THE UNIVERSITY OF TENNESSEE CHATTANOOGA

Developing a Conservation Priority Model for Lookout Mountain Conservancy

REPORT PROVIDED BY THE UNIVERSITY OF TENNESSEE CHATTANOOGA, IGTLAB AND LOOKOUT MOUNTAIN CONSERVANCY – DECEMBER 2022.

HUNT, NYSSA - GIS ASSISTANT DIRECTOR; GAYLORD, ERIN - GIS TECHNICIAN; MONA LATIL-QUINN – GIS TECHNICIAN; & HOLLY SEILER-ODELL

Introduction

The University of Tennessee Chattanooga Interdisciplinary Geospatial Technology Lab (IGTLab) is pleased to provide this report and accompanying geodatabase of data created for Lookout Mountain Conservancy (LMC). The models and analysis described in the following sections of this report were at the request of LMC for the development of a conservation management plan throughout the organization's managed areas ranging across Lookout Mountain, a geographic feature spanning parts of northern Alabama, northern Georgia, and southeastern Tennessee.

Lookout Mountain Conservancy Description and Attributes

Lookout Mountain provides essential habitat for hundreds of species of plants and animals, including many rare and endangered species, and is part of one of the most biodiverse freshwater ecosystems in the world (Nature Conservancy). The rivers and streams that flow off of Lookout Mountain fuel a lively outdoor tourism economy, water thirsty crops and cities, generate hydroelectric power, and contribute to local quality of life. Lookout Mountain is an ancient landform that was once part of a prehistoric ocean floor full of shelled organisms deposited over 300 million years ago, forming the sedimentary rocks that have now uplifted and slowly weathered into the landscape we know today for it's beautiful caves, waterfalls, scenic cliffs, and rich soil (Lookout Planning Commission).

Much of the Lookout Mountain (Figure 1) is forested, comprising 60.33% of the total land cover in the service area (Table 1). The many miles of intact hardwood forests, rare and unique species, karst geology, and aquatic resources have inspired Lookout Mountain to be designated as a "Conservation Opportunity Area" by Tennessee's State Wildlife Action Plan (TN Wildlife Resources Agency). Lookout Mountain has also been identified by the Natural Treasures Alliance as part of the "Cradle of Southern Appalachia," an area of critical importance for conserving regional biodiversity, habitat integrity, and recreation opportunities (Thrive Regional Partnership). Developed areas are centered around the Chattanooga, TN, Trenton, GA, Fort Payne, AL, and Gadsden, AL metropolitan areas, spanning across the northern, middle, and southern sections of the mountain. Agricultural activity exists in various areas throughout the geography, though it is more prevalent in Alabama (Figure 2).

Table 1: Land Cover Composition of the LMC Service Area. Source: 2019 NLCD.

Land Cover Class	***Percentage***
Open Water	2.28%
Barren Land	0.15%
Forest	60.33%
Shrub/Scrub/Grassland/Herbaceous	4.62%
Pasture/Hay/Cultivated Crops	20.3%
Wetlands	0.49%
Developed	11.42%

Climate change is affecting livability all over the United States and the world, causing regions to experience unstable water supplies, harsh wildfires, floods, and other natural disasters more frequently (NOAA). Lookout Mountain is not immune to any of these natural disasters, but is more well-situated to remain livable throughout environmental changes than many other areas (NOAA). The population of the tri-state region is predicted to grow by almost a half million people by 2055 (Thrive Regional Partnership). Forested areas often serve ecological roles in the landscape, where LMC's habitats are spread throughout the region. Based on Esri's Intact Habitat Cores data, about 375,450.4 acres of the region qualify as habitat cores, functioning as habitat strongholds (Table 2). The health, livability, and prosperity of our communities relies on healthy watersheds, plentiful agricultural land, and the connectivity of habitat for plants and animals.

Table 2: LMC Service Area conservation attributes.

Attribute	**Acres**	***Percent of Area***
LMC Service Area	*782,358*	—
Intact Habitat Cores (Esri)	*375,450.4*	*48%*
Resilient Lands (above average, TNC)	*276,383*	*35%*
Protected Area (USGS PAD)	*95,707.4*	*12%*

With all of these regional values in mind, Lookout Mountain Conservancy has partnered with the University of Tennessee at Chattanooga's Interdisciplinary Geospatial Technology Lab to create the following conservation models and maps to help guide land conservation efforts, furthering the protection of the most vulnerable and essential ecosystem services that make Lookout Mountain a great place to live, visit, and appreciate.

