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Red Wolf Reintroduction: Land Ownership and Protection Status Analysis

Abstract

Red wolves (*Canis rufus*) are critically endangered, and currently the only wild population exists in northeast NC ("Red Wolf," FWS, n.d.). Here, I use geospatial analysis to investigate the potential for another wild population to establish in the Delmarva Peninsula. I consider land ownership and protection status because these factors influence local public support (Nie, 2001; Naughton-Treves et al., 2003; Berger-Tal et al., 2020), as well as reintroduction success (Carroll et al., 2003; Wolf & Ripple, 2018). I compare the ownership and protection status of land in the Delmarva Peninsula to that in the Albemarle Peninsula, where the red wolf recovery program is generally considered successful, despite the recent decline in the red wolf population due to illegal killings, vehicle strikes, and interbreeding with coyotes ("*Red Wolf*," FWS, n.d.). The results of this study could be used to inform biologists, conservationists, and politicians in their search for a new reintroduction site for red wolves.

Introduction

Red wolves (*Canis rufus*) are indigenous to eastern North America, historically ranging North-to-South from southern Canada to Florida and East-to-West from central Texas to the Atlantic Ocean (Dellinger et al., 2013). Throughout the 19th and 20th centuries, overhunting and habitat loss drove red wolves to the brink of extinction (Chadwick et al., 2010). They were listed as an endangered species in 1967 and remain on the IUCN red list today ("*Red Wolf*," FWS, n.d.). Twenty years later, the first recovery program was established in the Albemarle Peninsula, with the goal of rehabilitating the iconic species to their native habitat in northeastern N.C. ("*Red Wolf*," FWS, n.d.). This program was initially successful, and the wild population was stable in the early 2000s/2010s, with annual counts of 114–131 individuals during 1999–2007 (Chadwick et al., 2010). In recent years, however, the red wolf population has declined markedly. As of 2021, only an estimated 15-17 red wolves remain in the wild ("*Red Wolf*," FWS, n.d.). The primary reasons for the decline in the red wolf population are illegal killings (either unintentionally by hunters or intentionally by poachers), vehicle strikes, and interbreeding with coyotes, which dilutes the red wolves' bloodline ("*Red Wolf*," FWS, n.d.).

Despite the recent decline in the red wolf population, the recovery program in the Albemarle Peninsula is generally considered to be successful (Joey Hinton, personal communication, February 7, 2022). Excluding social, political, and economic factors, the success of the program can partially be attributed to the characteristics of the Albemarle Peninsula (Joey Hinton, personal communication, February 7, 2022). Firstly, the red wolves in the recovery

program are considered a non-essential experimental population, and therefore they are extensively managed by the U.S. Fish and Wildlife Service ("Red Wolf," FWS, n.d.). One aspect of the FWS intervention is the creation and implementation of the "Red Wolf Recovery Plan," which is in the process of being updated to include 1) a Species Status Assessment (SSA) to evaluate red wolf viability and provide the biological information to develop and support a recovery plan, 2) a recovery plan which contains the elements required under section 4(f)(1)(B) of the ESA (recovery criteria, recovery actions, and time and cost estimates), and 3) a recovery implementation strategy which will itemize the prioritized activities needed to implement the actions identified in the recovery plan ("*Red Wolf Recovery*," FWS, n.d.). FWS management actions have included the use of radio collars to track the location and health of red wolves, the intermittent release of captive red wolves into the Red Wolf Recovery Population Area (RWEPA), and coyote sterilizations ("*Red Wolf Recovery*," FWS, n.d.). The close management of this fragile species is one reason why the recovery program has been successful.

Another factor which contributes to the success of the recovery program is that the Albemarle Peninsula is an ideal habitat for red wolves. Red wolves preferred habitat is agricultural fields, followed by lowland forests, pine forests, and wetlands (Hinton et al., 2016). Land cover in the RWREPA is a mosaic of human-associated types, such as agricultural fields (30%), early successional fields (20%), and commercial pine plantations (15%); and naturally occurring types, such as pocosins (upland areas covered with evergreen vegetation and inundated with water) (15%), lowland forests (10%), and wetlands (10%) (Chadwick et al., 2010). A study conducted by Hinton et al. (2016) found that red wolves actually prefer agricultural fields, followed by lowland forests, pine forests, and wetlands. An interesting caveat is that during agricultural harvests, red wolves prefer to take cover in forest habitats within 50-300 m of edges to barren agricultural fields and roads (Hinton et al., 2016). There are several paved highways and roads in and around the RWREPA, but the majority are dirt or gravel paths. The unpaved roads have a particularly intriguing role in red wolf movement. These roads can minimize energetic costs because they allow for easier travel as opposed to crossing heavily vegetated or inundated land, as well as enhance line of sight and olfactory senses of red wolves (Hinton et al., 2016). Furthermore, the Albemarle Peninsula has a low human population density, with only 100,404 people spread over five counties (Beaufort, Hyde, Tyrell, Washington, and Dare), which consists of an area of 6,630 km^2 (Gomez, 2022). This scenario benefits red wolves because they are more likely to select habitats in areas with low human population density (Dellinger et al., 2013). Another benefit is that a lot of the desirable red wolf habitat in the Albemarle Peninsula is protected, in areas such as Pocosin Lakes National Wildlife Refuge (PLNWR) and Alligator River National Wildlife Refuge (ARNWR) ("*Red Wolf*," FWS, n.d.).

