Mapping the South's Forests of the Future

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EXECUTIVE SUMMARY

Forest lands in the Southern States provide important ecological, social, and economic services from clean water and wildlife habitat to recreational opportunities and wood products across approximately 245 million acres. The Southern region of the United States, which includes 13 states, is the fastest-growing region of the U.S. with a population expected to increase from 109 million residents in 2005 to a projected 152 to 186 million residents by 2060 (U.S. EPA 2009). As the South's population grows in the 21st century, development and related socio-economic pressures will continue to exert pressure on our remaining forest resources with a forecasted net loss of 11 to 23 million acres of forestland to other land use by 2060 (Wear and Greis 2013). To prevent large-scale conversion to non-forest use, many organizations have focused their efforts on forest protection and reforestation, prioritizing forest connectivity, rare and sensitive ecosystems, working forests, and resilient landscapes for funding. State forestry and wildlife agencies and organizations have developed a series of action plans (i.e., Forest Action Plans, and Forest Resource Assessments, State Wildlife Action Plans) to prioritize proactive, non-regulatory, and incentives-based conservation actions and to identify areas of greatest conservation opportunity to focus strategic conservation efforts and maximize state conservation successes. Non-governmental conservation partners (e.g., The Nature Conservancy, The Conservation Fund, and Migratory Bird Joint Ventures) have developed their own plans to establish priorities at national, regional, and local scales (e.g., The Nature Conservancy's Longleaf Protection Priorities). With a plethora of organizations developing large-scale conservation plans relevant to their own missions and constraints, conservation priorities risk being developed in isolation. This can result in disjointed priorities for forest conservation across geopolitical and ecological boundaries in the Southern U.S. that lack a consistent message and regional conservation perspective. Thus, there is a critical need to integrate conservation priorities across planning efforts into a single map of current and potential future forest, with an emphasis on protected and working forests.

To address this need, the Mapping the South's Forests of the Future project leveraged the existing regional and partnership-driven conservation planning efforts collectively defining the Southeast Conservation Adaptation Strategy, which had compiled several geospatial priorities, and expanded that work to other forest and conservation entities to produce a comprehensive geospatial inventory of planned and prioritized areas of forest protection/retention and restoration. Objectives of this project included:

1) An inventory of existing conservation plans, programs, and initiatives that targeted forest retention or had forest protection as a necessary component of achieving initiative objectives.

2) A compilation of geospatial elements of plans, programs, and initiatives that targeted forest retention into a comprehensive map of future extent and location of protected forests, reflecting a gradient of uncertainty associated with planned and prioritized forest retention.

3) Overlaid maps of current protected forest and planned/prioritized future forest retention to identify potential gaps in future forest connectivity in the landscape.

4) Incorporation of projected spread of urbanization and climate change to identify areas where future forest retention programs will maximize forest ecosystem integrity.

The comprehensive future forest map product reflects a gradient of uncertainty associated with conservation plans, development and other socio-economic pressures, and climate change. Dataset categories include the following:

1) Protected lands, obtained from Protected Areas Database-U.S., National Conservation Easement Database, state databases, and non-governmental organizations;
2) Prioritized lands, obtained from federal and state agencies (e.g., state wildlife action plans and forest legacy areas) and numerous non-governmental organizations (e.g., joint ventures and land trust partnerships);
3) Threats to forest retention, including urbanization, sea level rise and associated coastal changes, and energy development sites;
4) Lands of high socio-economic value, defined as forestlands important to the South's timber industry and forests important to maintaining surface drinking water quality; and
5) Reforestation opportunities on non-forested land, derived from two datasets about marginal agricultural land and potentially restorable wetlands.

Using these datasets, we developed two qualitative indices, the Forest Retention Index and the Potential Reforestation Index, to provide a gradient of future forest retention and reforestation likelihood on presently forested and non-forested lands, respectively.

Protected lands currently occupy 48.6 million acres, of which 36.3 million acres are forested and 5.1 million acres can be reforested. Nearly half of all forestland is classified as High on the Forest Retention Index. However, some states (e.g., Georgia, Mississippi, Oklahoma, Illinois, and Florida) have a marked decline in forestland classified as High, the most dramatic of these losses occurring between 2030 and 2040. These losses tend to be driven by urbanization, but migration of coastal forests inland plays a key role in coastal areas (e.g., Florida). By 2060, nearly 18 million acres are at high risk of being deforested (Forest Retention Index classes Low and Very Low). North Carolina, Georgia, and South Carolina had the greatest increases in forestland classified as Very Low by 2060 with high total potential forestland loss. The greatest potential for reforestation on lands not currently protected occur in Oklahoma, the Mississippi Alluvial Valley of Arkansas and Tennessee, and peninsular Florida. Biodiversity gap analysis indicates that approximately 3 million acres with high biodiversity are already protected. An additional 4 million acres with high biodiversity are classified as High on the Forest Retention Index.

The Mapping the South's Forests of the Future builds upon the work of the USFS Southern Forest Futures Project to identify areas of existing, planned and prioritized forest retention and reforestation in the Southern U.S. As with any other planning effort it is important to use tools such as this to identify areas to target forest retention efforts, particularly as landscapes are subject to rapid conversion to development and volatility in timber markets increases risk in

private-lands timber production. This tool provides a collaborative, transparent, and defensible mapping product that can aid in identification of key watershed areas where retaining forest is critical to ecological and socioeconomic integrity in the South.

JUSTIFICATION

The Southern United States contains diverse forest types and other native land covers that support myriad endemic plant and wildlife species across an equally diverse set of physical, economic, and ecological conditions. Forest lands in the Southern States provide important ecological, economic, and cultural services for its residents from clean water and wildlife habitat to wood products to recreational opportunities. As the South's population grows, development and related socio-economic pressures will continue to threaten our remaining forest resources with effects ranging from outright conversion of forest to non-forest use to forest fragmentation and degradation, leading to loss of ecological function and corridors essential for wildlife movements across the landscape. The high degree (≈90% of land area) of private ownership along with the increasing numbers of urban and absentee landowners as well as losses to heirs' property parcelization makes forestlands in the Southern States particularly susceptible to fragmentation and land use conversion. Using the best available urbanization, economic, and timber market models, the Southern Forest Futures Project forecasts a potential net loss of 11 to 23 million acres of forestland to other land use by 2060 (Wear and Greis 2013).