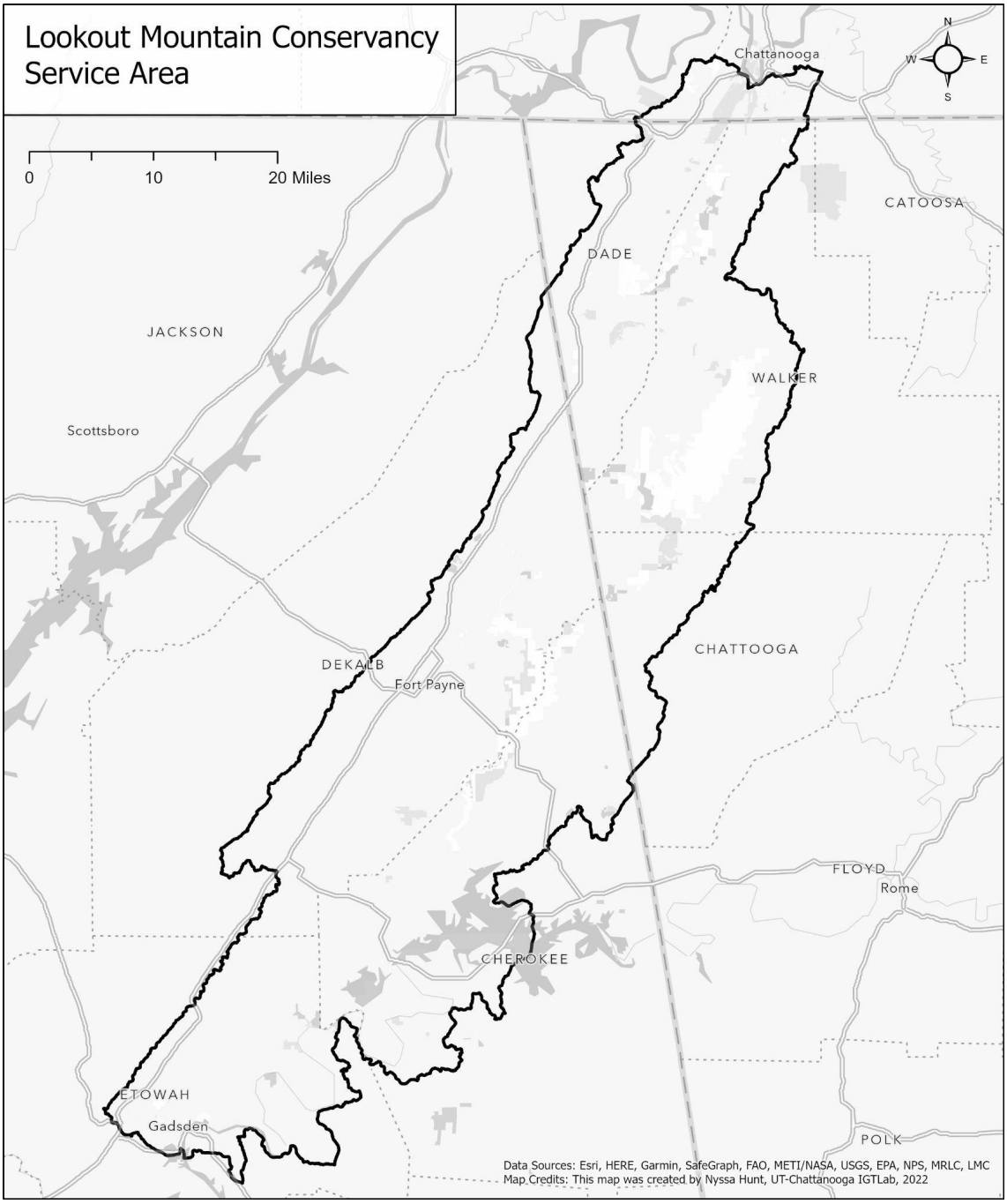

Figure 1: Lookout Mountain Conservancy Service Area, spanning from south of Chattanooga, TN to Gadsden, AL.

