Introduction to QGIS

# Overview

Geospatial data is prevalent everywhere in ecology and environmental science. We use it to map where species are found, to characterize the environment, and to look at how land use changes over time. It can also be used to map pollution, visualize urbanization, track diseases, and explore different geographic regions of the world. In short, it is an essential type of data that we use all the time in our classrooms and research programs. In this activity, we will explore some of the basics of GIS and introduce a free program you can use called QGIS that you can use to explore spatial data.

# Activity Overview

This intro activity has three main goals: 1) To familiarize you with what GIS is and how spatial data are organized, 2) To introduce you to the free GIS program QGIS, and 3) To help you learn the basics of making maps. This is not meant to be an exhaustive guide and instead is just a quick primer. If you want to explore this more, there are additional resources at the end of the document. To get the most out of this, please read through the QGIS and Spatial Data Overview sections below. Once you feel comfortable with them, you will then learn how to install QGIS and you will make several different kinds of maps using data that are freely available.

# Introduction to GIS and Spatial Data

\*Please note that when you read through this the first time, it can feel a little tough to grasp for some folks. Remember though that this is just meant to help you understand how these programs work and how they organize/look at data. Don’t get overwhelmed at all! The map making is honestly the easiest part. But in the end, if you want to use these types of data in your class and research, you will benefit greatly from knowing these basic terms and functions.

GIS programs like QGIS and ArcGIS make maps and analyze data using layers of information. To understand this, think about Google Maps and how it works. You may put in directions from one location to another or try to find something on the map. The map itself though includes way more information than just what you need to provide context. It has roads, topography, businesses, houses, parks, greenspace, etc. Each of these is a “**layer**” and the information is essentially geographically referenced so that it shows up in the exact same place. Think of the world as essentially being a giant grid with latitude and longitude pinning everything in place.



Google Maps Image of Nashville, TN. Note the layers of spatial information included on here: roads, airports, greenspace, waterways, etc.

# Spatial Layers & Data Types

Spatial layers like the ones noted above essentially come in two formats. For Google Maps, all of these are what we call “**vector layers**.” These are layers that are essentially points on a map, lines that are drawn, or boundaries (polygons) that are lined with the correct latitudes and longitudes. If you look above at the image, you can see the following types of “layers”:

Interstate/Roads = Lines

Waterways/Lakes are Either Lines or Polygons (Shapes on a map with clear boundaries like the lake in the bottom right corner)

Businesses or Locations (like Airports = Points

# Vector Layers

Vector layers are fantastic, but can be labor intensive to make. They require having exact boundaries or latitudes and longitudes for everything. But they are also some of the most commonly used types of layers and the easiest to create for faculty/students. For example, if you have GPS data on trees on your campus or you want to create a map of field sites across the US, you can put these in a spreadsheet and then voila – you can create a new vector layer that has “point data.” Similarly, if you work with programs like iNaturalist or GBIF, these programs are built on point data that is really just a vector layer.

When you work with vector data, you will often encounter a few types of files. These are important to know since we will be working with them later.

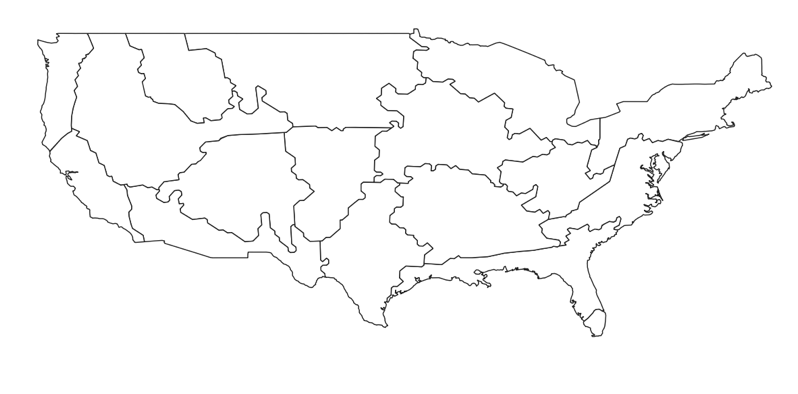
## Shapefiles:

These are the most common vector files that you work with. They can have points on a map (e.g. trees on a campus with latitudes and longitudes) or be polygons/lines that depict something like a river, a park boundary, or things like counties/states.

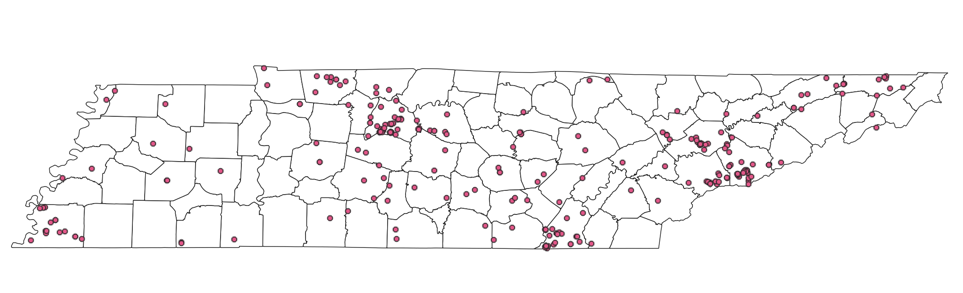
## Point Files:

These are specialized versions of shapefiles, but they are often treated differently. Typically, these files are .csv files (comma separated value files – like you work with in R).

