Red-cockaded Woodpecker Interactions with Longleaf Pine Ecosystem

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Introduction

Red cockaded Woodpeckers (RCW), *Leuconotopicus borealis*, live in the southeastern United States. This birds once highly populated, has diminished down to a near threatened population as of 2020 by IUCN Endangered List (IUCN, 2023).

RCW eat ants, termites, southern pine beetles, other bark beetles, wood roaches, and centipedes. Less often they will eat vegetation such as berries, grapes, and cherries. Nests of these birds are placed within the male's cavity, usually stored inside of a pine tree of sorts. Cavities tend to be 100 ft from the ground facing west or south with 2–3-inch entrance into the cavity (Cornell University, 2024). Tree tends to be old growth, 70+ years of age, before a bird begins making cavities (Florida State Parks, 2024). There are 2-3 shiny white eggs, only a couple centimeters in size. The time frame from incubation to hatching to letting the birds free is approximately 40 days. The birds live in small groups, two to five, with one adult female. The males are strong roosters and usually protect the eggs. Females and males sleep independently. Males will often continue to use their same roosting post for multiple years, decades. Once mated, partners typically stay together for life (Cornell University, 2024).

Figure 1. Red-cockaded Woodpecker Habitat

An ecosystem that has great population of RCW is that of the Longleaf Pine (LP), *Pinus palustris*. From 24-37 million ha along the gulf coast to 1.2 million ha, a near 3% of the population (Center for Biological Diversity, n.d.). From 90 million acres to 3 million acres in

Florida, due to urbanization, overutilization, fire regimen, etc. (Kiser, 2024). This population of LP has been greatly depleted.

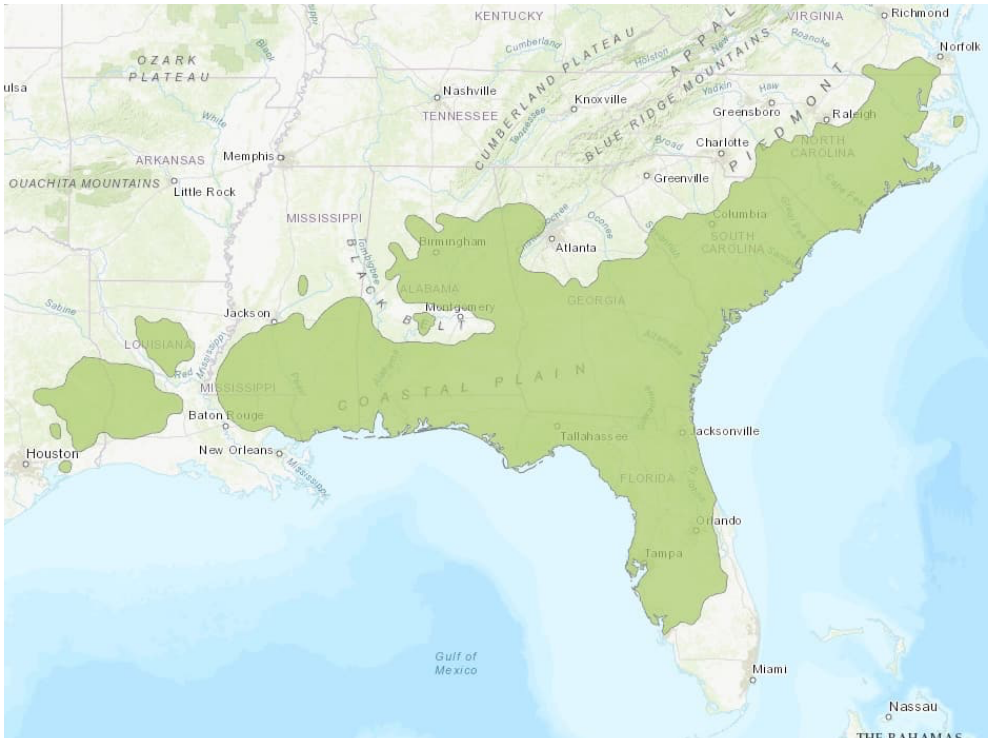

Figure 2. Longleaf Pine Habitat

Due to the Florida climate, in 2018 it was struck with Hurricane Michael, destroying the population of LP. Research and recovery methods have already been put in place in Apalachicola National Forest, according to a recent ArcGIS Story Map by the USDA in 2021, "Red-cockaded Woodpecker Recovery." After the hurricane struck many trees within this forested area, damage was controlled, and new RCW cavities have been created (Cast et. Al, 2021).