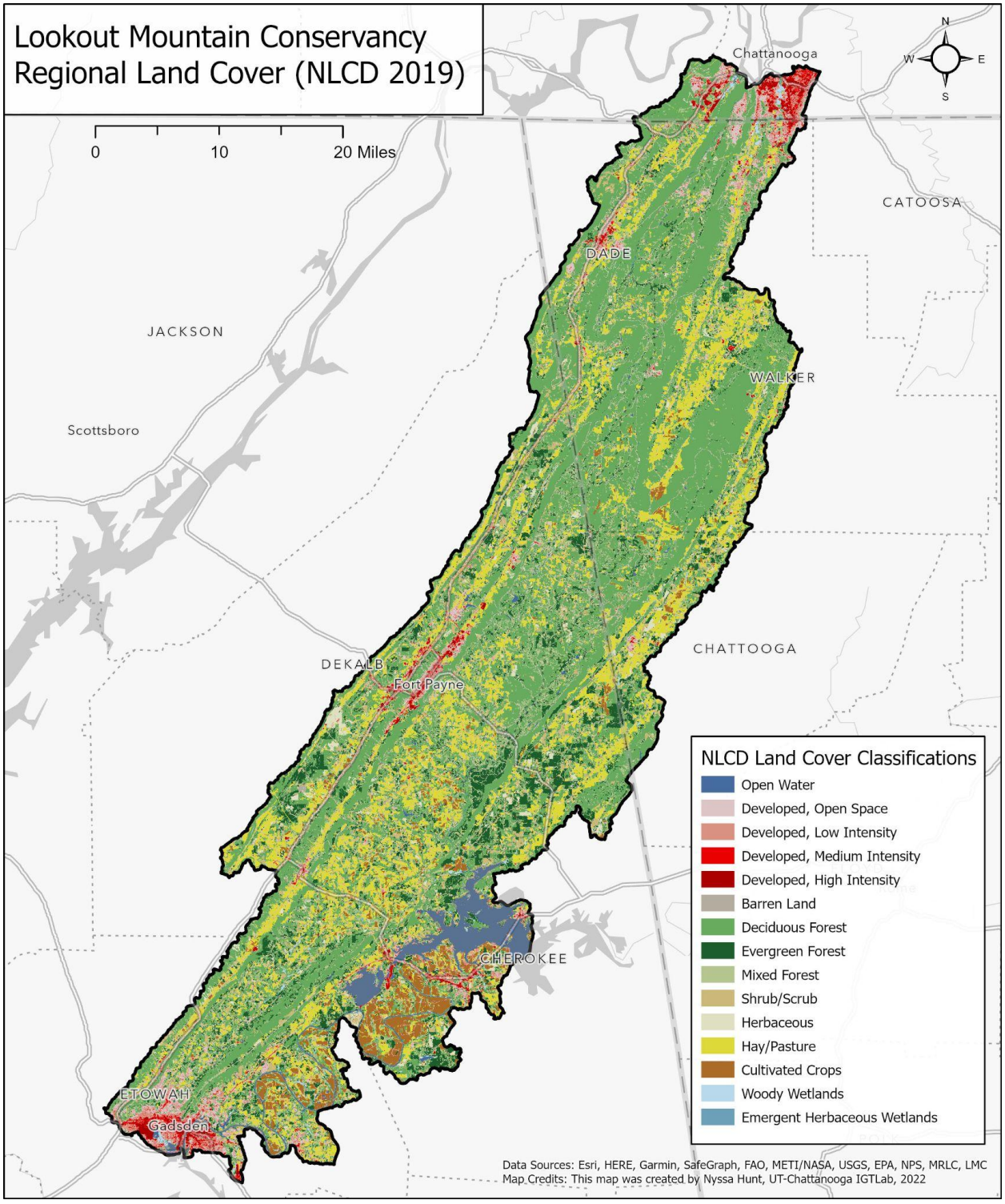

Figure 2: Map of Land Cover for the LMC Service Area. Source: NLCD 2019

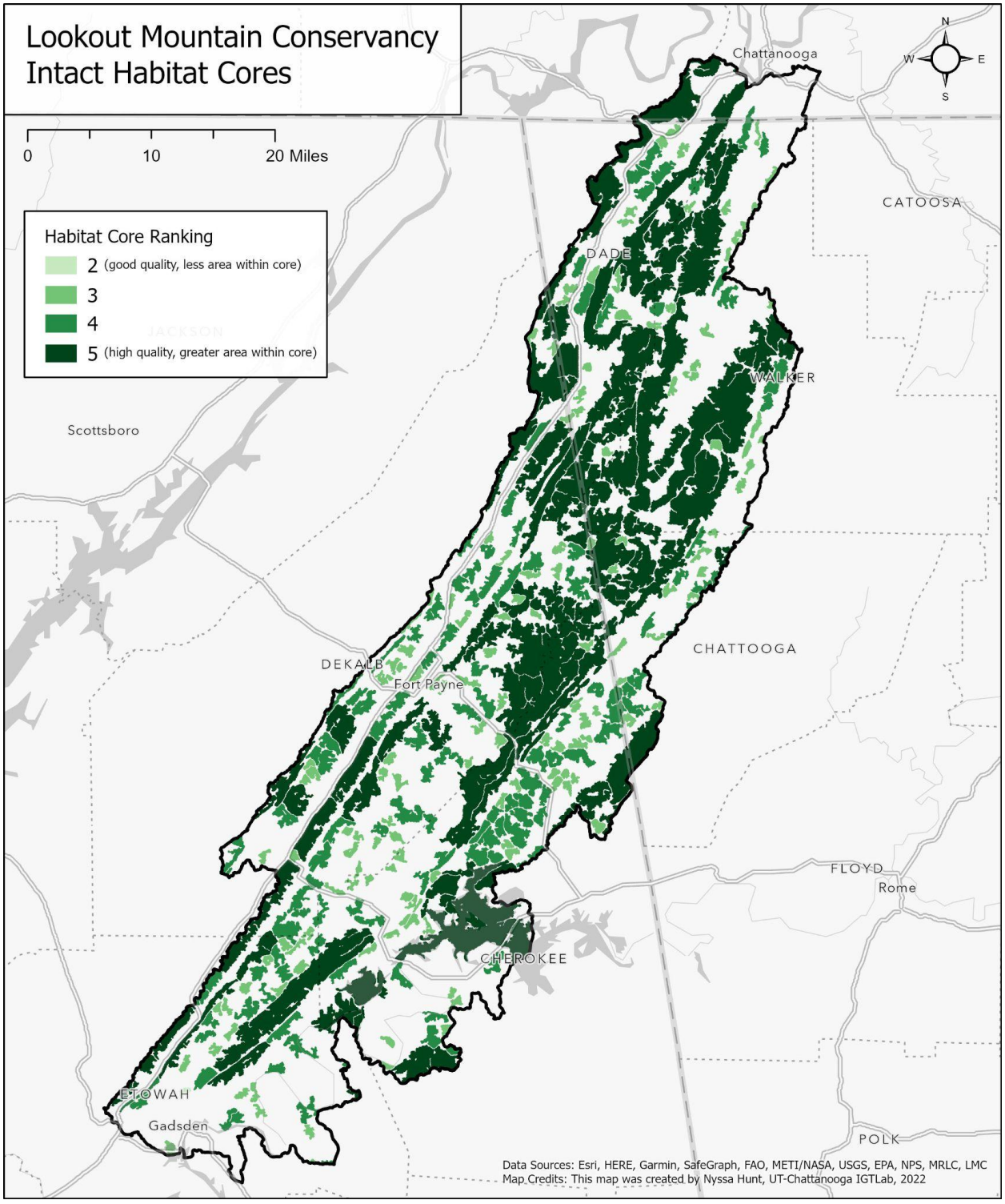

Figure 3: Map of Intact Habitat Cores and Corridors. Source : Esri Green Infrastructure