Here are some examples of shapefiles/point files that you will create in the activity below:



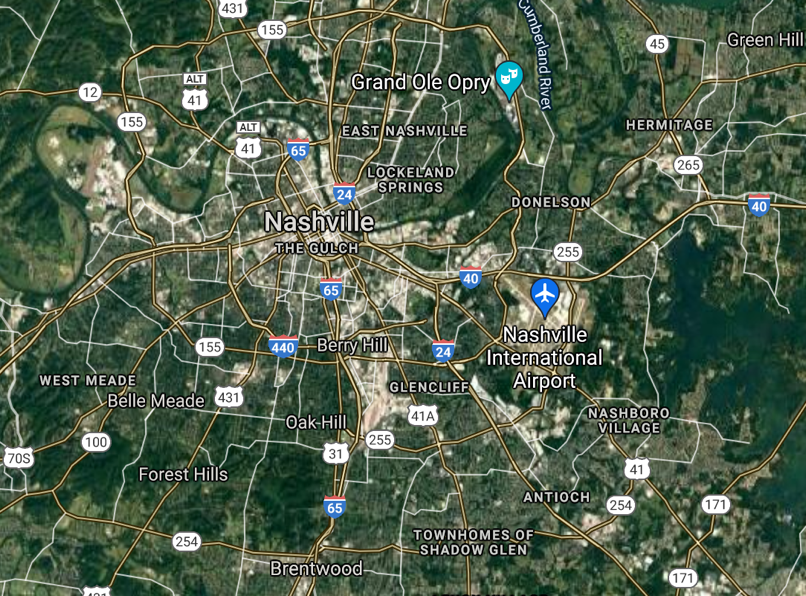
**NEON Ecoclimatic Domains**



**iNaturalist Observations of Common Five-Lined Skinks in Tennessee**

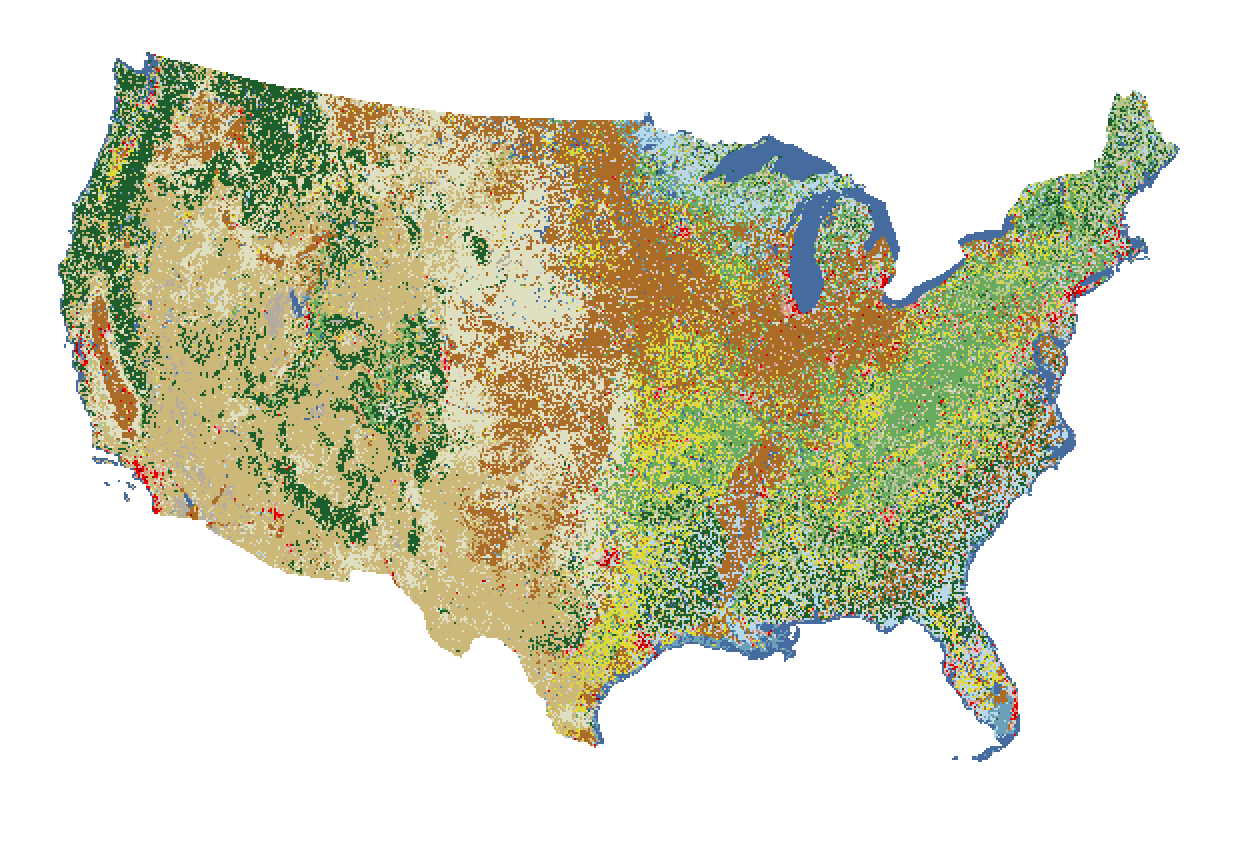
# Raster Layers

The second type of layers that you commonly work with in GIS programs are **raster layers**. These are essentially pictures or small grids that are overlaid onto specific geographic locations. If we go back to our example of Google Maps, you can think about this pretty easily by just clicking on the satellite button that is in the bottom left corner. If you do that, for the image that we had above of Nashville, you will get an image that looks like this:



In this image, you will see that the vector layers are still present, but that instead of the boundaries for things like rivers/forests, there is now a satellite image. This image has been placed on top of this map as a layer according to its latitude and longitude. Because the earth is a globe and the earth is very big, these images have to be pieced together. But raster data is amazing because it is often used to characterize an ecosystem, evaluate things like land-use or tree cover, or to analyze how ecosystems change over time (by comparing photos).

The one thing to note about rasters is that because they are pictures, they are very very large in size. In addition, when you zoom in to the finest levels, they eventually become pixelated. You can also work with raster files that are not pictures, but are instead gridded cells. These are often used for characterizing land-use types or for looking at the climatic variables for a given location. Here is an example of a raster map that you will make in the mapping activity below.



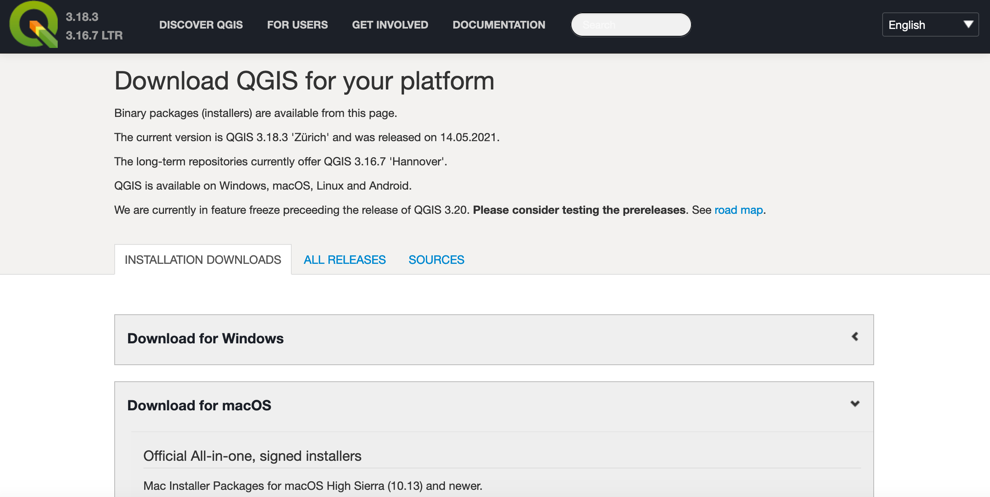
**Raster Map of Land Cover Type for Lower 48 States**

# Activity 1: Downloading & Installing QGIS

QGIS is a free open-source geographic information systems application. It is similar in some ways to R and you can do some of the same exact things. However, this program is built explicitly for making maps and analyzing spatial data. So it is a specialized program. I often use this program when I teach GIS, Environmental Science, or other courses because it is free and can operate on a Mac or PC. The other main GIS software that is widely used is ArcGIS, which is a proprietary program that was built by ESRI. It is also fantastic, but you have to pay for a license and it really only works on PCs unless you do the online version, which does not have the same functionality.

In this first activity, we will download and open QGIS. To do this, please follow the steps below for Macs and PCs.

1. Go to the QGIS download page: <https://qgis.org/en/site/forusers/download.html>. When you do this, you should see a page that looks like this:



1. Because QGIS is an open source program it is important to note that there is an experimental or sort of cutting edge version of the program that is designed for developers. This version is the most up to date, but also has the most bugs. So typically everyone who wants to work on this and work with students will use what is called the “long term release” or “most stable version.” As of 5/24/21, the most stable version is QGIS 3.16.7 ‘Hannover’.
2. Depending on whether you are on a PC or a Mac, you will need to download QGIS 3.16. On a PC, you have two options – the 32 bit version or the 64 bit version. **Only download the 64-bit version**. There is a picture below to help you. For Macs it is a bit different, there is only one installer so just make sure you select version 3.16. Pictures are listed below. Also note that these files are large and can take some time to download/install.

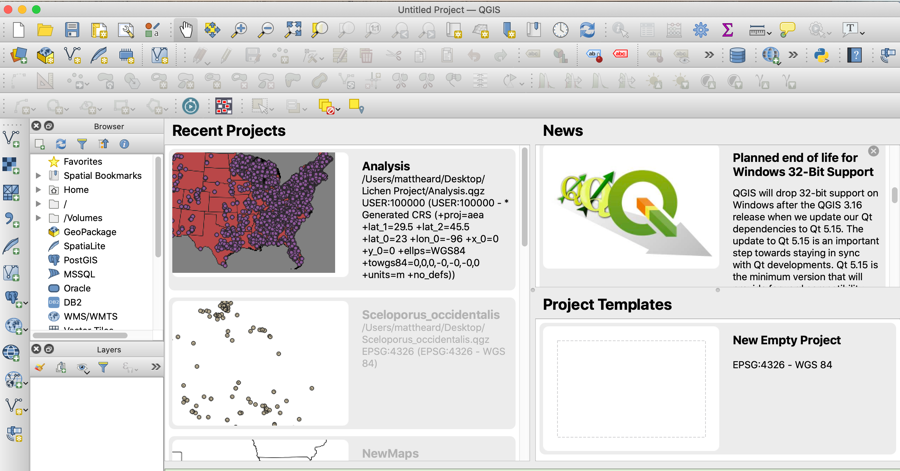


To download, click on the link and install the file. This is the PC one you should use.



