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Dead Wolf to Red Wolf: Virginia Reintroduction Habitat Suitability

Abstract

Red wolves (Canis Rufus) are the most endangered species of red wolves. All red wolves currently in the wild are in the Albemarle Peninsula in North Carolina. Red wolf population in the Albemarle decreased from a peak of around 113-149 wolves in 2014 to 15-17 wolves in 2021. Most red wolf mortalities for this wild population occurred from anthropogenic causes such as accidental shooting, poaching, and vehicle strikes. The purpose of this study is to assess the suitability of the Delmarva Peninsula as a potential reintroduction site for another red wolf population. To do so I analyzed the land cover, deer harvesting records, and distance from roads of the Delmarva Peninsula and compared it to the Albemarle Peninsula as a baseline for suitability. Both Peninsulas proved to be very similar, with very close amounts of the focus land cover, cultivated crops; deer harvesting amounts between the peninsulas were also alike with the Albemarle Peninsula having higher amounts of deer harvesting by around 400 in 2021. Lastly, the average distance from roads was much higher for the Albemarle than the Delmarva Peninsula with a difference of 2,423 meters. Therefore, the results suggest that the Delmarva Peninsula would be a suitable location for red wolf reintroduction

Introduction

Red wolves (Canis rufus) are a species of wolf that are smaller than gray wolves and morphologically resemble coyotes (Wayne 1995). Red wolves are the most endangered wolf species (Mulholland 2021). Originally, they were distributed throughout the entire southeastern to eastern United States. However, they were driven nearly to extinction in the 1900's because of predator control programs and habitat destruction. In the 1980's red wolves were declared officially extinct in the wild. Some red wolves were captured before this to create breeding programs to avoid the species becoming completely extinct. In the years between 1986 and 1994, around 60 red wolves were released into North Carolina, making all red wolves that are in the wild at the time located in North Carolina in the Albemarle Peninsula. The population of red wolves in North Carolina peaked at around 113-149 wolves in 2013-14 only to fall to around 15-17 wolves in 2021. Currently there are only around 256 red wolves in total, with 241 of them being in captivity and around 15 living in the wild (U.S. Fish and Wildlife Service 2021).

The main threat to red wolves is humans. In the first 25 years of reintroduction, 72% of all red wolf mortalities had anthropogenic causes. This was mainly from poaching, illegal trapping, and vehicle strikes (Agan 2021, Davis 2021). North Carolina allows nighttime coyote hunting which led to further accidental shootings because of red wolves being very visibly similar to coyotes. Red wolves that were reintroduced into North Carolina were also classified as non-essential under the Endangered Species Act (Rippe 2017). This classification was applied because of a captive population existing, however, it made it so that the red wolf could not receive full protections from the Endangered Species Act. With the full protection of the

Endangered Species Act, red wolves could not be killed for any reason aside from defending one's life or safety (Animal Welfare Institute 2022). The nonessential classification also made it so that problematic wolves could be removed from the wild by managers if prompted by landowners. Another large increase in gunshot mortality was caused by this same classification that allowed for the killing of red wolves on private lands if not intentional (Rippe 2017). This proved especially problematic because of red wolves' low population numbers, any red wolf mortality can have devastating effects on the species' recovery and future (Simonis 2018).

Red wolves in the Albemarle Peninsula have been found to be mainly residing in croplands. This is different from their historical habitat of forests and wetlands where they were rarely spotted in. Agricultural fields are the preferred habitat for red wolves because of they quality foraging they offer (Hinton 2010). Red wolves diet consists of smaller mammals such as rodents (Natural History 2022). These small mammals are more often present in agricultural fields making them very efficient for food foraging. When placed in less optimal areas, red wolves are likely to move to an area that offers more foraging potential. This was observed even during the summer, where temperatures are much higher and forested areas can offer more cover (Hinton 2010).

