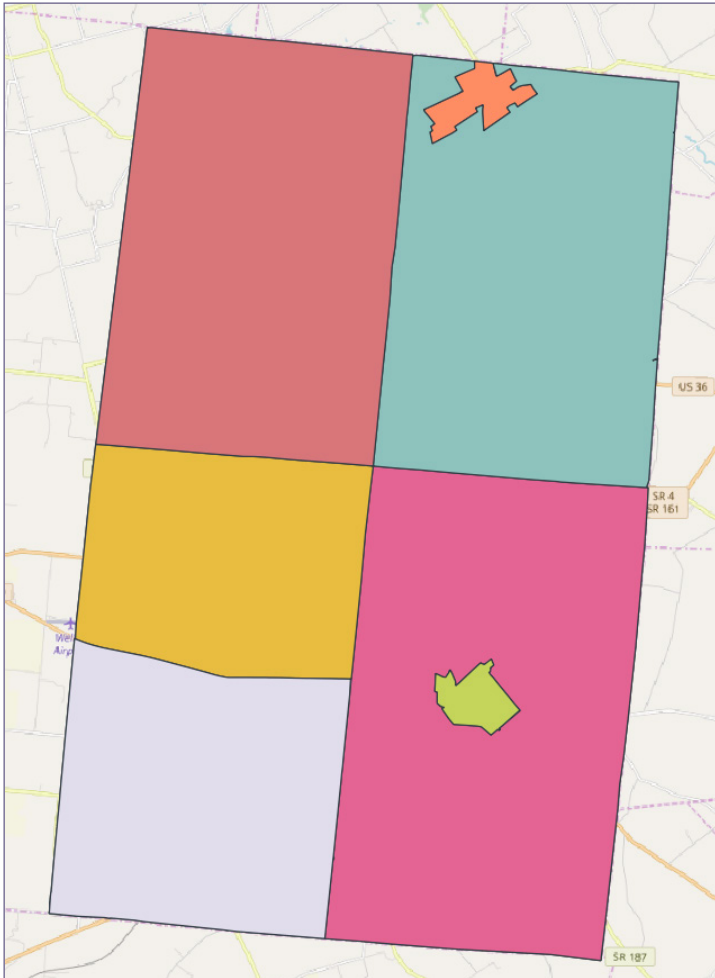
You should vectorize until you have the whole county done, but for the purposes of demonstration I'm just going to do this chunk of Champaign County.

Dissolving Blocks into Precincts

¶ In this part you will simplify your multi-part precincts into one complete feature.

1. Under the **Vector** tab, mouse over **Geoprocessing Tools** and click **Dissolve...**
2. At the bottom of the **Dissolve** window, click **Run as Batch Process...**
3. Under **Input layer**, click ..., then **Select from Open Layers...**
4. Select all of your precinct shapefiles (but not **filtered_county**) and click **OK**
5. Under **Dissolved**, click ... next to the first row
6. In your main project folder, create a folder called **dissolved** to store your dissolved shapefiles
7. In the **File name** bar, type just **dis_** and save it as either a shapefile or GeoPackage (GPKG, the newer and sleeker option), then click **Save**
8. An **Autofill settings** window will pop up, for **Autofill mode** select "Fill with parameter values" and for **Parameter to use** select "Input layer" and then click **OK**
9. Make sure **Load layers on completion** is checked, then click **Run in Background**
10. Save your project!




§ Vectorizing



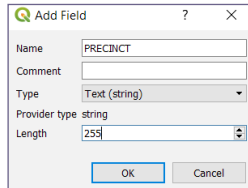
Some wonderfully dissolved precincts!

Editing Attributes

¶ In this part you will add relevant data to the attribute tables.