To download, click on the link and install the application. This is the Mac installer.

1. Once you have installed the program, click on the application to open QGIS. This may take a minute to verify and get everything set up. \*Please note that mac computers can sometimes have trouble opening applications not downloaded from an Apple verified provider. If your computer says you can’t open the file, then all you have to do is go to your settings button and go to where it says general. At the bottom of the page, you will see a note that says you need to allow QGIS to open. Select open regardless of the message that is there and QGIS will open up.
2. When this is done, you should see a screen that looks similar to this (but please note that you will likely not have recent projects if this is the first time you’ve opened this program).



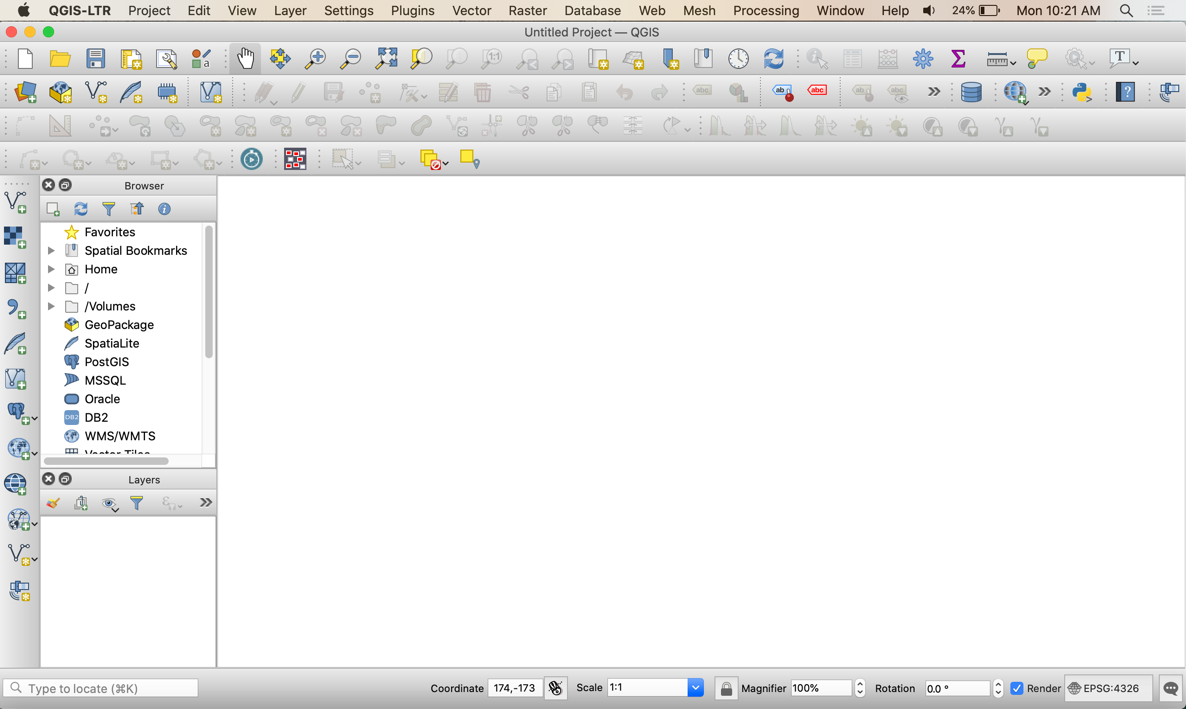
# Activity #2 – Orienting Yourself In QGIS

In this activity, we will briefly walk through QGIS and what the screens look like. It is a bit overwhelming at first. But remember, that you will start out only doing a few things and it is basically a point and click or drag and click program at first. So you’ll get the swing of it pretty quick!

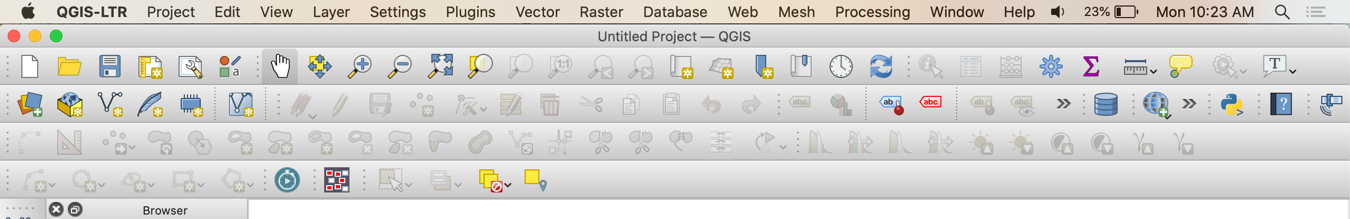
1. To get rid of all the things on the screen, go up to the top left corner and hit the white button that looks like a piece of paper. This will open up a new project, which is essentially a blank canvas.



