Potential Impacts of Impervious Surface Growth on Biodiversity & Habitat in North Carolina

Introduction

Throughout the past couple of decades, the Southern United States has seen significant growth in population sizes. This trend is particularly noticeable in North Carolina, heralded especially in the metropolitan area of Charlotte. Since 1990, it is estimated that the Charlotte metropolitan area has seen a growth of nearly 1,500,000 people, and some organizations suggest that 117 people move to the metropolitan area daily. (Charlotte Regional Business Alliance, 2024) Between 2010 and 2019, researchers from a University of North Carolina-backed program called Carolina Demography determined that Charlotte was the eighth fastest growing metropolitan area in the country, in company with areas like Austin, Texas, and Raleigh, North Carolina. (Ordoñez, 2020)

This accelerated population growth has been accompanied by accelerated rates of development, in order to house and provide business towards increased populations. This can largely be modeled by examining land coverage of impervious surfaces over the years in these two metropolitan areas. Impervious surface generally refers to artificial, man-made structures that are impervious to water such as buildings or asphalt. This is an excellent signifier of the growth of a region as development to enable increased populations is almost always done with impervious surfaces and materials.

Additionally, North Carolina as a state hosts a great deal of both habitat areas and areas with high amounts of biodiversity. This is largely due to the topology of the state, offering various living conditions from its mountains to its coastline. As the writer of the PBS series *Exploring North Carolina* put it, the state has “ecosystems that other states can only dream about.” (Cox, 2023). The Charlotte metropolitan area is located in the Piedmont of North Carolina, sandwiched in between the Appalachian Mountains to the west and the Outer Banks as well as the Albemarle and Pamlico Sounds to the east. The Piedmont is marked with rolling hills that gradually decline towards the coast, featuring hotspots of biodiversity and habitat being centered around freshwater lakes, rivers, as well as vast forest areas such as the Uwharrie. (Whitaker, 2024)

When the unique biodiversity of the Piedmont region of North Carolina is taken into account, it can be easy to see why population growth and development in its two largest metropolitan areas may be an issue. Using impervious surface land coverage data, this report aims to predict how impervious surface land coverage will change through 2033, and identify areas of biodiversity and habitat within this metropolitan area that may be threatened at the current rate of growth. I am interested in investigating this as I have been able to witness firsthand rapid human development and population growth in suburban Charlotte and its subsequent consequences on habitat areas, and I believe that it is important to understand how further development at the current rate in Charlotte may impact the biodiversity and health of local ecosystems.

Data & Sources

The impervious surface data was sourced from National Land Coverage Data, and was offered through the Multi-Resolution Land Characteristics Consortium in conjunction with the United States Geological Survey. (USGS, 2024) The data used in this report was gathered from 1993 to 2023, a thirty year span. Raster data was taken from the Impervious Descriptor product, which provides raster data making distinctions strictly between urban and rural areas, as well as roads. This is important, as it allows for simpler interpretations, processing, and interpretation of data. Initially, fractional impervious surface raster data from this thirty year span was used, however there were issues with modeling and interpretation that will be further discussed in the Limitations & Challenges section of this report.

Data regarding biodiversity and habitat areas in North Carolina was sourced from the North Carolina Natural Heritage Program, from July of 2024. This data identifies and evaluates areas within the state that are important in regards to maintaining sustainable and healthy ecosystems by measuring aquatic and terrestrial biodiversity, habitat landscape, as well as land features that are important towards maintaining habitat. This data is gathered and provided by a wide variety of both state agencies and non-governmental conservation organizations. (North Carolina Natural Heritage Program, 2024) The projection used for this data is the NAD83 State Plane for North Carolina, which specifically focuses on preserving the size, area, and shape of North Carolina. To display bodies of water such as lakes and notable rivers on the map, a map of waterbodies in North Carolina was sourced from NC One Map, developed by the NC Center for Geographic Information and Analysis. In terms of borders and boundaries, the county outline was created using data from the North Carolina Department of Transportation, whereas the state outlines were created using data from the US Census Bureau.

Methods

To obtain the final results, first, raster data regarding impervious surface coverage for the entire contiguous United States was obtained from the National Land Coverage Data program from 1993 to 2023, in five year intervals. In order to keep projection consistent between data layers, the map projection was changed to NAD83 State Plane for North Carolina. This collection of raster data was assembled into a mosaic dataset, which was then transformed into a multidimensional raster using the Create Multidimensional Raster tool. From here, a harmonic trend raster was created using the Generate Trend Raster tool to determine the change in impervious surface coverage for the Charlotte metropolitan area. A harmonic trend was used as opposed to a linear trend raster, as the change in coverage from interval-to-interval did not necessarily follow a linear pattern. Finally, a prediction model was created using this trend raster with the Predict Using Trend Raster tool to create a prediction model through 2033 to determine how impervious surface coverage will change throughout the next ten years.