Due to the recent decline in the red wolf population, there have been conversations among scientists, conservationists, and politicians about establishing another reintroduction area, which should be similar to the Albemarle Peninsula (Joey Hinton, personal communication, February 7, 2022). From a biological and ecological perspective, this new site will need to meet several requirements in order to be suitable habitat (i.e. remote, lots of agriculture, forest edges, unpaved/low trafficked roads) (Dellinger et al., 2013; Hinton et al., 2016). One site being considered is the Delmarva Peninsula (Joey Hinton, personal communication, February 7, 2022).

There are many similarities between the Albemarle and Delmarva Peninsulas due to their close proximity on the Eastern Seaboard (Fig. 1). However, there are many factors to consider when planning a large carnivore reintroduction. Land ownership and protection status are important aspects of red wolf reintroduction because they influence securing local public support (Nie, 2001; Naughton-Treves et al., 2003; Berger-Tal et al., 2020), as well as reintroduction success (Carroll et al., 2003; Wolf & Ripple, 2018). This raises the question: how do the Albemarle and Delmarva Peninsulas compare in terms of land ownership and protection status? I investigated this issue with the intent to provide results which could help inform biologists, conservationists, and policymakers in their search for a new reintroduction site for red wolves. For the sake of simplicity and time, I narrowed my area of interest to the Albemarle Peninsula of North Carolina, along with the Virginia portion and Somerset and Worcester counties in Maryland for the Delmarva Peninsula (Fig. 1).

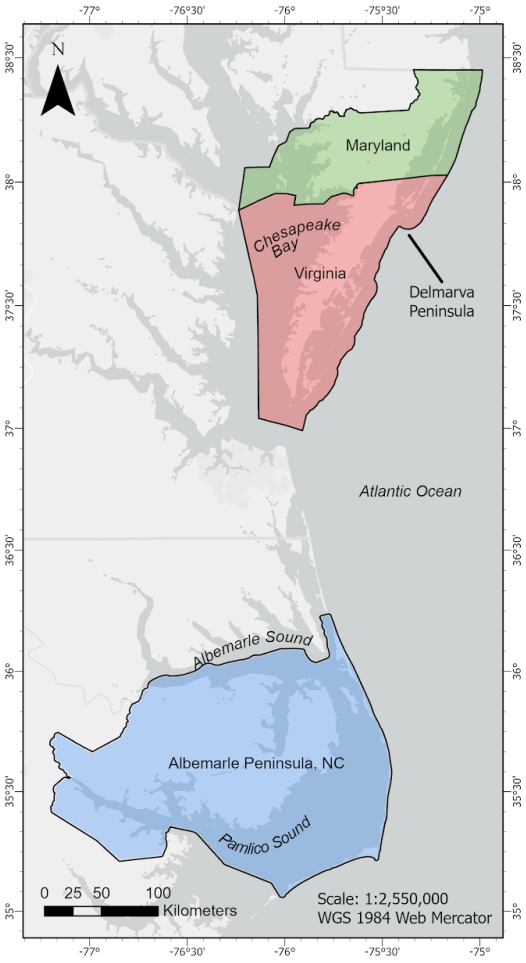

Figure 1. Map of the Albemarle Peninsula of North Carolina (blue) and the Maryland (green) and Virginia (red) portions of the Delmarva Peninsula used as the area of interest. Land area: Albemarle Peninsula, NC– 6,632 km^2; Delmarva Peninsula, VA– 1,712 km^2; Delmarva Peninsula, MD– 2,041 km^2. Map created by Anna Frisbie (University of Richmond) on 04/19/2022.

Methods

To compare the land ownership and protected status of the Albemarle and Delmarva Peninsulas, I firstly located and downloaded the relevant data (Table 1). I used the geographic information system (GIS) ESRI ArcGIS Pro Version 2.8 to conduct all geospatial analysis. I focused first on cartography by using definition queries and symbology, along with the clip tool and the dissolve boundaries tool, to display spatial data in aesthetic layouts. Then, I symbolized land ownership data to display categories of federal, state, local government, joint, private, NGO (non-governmental organization), and private. Next, I created maps showing the land ownership of the Albemarle and Delmarva Peninsulas, respectively. I also added a field to the attribute tables of the GAP Analysis PAD-US 2.1 data for both peninsulas, which I used to calculate geodesic area (km^2). I exported the updated attribute tables to Microsoft Excel and created pivot tables to calculate the area (km^2) and percent land cover. Similarly, for the protection status analysis, I symbolized protection status according to GAP status codes 1 – 4. Then I created maps showing the GAP status codes of the Albemarle and Delmarva Peninsulas, respectively. Again, I exported the attribute tables to Microsoft Excel, which I used to create pivot tables to calculate the area (km^2) and percent land cover.