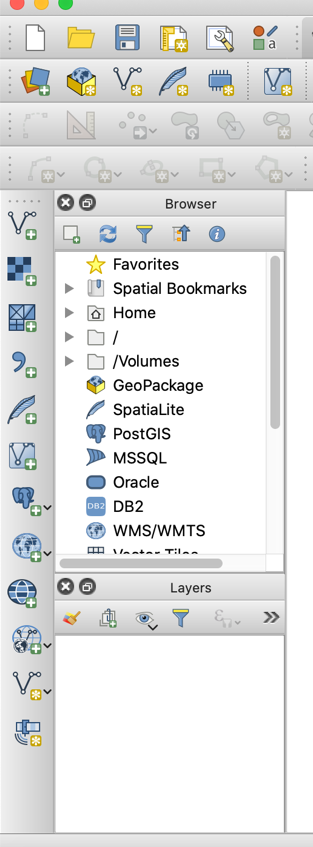
1. Once you open up the new project, your page should look like this:



1. At the top of the screen (slightly different if you’re on a PC) is the menu bar and these various tool bars. If you don’t have all of them, don’t worry. You don’t really need them yet, but you can access them by clicking view in the menu bar and scrolling down to the toolbars section and clicking everything.



1. On the left side of the screen, you will see the browser, the layer menu, and some buttons. The browser you also won’t do a lot of using at first. But the layers box is really important since it will be where each of your layers are stored when you make a map. The buttons on the left are for adding layers. You can use these, but you can also use other ones. The one at the top is the Add Vector layer (it looks like a V!) and the second one is the Add Raster Layer (it looks like a grid!).



1. There are lots more things you can look through, but we are going to skip ahead to making basic maps because that is more interesting. However, if you want to learn more just take your mouse and hover over buttons on the toolbar. It will tell you what its function is.

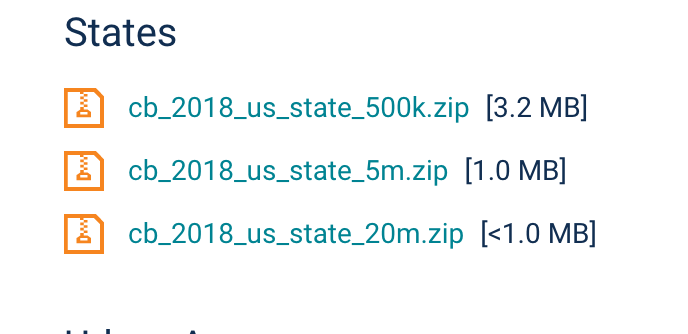
# Activity #3: Making Basic Maps

Making maps in QGIS is one of the easiest parts. But you have to have a little patience for working with them. Also, it is important to remember that not all data layers have the same coordinate systems so sometimes they can be a bit wonky in QGIS. Don’t worry about that now. But if you try this on your own with other files, ask us about the issues you hit in the office hours.

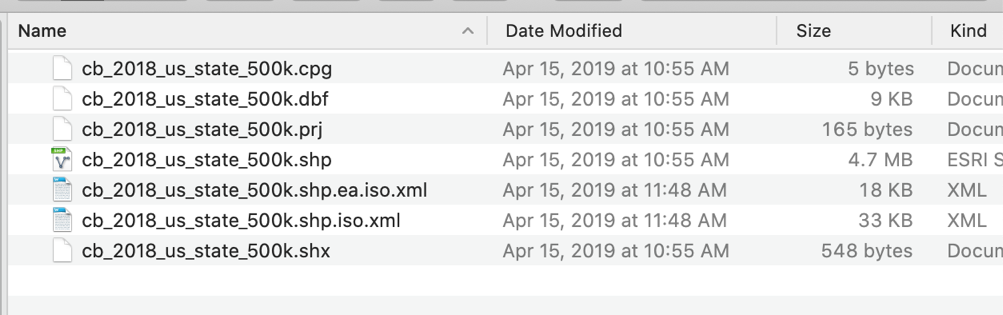
In this activity, we will start out by making four basic maps: 1) A vector map of the US with the state boundaries, 2) a boundary map of the NEON ecoregions, 3) a point map of iNaturalist observations of lizards, and 4) a raster map of the US with land-use type for the lower 48.

## Vector Map of US States

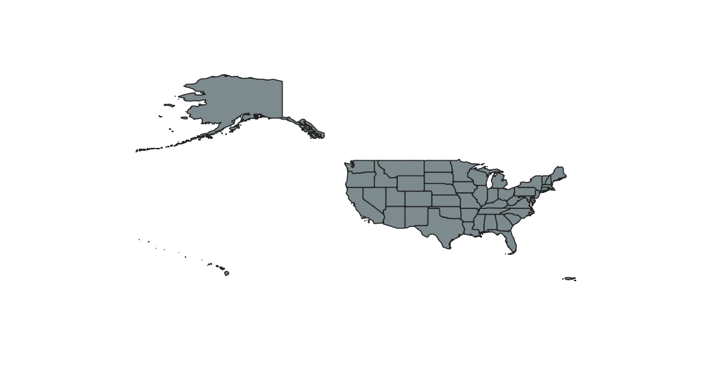
1. Head to the US Census Bureau website (<https://www.census.gov/geographies/mapping-files/time-series/geo/carto-boundary-file.html>) and then scroll down to where it says “States”. Click on the top file titled cb\_2018\_us\_state\_500k.zip and download the file. This file contains a shapefile with the US state boundaries. \*Note that this is in zip form so you’ll have to extract this file. Macs do this automatically and typically so do PCs.