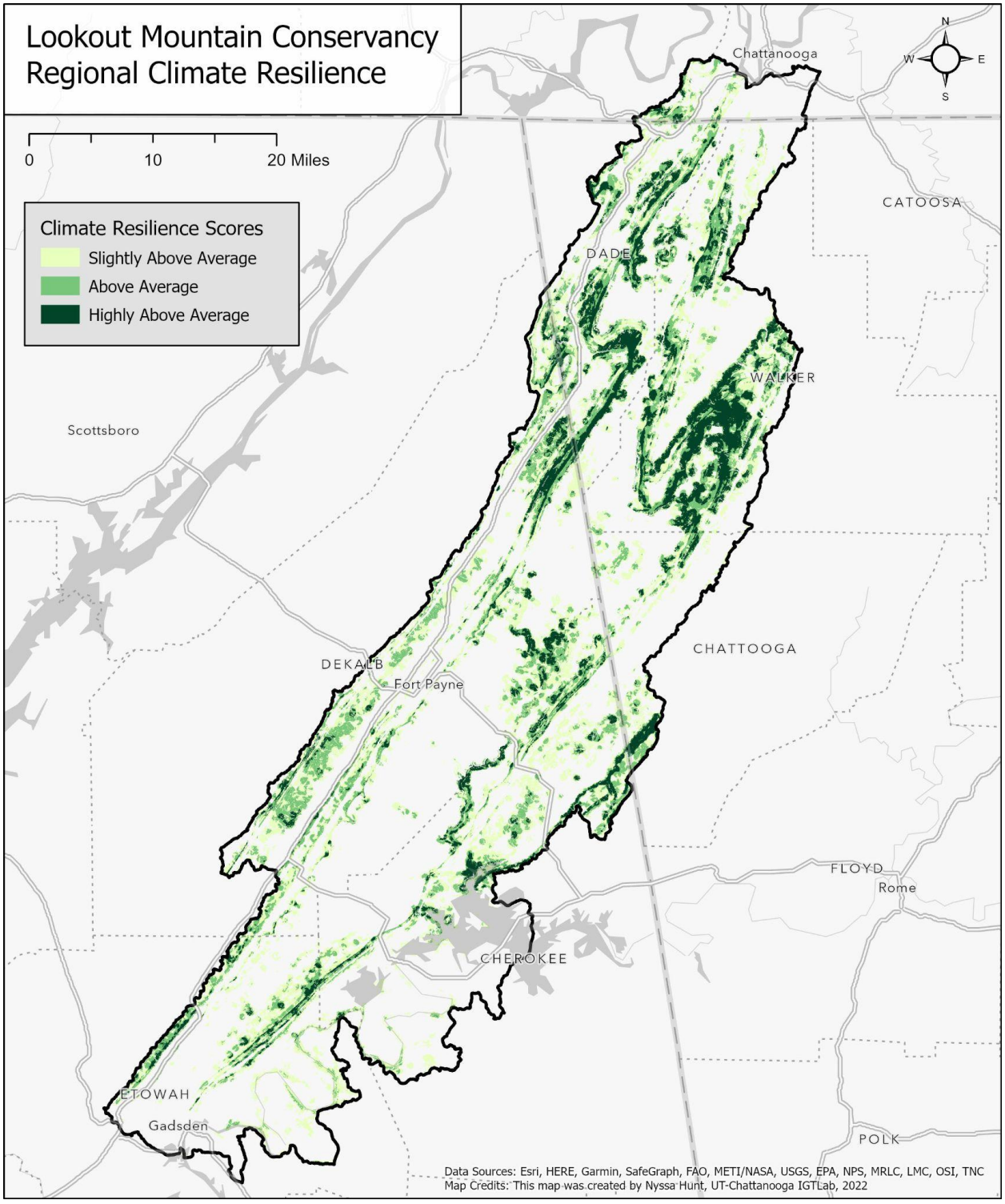

Figure 4: Map of Resilient Lands. Higher ranked areas indicate places that are more resilient to climate change, containing landform diversity and connectedness. Source: The Nature Conservancy