Analysis of non-protected, private land varied between states due to discrepancies in the data. For the Albemarle Peninsula, I analyzed 1) 100 randomly selected plots, 2) the top 100 largest plots, and 3) plots owned by Weyerhaeuser Company, a prominent timber company in the region, which was determined by my own local knowledge of Eastern NC. I randomly selected 100 plots by using an online random number generator (numbergenerator.org). I choose the top 100 plots by sorting by area (km^2). Using Microsoft Excel, I manually classified the 100 randomly selected plots and the top 100 largest plots based on keywords and logical reasoning into categories of ownership such as federal, state, local government, etc. (Table 2). I also closely evaluated over 2,000 parcels, which I categorized into broad categories such as residential, commercial, agricultural, federal, state, county, city, non-governmental organizations (NGO)/non-profit organizations, trust, university-owned, and unknown. Then, I made pivot tables for the 100 randomly selected plots and the 100 largest plots to summarize area (km^2) and percent land cover of each designated ownership category. To analyze plots owned by Weyerhaeuser Company, I used a definition query for the non-protected, private parcel layer to display only the 8 variations of the name of the company. Then, I used the statistics function in ArcGIS Pro to find the total amount of land (km^2) and the average parcel size (km^2). Unfortunately, due to incomplete data, I was unable to conduct a private land ownership analysis for the VA portion of the Delmarva Peninsula. However, I analyzed the private land of the MD portion of the Delmarva Peninsula using a pivot table in Microsoft Excel, which summarized land area (km^2) and percent land cover for different landownership designations.

Source	Date	Application
GAP Analysis PAD-US 2.1	2020	Determine protection status of land
TIGER (US Census Bureau)	2021	Administrative boundaries
US Census Bureau	2010	Land area of all counties in the Albemarle & Delmarva Peninsulas
NC OneMap	2022	Parcel ownership in Albemarle Peninsula
VGIN	2021	Parcel ownership in Delmarva Peninsula (VA)
MD Dept. of Planning	2018	Parcel ownership in Delmarva Peninsula (MD)

Table 1. Data used in land ownership and protection status analysis.

Landownership Designation	Keywords
Federal	National, federal
State	Department of Transportation (DOT)
County	County name (ex. Beaufort, Tyrell, Hyde, Washington, Dare)
City/Town	Volunteer fire department, Board of Education
NGO/Non-Profit Organization	Nature Conservancy, Wysocking Wildlife Sanctuary
Trust	Trust
University	University
Commercial	LLC, Weyerhaeuser, INC, property owner association/homeowners' association, limited partnership, PCS Phosphate, land corporation, electric/power company, bank, CSX railroad, Dominion Power, Limited Partnership (LP)
Residential	Names of people, church, regional housing, cemetery
Agriculture	Farm, Farm LLC

Table 2. Keywords used to manually assign a landownership designation to land parcels.

Results

There are 7 landownership designations in the Albemarle Peninsula of NC: federal, state, local government, joint, NGO, private, and non-protected private (Fig. 2). The Albemarle Peninsula consists of mostly (66.58%) non-protected, privately owned land, although almost one-fourth (24.174%) of land is owned by the federal government (Table 3). In the VA and MD portions of the Delmarva Peninsula, there are also 7 landownership designations: federal, state, local government, Eastern Shore Soil and Water Conservation District, NGO, private, and non-protected private (Fig. 3). The Delmarva Peninsula consists of mostly (VA- 65.40%, MD-

67.51%) non-protected, privately owned land (Table 4 & 5). In the VA portion, a lot (15.62%) of land is owned by an NGO (the Nature Conservancy), whereas over one-fourth (25.34%) of the MD portion is owned by the state (Table 4 & 5).