1. Once you have opened the download, you should have a folder that has the following files in it. These files are all the information for a shapefile. Do not delete any of them or the file will not open.



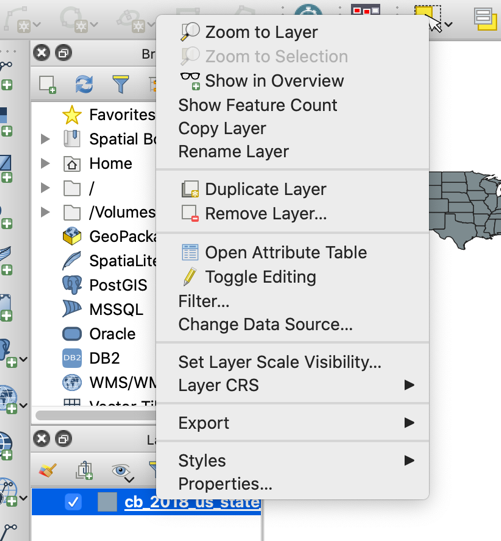
1. In the middle, you will see a file that ends with the extension .shp. It should have an icon that looks like a vector file! Once you see this, click on the file and then drag it on to the blank canvas in QGIS. Alternatively, you can click on the layer button on the top menu and then select add layer. This will give you an option to add a vector layer. When you have completed this, you should have your first map. Note that it may ask you to transform your file. If it does, just click ok.
2. When you have the map, you should see something that looks similar to this:



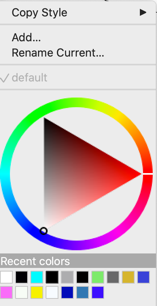
1. If you would like to move the map around, click on the hand at the top of the toolbar menu. If you want to zoom in our out, click on the magnifying glasses with the plus or minus in them. If you use the magnifying glasses, you have to click on the point you want to zoom in and out of. You can also zoom in with the hand by clicking the mouse.



1. You should also note that there is now a layer in the layer box. If you right click on this on a PC or control click on a Mac you will get a menu that pops up and looks like this:



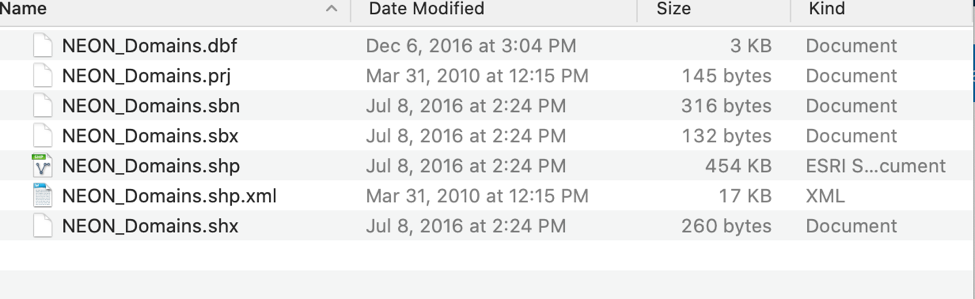
1. Using this menu, you can zoom to the layer, which will center the map on your screen or you can go to “styles” which will let you adjust the colors of the map. When you select styles a wheel will show up that you can use to pick a new color.