To mitigate large-scale conversion to non-forest use, many organizations have focused their efforts on forest protection and reforestation, prioritizing forest connectivity, rare and sensitive ecosystems, working forests, and resilient landscapes for funding. State wildlife and forestry agencies have developed a series of action plans (i.e., State Wildlife Action Plans, Forest Action Plans, and Forest Resource Assessments and Strategies) to prioritize proactive, non-regulatory, and incentives-based conservation actions and to identify priority ecological systems, species of greatest conservation need, and areas of greatest conservation opportunity. Federal Farm Bill-mandated Forest Resource Assessment and Strategy reports and subsequent Forest Action Plans improve understanding and strategic targeting of forest conservation and retention, identify state-specific threats to forest retention, and establish Forest Legacy Areas to receive funding from the U.S. Forest Service administered Forest Legacy Program. Similarly, State Wildlife Action Plans are developed every 10 years to meet requirements for federal funding under the congressionally-designated State Wildlife Grants Program and serve to focus strategic conservation efforts and maximize state conservation successes. Non-governmental conservation partners (e.g., The Nature Conservancy, The Conservation Fund, and Migratory Bird Joint Ventures) have also developed plans to establish priorities at national, regional, and local scales.

In the U.S. Forest Service "Summary of the 2010 Statewide Forest Resource Assessments and Strategies," states identified partnerships as being essential to the development and implementation of forest resource assessments and strategies. Furthermore, states have identified common themes (e.g., climate change, economics and changing markets, longleaf pine restoration, forest pests, urbanization, water quantity and quality, and wildfire risk and fire management) that may be better addressed at a regional scale across multiple jurisdictions (USDA Forest Service 2010). With a plethora of organizations developing large-scale conservation plans relevant to their own missions and constraints, there is a critical need to integrate conservation priorities to improve efficiency, effectiveness, and connectivity amongst

the myriad entities and plans involved in natural resource conservation (Open Space Institute 2013). Integration is needed across multiple spatial scales and both within and among states. Within states, Forest Action Plans, State Wildlife Action Plans, and other conservation planning efforts are often developed in isolation. This can result in disjointed priorities for forest conservation across geopolitical and ecological boundaries in the Southern U.S. that lack a consistent message and regional conservation perspective. Conservation and forest retention efforts may be more successful if priorities reflect multiple overlapping targets, providing opportunities for great leveraging of funds to support ecological and socioeconomic objectives.

The majority of plans offer some measure of spatial prioritization of focal areas for conservation and/or forest retention. However, methods used to spatially identify priority areas differ widely among states reflecting a spectrum of approaches from expert elicitation to empirically-driven spatial analyses. For instance, Arkansas used a geospatial overlay analysis to identify priority forested landscapes whereas Kentucky and Louisiana used expert and stakeholder input to define and map priorities (USDA Forest Service 2010). Spatial resolution also varies with states using counties and 12-digit hydrologic units to define boundaries or opting to refrain from any administrative or ecological boundary in favor of hand-digitized delineations. As a result, the proportion of land in a priority area differs by state and agency. Agencies and conservation partners may also choose to further prioritize landscapes by issues and actionability (e.g., wildfire risk, water quality, and working forests). Hence, any effort to integrate priority areas in the Southern U.S. must recognize the challenges associated with combining dozens of datasets across diverse methods. The call to integrate priorities (Open Space Institute 2013) underscores the importance of landscape planning to capitalize on existing and emerging partnerships, leverage funds, and visualize the future of the Southern forests.

To address this need, the Mapping the South's Forests of the Future project leveraged upon the existing regional and partnership-driven conservation planning efforts collectively defining the Southeast Conservation Adaptation Strategy, which had compiled several geospatial priorities, and expanded that work to other forest and conservation entities to produce a comprehensive geospatial inventory of planned and prioritized areas of forest protection/retention and restoration. This project integrates and incorporates priorities into a single map to visualize multiple potential futures of Southern forests while considering the gradient of uncertainty surrounding successful implementation of conservation plans, urbanization and other development pressures, and coastal forest response to sea level rise.

OBJECTIVES

1) Inventory existing conservation plans, programs, and initiatives that targeted forest retention or had forest protection as a necessary component of achieving initiative objectives.

2) Compile geospatial elements of plans, programs, and initiatives that targeted forest retention into a comprehensive map of future extent and location of protected and unprotected forests, reflecting a gradient of uncertainty associated with planned and prioritized forest retention.

3) Overlay maps of current protected forest and planned/prioritized future forest retention to identify potential gaps in future forest connectivity in the landscape.

4) Incorporate projected spread of urbanization and climate change to identify areas where future forest retention programs will maximize forest ecosystem integrity.

METHODS

Study Area

Our study area extends from Virginia to eastern Texas, including at least in part all states and U.S. territories in U.S. Forest Service Region 8 in addition to southern Missouri and southern Illinois (Figure 1). This land base covers 429 million acres across the majority of the Southeastern Conservation Adaptation Strategy (SECAS) geography. This area, henceforth, the Mapping the South's Forests of the Future (MFF) area, contains a wide variety of forest, natural non-forest, and developed lands across a diversity of ecosystems and land cover types.

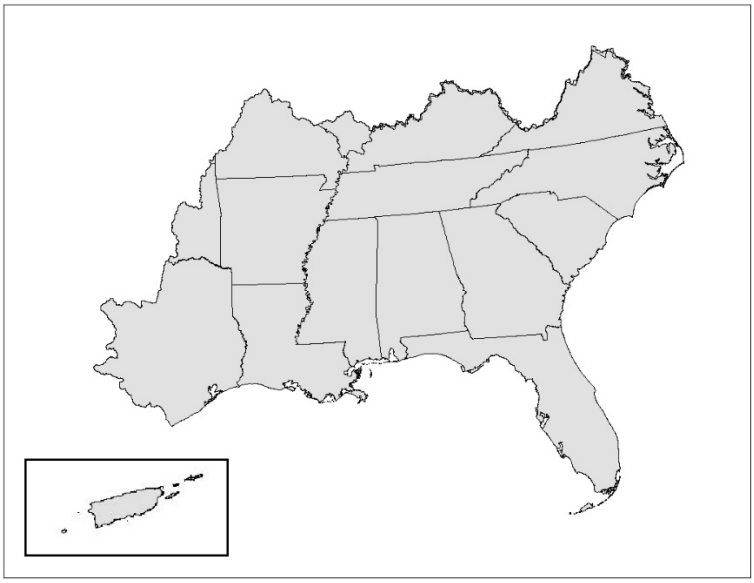

Figure 1. Mapping the South's Forests of the Future study area.