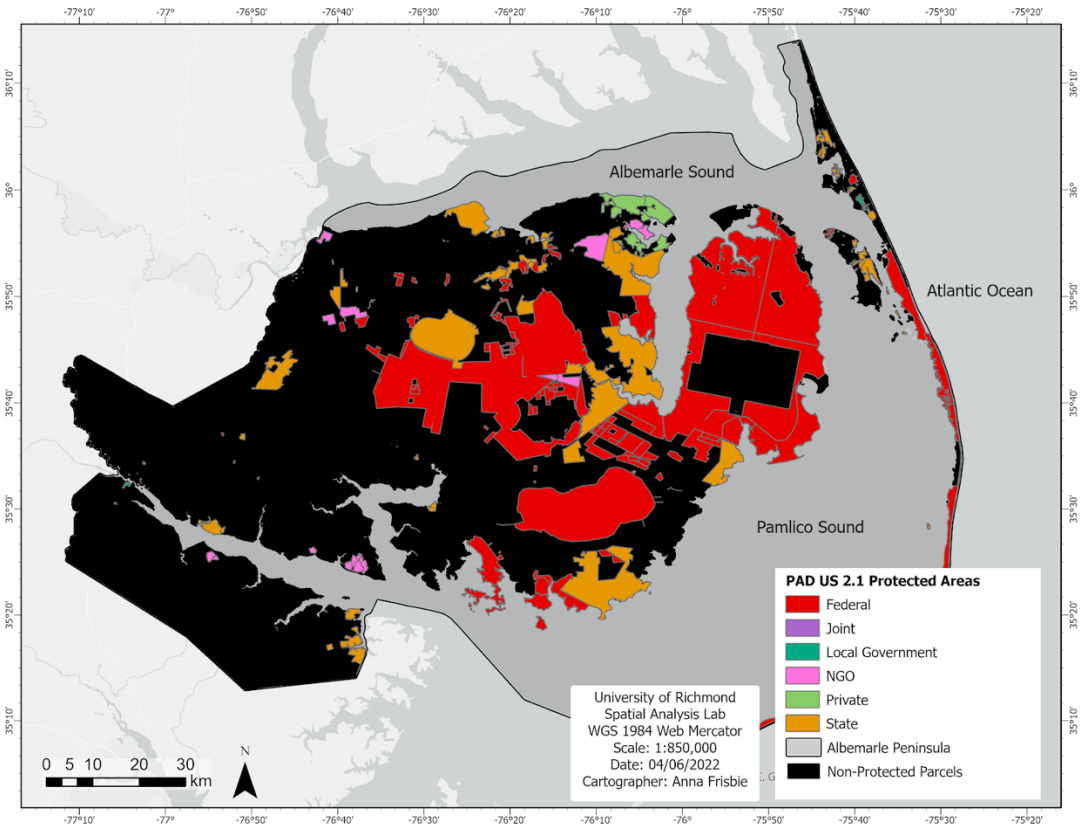

Figure 2. Map of land ownership of the Albemarle Peninsula, NC.

Landowner	Area (km^2)	% of Total Land
Federal	1603.2	24.174%
State	492.6	7.428%
Local Government	4	0.060%
NGO	54.2	0.817%
Joint	0.3	0.005%
Private (Easement/Trust)	61.8	0.932%
Non-Protected Parcels	4415.9	66.585%
Total	**6632**	**100%**

Table 3. Breakdown of landowners in the Albemarle Peninsula, NC in terms of area (km^2) and percentage of total land area.

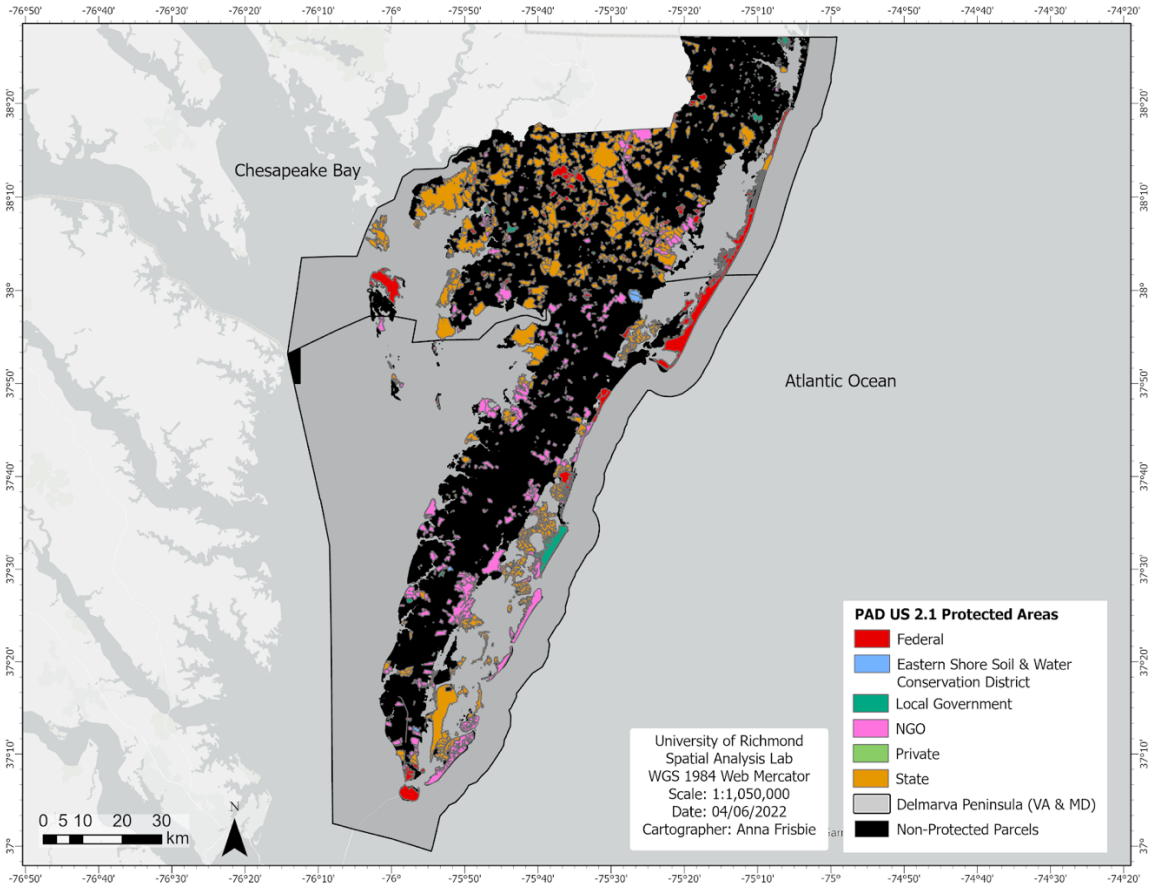

Figure 3. Map of land ownership of the Delmarva Peninsula (VA & MD).