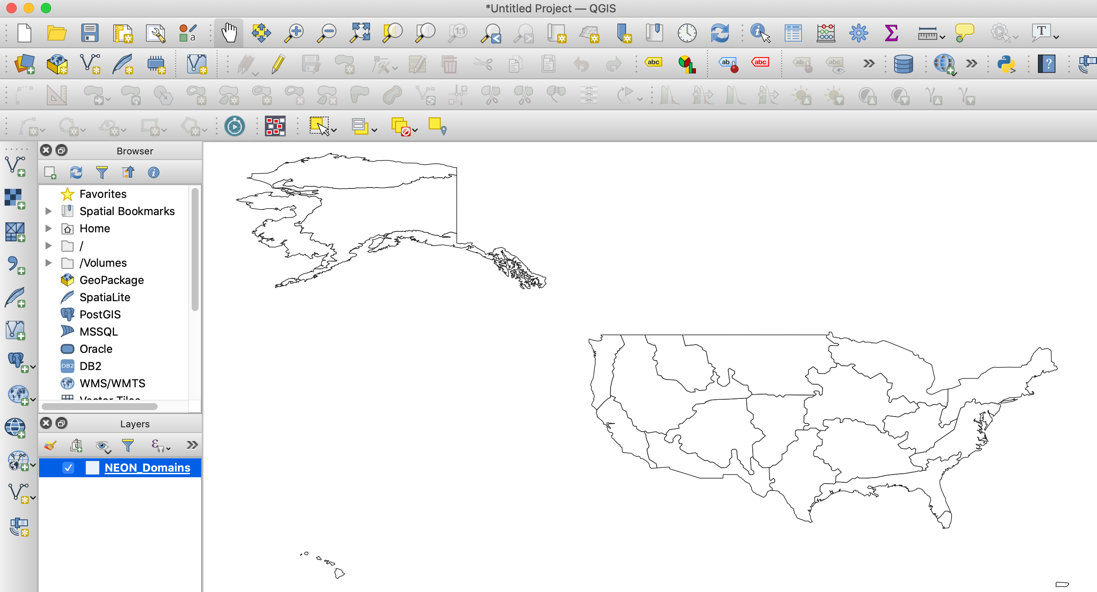
## Vector Map of NEON Ecoregions

NEON is an ecological database that has tons of free public spatial data. Most of it is housed in their data portals and on the ArcGIS servers. To see some of these data, you can click on the following link: <https://neon.maps.arcgis.com/home/index.html>. In this activity, we will explore one of these vector maps, the NEON ecoregions/domains.

1. To get started, open up a new project in QGIS by clicking on the piece of paper in the top left corner.
2. Then download the following NEON Shapefile that corresponds to the NEON ecoregions. <https://neon.maps.arcgis.com/home/item.html?id=e45d2bf677e245488a201afe02f1ad74>
3. Once you do this, you should see files that include these:

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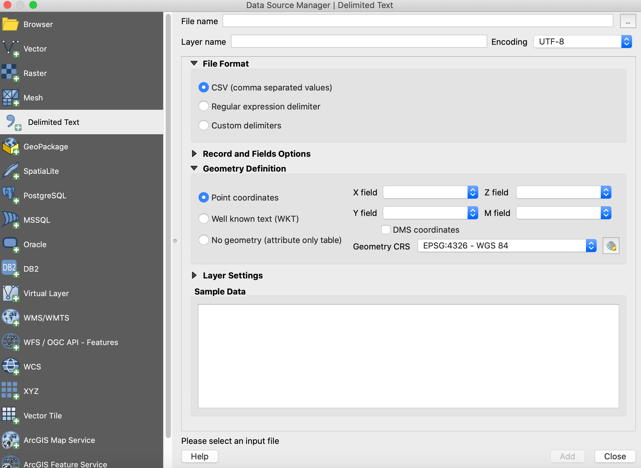
1. Similar to last time, load the shapefile by either adding it from the menu or dragging the NEON\_Domains.shp file. When you do this, you should see something that looks like this:

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## Point Map of iNaturalist Data

Another common source of GIS data that is often used by environmental scientists and ecologists is species occurrence data. In this mapping activity, we will use preexisting data from iNaturalist, a very common community science application that provides records of species occurrences documented by members of the community. For this activity, we will use data that was downloaded from iNaturalist about common five-lined lizards that have been observed in Tennessee. The file type is a .csv file, which can be opened in Excel, R, Pages, or Google Sheets. \*One important note here is to pay attention to the way this file is formatted. You can use it as a scaffold to create your own point files that you can load into QGIS in the future!

1. Head to Google Drive and download the csv file on Common Five-Lined Lizard occurrences in TN that was downloaded from iNaturalist: <https://drive.google.com/file/d/1BzuqiowWy7kjL0Ye6BmFq9NXBfld7ja_/view?usp=sharing>
2. You can open this file up in Excel, R, Pages, or Google Sheets to look at it. If you do, please make sure you remember to save it as a CSV file or it will not work with QGIS. Also, please note that the headers for the columns have no spaces in them.
3. Open up QGIS and start a new project.
4. From there, add back in your US states boundaries that you did in map 1.
5. Following this you will want to add the CSV file. It is important to note that you cannot just drop and drag like a vector file. Instead, you have to add the file by accessing the menu. To do this, click on the menu button at the top called “Layer” and then select “Add Layer” and then select “Add Delimited Text Layer.” This is a another name for a CSV file.
6. When you do this, a new box will pop up that looks like this. To select the file to upload click on the 3 dots at the end of the file name and navigate to the CSV file wherever you have it on your computer. Then when you select it, make sure that it puts the latitude and longitude data in the x and y-fields mid-way down the page. \*Note that longitude should be the x-axis and latitude should be the y-axis.



1. When you do this, it should look something like this and you will have two layers in your layers tab on the left side of the screen.

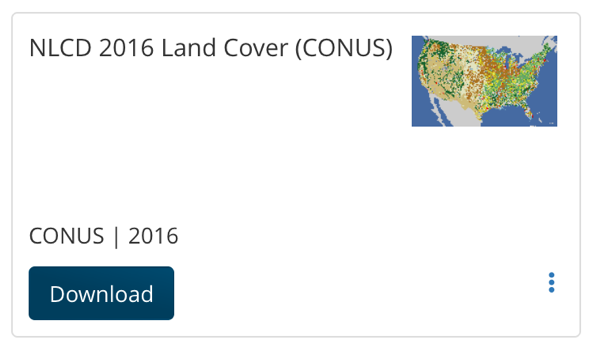


1. In the future, you can format any GPS data you have in this same format, save it as a CSV file and you just created your own point maps with students.