Geospatial Data Inputs

We collected geospatial data from August 2017 to March 2018 that were subsequently used to create future forest mapping products that reflect a gradient of uncertainty associated with conservation plans, development and other socio-economic pressures, and climate change. Dataset categories include the following:

1) Protected lands, obtained from Protected Areas Database-U.S. (U.S. Geological Survey, GAP 2016), National Conservation Easement Database (conservationeasement.us), state databases, and non-governmental organizations;
2) Prioritized lands, obtained from federal and state agencies (e.g., state wildlife action plans and forest legacy areas) and numerous non-governmental organizations (e.g., joint ventures and land trust partnerships);
3) Threats to forest retention, including urbanization, sea level rise and associated coastal changes, and energy development sites;
4) Lands of high socio-economic value, defined as forestlands important to the South's timber industry and forests important to maintaining surface drinking water quality; and
5) Reforestation opportunities on non-forested land, derived from two datasets about marginal agricultural land and potentially restorable wetlands.

Conservation Interests: Protected Lands and Priority Areas

We engaged 50 conservation partners (Appendix A) that assisted in data acquisition, developing a methodology for map creation, and reviewing mapping products. The majority of protected lands data were sourced from Protected Areas Database-U.S. (PAD-US) and National Conservation Easement Database (NCED). Newly protected properties can take several months or even years to be added to the national databases. Therefore, we contacted conservation partners for parcel information of recent acquisitions and easement transactions. Because conservation partners are at various stages in their prioritization and acquisition processes, we divided priority data into two groups: Tier 1 and Tier 2 Priority Areas. Tier 1 Priority Areas are defined as lands which are forested, or have the capacity to become forested, which are strategically planned for protection, usually associated with a formal acquisition program and designated at the parcel spatial scale. Examples include the Land, Water, and Conservation Fund through which the USDA Forest Service can purchase properties and The Nature Conservancy's Longleaf Protection Priorities which are strategically placed near protected lands and Department of Defense installations. Tier 1 Priority Areas also include parcels currently in the acquisition process. In contrast, Tier 2 Priority Areas are regional conservation priorities, typically designated at broad spatial scales and whose acquisition has varying degrees of certainty and may be more opportunistic in nature. Examples include conservation opportunity areas identified in state wildlife action plans, high priority areas identified in the Southeast Conservation Adaptation Strategy, and forest legacy areas identified in state forest resource assessments and strategies. A full list of Tier 1 and Tier 2 Priority Area datasets and description of data processing is available in Appendices B and C, respectively.

Threats to Forest Retention and Reforestation

We focused on three threats to future forests: urbanization, sea level rise and associated coastal forest migration, and energy development. Urbanization is perhaps the greatest threat to forests, especially in the South where population is expected to grow significantly. We used SLEUTH models (Jantz et al. 2009, NCGIA 2011, Belyea and Terando 2017) to capture future urbanization at three tiers: high risk (90 percent or greater), moderate risk (50 to 89 percent), and low risk (less than 50 percent).

Climate change has and will continue to affect forests in many ways (McNab et al. 2014, USDA Forest Service 2016). Because Mapping the South's Forests of the Future does not discriminate among forest types or condition classes, we limited our evaluation of the effects of climate change to coastal forests, where inundation from sea level rise and the associated inward migration of wetlands and forests can result in forest loss along the Southeast's extensive coast line (Williams et al. 1999, DeSantis et al. 2007, Doyle et al. 2010, Florida Oceans and Coastal Council 2010). We used datasets of inundation extent from National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center which projects potential inundation of coastal areas above current mean higher high water conditions. For decades 2030 through 2060, we implemented an inundation model of one-foot rise in sea level by 2100. Because inundation data does not capture coastal forest migration, we used Sea Level Rise Transition Areas, which reflects transition of ecosystems as well as complete loss of land projected to occur by 2050 for the Atlantic coast and Florida's Gulf coast line (South Atlantic LCC 2015). For the Gulf Coast, we used Tidal Saline Wetland Migration, which projects migration of mangrove forests, salt marshes, and salt flats based on alternative sea level rise scenarios for years 2030, 2040, 2050, and 2060 (Enwright et al. 2015).

The final threat to forest retention that we examined is forest loss to energy development in the Southern Appalachian Mountains. The Appalachian Landscape Conservation Cooperative (LCC) and The Nature Conservancy partnered to develop a risk assessment for future energy development to quantify potential impacts on forest and aquatic resources across 146 million acres in 15 states. The analysis determined that nearly 7.6 million acres, 71% of which is forested, within the Appalachian LCC geography have a high (< 90%) probability of energy development from one or more sources. Areas at high risk are concentrated on the Allegheny and Cumberland plateaus, and 10% of areas at high risk are intact patches of interior forest habitat (Dunscomb et al. 2014). While we acknowledge that energy development and extraction activities occur in other areas of the South, we were unable to obtain a satisfactory dataset that qualified risk of forests in areas outside the Appalachian LCC.

Socio-Economic Value of Forests

We also examined socio-economic value of forests as they relate to timber markets and surface drinking water. To determine areas of high timber value, we used the Timber Products Output dataset from the U.S. Forest Service's Forest Inventory and Analysis program. Timber Products Output details the amount of timber processed at mills for all categories of timber products (e.g., saw logs, veneer logs, pulpwood, composite, post) for every county in the Southeast. To

determine areas of high value to surface drinking water, we used the U.S. Forest Service's Forests to Faucets project output "Forest Importance to Surface Drinking Water." We used a quantile analysis to identify the top 40% of timber-producing counties and HUC12 watersheds with the highest forest importance to surface drinking water values. Because Timber Products Output and Forests to Faucets output are inherently forest-based, these datasets were used to determine socio-economic value only for areas currently in forest land cover.

Reforestation Opportunities

We used two datasets to determine areas currently occupied by agriculture that may be most conducive to reforestation efforts: National Commodity Crop Productivity Index (NCCPI) and Potentially Restorable Wetlands on Agriculture Land (PRWAg). The NCCPI is available from USDA Natural Resources Conservation Service as part of Gridded Soil Survey Geographic (gSSURGO) Database's National Value Added Look Up (Valu1) Table (gSSURGO Version 2.2; NRCS 2016). We used NCCPI to identify marginal agriculture land, defined as an index value of less than 0.4 for the highest-valued crop category. PRWAg has four classes of wetland restoration potential: unsuitable, low, moderate, and high summarized by 12-digit HUC. We included low, moderate, and high classes in our analysis.

Creating Indices for Future Forest Likelihood

Using protected, priority, threats, socio-economic value, and reforestation opportunity datasets, we developed two qualitative indices, the Forest Retention Index and the Potential Reforestation Index, to provide a gradient of future forest retention and reforestation likelihood on presently forested and non-forested lands, respectively. We implemented indices for years 2030, 2040, 2050, and 2060.