Next, the growth prediction model was converted to an integer raster layer in order to create a polygon layer. This was necessary as polygon layers were significantly easier to work with than raster data to compare differences and overlap. After the integer raster layer of the growth prediction model was created, it was then converted to a polygon layer. Similarly, the biodiversity and habitat raster layer was also converted to a polygon layer. It is important to note that in order to further reduce clutter, values equal to or less than zero for each of these layers were deleted as they were not relevant to the topic at hand. From here, the pairwise intersect

tool was created with these two polygon layers as the input in order to establish a polygon layer displaying the overlap areas between the two layers, thus showing the areas of current biodiversity that will be threatened by urban development within the next ten years.

On a smaller note, the waterbody layer displaying lakes and major rivers was added alongside county boundaries and state boundaries. After this was done, color ramps and symbology were updated to better convey the information.

Results & Findings

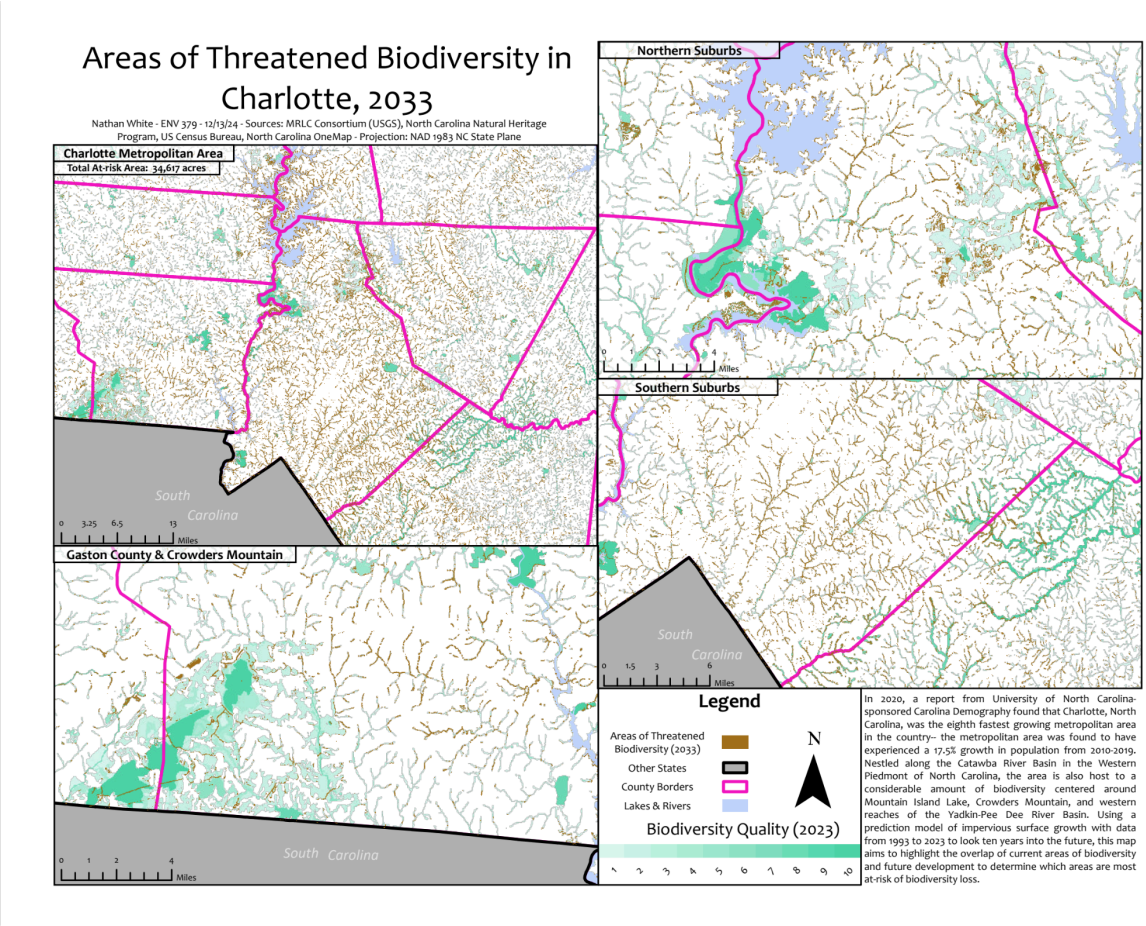

Figure 1.1 - Areas of Threatened Biodiversity in Charlotte, 2033

Quantitatively, it was determined that in 2033 in the area of interest, 34,617 acres of land that currently has value in regards to biodiversity and habitat would be compromised or at-risk based on the prediction model. From the final map product, it would appear that the wide majority of this acreage is along creeks and local watersheds. In the lens of biodiversity, this presents an issue as the habitat loss will undoubtedly damage the biodiversity and health of local ecosystems. Creeks offer egg-nesting places for a wide variety of insects, and the removal of this species' habitat would negatively impact biodiversity and possibly as an extension trigger trophic cascades for the local systems. Though often overlooked, insects offer an important role

in ecosystems as pollinators and food sources for other lower level consumers, and their removal could in turn result in a reduced number of primary producers as well. A trophic cascade occurs when a trophic level in an ecosystem is disrupted, and has long reaching effects on other trophic levels in the ecosystem. If primary producers and lower trophic consumers are removed from the equation, trophic levels