The goal of this project was looking at the Delmarva Peninsula and assessing its suitability as a potential reintroduction site for red wolves. To achieve this, variables that could impact red wolf reintroduction were analyzed such as land cover, deer harvesting records, and distance from roads in the Delmarva Peninsula to then be compared to the Albemarle Peninsula. For the purpose of this analysis, the Albemarle Peninsula will be considered a suitable location for red wolves and will be the standard to compare the Delmarva Peninsula to.

Methods

This project focuses on the Delmarva Peninsula and whether it serves as a potential red wolf reintroduction zone. The Delmarva Peninsula is located near the Chesapeake Bay and is made up of three states: Delaware, Virginia, and Maryland. As shown in Table 1, the main counties we are focusing on are two Virginia counties, Accomack and Northampton, and two Maryland counties, Somerset and Worcester. The total population of these counties is 122,775 and the total area is 3,790 km^2 (U.S. Census 2021). Also as shown in Table 2, the Albemarle peninsula, where the wolves are located, is made up of 6 counties: Hyde, Dare, Tyrell, Beaufort, and Washington. The total population of these counties is 100,404 people and the total area in 6,630 km^2 (U.S. Census 2021). The project used spatial analysis using ArcGIS Pro to analyze land cover, deer harvest amounts, and distance from roads in the focus counties of the Delmarva and Albemarle Peninsulas.

Data was obtained from many different sources. Land cover data was obtained in a raster from the National Land Cover Database for 2019. Deer harvesting data from 2021 was obtained from the Virginia Department of Wildlife Resources for the Virginia counties, Maryland Department of Natural Resources for the Maryland counties, and North Carolina Wildlife Resource Commission for the North Carolina counties. Road centerline shapefiles from 2016 were obtained from the Department of Commerce. Lastly, a U.S. counties shapefile was obtained from the United States Census Bureau.

To begin the analysis, the land cover raster was symbolized on a map by land cover type. The extract by mask tool was then used to clip the raster to the focus counties. Water pixels were removed from the raster as they were not important for the analysis. Pixel counts were then obtained from the attribute table and used to calculate the percentage of each land cover by dividing the total count of pixels for each land cover by the total count of all types of pixels. A new field was then made in the attribute table with these percentages added to them.

The deer harvest analysis used county level deer harvest data and county shapefiles for all the focus counties in the Delmarva and Albemarle Peninsulas. The U.S. counties shapefile was filtered to only show our counties of focus. Then deer harvest amounts for 2021 were then added as a new field to each of the counties. On the map, counties were then labeled with name and the deer harvest amount for 2021. No color-based symbology was used, instead the labels were the main way of displaying the information.

The final spatial analysis performed was the distance from roads. The road centerline shapefile was filtered to only show major highways. It was then clipped to the focus areas in the Delmarva and Albemarle Peninsulas. The land cover raster used in the previous analysis was then reclassified to only display water pixels and have no data for other land covers. The Euclidean Distance Analysis tool was then used using a pixel size of 30 m, the water raster as a barrier, and a maximum distance of 35,000 meters. The raster output was then clipped to the study area and symbolized using the inverted green to red symbology. Distance from roads averages were then obtained by creating a histogram of the raster pixels.

Results

As shown in Figure 1, the land cover analysis of both the Albemarle and Delmarva Peninsulas showed mostly similar land cover percentages between the two peninsulas. Cultivated crops, the preferred land cover for red wolves, was 25.6% of the total land cover in the Delmarva Peninsula and 27.2% of the total land cover in the Albemarle Peninsula. The Albemarle Peninsula's cultivated crop land cover was in larger patches than in the Delmarva Peninsula, which had more spread out and fragmented croplands. The Albemarle Peninsula had a

significantly higher amount of evergreen forest cover at 15.8% compared the Delmarva Peninsula's 8.4%. The percentage of woody wetlands were also similar, with the Delmarva Peninsula at 39.4% and the Albemarle Peninsula at 37.1%. The Delmarva Peninsula had a higher percentage of developed lands with 4.6% open space, 2.1% low intensity, 1.2% medium intensity, and 0.6% high intensity. While the Albemarle Peninsula had 3.6% open space, 1.6% low intensity, 0.7% medium intensity, and 0.2% high intensity.