GIS Modeling and Spatial Analysis

The landscape conservation suitability model for LMC was inspired by a modeling approach developed for the Thrive Regional Partnership Natural Treasures Alliance by UTC's IGTLab, with input from representatives of the Open Space Institute (OSI) and LMC. The proposed submodels were aimed to prioritize two aspects: Habitat Priority and Ecosystem Services. Each submodel considers unique layers contributing to their respective modes. The Habitat Priority submodel considered above average climate resilient lands (TNC), underrepresented geophysical settings (TNC), proximity to existing protected lands (PAD-US), intact habitat cores (Esri), Map of Biodiversity Importance - Imperiled Richness (NatureServe), and habitat least cost path surfaces and corridors (Esri). The Ecosystem Services submodel considered the national wetland inventory data (NWI), active river area (TNC), and areas with high potential carbon storage/sequestration (Clark Labs) (see Table 3 for a more descriptive list of the layers). Layers were combined in GIS using a weighted overlay approach to produce the final suitability model for LMC, with potential scores ranging from 1-45, with higher scores being more ideal for conservation of wildlife habitat and ecological services.

To create the suitability submodels, data files were acquired from the appropriate sources (Table 3) and clipped to the Lookout Mountain Conservancy area of interest. Certain layers were converted from vectors to rasters of a 30 meter cell size, and projected to the appropriate coordinate systems. Once the initial round of processing was complete, values in each layer were reclassified and any unneeded attributes were removed. The reclassification consisted of assigning numerals ranging from 0-5 to the values that the data layers were representing, as the data layers were representing differing attributes (I.E. distances, levels, or presence of a feature); the assigned numbers varied for each data layer based on conservation priority and contribution (Table 3).

A few layers required a slightly different process. To create an attribute that represented the proximity to protected lands, Protected Areas Database of the United States (PAD-US) 2.1 was downloaded from the USGS and the euclidean distance tool was ran with the distance between the protected lands and trails being classified from 0-5 with 5 being equal to 1 km or less and 0 being over 5km. For Underrepresented Settings and Little River (a designated scenic river), the reclassification portrayed either presence (5) or no presence (0).

Upon completion of the data preparation, the "Weighted Sums" tool was executed, setting each data layer to be weighted equally, combining layers to create two separate submodels - Habitat priority and Ecosystem services - which were ultimately combined into a composite conservation model for the LMC region (*Figure 5*). Areas that overlapped with human development were excluded from the finalized model, which were identified with the NLCD 2019 dataset. To aid with interpreting the value scale of 1-45 on the conservation model, these numbers were grouped into five rankings, where 1-9 became 1, 10-18 became 2, and so on (Table 4). Acreage for the varying rankings were measured, along with acreage of currently unprotected areas (Table 4). Finally, to identify priority areas for conservation, the tool "Locate Regions" was executed with the composite conservation model, which searched for highly connected and valued areas; five regions were selected to be focused on for initial efforts (Figure 6).

Table 3: Input data and weights for the landscape conservation suitability model.

Dataset	Key Attribute (reclassified to 1-5 scale)	Weighted Overlay Value	Data Source	Description
Climate Resilience	0 - 500 (Average) = 1 500 - 977.62 (1 SD) = 2 977.62 - 1455.24 (2 SD) = 3 1455.24 - 1932.86 (3 SD) = 4 1932.86 - 3376 (4 SD) = 5	1	https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/Pages/default.aspx	A measure of a landscape and ecosystem's ability to withstand harsh climate changes, having the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate.
Underrepresented Settings	All categories = 5	1	https://s3.amazonaws.com/osi-craft/ALPF_Definitions_Datasets_-Round-II-FINAL_Nov-2021.pdf?mtime=20211130164615	A section of landscape that has a relatively low percentage conserved and a relatively high percentage converted out of land cover; these areas don't typically receive as much attention for conservation.
Map of Biodiversity Importance (MoBI) (imperiled richness)	Importance Index values: 0 – 5 = 1 5 – 7 = 2 7 – 9 = 3 9 – 12 = 4 12 – 18 = 5	1	https://igtlab.maps.arcgis.com/home/item.html?id=6e90cefddb634e6a949838e7efff55fb	This layer is intended to identify areas of high potential value for on-the-ground biodiversity protection efforts. High values identify areas where more imperiled species are most likely to occur.
Proximity to Existing Protected Lands	Distance from lands: 0 - 1km = 5 1-2km = 4 2-3km = 3 3-4km = 2 4-5km = 1 above 5km = 0	1	https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap/science/protected-areas	Existing protected land serves as habitat that will be sustained over time with minimal changes, where a given distance within or surrounding a protected area may serve as a habitat stronghold and areas gradually outside of it will be less so.
Esri Green Infrastructure Intact Habitat Cores	Habitat core scores: 1.93 - 2 = 2 2-3 = 3 3-4 = 4 4-5 = 5	1	https://www.arcgis.com/home/item.html?id=0d2f35395c3c43ecb7685df9be63dd84	This layer represents modeled Intact Habitat Cores, or minimally disturbed natural areas at least 100 acres in size and greater than 200 meters wide. The higher the core score, the better quality the habitat.
Habitat Least Cost Path Surface (corridors)	Cost surface values: 35 – 112 = 5 112 – 235 = 4 235 – 492 = 3 492 – 1754 = 2 1754 – 11200 = 1	1	https://nation.maps.arcgis.com/home/item.html?id=98882d18558a4659962d2b39a49ae7ed	This layer represents a cost surface for use in landscape connectivity modeling. It reflects the relative ease of movement for terrestrial species taking into account several factors including: NLCD landcover classes, slope, proximity to water, and habitat core score. The lower the score, the more connected sections of landscape are – these would be less likely to inhibit wildlife movement.