Landowner	Area (km^2)	% of Total Land
Eastern Sore Soil & Water Conservation District Easement	25	1.46%
Federal	79	4.61%
State	201.4	11.76%
Local Government	19.1	1.12%
NGO	267.4	15.62%
Private (Easement/Trust)	0.5	0.03%
Non-Protected Parcels	1119.6	65.40%
Total	**1712**	**100%**

Table 4. Breakdown of landowners in the Delmarva Peninsula, VA in terms of area (km^2) and percentage of total land area.

Landowner	Area (km2)	% of Total Land
Federal	90.2	4.42%
State	496.7	24.34%
Local Government	14.5	0.71%
NGO	61.7	3.02%
Non-Protected Parcels	1377.9	67.51%
Total	**2041**	**100%**

Table 5. Breakdown of landowners in the Delmarva Peninsula, MD in terms of area (km^2) and percentage of total land area.

Approximately one-third (33%) of the Albemarle Peninsula is protected, which amounts to an area 2,215.93 km2 in size (Fig. 4). The GAP status of protected land in the Albemarle Peninsula is mostly 2 (73%), followed by 3 (16%), 1 (10%), and 4 (1%). Similarly, approximately one-third of the land in the Delmarva Peninsula is protected (VA- 35%, MD- 32%) (Fig. 5). The GAP status of protected land in the Delmarva Peninsula is mostly status 2 (VA- 66%) & 3 (MD- 55%). In the VA portion of the Delmarva Peninsula, the next largest tracts of protected land are classified as GAP status of 4 (33%), 3 (9%), and 1 (3%). Comparably, in the MD portion of the Delmarva Peninsula, the next largest tracts of protected land are classified as GAP status of 4 (23%), 2 (18%), and 1 (4%).

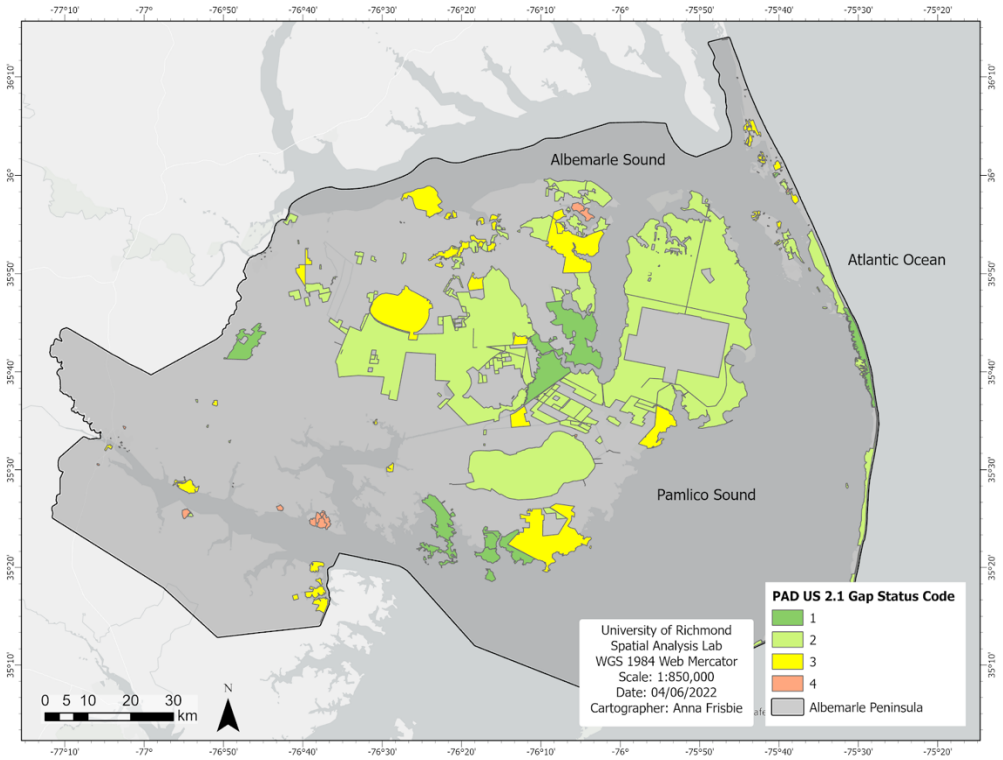

Figure 4. Map showing the Pad US 2.1 Gap Status Codes of protected areas in the Albemarle Peninsula, NC. Key: 1 – managed for biodiversity – disturbance events proceed or are mimicked, 2 – managed for biodiversity – disturbance events suppressed, 3 – managed for multiple uses – subject to extractive (e.g. mining or logging) or OHV use, 4 – no known mandate for biodiversity protection.