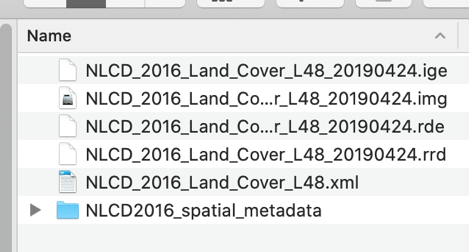
## Making a Raster Map

In this final map, we will use a common source of raster data, the National Land Cover Database. These data are amazing and provide an estimate of land use for every location in the lower 48 states.

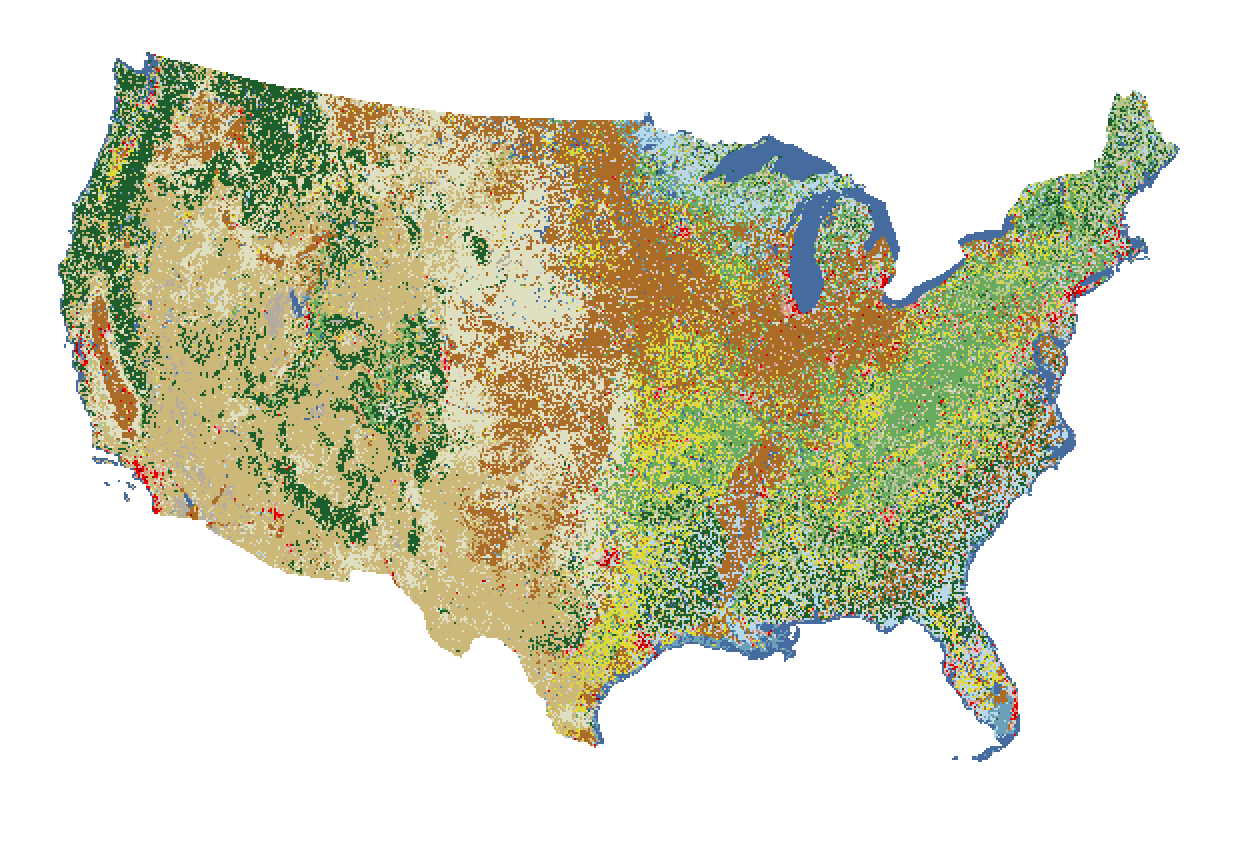
1. Open up QGIS and start a new project.
2. Then navigate to <https://www.mrlc.gov/data> where the NLCD data is stored. From there, select the NLCD 2016 Land Cover data to download. \*Note this is a massive file (>1GB) so it may take some time to download.



1. Once you have downloaded, this you should get a folder with the following files:



1. You can then drag the file that ends in the extension .img onto the blank canvas or add a raster layer using the menu bar. Once you have done this, you should end up with a map that looks like this:



# Additional Comments

One of the other major components of QGIS and GIS in general is spatial data analysis. To explore this, you can look through the QGIS 3.16 training guide: <https://docs.qgis.org/3.16/en/docs/training_manual/index.html>

# Additional Resources

NEON Spatial Data Repository on ArcGIS Server: <https://www.arcgis.com/home/group.html?id=aa95f6e233ae45e99c2e98d2edafa11c>

Global Biodiversity Information Facility: Point Data on Species Around the World

<https://www.gbif.org/>

iNaturalist: Occurrence Records Using Community Science

<https://www.inaturalist.org/home>

QGIS for Beginners:

<https://www.youtube.com/watch?v=NHolzMgaqwE>