We used a binary decision tree approach to create two qualitative indices of future forest likelihood based on conservation status and interest, forest threats, socio-economic value of forests, and reforestation opportunities. Currently forested land, determined by using the 2011 National Land Cover Database (U.S. Geological Survey, GAP 2011), was divided into six Forest Retention Index classes ranging from Very High (i.e., almost certain to remain forested) to Very Low (i.e., forest almost certain to be lost) using the forest retention decision tree (Figure 2). Currently non-forested land was first evaluated for its potential to be forest using the Biophysical Settings in LANDFIRE. Non-forested land that has the potential to be forest (as opposed to prairie or non-forested wetland) was classified into five Potential Reforestation Index classes ranging from High (i.e., high likelihood of being reforested) to Very Low (i.e., almost certain to remain in non-forest land cover; Figure 3). The categorization of the Potential Reforestation Index was adjusted to align with the Forest Retention Index in terms of likelihood in order that the two indices can be displayed together on maps. The Forest Retention Index Very High class consists of protected forest not at risk of loss due to sea level rise. The Very High class is absent from the Potential Reforestation Index because it is highly improbable that an un-forested area could have an equivalent future forest likelihood as protected forest.

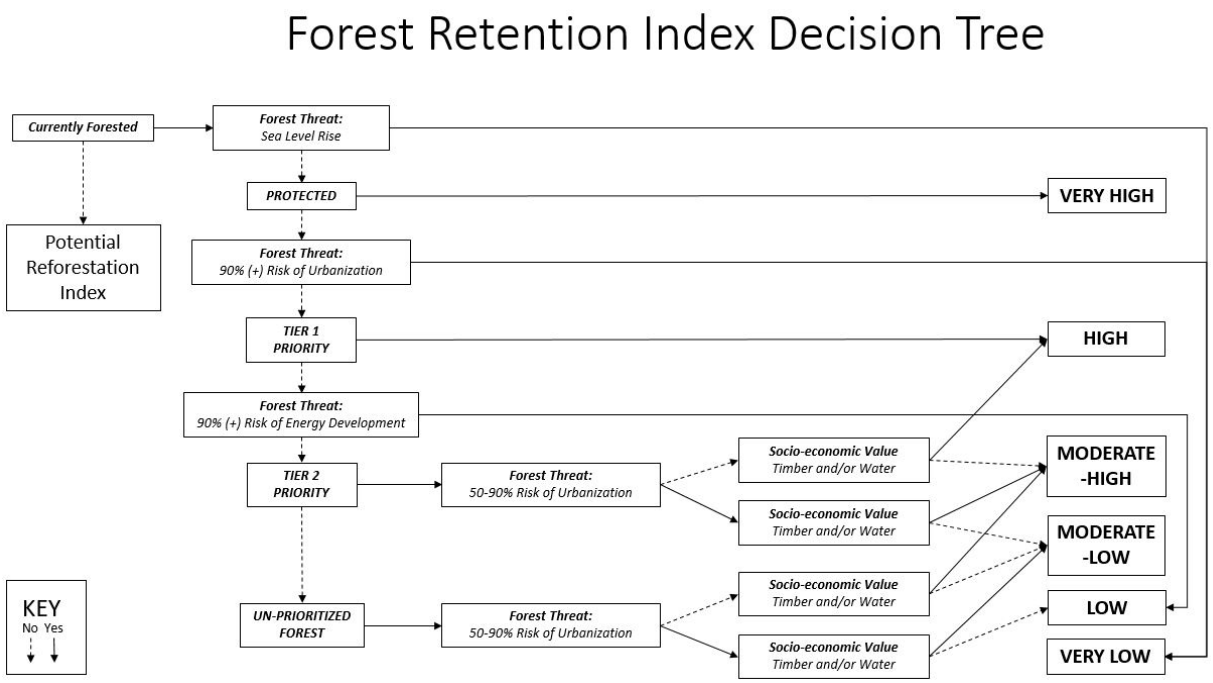

Figure 2. Decision tree for Forest Retention Index, a qualitative, 6-point index of future forest likelihood for land currently forested.

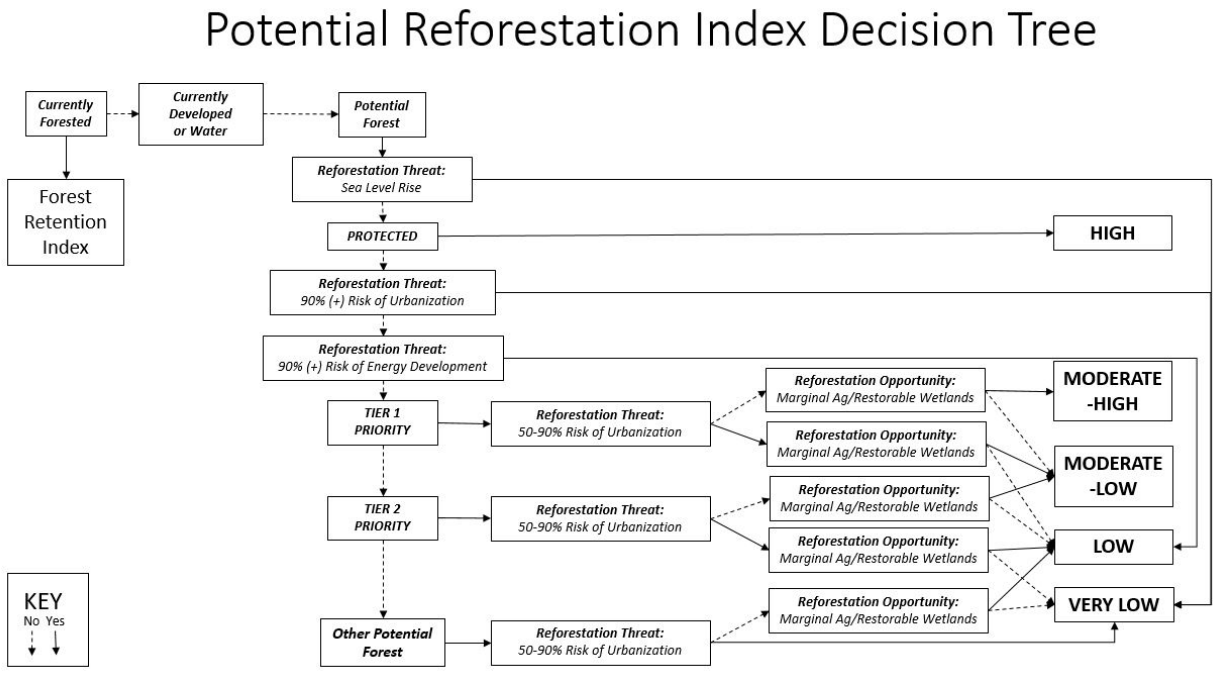

Figure 3. Decision tree for Potential Reforestation Index, a qualitative, 5-point index of future forest likelihood for land currently in non-forest cover. The Potential Reforestation Index classes

align with their counterparts in the Forest Retention Index, allowing the display of both indices on the same map.