National Wetlands Inventory	All presence = 5	1	https://www.fws.gov/program/national-wetlands-inventory/data-download	Accounts for the rivers, streams, wetlands and other waterbodies in the landscape that serve ecosystems.
Active River Area	Area classifications: FEMA, non-wetflat = 3 FEMA, wetflat = 3 input water cells = 5 base zone, non-wetflat = 5 base zone, wetflat = 5 material contribution, non-wetflat = 5 material contribution, wetflat = 5	1	https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/freshwater/floodplains/Pages/default.aspx	Captures the ever-changing nature of streams and rivers, helping to identify the full range of riparian and floodplain conditions.
Carbon Storage/Sequestration (high potential)	Pixel values: 29 - 53 tons = 1 53 - 64 tons = 2 64 - 74 tons = 3 74 - 85 tons = 4 85 - 122 tons = 5	1	https://maps.tnc.org/resilientland/	Documents the amount of above-ground stored carbon, where vegetation has offset airborne carbon.

Table 4. Overall rankings of the Composite Conservation Model values, and the acreage of these modeled areas, including the amount of area unprotected in each category.

Model Rankings (indicating conservation priority value)	***Pixel Scores***	***Acres (all)***	***Acres (unprotected)***
5 (very above average)	*37 - 45*	*13693.4*	*10947.30*
4 (above average)	*28 - 36*	*147703.7*	*115838.00*
3 (average)	*19 - 27*	*298000.3*	*274964.60*
2 (below average)	*10 - 18*	*210374.7*	*204538.40*
1 (very below average)	*1 - 9*	*37039.3*	*36887.60*

Results and Discussion

With the composite conservation model, areas where multiple high ranking values aligned became apparent across the LMC service area, with a fair amount of these areas being approximate to existing protected locations. The periphery of these areas often ranked highly for conservation priority, which present opportunities in the near future. Pieces of the Chickamauga Battlefield and National Military Park and Reflection Riding Nature Center and Arboretum were the main protected areas to consider in Tennessee, which also seep into potential areas of focus in northern Georgia. Cloudland Canyon State Park, Lula Lake Land Trust, and the Crockford-Pigeon Mountain Wildlife Management Area all encompass northern Georgia's larger protected areas and are continuous pieces of land that contribute to higher habitat scores. Last, Little River Canyon National Preserve and areas surrounding Weiss Lake contributed to higher conservation values towards the Alabama section of the LMC region.

Sections of these protected areas were included by the "Locate Regions" tool, which searches for high average pixel scores of greatest area and connectivity throughout the given model. Protected lands themselves were still included in the modeling, as these pixels represent physical areas that contribute to surrounding areas of opportunity. As shown in Figure 6, the top two priority regions surround parts of Pigeon Mountain and Cloudland Canyon, extending beyond the protected areas and identifying high-ranking unprotected lands in proximity. With all of the regions identified, it is suggested to use these areas and this conservation model as a guide towards areas of high conservation priority within feasible grasp.

In addition to the maps and models produced for this project, the datasets and models created in this analysis have also been uploaded on ArcGIS Online and are available to view in a web application. This web application allows for a more dynamic view of the datasets, allowing the user to zoom in on areas of interest and locate areas to investigate for potential acquisition. Culturally valued locations, such as trails, museums, historic monuments and/or areas are also included in the web versions of the map, to provide context on surrounding values in a given area. These online datasets and applications are provided by the IGTLab, to expand on conservation management and plans towards LMC's goals.

Thrive Regional Partnership (Thrive), which aims to guide regional growth and assist in conservation management goals, includes Hamilton (TN), Dade and Walker (GA), and DeKalb (AL) counties within their service region, which overlaps with the LMC region. With the combined efforts of Thrive and LMC, focusing conservation efforts within the named counties may yield feasible opportunities for acquisition of new lands to protect within a closer time frame.

Given the number of unprotected acres in Table 4, especially those of above average ranking, it is evident that there is still a great amount of conservation opportunity within the LMC region. Unique species and habitats are contained within these landscapes, where protecting these will help to retain living spaces for wildlife and likely reduce human/wildlife conflict. Many urban areas have observed wildlife entering human development, oftentimes because of habitat destruction/alteration, and these wildlife experience displacement (Dickman). Conserving habitat responsibly can ensure a more sustainable use of resources and prolonged protection for valuable ecosystems.