As shown in Figure 2, te deer harvest analysis of both Peninsulas showed similar amounts of deer harvesting in 2021. The total deer harvest amount for the Delmarva Peninsula was 4,786 and the Albemarle at 5,174. In the Albemarle Peninsula, most of the deer harvesting occurred on the West side with Washington County and Beaufort County having the highest amounts in the Peninsula at 1,139 and 2,467. Dare County had the lowest number of deer harvesting in both peninsulas at 99 total harvested. In the Delmarva Peninsula, most of the deer harvesting occurred on the two Virginia counties, Accomack and Northampton. Accomack had the highest number of deer harvesting out of both peninsulas at 3,153 total harvested. The two Maryland counties were significantly lower with Somerset County being 112 and Worcester being at 186 total harvests.

Lastly, as shown in Figure 3, the Albemarle Peninsula had more highways on it with a total shape length of 44,176 meters. While the Delmarva Peninsula's highways had a total shape length of 27,2408 meters. for the Euclidean Distance Analysis, the Albemarle Peninsula had a higher average distance from roads at 9,517 meters with a standard deviation of 7,795 meters. The Delmarva Peninsula had an average distance from roads of 7,094 meters with a standard deviation of 5,716 meters. Both peninsulas had areas that were not accounted for due to them being inaccessible by land.

Discussion

The Albemarle and Delmarva Peninsula both had similar results for all three analyses with only the distance from roads analysis showing a significant difference. Land cover in the Delmarva is very close in the amount of cultivated crops with the Albemarle only having a 1.6% higher amount of cropland. Both Peninsulas seem to offer a substantial amount of potential habitat for red wolves. One important factor to note is that the Delmarva's land covers were much more fragmented, while the Albemarle had larger and more connected patches. Habitat fragmentation is one of the reasons red wolves are in threat as it causes them to lose more habitat and increases the chance of interactions with humans, however, having forest edges near the cultivated croplands is recommended as it is the historical habitat of red wolves (Mulholland 2021, Hinton 2010). This could mean that many of the large patches of cropland in the Albemarle may be unsuitable or less suitable for red wolf habitation. The Delmarva Peninsula also had higher amounts of developed land, this could be problematic due to the Delmarva

Peninsula being almost half the size of the Albemarle Peninsula but still having around 20,000 more people, therefore, red wolves are likely to experience more human interaction. This extra human-wolf interaction could lead to more mortalities from accidental shootings or vehicle strikes in a situation where avoiding any red wolf mortality is extremely crucial for the success of the species (Simonis 2018).

Accidental shootings and poaching are the main cause of mortality amongst red wolves. The rate of mortality by gunshots also increases during hunting seasons (Hinton 2017). According to a study by Suzanne Agan, "11% of self-identified male hunters surveyed in the area reported they would kill any wolf they encountered on their own." Even though the majority of the people surveyed were for the reintroduction and restoration of red wolves, this small minority of hunters poses a significant threat to reintroduction. Due to this small percentage of hunters being one of the main drivers of red wolf extinction in the wild, deer harvesting records are very important to account for. Deer harvest amounts in 2021 had the Albemarle Peninsula at a higher total amount of deer harvested by around 400 deer. While this could be seen as a positive for the Delmarva Peninsula, there is another issue present. The two counties that have the lowest amounts of deer harvest, Somerset and Worcester, also have 63% of the total population in the Delmarva Peninsula making human-wolf interactions likely through other means such as vehicle strike or accidental killing. While the Delmarva Peninsula had lower amounts of deer harvest, by around 8% but it is 48% smaller than the Albemarle Peninsula, meaning that the deer harvesting that is occuring in the Delmarva Peninsula might be lower, but it is more concentrated and higher if normalized by area.