All data were geo-processed using ArcMap 10.5 (ESRI). Final data layers for both indices are raster datasets with a spatial resolution of 30-meter by 30-meter, which is the same spatial resolution of the National Land Cover Database.

Gap Analysis: Biodiversity

A recent study of biodiversity protection in the U.S. found that current protected areas are not effective in conserving the country's most biodiverse areas (Jenkins et al. 2015), and highly biodiverse areas are often in close proximity to areas with rapid development. Jenkins et al. (2015) mapped biodiversity (i.e., total richness, number of endemic species, and priority score) for mammals (359 spp), birds (591 spp), amphibians (270 spp), reptiles (295 spp), freshwater fish (863 spp), and trees (641 spp) in the conterminous U.S. The authors recommended nine priority areas to expand conservation based on their biodiversity priority index, five of which occur in the southeastern U.S.: 1) middle to southern Blue Ridge Mountains, 2) Tennessee, Alabama, and northern Georgia watersheds, 3) Florida panhandle, 4) Florida Keys, and 5) south-central Texas around Austin and San Antonio.

We used Jenkins et al.'s (2015) biodiversity priority index to analyze how well biodiversity conservation aligns with future forest likelihood. To determine how well highly biodiverse areas are currently captured on protected lands and in conservation plans, we calculated the area in protected lands and Tier 1 and Tier 2 Priority Areas that had a biodiversity index score of at least 12. For protected lands, we analyzed how areas of high biodiversity (score $\geq$ 12; Jenkins et al. 2015) are stratified across gap status categories one through four in PAD-US and easements on privately-owned lands. Finally, we analyzed how biodiversity was captured in each Forest Retention Index class to determine biodiverse areas at high risk of being de-forested.

RESULTS

Key Findings

- Protected lands currently occupy 48.6 million acres, of which 36.3 million acres are forested and 4.6 million acres can be reforested.
- Nearly half of all forestland is classified as High on the Forest Retention Index. However, some states (e.g., Georgia, Mississippi, Oklahoma, Illinois, and Florida) have a marked decline in forestland classified as High, the most dramatic of these losses occurring between 2030 and 2040. These losses tend to be driven by urbanization, but migration of coastal forests inland plays a key role in coastal areas (e.g., Florida).
- By 2060, nearly 18 million acres are at high risk of being deforested (Forest Retention Index classes Low and Very Low). North Carolina, Georgia, and South Carolina had the

greatest increases in forestland classified as Very Low by 2060 with high total potential forestland loss.

- Biodiversity gap analysis indicates that approximately 3 million acres with high biodiversity are already protected. An additional 4 million acres with high biodiversity are classified as High on the Forest Retention Index.

Puerto Rico and the U.S. Virgin Islands differ from the Southern States in many aspects. Because urbanization projections for the islands are stagnant through 2060, and timber markets do not currently nor are they anticipated to play a role in forest retention. Therefore, we deemed it necessary to develop separate forest retention and reforestation decision trees for Puerto Rico and the U.S. Virgin Islands. This decision tree and the ensuing results will be presented in a separate report available in a public gallery at https://gcpolcc.databasin.org/galleries/337b2c3c457c4e828cf8101dbcb52409. All data and documentation related to forest retention and reforestation indices for the Southern States will also be available for download.

Protected Lands

Protected areas currently occupy 48.6 million acres (≈16% of study area) in the Southern States. Protected areas consist of 36.3 million acres of forest, 3 million acres of open water (not including Marine Protected Areas), 1.9 million acres of development (e.g., roads), and 7.2 million acres in other land cover (e.g., un-forested wetlands and agriculture). Of the 7.2 million acres in non-forest land cover, 5.05 million acres can be successfully reforested based on Biophysical Settings in LANDFIRE (LANDFIRE 2016). Some agricultural lands are listed as protected due to agriculture-based easements included in the National Conservation Easement Database. Non-forested areas of agriculture-based easements (i.e., easements designed to retain agriculture on rural lands) were excluded from the Potential Reforestation Index. The Protected Areas Database-U.S. assigns each protected area a GAP status based on stringency of protection mandates. Protected areas may be managed for biodiversity with disturbance events allowed to proceed or mimicked (GAP Status 1) or with disturbance events suppressed (GAP Status 2). There are fewer than 134,000 acres and 1.55 million acres in GAP Status 1 and 2, respectively. More than 1 million acres of protected areas are in GAP Status 3, which indicates areas managed for multiple uses, including extraction (e.g., mining) and off-highway vehicle (OHV) access. Nearly 2 million acres in PADUS are under no known protection mandate (GAP Status 4).

Tier 1 Priority Areas

Tier1 Priority Areas tend to cluster around already protected lands (Figure 4). Tier 1 Priority Areas are classified as High on the Forest Retention Index and either Moderate-High or Moderate-Low on the Potential Reforestation Index. The amount of land in Tier 1 Priority Areas classified as High, Moderate-High, or Moderate-Low declines from 20.6 million acres in 2030 to 18.3 million acres in 2060, a loss of 11.3% of Tier 1 acreage. By 2060, 2.3 million acres in Tier 1 Priority Areas are classified as Very Low. This loss is primarily driven by urbanization, with a notable exception on North Carolina's coast which is lost to sea level rise. The loss of Tier 1

Priority Areas to urbanization occurs throughout the Southern U.S., but is most concentrated in the southern Appalachians and central Florida.