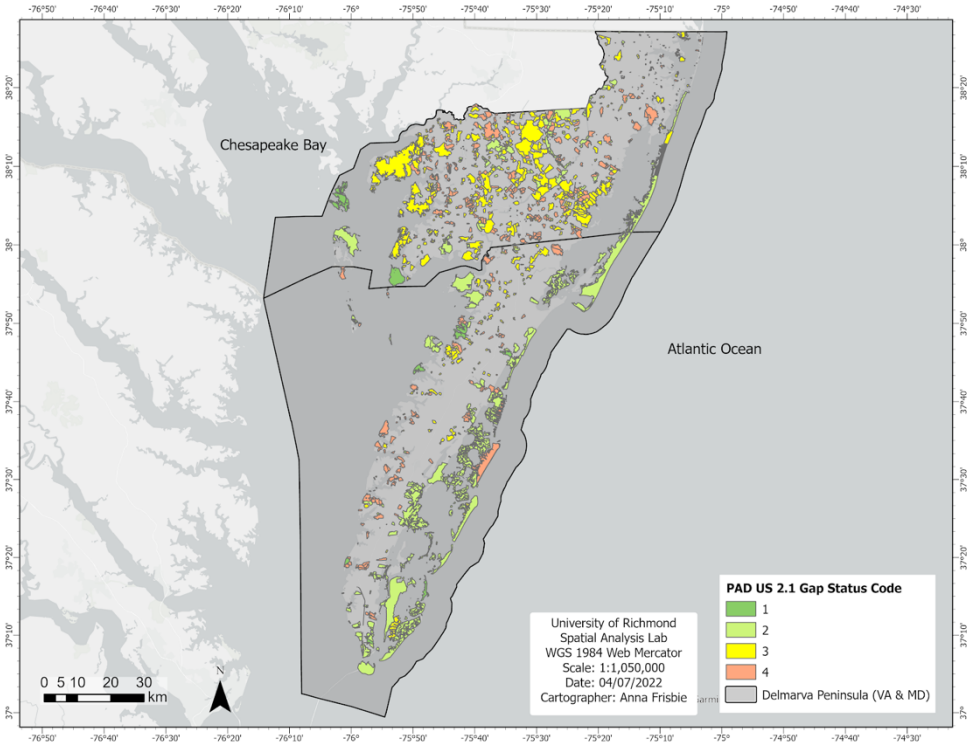

Figure 5. Map showing the Pad US 2.1 Gap Status Codes of protected areas in the Delmarva Peninsula (VA & MD). Key: 1 – managed for biodiversity – disturbance events proceed or are mimicked, 2 – managed for biodiversity – disturbance events suppressed, 3 – managed for multiple uses – subject to extractive (e.g. mining or logging) or OHV use, 4 – no known mandate for biodiversity protection.

Of 100 randomly sampled plots in the Albemarle Peninsula, the majority of landowners are residents and commercial enterprises (47% and 46%, respectively) (Table 6). The top 100 largest land parcels in the Albemarle Peninsula make up 61% of the total land area (Table 7). The largest private landowner of the top 100 largest parcels is the US government (Table 7). The case study of private landownership in the Albemarle Peninsula revealed that Weyerhaeuser Company owns 20.69% of non-protected privately owned land, an area 913.6 km^2 in size. The average size of their parcels is 1.32 km^2, and many are adjacent, forming large tracts of land (Figure 6). Upon close evaluation of over 2,000 parcels in the Albemarle Peninsula, I noticed that the most repetitive landowners in the commercial category were Weyerhaeuser Company, PCS Phosphate Company, and Dominion Energy Inc. A lot of the private land was also agricultural, much of which was listed as an LLC. The federal land was primarily National Wildlife Refuges (NWR), such as Pocosin Lakes NWR and Alligator River NWR. State land was mostly owned by the Department of Transportation (DOT), and likely were state highways. City-owned land was largely owned by volunteer fire departments and boards of education. There was also some land privately owned by NGOs or non-profit organizations, such as the Nature Conservancy and Wysocking Wildlife Sanctuary. There were also several parcels listed as trusts. A few parcels were owned by universities such as Wake Forest University. There were some miscellaneous parcels which I was unsure how to identify, such as land owned by special interest groups such as the Soldiers of Confederate Wars. In the MD portion of the Delmarva Peninsula, the majority of privately owned land belongs to agriculturalists (56.88%) (Fig. 7).

Landowner	# Landowners	% Landowners	Area (km^2)	% of Sampled Area
Residential	21	21%	2.546	47%
Commercial	77	77%	2.490	46%
State	1	1%	0.030	1%
Unknown	1	1%	0.407	7%
Total	**100**	**100%**	**5.473**	**100%**

Table 6. Landownership of 100 randomly selected parcels in the Albemarle Peninsula. Note the small sample area (5.473 km^2).

Landowner	Area (km^2)
Commercial	586.76
Federal	2628.80
State	423.05
NGO	46.24
Residential	195.31
Unknown	170.29
Total	**4050.44**

Table 7. Landownership of the 100 largest parcels in the Albemarle Peninsula. Federal, state, and NGO land is protected.