The distance from roads analysis showed that the Delmarva Peninsula had less available area away from roads. The difference was significant with the Delmarva Peninsula having an average distance from roads 2,423 meters lower than the Albemarle Peninsula. The significantly lower average distance from roads in the Delmarva Peninsula compared to the Albemarle Peninsula is the most concerning factor for red wolf reintroduction. Vehicle strikes are the second leading cause of mortality amongst the red wolves in the Albemarle Peninsula. Highways and other large roads are more dangerous for these animals due to them typically having higher speed limits. Animals that are hit by vehicles usually die immediately or soon after the collision (Davis 2021). The Delmarva Peninsula is shaped in a way where there is not much land away from roads even though it has only around half the amount of highway that the Albemarle Peninsula has. Due to its narrow shape, any animal in the Delmarva Peninsula has a higher chance of getting near a major highway. On the other hand, the Albemarle Peninsula has its main roads located around the coasts of the Peninsula creating a large region in the center that is much farther than roads.

Due to their similarity, the Delmarva Peninsula does seem like a suitable habitat for red wolf reintroduction. However, a reintroduction in the Delmarva Peninsula would most likely

proceed in a way akin to the Albemarle Peninsula. While the Delmarva Peninsula is suitable for reintroduction, it does not seem to provide a better habitat for red wolves than the Albemarle Peninsula, with its only advantage being in deer harvesting, a small difference. Before reintroduction in the Delmarva Peninsula is to be considered, the many issues that led to the red wolf population decreasing to 15 individuals need to be addressed. Red wolf mortality caused by humans needs to be considered and policy should be created to assert more protection to red wolves. Many policy actions need to be taken such as outlawing the hunting of coyotes in areas that are occupied by red wolves and not allowing landowners to kill wolves on their lands (Rippe 2017). Until policy changes occur, a Delmarva Peninsula reintroduction will fail. However, if policy changes protecting red wolves do occur, the Delmarva Peninsula would serve as a potential reintroduction area for a second population.

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Figures and Tables

Table 1. Population and Area of the focus counties in the Delmarva Peninsula. Two Virginia counties, Accomack and Northampton, and two Maryland counties, Somerset and Worcester.

County	Population	Area km²
Accomack	33,413	1,200
Northampton	12,282	550
Somerset	24,620	830
Worcester	52,460	1,210
Total	122,775	3,790

Table 2. Population and Area of the focus counties in the Albemarle Peninsula.