higher up may see worsened resource availability and dwindling populations from either increases in competition or migration towards systems with available resources. Biodiversity of plant life could also suffer in this scenario, as well. Creeks and streams in watersheds play an important role in the mediation of the cycling of nutrients, and without this cycling, the soil which supports plant life may not be able to hold the proper nutrients to ensure that it flourishes. (Essington & Carpenter, 2000) Depending on the nuances of the ecosystem, this could also have an impact on trophic levels and possibly even give way to invasive species which may be able to outcompete native species for the even more limited nutrients. Though not necessarily related to biodiversity, another possible issue that could stem as a result of this prediction is increased flooding. Creeks and watersheds generally do an excellent job of holding water in flooding events, and should development occur here, flood damage could impact these developments. Furthermore, nearby development would also be impacted as this in a sense could act to further expand flood plains.

One solution to reduce the damage to creeks and the consequences of biodiversity and habitat loss could be the creation and maintenance of riparian buffers. Put simply, riparian buffers are a land management technique in which native plants are planted alongside the creek bed with the idea that these buffers will prevent sediment, pollution, and other runoff from entering the waterway and reducing the overall health of it. By promoting doing this, the main impacts of human development on and near creeks is avoided. Though outright conservation is preferable to relying on riparian buffers, they could be utilized as a solution to mitigate damage from what could be considered inevitable development. (Harding et al., 1998)

Another interesting trend is where the tightest “concentration” of development occurred. The two areas that appeared to have the most amount of predicted development were around Mountain Island Lake and Crowders Mountain. The western peninsula that juts into Mountain Island Lake, despite the whole area of the lake and river hosting a great deal of biodiversity, was predicted to be developed. What was interesting about this specifically, however, was the stark contrast in development between the western banks of the Catawba River and Mountain Island Lake and the eastern banks.

