Mapping Optimized Future Carbon Stock Corridors For Climate and Biodiversity

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Abstract

Given the recent availability of high-resolution data on both current forest carbon stocks and restoration potential, the next geospatial and computational challenge is to utilize this data to identify priority areas for reforestation. Strategic reforestation activities, which account for both carbon sequestration potential as well as co-benefits, such as biodiversity protection, riparian management, and economic opportunity, can provide particularly attractive options for policy-makers who must manage competing social and environmental goals. The objective of this work is to identify potential future carbon corridors that can advance habitat connectivity while maximizing co-benefits for climate mitigation. While there have been efforts to map existing habitat corridors, we identify future corridors to incorporate strategic reforestation into land-use planning. First, we mapped current protected areas and the distribution of priority habitat across Maryland (USA) using the MD BioNet and PAD-US databases. Then, using high-resolution NASA Carbon Monitoring System forest carbon products, we identified optimal future corridors between existing protected areas in the state based on established viability factors, including the: amount of carbon stored, time to achieve habitat requirement, path length (land required), land ownership, and current land-use. Using a least-cost corridor model (prominently used by Jantz et al. 2014 to identify current carbon-habitat corridors in the Amazon), we found that reforesting a 1km habitat corridor connecting all protected areas larger than 20 ha in size results in 48% of the state's land area being protected. Such a corridor would sequester an additional 80 Tg C and protect more than 132 Tg C in total, including the ongoing growth of existing trees along corridor pathways. This estimate is close to 50% of the state's remaining carbon sequestration potential and would advance the state's climate goals outlined in the Maryland Greenhouse Gas Reduction Act. More broadly, this approach to reforestation is useful for states interested in facilitating species migration in the face of ongoing environmental change while maximizing co-benefits.

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Introduction

- National and state climate mitigation plans are calling for more land-based carbon sequestration (e.g., 1t, NDCs, Bonn Challenge)
- IUCN and the CBD advocate for more protected area to bend curve on biodiversity loss (e.g., 30-50% globally protected area)
- Goal is to mitigate climate change while protecting biodiversity, but both are not assumed
- Do the areas of remaining carbon sequestration potential (carbon optimum) overlap with areas that are good for biodiversity or not?
- Regrowing future habitat corridors may maximize the CSPG (for climate) while preparing for ongoing species movement through a rapidly fragmented landscape (for biodiversity)

Research Overview

Key Question: Where are viable future carbon stock corridors for jointly maximizing climate mitigation and biodiversity protection in Maryland?

Underlying this work are high-resolution (90m) forest carbon mapping and modeling products (Hurtt et al. 2019), that provide contemporary carbon stocks as well as future carbon sequestration potential. This NASA Carbon Monitoring System (CMS) science has been used across the Northeastern United States to inform climate mitigation planning and identify strategic areas for reforestation.

While there are multiple co-benefits of interest, this work specifically looks at areas of opportunity for maximizing reforestation to the benefit of both climate mitigation and biodiversity conservation.

The study area for this work is Maryland (USA). This is a heavily studied region, boasting some of the most advanced and high-resolution NASA CMS products. The state has also invested in natural and working lands with a focus on both climate mitigation and wildlife protection.