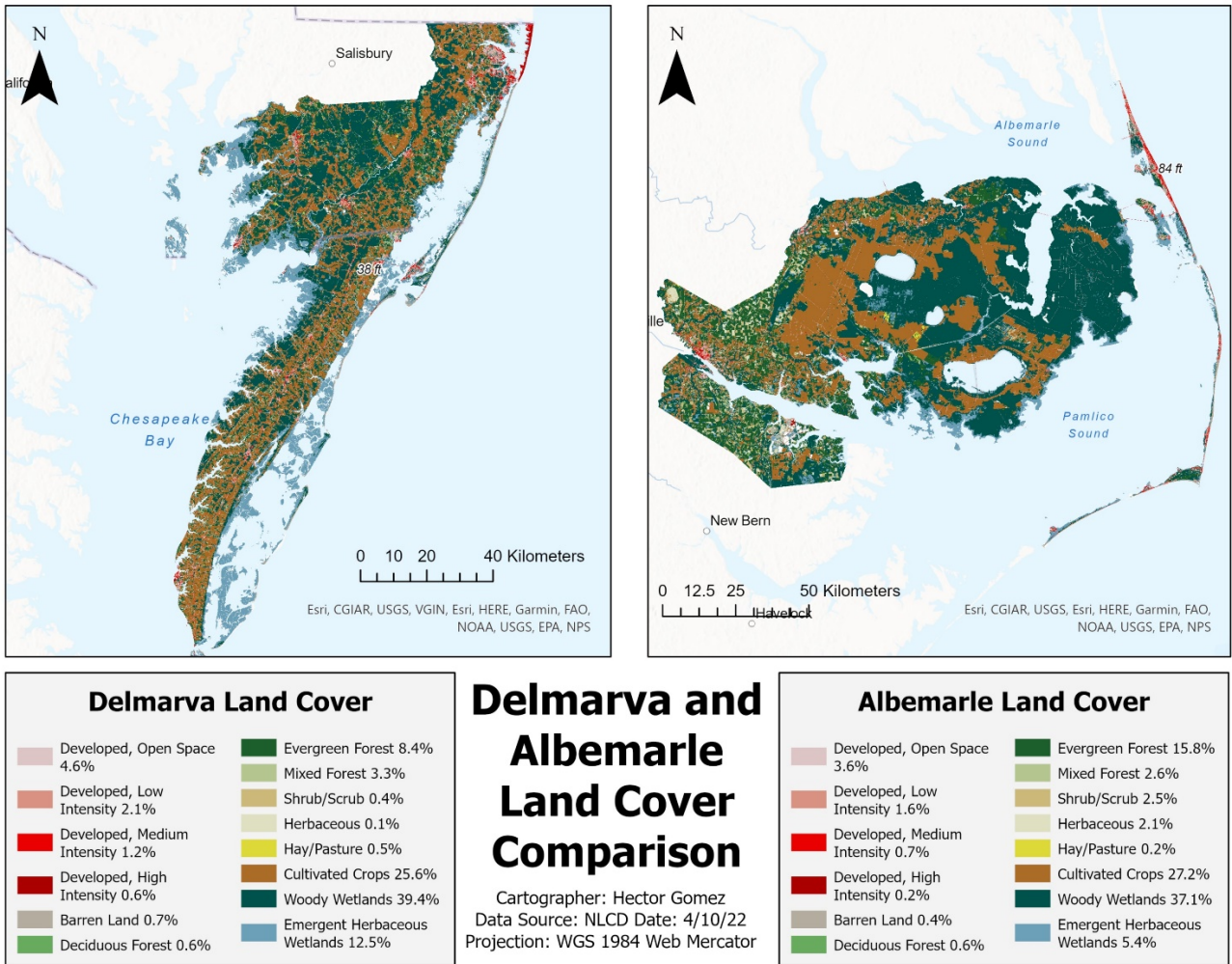| County	Population	Area km²
Hyde	4,589	1,590
Dare	36,915	990
Tyrell	3,245	1,010
Beaufort	44,652	2,140
Washington	11,003	900
Total	100,404	6,630