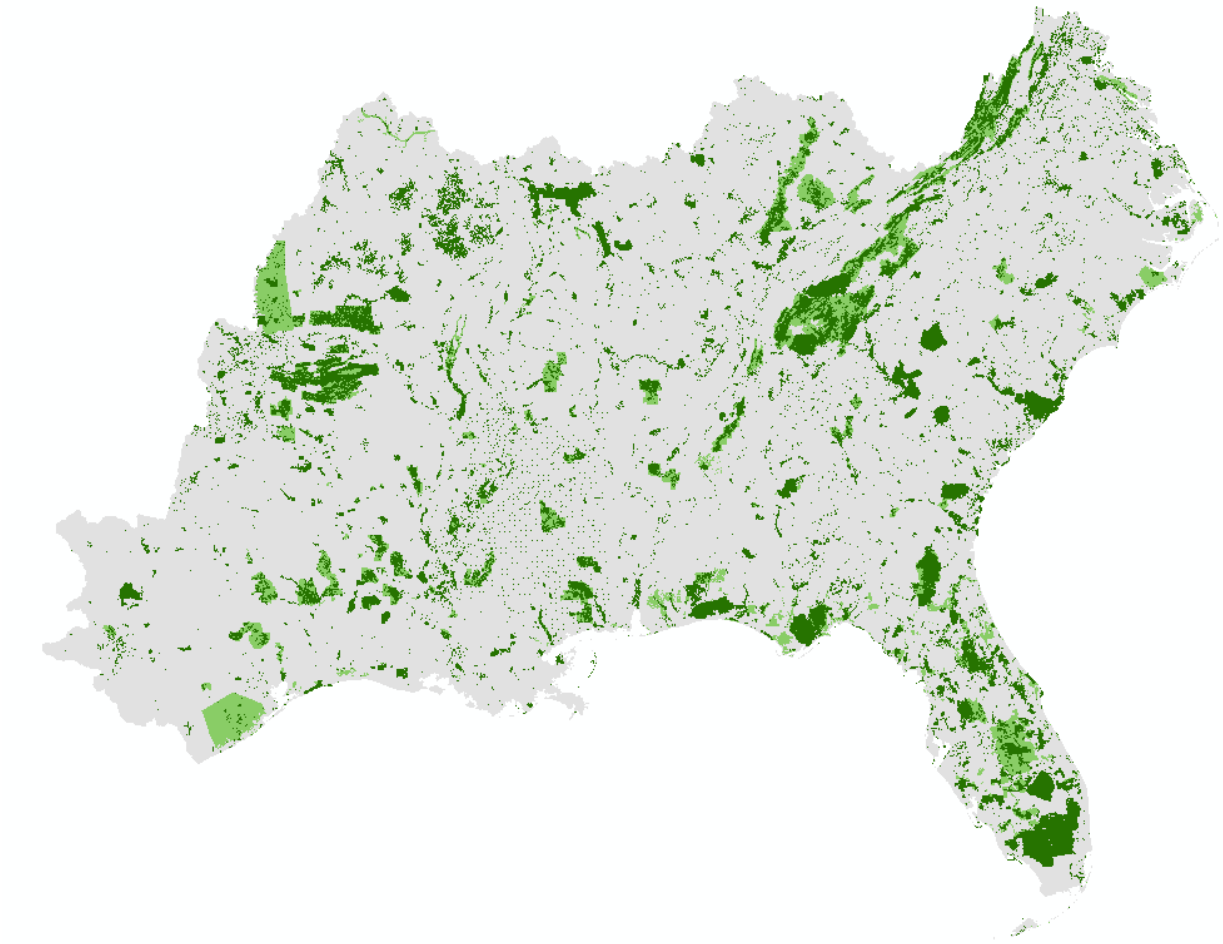

Figure 4. Protected lands (dark green) and Tier 1 Priority Areas (light green) in the southeastern United States. Protected lands include fee simple and easement properties. Tier 1 Priority Areas are defined as forested or potentially forested lands that are strategically planned for protection, usually associated with a formal acquisition program and designated at the parcel spatial scale.

Forest Retention Index

Forest Retention Index classes followed similar distributions for all years of analysis with nearly half of current forestland classified as High followed by Moderate-High, Very High, Moderate-Low, Very Low, and Low in order of most to least captured acres of forest (Table 1, Figures 5 and 6). Forestland in each Forest Retention Index class changed as a function of sea level rise and urbanization. Class Very High decreased by approximately 33,000 ac between 2030 and 2060 as coastal forests retreated inland in response to sea level rise (e.g., saltwater intrusion,

migration of salt marshes). Classes High and Moderate-High decreased in acreage primarily due to loss of forest to urbanization. Although class High decreased almost negligibly, Moderate-High lost 5.89 million acres while Moderate-Low gained 1.44 million acres between years 2030 and 2060. Most of the acreage lost in the Moderate-High class was re-classified as Very Low, but a very small percentage transitioned from Moderate-High to Moderate-Low as some points transitioned from low risk to moderate risk of urbanization. Class Very Low increased by 10.55 million acres. Of the total 17.66 million acres classified as Very Low, approximately 14 million acres (80%) of the class received its designation due to high urbanization risk. Class Low showed a slight increase in acreage across years of study.

North Carolina showed the greatest increase in Very Low from 710,273 acres in 2030 to 2,697,059 acres in 2060, a difference of nearly 2 million acres (Table 2). This potential for forest loss is equivalent to 14.4% of North Carolina current forestland. Georgia and South Carolina also had large gains in Very Low. Nearly 2 million acres of forestland in Georgia moved to the Very Low class between 2030 and 2060, with potential forest loss for the state at 12.4% of current forestland. More than 974,000 acres in South Carolina were moved to the Very Low class, with acreage in Very Low at 2060 equivalent to 10.5% of current forestland in the state. Illinois and had the least amount of forestland move to the Very Low class between 2030 and 2060, and their total potential forest loss appears to be quite low. Louisiana also had little forestland reclassified as Very Low; however, the state had nearly 1.3 million acres classified as Very Low in 2030, primarily due to coastal forest loss, and therefore, total potential forest loss could still be high.

Forestland in class High generally decreases between 2030 and 2060, with the greatest loss usually occurring between 2030 and 2040 (e.g., Georgia, Mississippi, Oklahoma, and Arkansas). For example, in Georgia more than 2 million acres are lost from class High between 2030 and 2040, representing a lost opportunity for conservation unless action is taken in the next 15 to 20 years. In Florida, more than 1.6 million acres are lost from the class High between 2030 and 2060, equivalent to nearly 9% of forestland in Florida. Of this 9%, approximately 5% is reclassified as Very Low with the remaining forestland moved to the Moderate-High class. Forestland classified as High in 2030 and Moderate-High in 2060 presents an opportunity for forest conservation efforts, while forestland reclassified as Very Low may be more suited to wetland restoration and coastal resilience projects.

Table 1. Forest Retention Index classes as forested area (in millions of acres) and percent of total forestland[1] for years 2030 and 2060.

	2030		**2060**	
	ac	%	ac	%
Very High	36.07	15.2	35.74	15.1
High	117.93	49.9	103.13	43.7
Moderate-High	52.85	22.4	58.74	24.9
Moderate-Low	22.39	9.5	20.95	8.9
Low	0.26	0.1	0.32	0.1
Very Low	6.83	2.9	17.38	7.4

[1] When comparing acreage of MFF Forest Retention Index classes to other projects in U.S. Forest Service Southern Region (Region 8), note that the MFF study area partially includes Texas and Oklahoma, which may create discrepancies in cross-project comparisons.