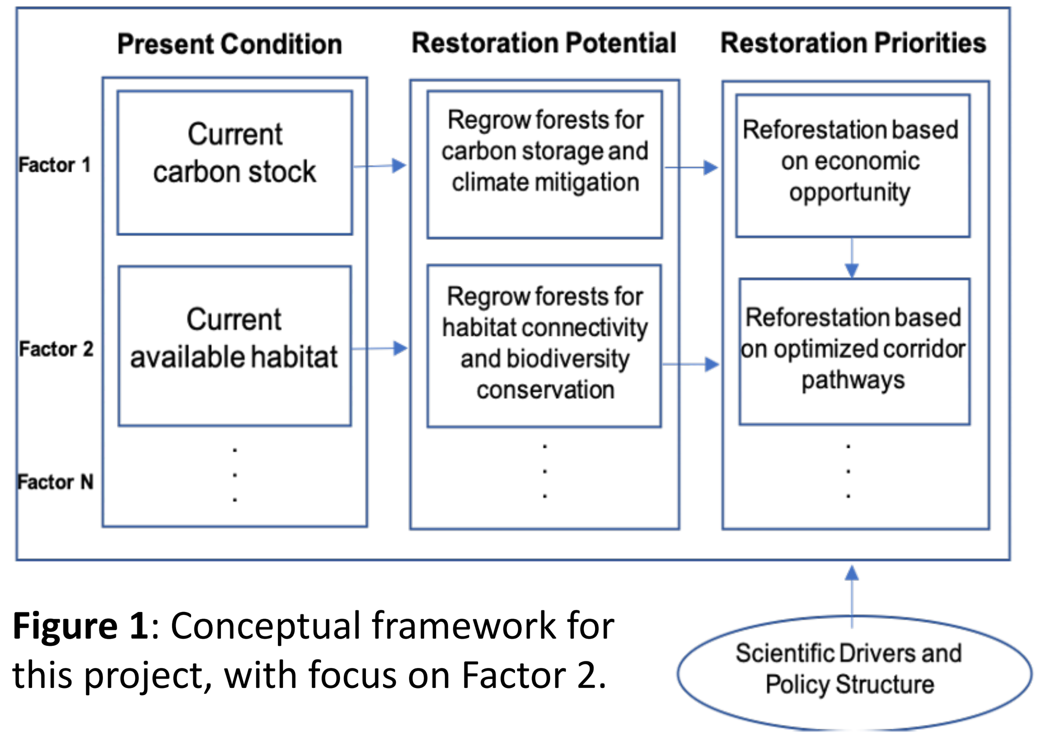

Figure 1: Conceptual framework for this project, with focus on Factor 2.

Methods

Version 1 of this approach required several key data inputs to identify and map viable carbon-habitat corridors between protected areas:

- Core areas: PAD-US (updated in Sept 2020) (USGS 2020)
- Resistance raster (to identify the "cost" of traversing the land):
  - Carbon sequestration potential gap (CSPG) (Hurtt et al. 2019)
  - Maryland BioNet map (updated in Oct 2020) (MDNR 2020) (**fig 2**)
  - Both of the above are weighted evenly; lowest cost areas = high CSPG and high BioNet Tier
- Maximum Corridor Width: 1km, in line with Jantz et al. 2014
- Degree of Connectivity: Connect up to 4 nearest neighbors, plus otherwise isolated constellations of protected areas

Processing utilizes a *Linkage Mapper* tool (McRae and Kavanagh 2011) in ArcGIS to : **1)** Identify adjacent core areas, **2)** Construct a network of core areas and calculate least-cost paths, **3)** Determine which core areas to connect, and **4)** Calculate and map least-cost corridors.