Figure 1. Percentage of each type of land cover in the Delmarva and Albemarle Peninsulas. Data was acquired from the National Land Cover Database from 2019. The main land covers of focus are cultivated crops, woody wetlands, evergreen forests, and mixed forests. Percentage of each land cover is present in the legend.
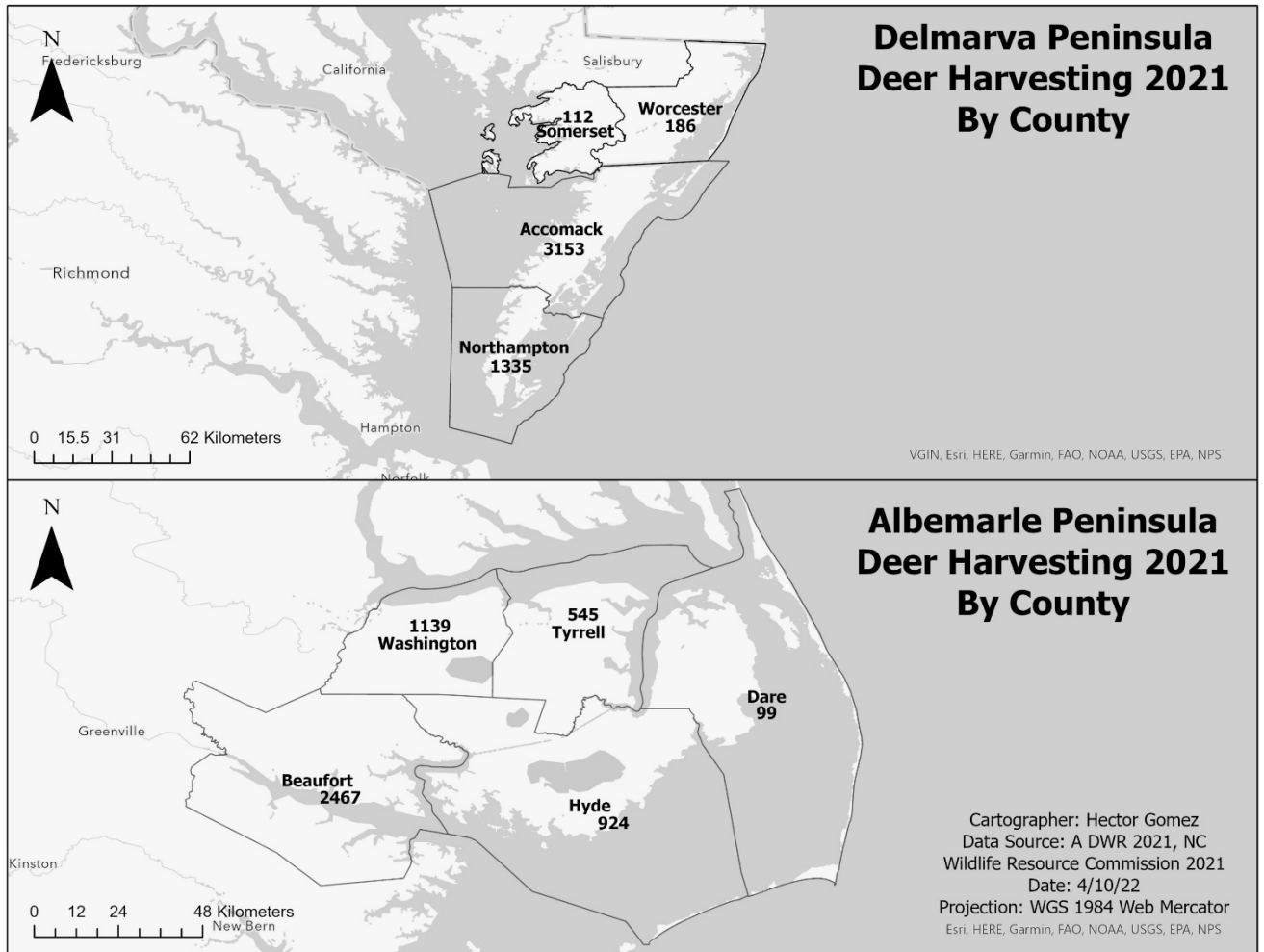
Figure 2. Deer harvesting records from 2021 by county for the Albemarle and Delmarva Peninsulas. The total deer harvest amount for the Delmarva Peninsula was 4,786 and the Albemarle Peninsula at 5,174 deer. Data obtained from the Virginia Department of Wildlife Resources