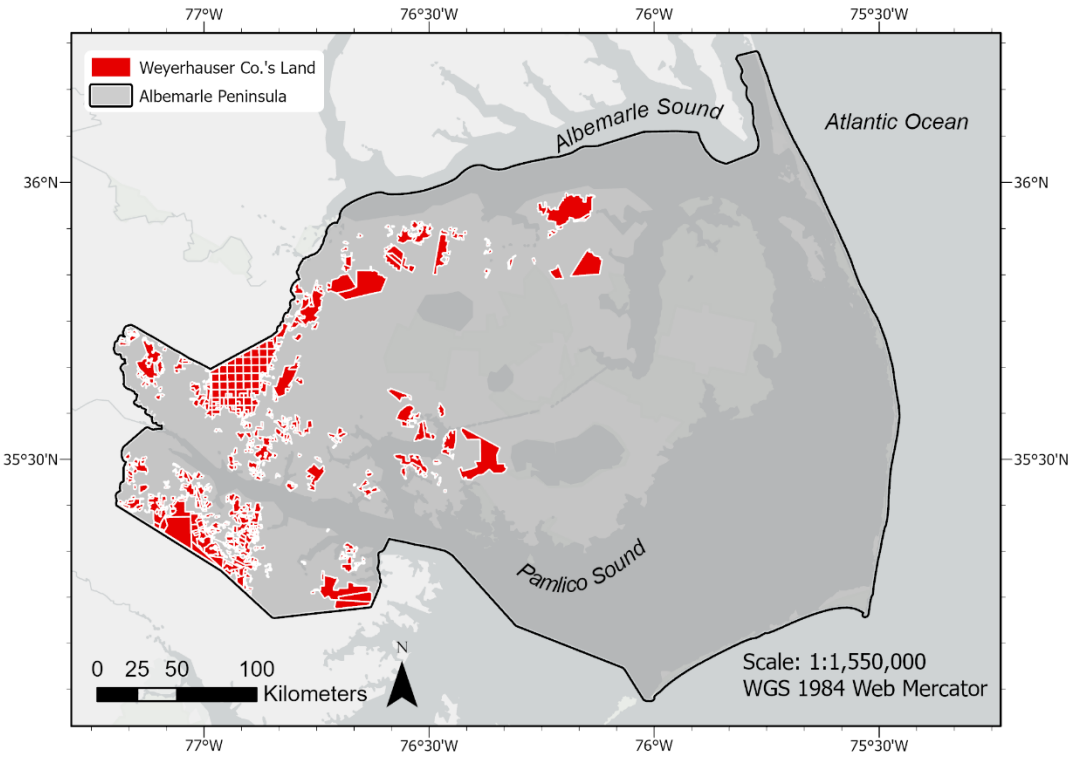

Figure 6. Map showing land owned by Weyerhaeuser Company in the Albemarle Peninsula.

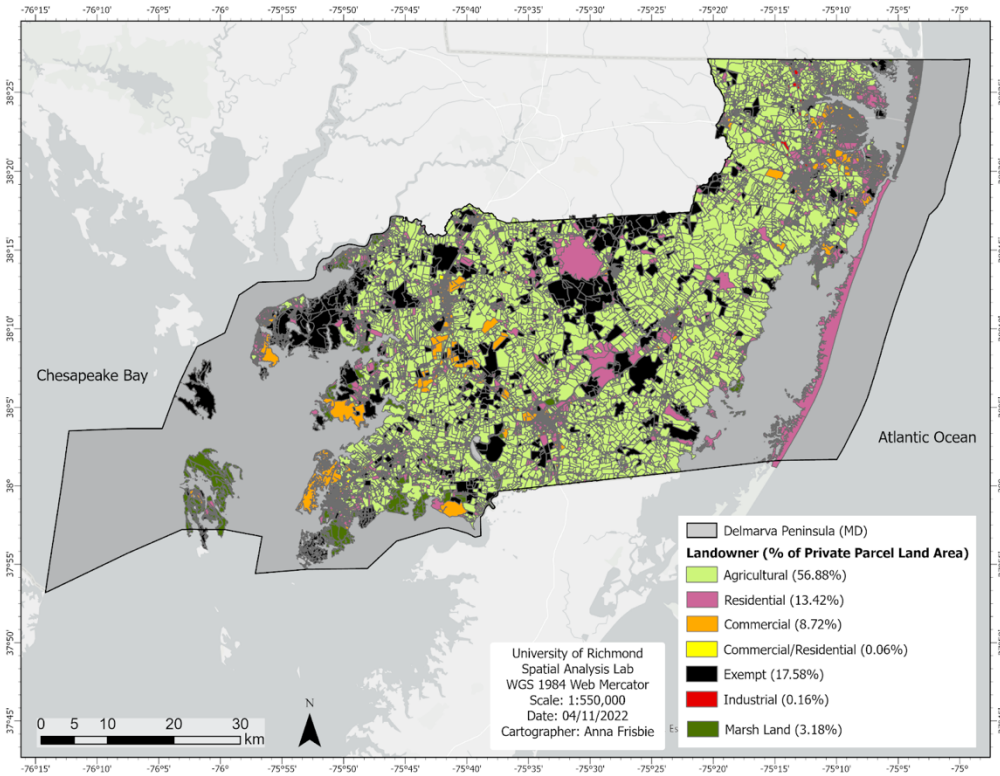

Figure 7. Privately owned parcels in the Delmarva Peninsula, MD. Legend shows the percentage each category makes up of the total privately owned land in the MD portion of the Delmarva Peninsula.