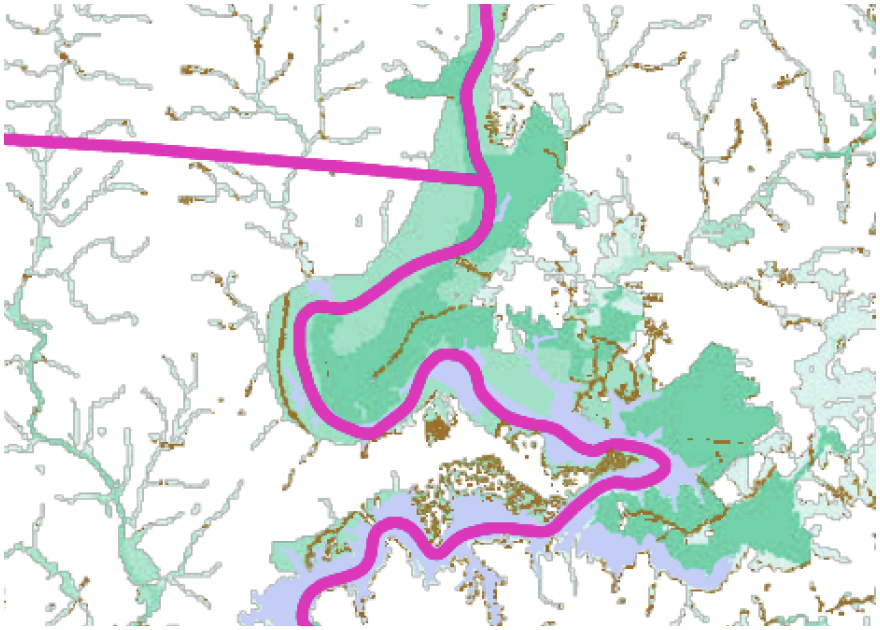

Figure 1.2 - *Mountain Island Lake*

The banks of Mountain Island Lake and the Catawba River in this area both appear to be hotspots for habitat and biodiversity, but only one portion of the area will have negative impacts as a result of population growth. This is likely due to the eastern portions being protected– Cowan's Ford Nature Preserve, Latta Plantation Nature Preserve, and Rural Hill Nature Preserve all exist here. Given that this land has been protected for a couple of decades at this point in time, the model did not predict any development that would encroach upon biodiversity with the exception of a few roads. In this, sits another possible solution to maintaining biodiversity in the face of population growth: establishing protected conservation areas. The peninsula on the western bank lacks any significant protected areas, thus resulting in development on lands with high values of biodiversity. Should areas such as these that the model predicted be protected, further loss of habitat and biodiversity and the associated consequences could be avoided.

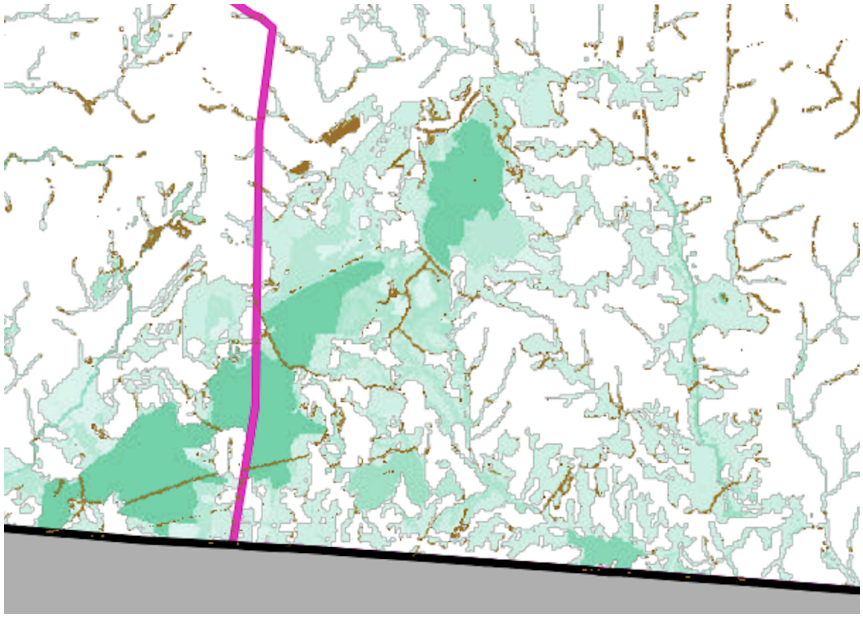

Figure 1.3 - Crowders Mountain State Park

Similarly, Crowders Mountain State Park is also a protected area with a significant deal of biodiversity. However, especially in the northern areas, it can be seen that development may encroach closer and closer to the boundaries of the state park and threaten the biodiversity and areas of habitat the landmark offers. In a similar light to the Mountain Island Lake example, reinforcing and expanding protected areas to better include and protect these areas of biodiversity would prevent their degradation and the onset of consequences.

Limitations & Challenges

One limitation of this report is the scope in which it was done. Though it initially intended to cover three other metropolitan areas, namely Wilmington, Raleigh, and Asheville, in order to compare development and the threats to biodiversity across the state's various regions and landscapes, the scope needed to be reduced in order to fit the time constraints of the project. Future research could expand on this to determine how development has impacted arguably more precarious and important biodiversity areas, specifically in the mountains of Asheville and the forests around Wilmington and Cape Fear.

Another limitation could be that while this report does offer a prediction of where biodiversity and habitat will be at-risk in the future, it is unable to do anything but speculate on what the consequences of this may be. It is hard to know the exact extent of the impact should the next ten years of development play out the way the prediction model suggests, therefore it should be an all hands on deck effort to cushion the possible consequences that may stem from this. This could also serve as a jumping off point for future research as well, as this could be used as a basis to determine more specific ecological impacts of development using the prediction model.

Perhaps the largest challenge during the compilation of this report was working with the raster data– initially, fractional impervious surface data was used to model human development. However, due to the wide range of values that were measured, the model failed to show where

impervious surface coverage would extend to and instead provided a model which showed where pre-existing areas of impervious surface coverage would intensify. To solve this issue, impervious surface descriptor raster data from the same data source was used instead as it provided a significantly more simpler and almost binary view of impervious surface coverage which was easier to geoprocess and interpret.

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***Denotes spatial data used to compile the final map.*