Note: We do not know how the existing protected lands are being managed or if there are other protected areas not captured in the USGS PAD data. Known protected areas (more than the named above) were included in the analysis for this model.

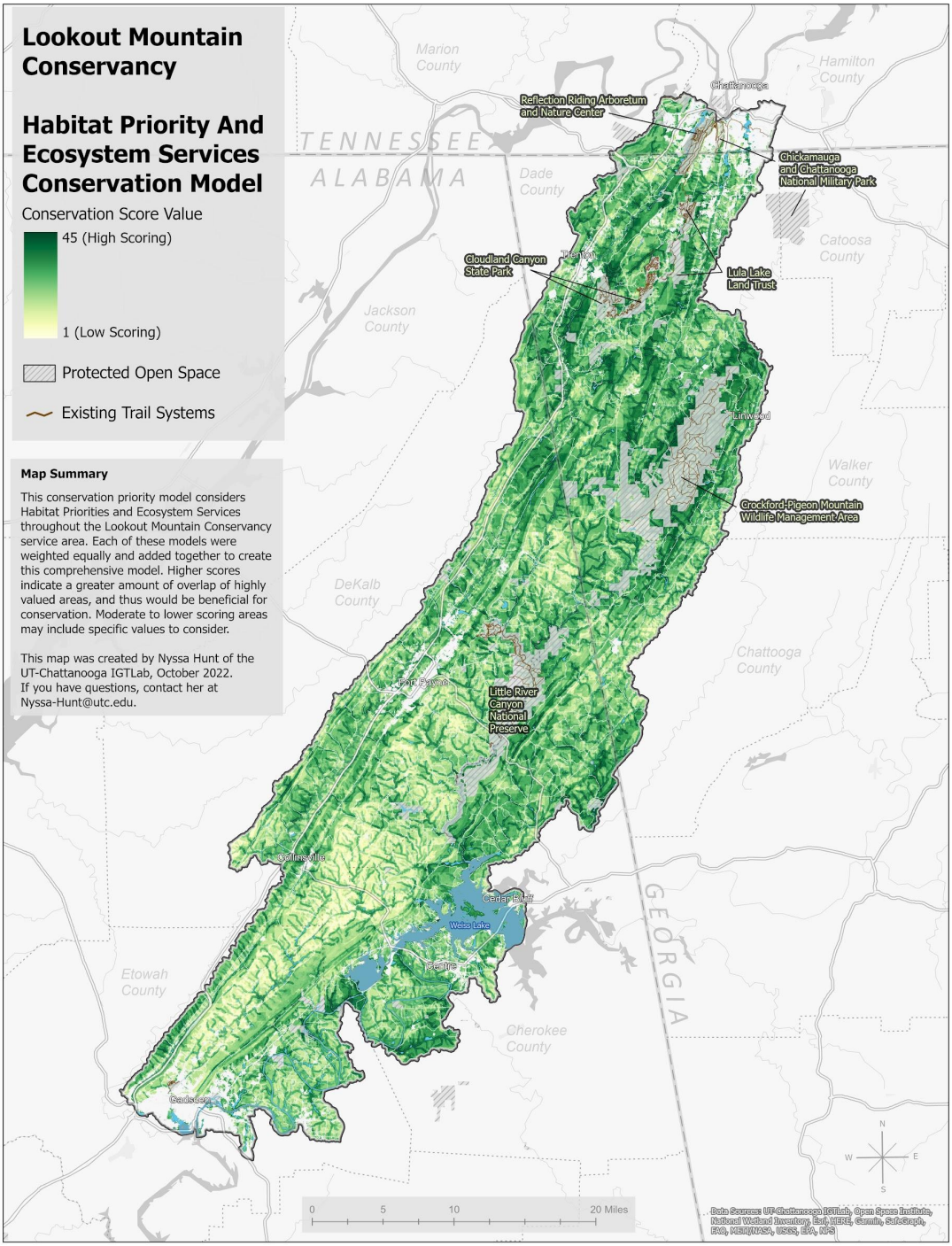

Figure 5: Map of Landscape Conservation Suitability. Areas of high value (dark green) indicate lands with intact habitat, high resilience, and connectivity. These are areas that can sustain and protect ecosystems, species richness, viewsheds.