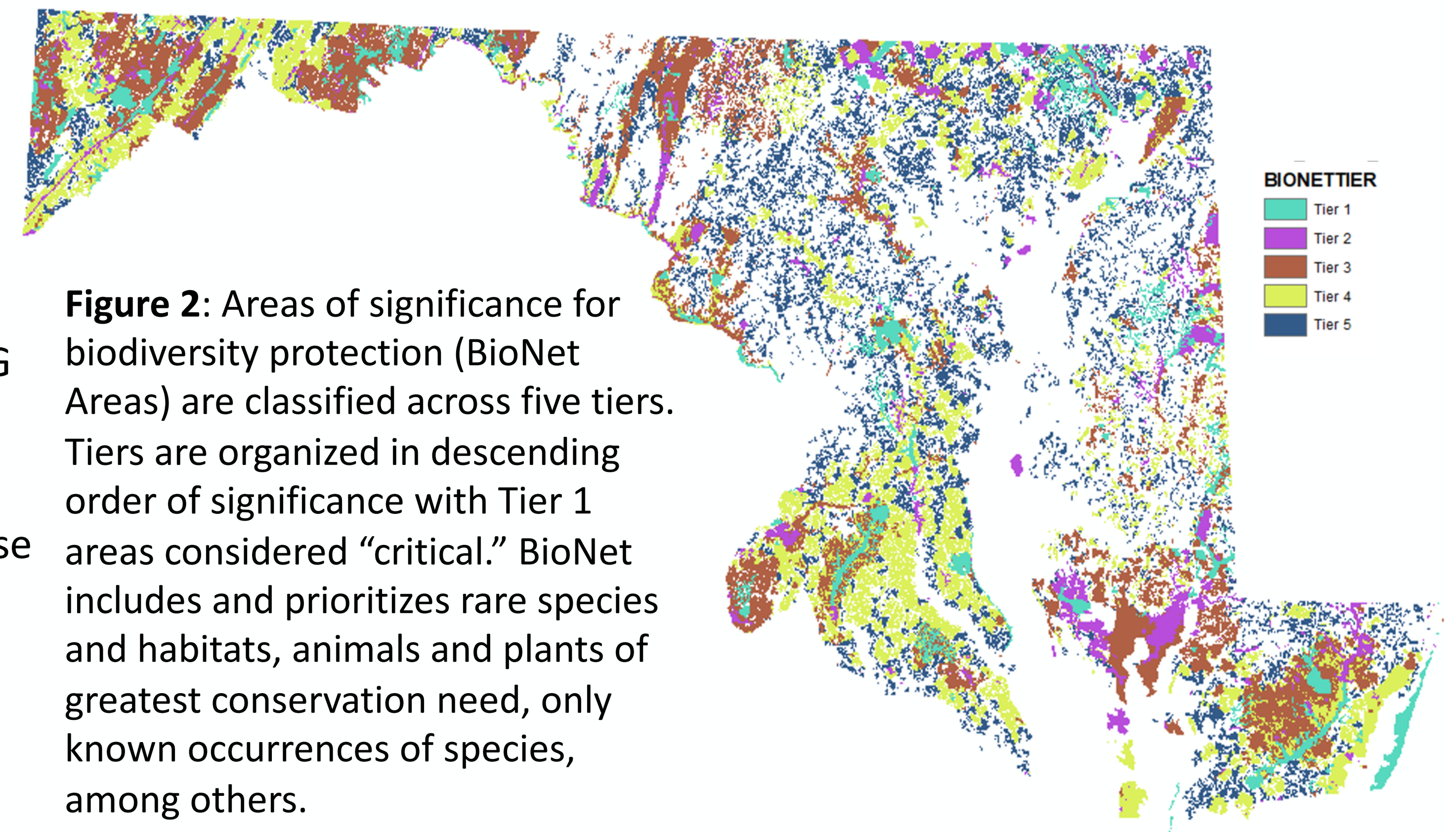

Figure 2: Areas of significance for biodiversity protection (BioNet Areas) are classified across five tiers. Tiers are organized in descending order of significance with Tier 1 areas considered "critical." BioNet includes and prioritizes rare species and habitats, animals and plants of greatest conservation need, only known occurrences of species, among others.

References and Acknowledgments

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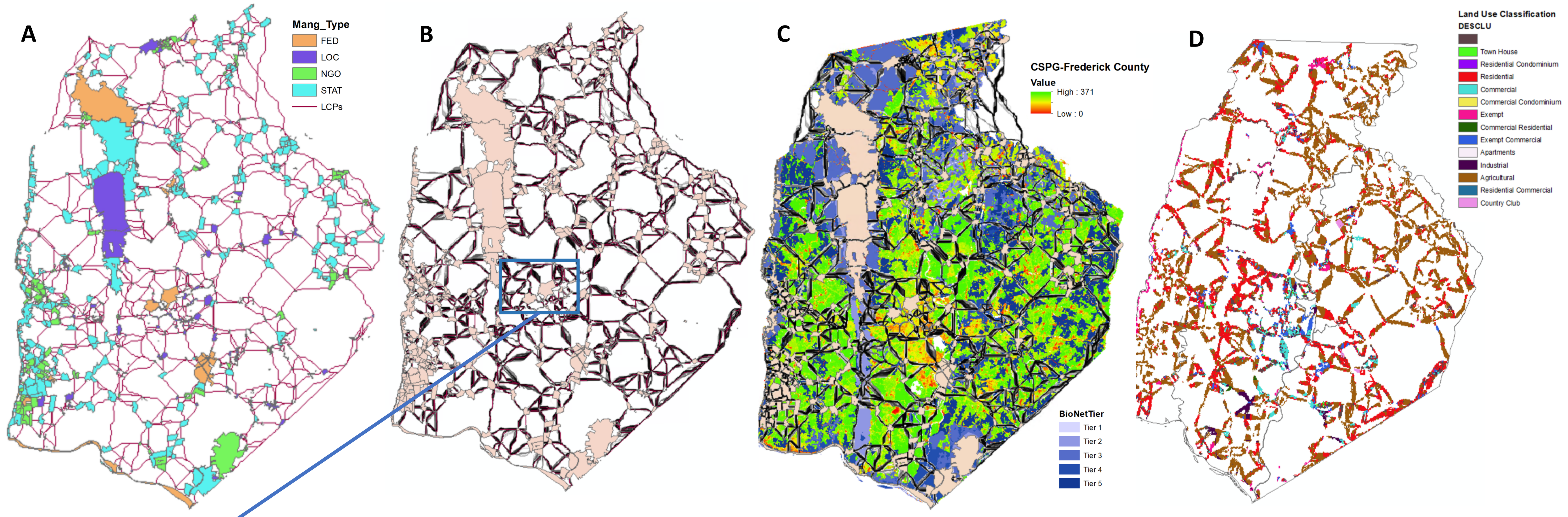
A special thanks to A. Spivy for her help with the ArcGIS corridor tools.