for the Virginia counties, Maryland Department of Natural Resources for the Maryland counties, and North Carolina Wildlife Resource Commission for the North Carolina counties.
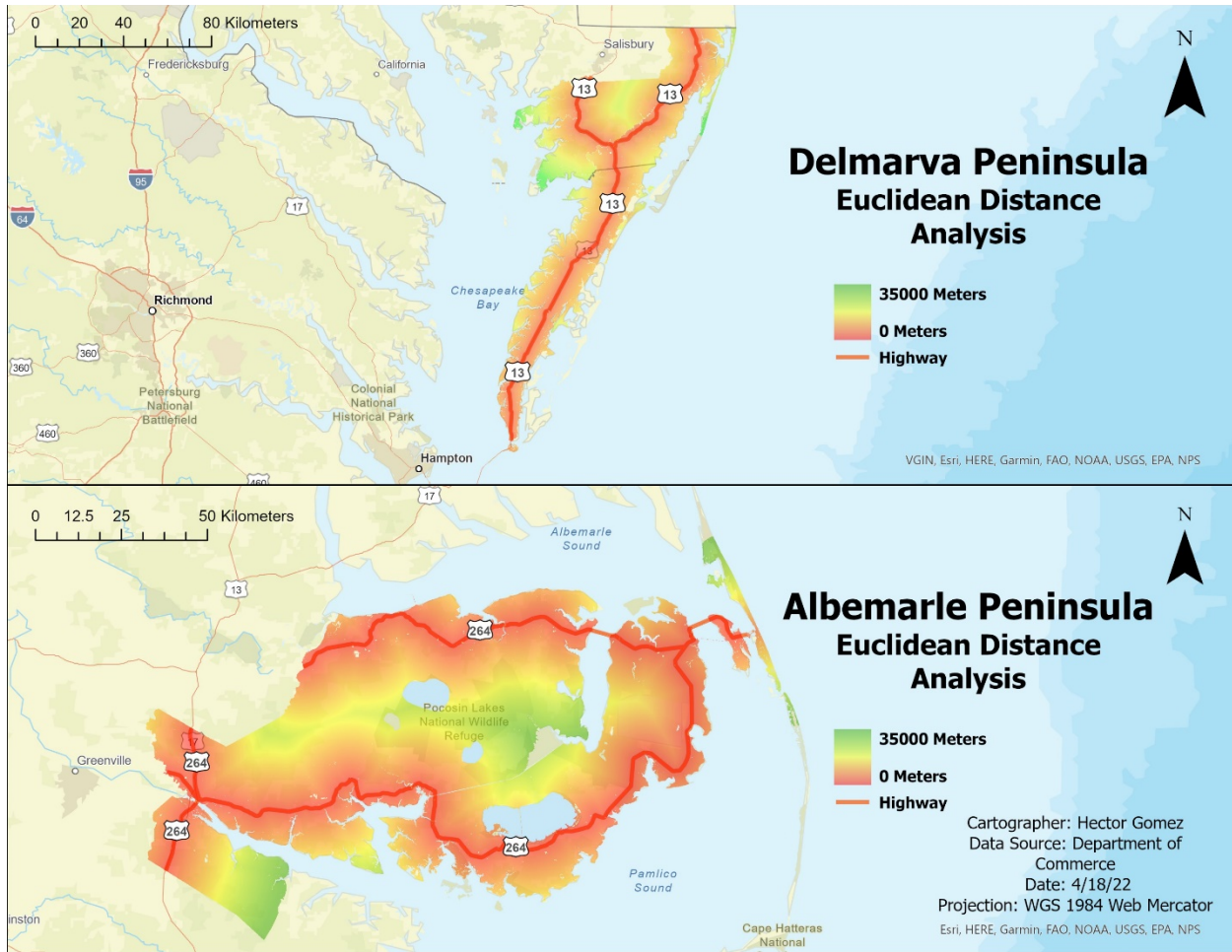
Figure 3. Euclidean distance analysis showing distance from highways in the Delmarva and Albemarle Peninsulas. Raster pixel size is 30 m with a maximum distance of 35,000 meters. The Albemarle Peninsula had a higher average distance from roads at 9,517 meters with a standard deviation of 7,795 meters. The Delmarva Peninsula had an average distance from roads of 7,094 meters with a standard deviation of 5,716 meters.