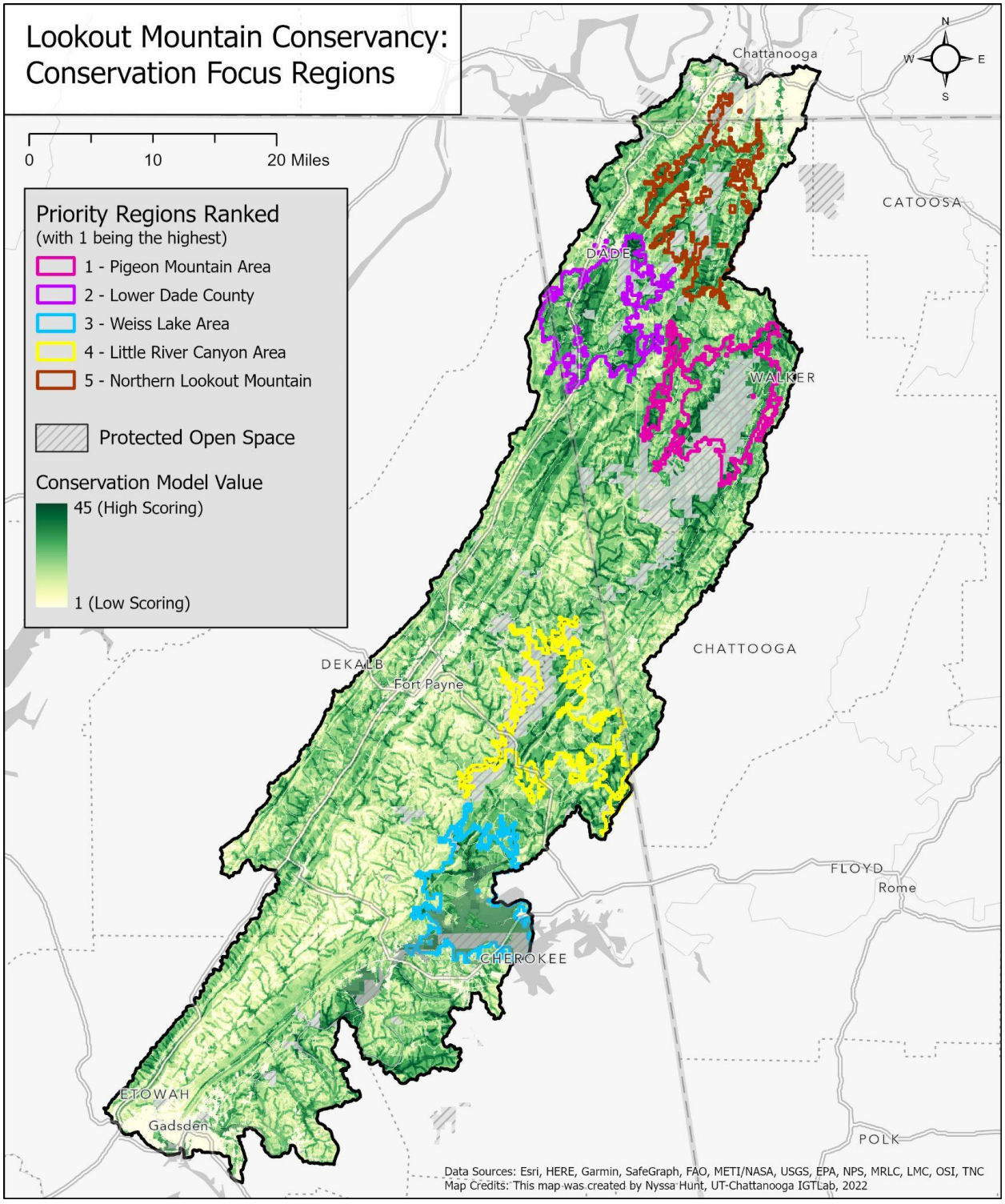

Figure 6: Map of Super Regions to focus conservation efforts on

References

Anderson, M. B. (2016). *Resilient and Connected Landscapes for Terrestrial Conservation.* The Nature Conservancy .

Dickman, A. J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal conservation*, *13*(5), 458-466.

Esri. (2016). *Green Infrastructure .*

Gatewood, A. (2020, February 19). *Family Lands, Stories from the Land: A Focus On Lookout Mountain*. North American Land Trust. Retrieved December 20, 2022, from https://northamericanlandtrust.org/a-focus-on-lookout-mountain/

Krueger , E., & Jordan, N. (n.d.). *Preserving Water Quality in the Savannah River.* The Nature Conservancy, https://s3.amazonaws.com/tnc-craft/library/Savannah-Potable-White-Paper-Final-091614.pdf?mtime=20180822151837.

Multi_Resolution Land Characteristics Consortium . (2016). *National Land Cover Data Set.* MRLC.

NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

Lookout Planning Commission, 2020 Comprehensive Plan: Lookout Mountain, Georgia (2020). https://www.lookoutmtnga.com/sites/default/files/fileattachments/planning_commission/page/2381/draft_of_lookout_mountain_comp._plan_-_6.29.20.pdf

Tennessee Wildlife Resources Agency, TN SWAP Conservation Opportunity Areas: South Cumberland Plateau (n.d.). Chattanooga, Tennessee.

The Nature Conservancy. (2004). *Ecoregions of the United States.* https://maps.tnc.org/resilientland/assets/Biodiversity_Sources_Ecoregional.pdf

Thrive Regional Partnership. (2022). *Preserving the Cradle of Southern Appalachia: A Tri-State, Collaborative Landscape Conservation Blueprint.* https://drive.google.com/file/d/1NTAgtBsoBQnxlqWXJdr6PYv3YqbZOzqO/view

U.S. Fish & Wildlife Service. (2020). *Pine Log HUC 10 Watershed Report*. Retrieved from https://www.fws.gov/athens/transportation/huc10/0315010206_FWS_guidance.pdf