A two-year study was conducted in St. Sebastian River Preserve State Park. Seven things were done to this population: LP were prescribe burned, RCW habitat target for restoration, RCW population tracked and monitored, new clusters in existing and artificial cavities created, cavities cleaned and maintained, State Park became members of the RCW Recovery Unit to track the birds, and protection of all the cavity trees from prescribed fires (Florida State Parks, 2024). Since this time, the bird populations have grown significantly.

This project will use QGIS and PostgreSQL to look at the RCW degrading population in the southeastern United States. It will also look at their primary habitat the LP forest within this same location: Louisiana, North Carolina, South Carolina, and Florida. Using PostgreSQL various SQL statements will be formed looking into the population. QGIS will be used to investigate various information that cannot be utilized in PostgreSQL. QGIS will be used to make three various maps in TerpConnect Software.

Data Description

This study is primarily focused on the southeastern region of the United States. Data that has been found for Red-cockaded woodpeckers (RCW) in the southeastern United States form iNaturalist in states of Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, North Carolina, South Carolina, and Virginia. These are all represented as point data: 1,636 observations. Another form in point representation from ArcGIS Online, a map of the RCW, has been found. This data only represents the state of Florida with its Red-cockaded Woodpecker Observation Locations. Representation in the attribute table are latitude, longitude, and last edit data. Due to the small amount of data, this will not be used.

Data that has been found for Longleaf Pine (LP) in the southeastern United States form iNaturalist in states of Texas, Oklahoma, Louisiana, Mississippi, Alabama, Tennessee, Georgia, Florida, North Carolina, South Carolina, and Virginia. These are all represented as point data: 9,547 observations. A map from Florida Natural Areas Inventory maps the LP congregation. This data is represented as polygons within the state of Florida. A conversion from polygon to point would need to be done. Due to this conversion reasoning, this data will not be used.

iNaturalist is accessible and downloadable, with an account being made. For this reason, it was used in the various overlapping states for RCW and their habitat, LP: Texas, Oklahoma, Louisiana, Mississippi, Alabama, Georgia, North Carolina, and South Carolina. For the data from iNaturalist, observations were selected from 4 states: Louisiana, Florida, South Carolina, and North Carolina. CSV files were downloaded from iNaturalist and uploaded into QGIS and PostgreSQL. iNaturalist process will be explained as well as QGIS and PostgreSQL.

Methodology

iNaturalist

iNaturalist Observations were selected from Louisiana, Florida, South Carolina, and North Carolina for RCW and LP populations. After typing in the taxonomic name of the species, select “Filter” along the top righthand side, above the map. Along the bottom portion of the filter menu bar, select the bottom righthand selection “Download.” A page titled, “Export Observations,” appears. Scroll down to section 3, “Choose Columns,” and select the various outputs: *id, oberserved_on, created_at, url, description, place_guess, latitude, longitude, scienetific_name, and common_name*. Next select “Export,” and start downloading the data. Due to the large download, it was saved as a CSV file. After downloading both Red-cockaded Woodpecker and Longleaf Pine from selected states of LA, FL, NC, and SC, continuation will be processed in further steps.

County and Land Use

The do the results of the point data in the iNaturalist download county and land use data will be downloaded. The counties of North Carolina were the only out of the three states found. Other county data needed to be purchased or only a PDF file upload was accessible. Land use data for LA, SC, and FL were accessible. These were downloaded by clicking "Download" on the webpage they were accessed at. Counties for the selected states of LA, FL, NC, and SC, continuation will be processed in further steps.