Results



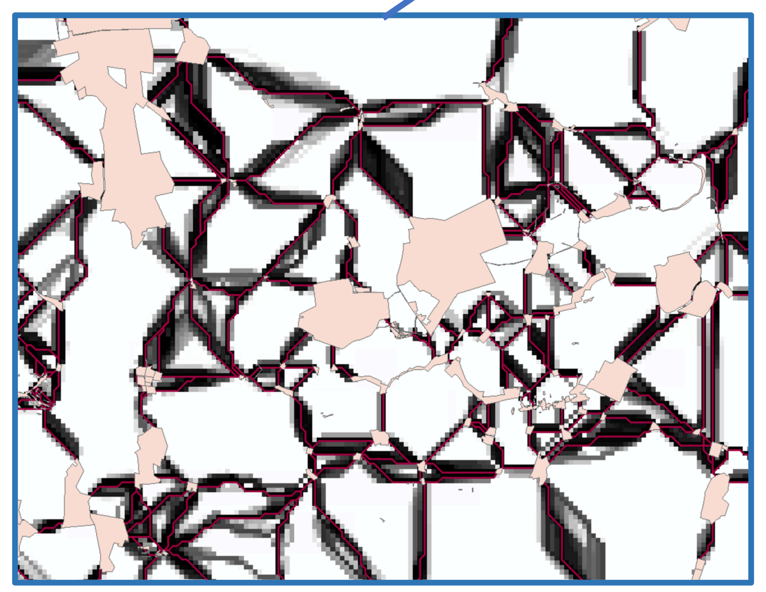


Figure 3: Process of mapping least cost corridors in Frederick County, MD, where (**A**) shows the type of protected area by land manager and least cost paths among them, (**B**) shows the construction of 1km-wide corridors where the costs are lowest, (**C**) highlights the BioNet area and CSPG that remain unprotected and (**D**) characterizes the type of land-use along mapped corridors, with 53% of the corridors crossing zoned agricultural land.

Layer	Size	% Land Area	AGB	CSPG	Average Density
State of Maryland	**25256.34 km2**	**100%**	**110.8 TgC**	**204.1 Tg C**	
Protected Areas (PAD-US)	**6280.29 km2**	**25% of state**	**28.39 TgC 26% of state**	**36.46 TgC 18% of state**	**125.64 Mg/Ha**
MANAGEMENT					
Federal	1143.41 km2	18% of PAD-US	2.83 TgC (10%)	2.84 TgC (8%)	140.19 Mg/ha
Local	919.74 km2	15% of PAD-US	5.95 TgC (21%)	6.30 TgC (17%)	152.40 Mg/ha
NGO	662.83 km2	11% of PAD-US	2.58 TgC (9%)	5.09 TgC (14%)	109.5 Mg/ha
State	3552.91 km2	57% of PAD-US	17 TgC (60%)	22.20 TgC (61%)	127.87 Mg/ha
Unknown	1.5 km2	<1% of PAD-US	0.001 TgC (<1%)	0.0003 TgC (<1%)	208.10 Mg/ha
GAP STATUS					
Status 1 - managed for biodiversity, disturbance proceeds	23.51 km2	<1% of PAD-US	0.0003 TgC (<1%)	0.00 TgC (<1%)	84.21 Mg/ha
Status 2 - managed for biodiversity - disturbance suppressed	830.39 km2	13% of PAD-US	4.76 TgC (17%)	2.40 TgC (7%)	165.38 Mg/ha
Status 3 - managed for multiple uses	2570.32 km2	41% of PAD-US	15.11 TgC (53%)	11.52 TgC (32%)	203.80 Mg/ha
Status 4 - no known mandate for biodiversity protection	2856.08 km2	45% of PAD-US	8.52 TgC (30%)	22.54 TgC (62%)	153.25 Mg/ha

Table 1: Comparison of current and future carbon storage between protected areas and the rest of the state. Percentages highlight where there is disproportionately high (green) or low (red) aboveground biomass (AGB) or carbon sequestration potential gap (CSPG) relative to the amount of land area.

Conclusions & Research Significance

- Identified areas of carbon opportunity (high carbon sequestration potential gap remaining) do not naturally overlap in MD with current protected areas; however, regrowing corridors on BioNet area would provide opportunities for both climate mitigation and biodiversity protection
- USGS Landcover Modeling shows that a high number of future corridors are threatened by urbanization, and warrant intervention for protection
- The land-use requirements for corridors vary from county-to-county but emphasize that incentive programs targeting private landowners would be important for reforestation (esp. residential areas and agricultural interests)