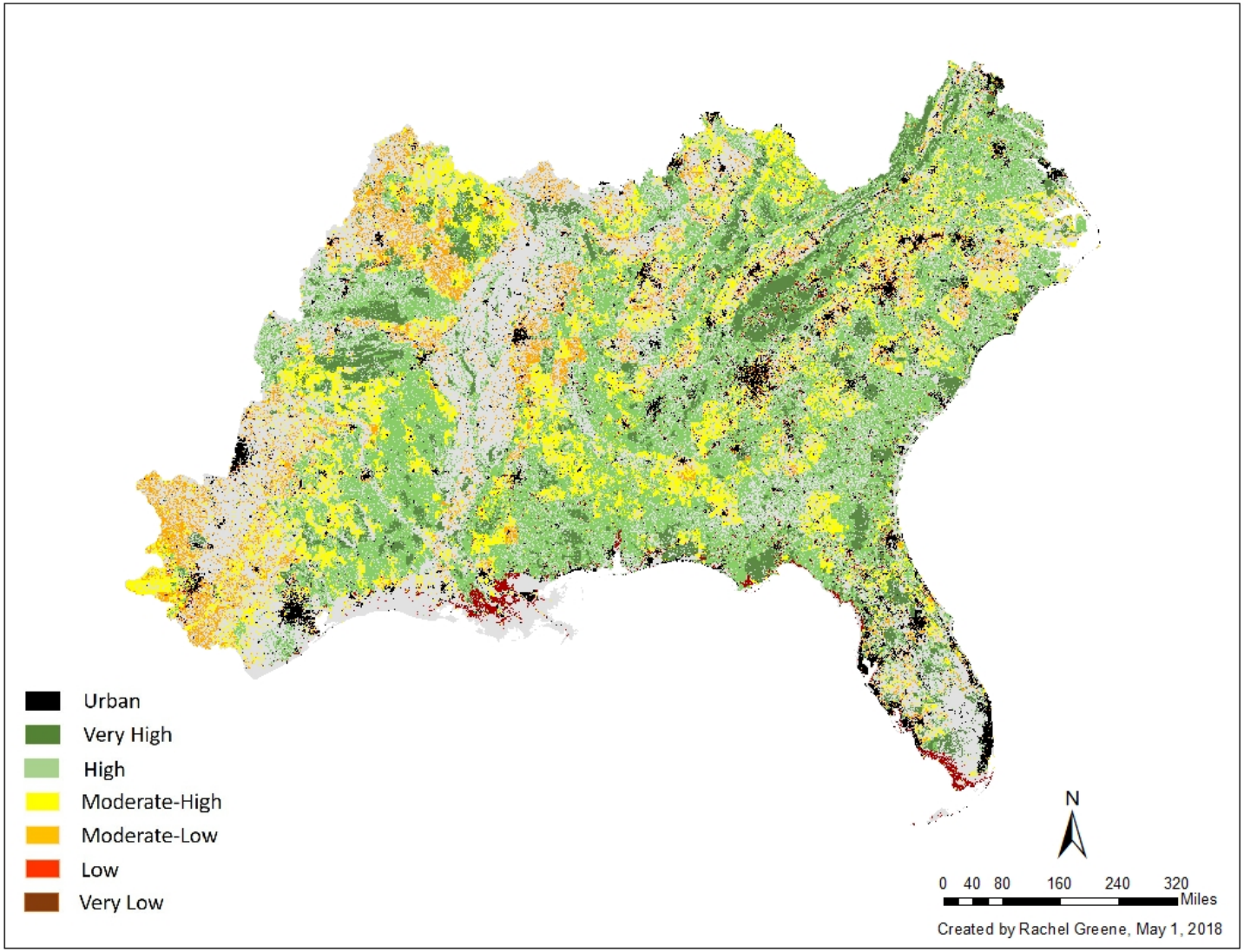

Figure 5. Forestlands of the Southern U.S. stratified by Forest Retention Index classes at year 2030.

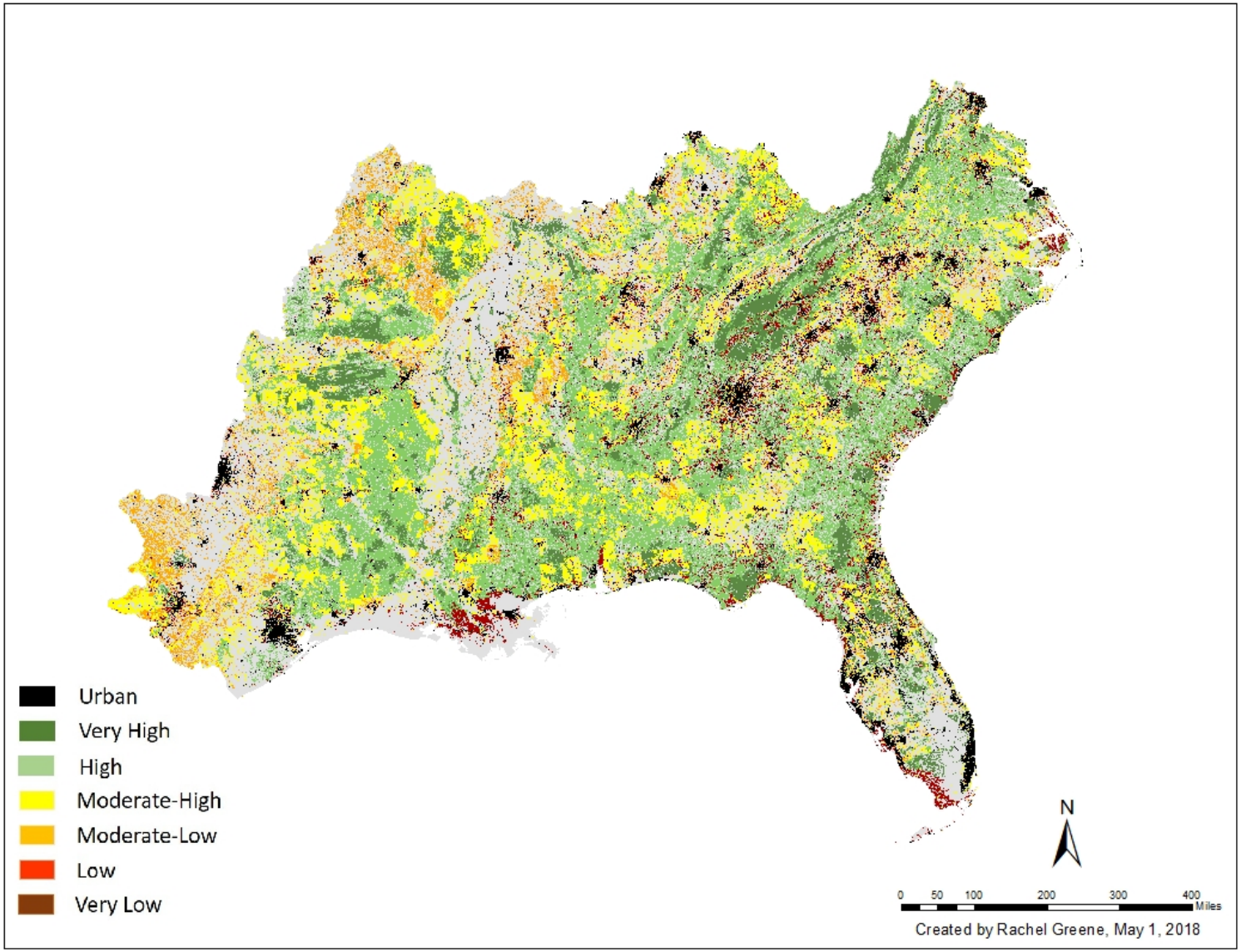

Figure 6. Forestlands of the Southern U.S. stratified by Forest Retention Index classes at year 2060.