1. Your layers should all be labeled as **Dissolved** in your **Layers** panel. To figure out which precinct name goes with each of your **Dissolved** layers, right click on the layer, click **Properties...**, then select the **Information** tab from the menu
2. The **Source** field will tell you which precinct layer it came from. You can then change the display name by clicking on the **Source** tab and typing a more descriptive name in the **Layer name** field (do this for each **Dissolved** layer)
3. At this point you can turn off your **OSM Standard** layer
4. Once you've done that, right click on one of your dissolved layers and click **Open Attribute Table**
5. Select  (Toggle editing mode), then  (**Delete field**)
6. Hold down **ctrl/cmd** to select all of your fields except **fid** then click **OK**
7. Select  (**Add field**)
8. Type PRECINCT in the **Name** field, change **Type** to Text (string), and type 255 in the **Length** field (the maximum number of characters), then click **OK**

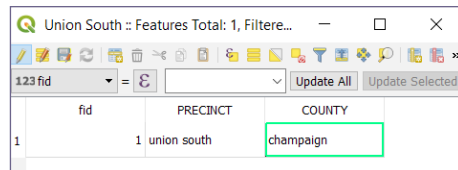
§ Vectorizing



Adding a PRECINCT field



9. In the cell, type the precinct name

10. Repeat this process for COUNTY



	fid	PRECINCT	COUNTY
1	1	union south	champaign

This is what your attribute table would look like for Union South precinct in Champaign County

11. Once you're done with a table, click  (**Save Layer Edits**) and then click  to leave the editing session

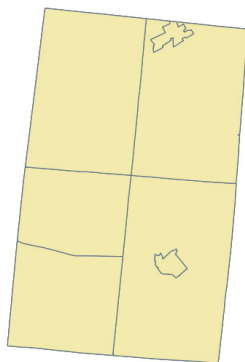
12. Edit the attribute table for each of your dissolved layers

Merging Precincts

¶ In this part you will merge your individual precinct shapefiles into one shapefile with multiple features.

1. Under the **Vector** tab, mouse over **Data Management Tools** and click on **Merge Vector Layers...**
2. Click the ... next to **Input layers** and select your edited and dissolved precincts
3. For **Destination CRS**, select the same one you have been using throughout the project
4. Click the ... next to **Merged** and choose **Save to File...**
5. Create a new folder called **merged** in your main project folder and save your new file there as **merged_countyname**, then click **OK**
6. Make sure the box next to **Open output file after running algorithm** is checked
7. Click **Run in Background**
8. Save your project! You may need to drag your **Merged** layer to the top for it to be visible

Merged
shapefile! <<





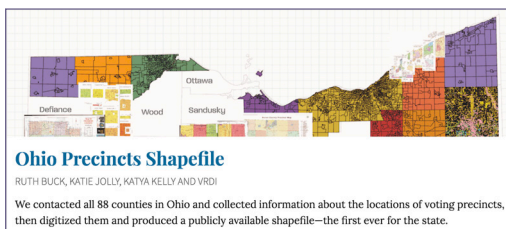
§ Appendix

Ohio Precincts Project

The content for this digitizing guide largely comes out of our work at the Voting Rights Data Institute (VRDI) at Tufts University. VRDI is run by the Metric Geometry and Gerrymandering Group (MGGG), a working group that studies the applications of geometry and computing to the U.S. redistricting process. They produce high quality research, open-source tools and research, and expert witnesses to combat gerrymandering.

The three of us (Katie, Katya, and Ruth) co-led the effort to create the first open-source precinct shapefile for the state of Ohio to study gerrymandering. In total, we digitized over 450 images with the help of many other people at the institute. We needed a way to quickly and effectively teach over 40 people how to digitize well, so we created this guide.

The final product of that project is currently being used by groups like Open Elections, The Democratic Party of Ohio, ACLU, and MGGG to study voting rights in Ohio. You can access the shapefile at the link on mggg.org, as well as check out the other projects.



Links to More Resources

Metric Geometry and Gerrymandering Group
mggg.org

All About Redistricting
redistricting.lls.edu/index.php

Georeferencing Topo Sheets and Scanned Maps
http://www.qgistutorials.com/en/docs/georeferencing_basics.html

Georeferencing Aerial Imagery
https://www.qgistutorials.com/en/docs/advanced_georeferencing.html

Public Lab (aerial imagery to practice georeferencing)
<https://publiclab.org/archive#2/15.0/2.8>

Code For America (if you want to get involved with other civic engagement work)
<https://brigade.codeforamerica.org/>

Election Geodata (the largest collection of open-source precinct shapefiles)
<https://github.com/nvkelso/election-geodata>

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