PostgreSQL

A database was created in the PostgreSQL. The following steps were completed: "Databases > Create > Create New Database". It was named finalProject. Extension will be created by clicking "Extension > Create > Extension". The name was set to postgis in the create extension window and then save. Go back to the QGIS system, go to Database and DB Manager. In the system, PostGIS will appear as a crated database. Various questions were answered once the continuation will be processed in further steps were completed in QGIS.

QGIS

The qgis2web Plugin needed to be installed to access the Web Mapping portion of this project. Due to iNaturalist downloading as CSV, each of the 8 files were uploaded to QGIS: adding a "Delimiter Text Layer" within the "Add Layer" feature. Make sure each layer is saved by right clicking the "Export" and "Save Feature As". There was a total of 12 files uploaded: 4 CSV files for RCW (FL, NC, SC, LA), 4 CSV files for LP (FL, NC, SC, LA), 3 land use shapefile (FL, SC, LA), and one county shapefile (NC). Once all have been uploaded to QGIS, they need to be accessed in PostgreSQL. To do so, "DB Manager" was selected on the toolbar. The database that was entered into PostgreSQL, finalProject, was run to see if the two connected by entering the information for PostgreSQL and making sure the SSL Mode is set to "Disable". Next, in the system, PostGIS was selected and the database, finalProject, in the PostgreSQL step was clicked on. "Import/ Export File" was selected, and the 12 files were uploaded into PosstgreSQL by selecting the three dots next to the drop-down menu. The steps were run in PostgreSQL in the methodology section.

TerpConnect

After the maps are built, qgis2web was selected and the final maps were created. Fetch was accessed and the following maps were uploaded to for TerpConnect: all the data for the 4 states, the point data post 2008, and the NC counties data along with the most populated polygon data in the counties for the RCW and LP. The following three website URLs can be selected to access the data.

Results and Findings

For the analysis of the various data uploaded, a couple of questions were asked. The questions are as follow:

1. From the upload in iNaturalist of the 8 RCW and LP:
    a. What is the count for the iNaturalist upload of RCW and LP?
2. Since its creation in 2008, iNaturalist may have errors with dates before 2008.
    a. Where do these errors lie?
    b. How can they be updated to 2008 and further on?
3. According to the North Carolina input of counties, there are location in which there is overlap between RCW and LP.
    a. Where are the overlaps?
    b. How many overlaps are there total between the 2008 data of RCW and LP?

Question 1

In QGIS, a point data representation of the RCW and LP was created and saved as *RCW_state* and *LLP_state*. In PostgreSQL, after the upload was completed from QGIS, various SQL statements were run to test what the count was for each state the RCW and LP populations.

The statements are as follows:

- *SELECT COUNT(geom) FROM public."LLC_state"*
- *SELECT COUNT(geom) FROM public."RCW_state"*

The results for LP and RCW in each state are as follow:

- *Longleaf Pine: SC – 83, NC – 2048, FL – 3761, LA – 366*
- *Red-cockaded Woodpecker: SC – 140, NC – 271, FL – 502, LA – 257*

A map was created for all the various states and the LP and RCW that were associated between them. The maps are as follow:

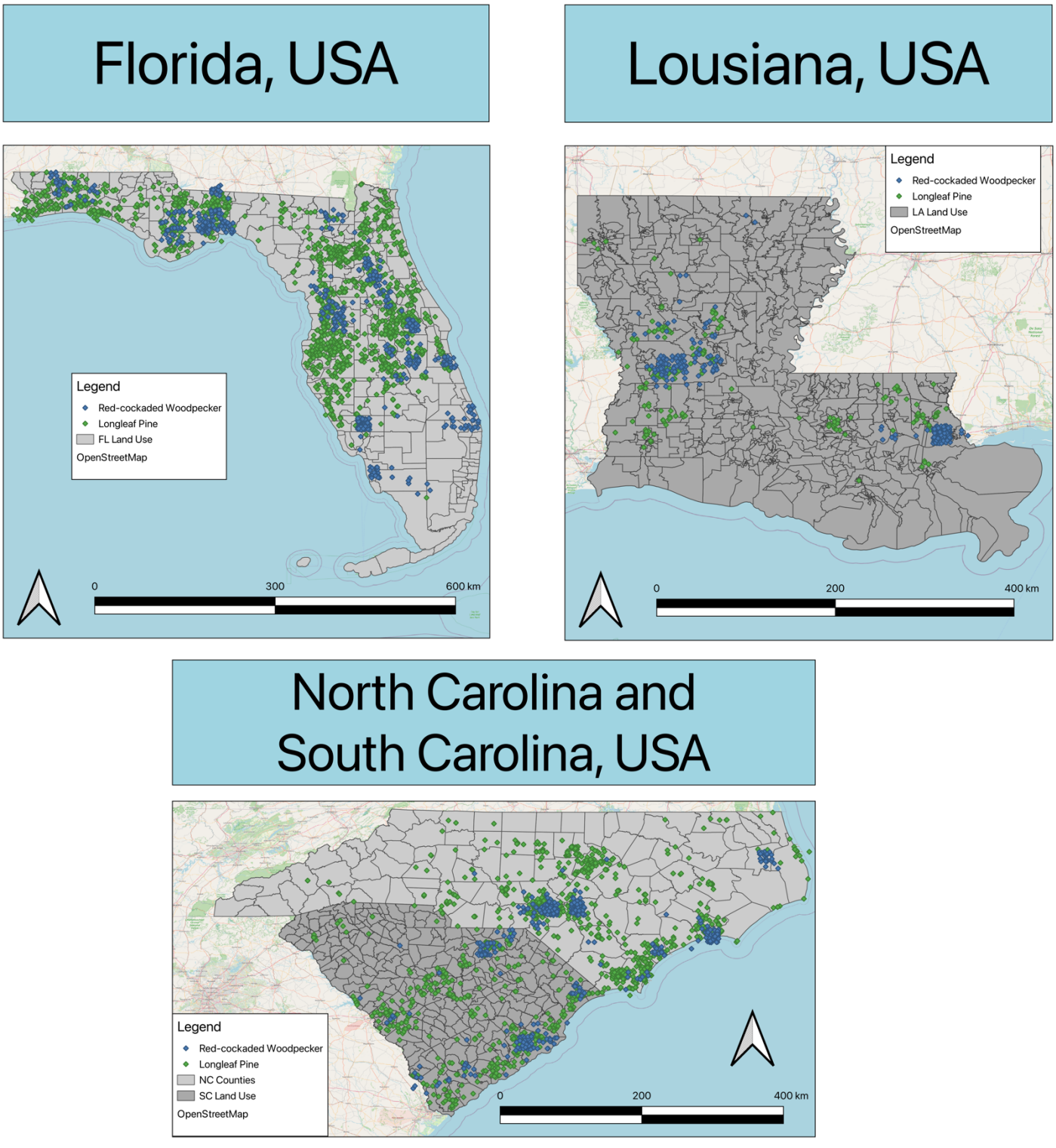

Figure 3. Maps of Red-cockaded Woodpecker and Longleaf Pine iNaturalist data in Florida, Louisiana North Carolina, and South Carolina.