Discussion

Land ownership has been used in several studies as a predictor of large carnivore reintroduction success (Mladenoff et al., 1995; Houts, 2000; Sneed 2001). Gray wolves reintroduced to the Great Lakes Region preferred public lands and private industrial forests, which can be explained by the fact that public lands generally have lower levels of human disturbance, while private property is often more developed and less accommodating for wolves (Mladenoff et al., 1995). I found that most (>60%) of the land in the Albemarle and Delmarva Peninsulas is private, with a lot of residential, commercial, and agricultural land (Fig. 2 & 3, Table 3-7). Close evaluation of privately owned plots in the Albemarle Peninsula revealed that there are many stakeholders in red wolf reintroduction, such as the federal, state, and local government, NGOs, universities, residents, commercial enterprises, and more. Furthermore, there is a lot of private industrial forest (≥20% of privately owned land) in the Albemarle Peninsula, which is owned by Weyerhaeuser Company (Figure 6). While this forest habitat is important, as red wolves rely on forest edges for cover, particularly while denning, they differ from gray wolves in that agricultural fields are more important than forest environments (Hinton et al., 2016). Over half of the privately-owned land in the MD portion of the Delmarva Peninsula was attributed to agriculturalists, which suggests that this section of the Delmarva Peninsula is suitable red wolf habitat, regardless of private ownership (Fig. 7). Overall, these results imply that while there are many different stakeholders in red wolf reintroduction, composition of land ownership contributes to desirable red wolf habitat, and therefore land ownership would likely not hinder reintroduction of red wolves to the Delmarva Peninsula. However, further study of the VA portion of the Delmarva would need to occur before concluding that the Delmarva Peninsula is comparable to the Albemarle Peninsula in terms of private land ownership.

In a study that examined the Grand Canyon Ecoregion as a potential site for gray wolf reintroduction, favorable land status was defined as lands in public ownership, especially designated protected areas (Sneed, 2001). Furthermore, while gray wolves in the Greater Yellowstone Ecoregion often exist outside of protected areas, they depend on them for long-term population persistence (Caroll et al., 2003). Protected areas are important in large carnivore reintroductions because they provide large corridors of high-quality habitat, often contain a lot of prey, and limit negative human-carnivore interactions (Wolf & Ripple, 2018). In the Albemarle and Delmarva Peninsulas, approximately one-third of land is protected (Fig. 4 & 5). Furthermore, most of the protected land is GAP status 2 (NC and VA) or 3 (MD), which indicates a moderate-to-high level of protection, in which land is managed for biodiversity and may be subject to extractive processes such as mining or logging. These results suggest that the Albemarle and Delmarva Peninsulas are comparable in terms of the protection status of land, which has positive implications for red wolf reintroduction.

While land ownership and protection status of land in the Albemarle and Delmarva Peninsulas points to the conclusion that these areas are well suited for red wolf reintroduction, large carnivore reintroductions are not that simple. The coexistence of human and wolves is historically complex, and there is a need to de-stigmatize large carnivores as "wild," because they can exist in built landscapes, as proven by the success of the red wolf recovery program in the Albemarle Peninsula (Serenari, 2020). To successfully reintroduce red

wolves to private lands, the socially dominant idea of wilderness should be expanded to include the true nature of many landscapes, which are mosaiced with human influence (Serenari, 2020). I predict that the people living in the Delmarva Peninsula will be wary to accept red wolves, as rural people in the past have interpreted wolf reintroductions as a political ploy for more regulatory federal land management, therefore threatening rural communities which value extractive industries, private property, and individual freedom (Nie, 2001).

Even in the Albemarle Peninsula, there has been a struggle for the local people to accept red wolves. Earlier this year, a red wolf was fatally shot by a private landowner who indicated that the wolf was in the general vicinity of their chicken coop, and this is not an unusual fate for a red wolf living in the Albemarle Peninsula (Cooper, 2022). The need for acceptance by people sharing the landscape with red wolves is crucial, as red wolves are critically endangered, and each wolf killed reduces the wild population by a large fraction ("*Red Wolf*," FWS, n.d.). This iconic species is a top predator which exerts many top-down effects on the entire ecosystem (Sacks et al., 2021), and in the absence of red wolves, coyotes may evolve to fill its niche, bringing a suite of unknown impacts to historic red wolf territory (Heppenheimer et al., 2020; Brzeski et al., 2021). While I cannot conclude that the Delmarva Peninsula is a perfect location for red wolf reintroduction, it is a strong contender in terms of ownership and protection status of land; however, the issue of local rejection and mistrust of red wolves in the Albemarle Peninsula is likely to plague the Delmarva Peninsula as well. Furthermore, other factors such as land cover and economic impact should be considered as well when picking a suitable reintroduction site. Overall, I hope that the results of this study can be used by biologists, conservationists, and politicians searching for a new red wolf reintroduction site.

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