Question 2

iNaturalist was created in 2008 by a master's student for their final project at UC Berkeley's School of Information (iNaturalist, 2023). In the collection of the Red-cockaded Woodpeckers and Longleaf Pine, there are entries from 1898 all the way to 2007. These human errors should be corrected since they do not fit within the timeline of 2008-2024, the time in which iNaturalist was created and has been used. It is important to delete these pieces of data due to the human error when entering them. There was an unresolved issue with the *date* column in PostgreSQL. Many different things were tried to access it. Since they couldn't be accessed, the processes were completed in QGIS. In QGIS, "Query Builder" and "Save Feature As" were selected to discard the following data before 2008. After this selection was made for each state in the RCW and LP data this process was completed and uploaded into PostgreSQL. They were saved as *LLP_state_GT_2008* and *RCW_state_GT_2008.*

The statement as follows was deleted for each state of RCW and LP data:

- *Query Builder: "observed_on" < '2008-MM-DD'*

The results for LP and RCW in each state are as follows:

- *Longleaf Pine: SC – 3, NC – 18, FL – 22, LA – 3*
- *Red-cockaded Woodpecker: SC – 2, NC – 4, FL – 6, LA – 1*

The statement as follows was kept for each state of RCW and LP data:

- *Query Builder: "observed_on" >= '2008-MM-DD'*

The results for LP and RCW in each state are as follows:

- *Longleaf Pine: SC – 832, NC – 2029, FL –3739, LA – 363*
- *Red-cockaded Woodpecker: SC – 138, NC – 267, FL – 496, LA – 256*

The maps are as follows:

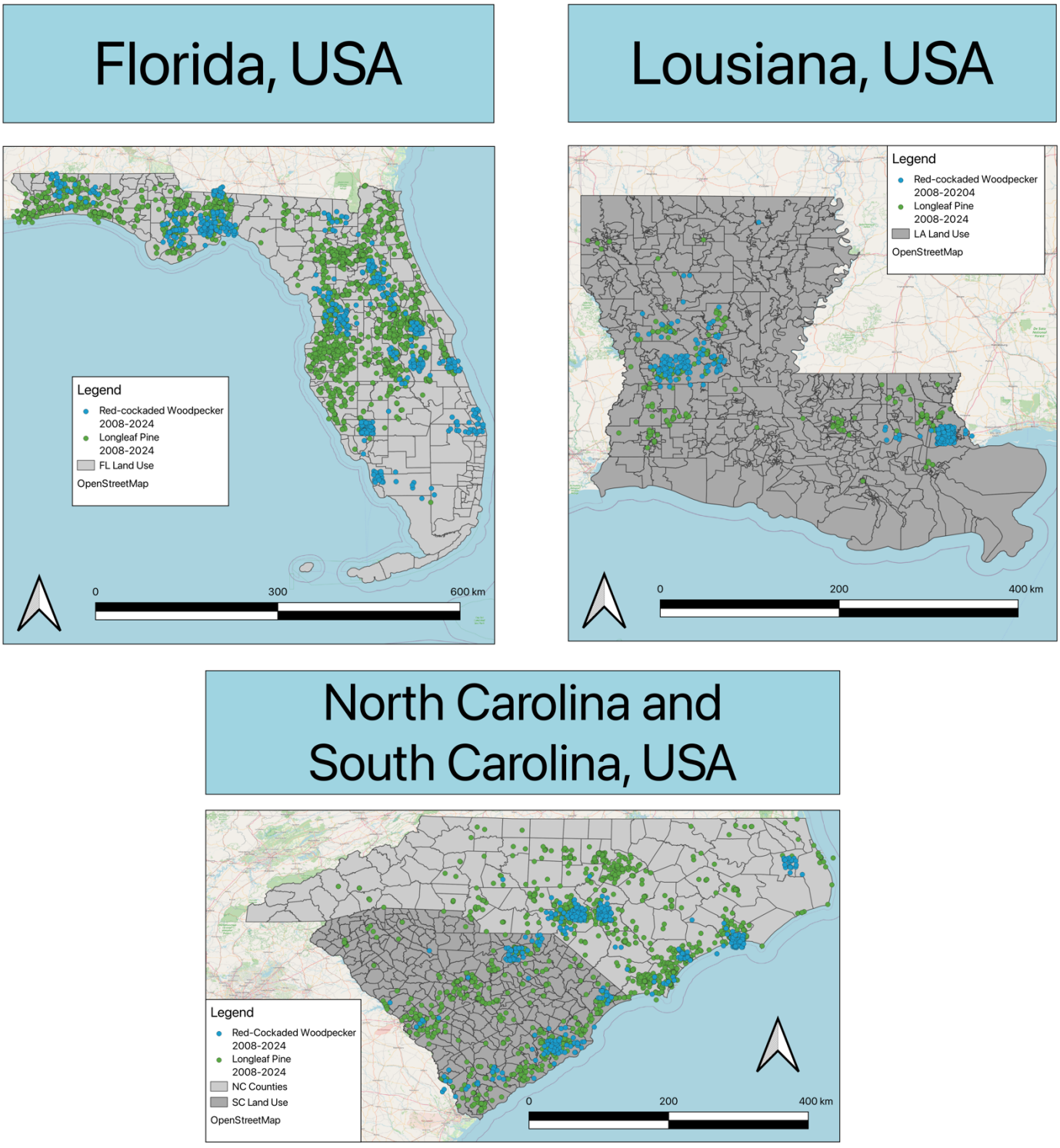

Figure 4. Maps of Red-cockaded Woodpecker and Longleaf Pine iNaturalist data from 2008 – 2024 in Florida, Louisiana North Carolina, and South Carolina.

Question 3

A polygon data representation of the various Land Use and County databases were saved as *state_LandUse* and *state_County*. Since the county shapefiles could not be uploaded for Florida, Louisiana, or South Carolina, due to there being a cost or only a PDF accessible, only North Carolina counties were processed. The data in QGIS was looked at. It was noticed were the most concentrated population of LP and RCW were located. These counties were selected with a query.

The query is as follows to select the various regions:

- *Query Builder: "CountyName" IN ('Richmond', 'Scotland', 'Moore', 'Hoke', 'Cumberland', 'Pender', 'Carteret', 'Brunswick', 'Tyrrell', 'New Hanover')*

After the selection was created, they were exported into their own feature in QGIS. A join attributes by location was then completed for the various counties that had the highest population with the RCW and LP 2008 onward data. After the join was competed, labels were created to the map to highlight the counties names. They were then uploaded to PostgreSQL per the DB Manger as *NC_RCW_Counties_Most* and *NC_LLP_Counties_Most*.

The following SQL statement was selected:

- *SELECT COUNT('county') FROM public."NC_RCW_Counties_Most" WHERE "countyname" = 'county'*
- *SELECT COUNT('county') FROM public."NC_LLP_Counties_Most" WHERE "countyname" = 'county'*

The following were selected in each county for the RCW and LP:

- *Longleaf Pine: Richmond – 21, Scotland – 25, Moore – 229, Hoke – 24, Cumberland – 94, Pender – 81, Carteret – 154, Brunswick – 226, Tyrrell – 2, New Hanover – 489*
- *Red-cockaded Woodpecker: Richmond – 9, Scotland – 6, Moore – 23, Hoke – 57, Cumberland – 54, Pender – 18, Carteret – 32, Brunswick – 5, Tyrrell – 18, New Hanover – 1*

The map is as follows:

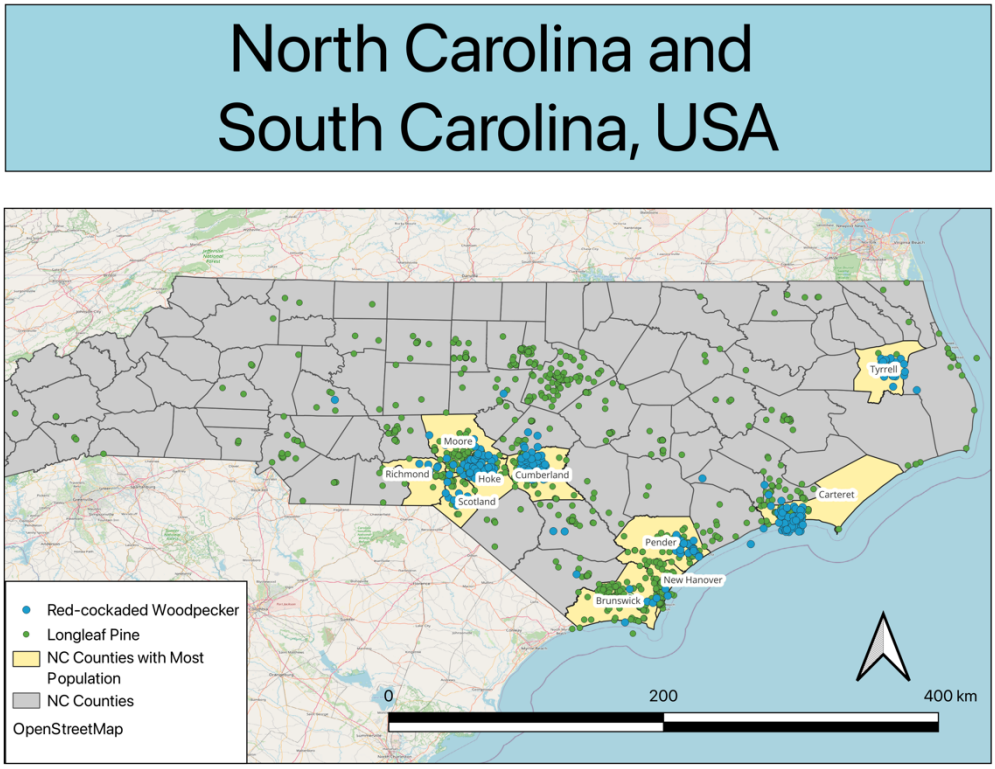

Figure 5. North Carolina representing the 2008 – 2024 data for iNaturalist within the counties that hold the most population.

Upload into TerpConnect

After completion of the 3 necessary items, they were uploaded into TerpConnect so everybody could access the information. Each of the three overall maps were created: iNaturalist raw data of RCW and LP, iNaturalist 2008 – 2024 selection, and NC Counties with the highest populations.

Websites for the maps can be found here:

- *NC Counties and LP and RCW Populations Highest: https://terpconnect.umd.edu/~gzeck/GEOG670FinalProject/qgis2web_2024_05_09-16_19_42_425486/#6/35.022/-79.606*
- *iNaturalist Data for NC, SC, LA, FL: https://terpconnect.umd.edu/~gzeck/GEOG670FinalProject/qgis2web_2024_05_09-16_29_52_742027/#6/31.323/-84.021*
- *iNaturalist Data for NC, SC, LA, FL 2008 – 2024: https://terpconnect.umd.edu/~gzeck/GEOG670FinalProject/qgis2web_2024_05_09-16_58_32_486663/#5/33.009/-83.716*

Conclusion

There were several things considered when completing this project. First, iNaturalist data is not always accurate. When downloading a certain state data it results in another nearby state or ocean or lake. Unfortunately, there is nothing that can be done about this. If more time was allotted or if the data was freely accessible, a different data source would have been chosen.

Secondly, due to the numerous states in the selection, I considered doing Georgia to make the states flow more fluidly together. After examining the iNaturalist data and seeing not much present, it was decided to go with Louisiana due to more existing data.

Thirdly, because none of the other states than North Carolina had freely accessible county data, it was not considered to partake in this data. After an examination on the data with multiple incorrect calculations was completed, it was decided that it was okay to not have the other counties accessible.

Fourthly, it was unrecognizable how to calculate the “date” column in PostgreSQL. After looking on the internet for multiple hours, it was decided not to use this in SQL. Instead, the dates were selected by query in QGIS. It was completed in QGIS then uploaded to PostgreSQL.

Lastly, if to complete this project again, it would be considered to do all the southeastern states that have a population of Red-cockaded Woodpeckers to succumb to the entire population. As stated previously, I would consider looking into other data than iNaturalist, to see if the possibility for more accurate data.

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