Table 2. Forest Retention Index classes in each state and region as forested area (in millions of acres) for all years.

STATE	YEAR	FOREST RETENTION INDEX					
		Very High	High	Moderate-High	Moderate-Low	Low	Very Low
ALABAMA	2030	1.537	14.492	5.779	0.550	0.004	0.453
	2040	1.533	14.082	5.951	0.530	0.005	0.712
	2050	1.532	13.888	5.837	0.539	0.006	1.011
	2060	1.531	13.741	5.709	0.492	0.007	1.333
ARKANSAS	2030	3.843	10.021	3.416	1.571	0.005	0.074
	2040	3.843	8.274	5.104	1.566	0.006	0.137
	2050	3.843	8.247	5.065	1.560	0.007	0.208
	2060	3.843	8.232	5.028	1.533	0.008	0.286
FLORIDA	2030	5.546	7.450	2.564	1.128	0.002	1.639
	2040	5.528	6.307	3.507	1.061	0.006	1.920
	2050	5.507	6.034	3.236	1.202	0.017	2.334
	2060	5.502	5.839	3.239	1.011	0.031	2.708
GEORGIA	2030	3.262	14.690	4.110	0.380	0.006	0.893
	2040	3.262	12.620	5.565	0.368	0.006	1.521
	2050	3.243	12.148	5.314	0.369	0.006	2.263
	2060	3.243	11.865	5.014	0.324	0.006	2.888
ILLINOIS[1]	2030	0.708	0.272	0.031	0.465	0.001	0.003
	2040	0.708	0.062	0.241	0.462	0.001	0.005
	2050	0.708	0.62	0.239	0.462	0.001	0.008
	2060	0.708	0.062	0.240	0.458	0.002	0.011
KENTUCKY	2030	1.601	6.648	4.065	1.180	0.10	0.205
	2040	1.601	5.626	4.959	1.138	0.012	0.373
	2050	1.601	5.549	4.822	1.136	0.014	0.587
	2060	1.601	5.483	4.726	1.063	0.015	0.821
LOUISIANA	2030	1.725	9.068	2.225	0.545	0.001	1.266
	2040	1.716	8.701	2.612	0.545	0.002	1.254
	2050	1.714	8.662	2.592	0.542	0.002	1.319
	2060	1.711	8.640	2.570	0.536	0.002	1.371
MISSISSIPPI	2030	2.286	10.031	4.658	1.770	0.008	0.329
	2040	2.284	8.710	5.805	1.719	0.010	0.553
	2050	2.284	8.552	5.689	1.730	0.013	0.813
	2060	2.284	8.435	5.607	1.651	0.016	1.088
MISSOURI[1]	2030	2.403	1.947	4.667	4.021	0.010	0.071
	2040	2.403	1.789	4.793	3.996	0.012	0.126
	2050	2.403	1.782	4.764	3.969	0.014	0.186
	2060	2.403	1.775	4.732	3.940	0.016	0.253
NORTH CAROLINA	2030	2.889	9.306	4.540	1.242	0.037	0.710
	2040	2.889	8.796	4.685	1.143	0.036	1.175
	2050	2.766	8.284	4.292	1.122	0.035	2.224
	2060	2.769	8.092	4.115	1.016	0.034	2.697
OKLAHOMA[1]	2030	0.998	2.548	1.370	0.412	0.001	0.005

	2040	0.998	1.700	2.213	0.411	0.001	0.011
	2050	0.998	1.696	2.210	0.410	0.001	0.018
	2060	0.998	1.692	2.210	0.407	0.001	0.025
SOUTH	2030	2.232	7.473	1.946	0.332	0.009	0.312
CAROLINA	2040	2.232	7.124	2.101	0.308	0.010	0.529
	2050	2.176	6.872	1.926	0.305	0.010	1.017
	2060	2.179	6.770	1.796	0.263	0.009	1.286
TENNESSEE	2030	2.042	7.207	3.614	1.736	0.034	0.334
	2040	2.042	7.035	3.679	1.614	0.035	0.564
	2050	2.042	6.957	3.507	1.617	0.036	0.809
	2060	2.042	6.899	3.444	1.496	0.037	1.051
TEXAS[1]	2030	1.396	6.478	8.189	6.623	0.024	0.318
	2040	1.394	6.451	8.127	6.539	0.029	0.487
	2050	1.394	6.420	8.061	6.455	0.033	0.664
	2060	1.394	6.390	7.995	6.371	0.037	0.840
VIRGINIA	2030	3.540	10.297	1.673	0.432	0.109	0.213
	2040	3.540	9.379	2.461	0.423	0.101	0.362
	2050	3.527	9.270	2.394	0.423	0.100	0.551
	2060	3.528	9.215	2.314	0.388	0.100	0.720
USFS R8[2]	2030	32.896	115.710	48.149	17.901	0.251	6.752
	2040	32.864	104.806	56.767	17.363	0.259	9.598
	2050	32.628	102.578	54.945	17.412	0.280	13.816
	2060	32.627	101.292	53.767	16.552	0.306	17.114
TOTAL[2]	2030	36.007	117.929	52.847	22.388	0.261	6.826
	2040	36.261	107.168	62.163	21.929	0.273	9.743
	2050	35.739	104.423	59.948	21.843	0.296	14.010
	2060	35.738	103.129	58.739	20.950	0.324	17.377

[1] State is partially included in study area

[2] Excluding Puerto Rico and U.S. Virgin Islands

Potential Reforestation Index

Approximately 4.6 million acres (9.5%) of protected lands (excluding agricultural easements) are classed as High on the Potential Reforestation Index, meaning these lands are currently non-forested and have potential to be reforested. An additional 1.1 million acres are classified as Moderate-High and are concentrated in Oklahoma, Mississippi Alluvial Valley in Arkansas and Tennessee, and peninsular Florida (Figure 7). More than 73 million acres are likely to remain in a non-forest land cover (Potential Reforestation Index classes Low and Very Low) due to high agricultural value of those lands.

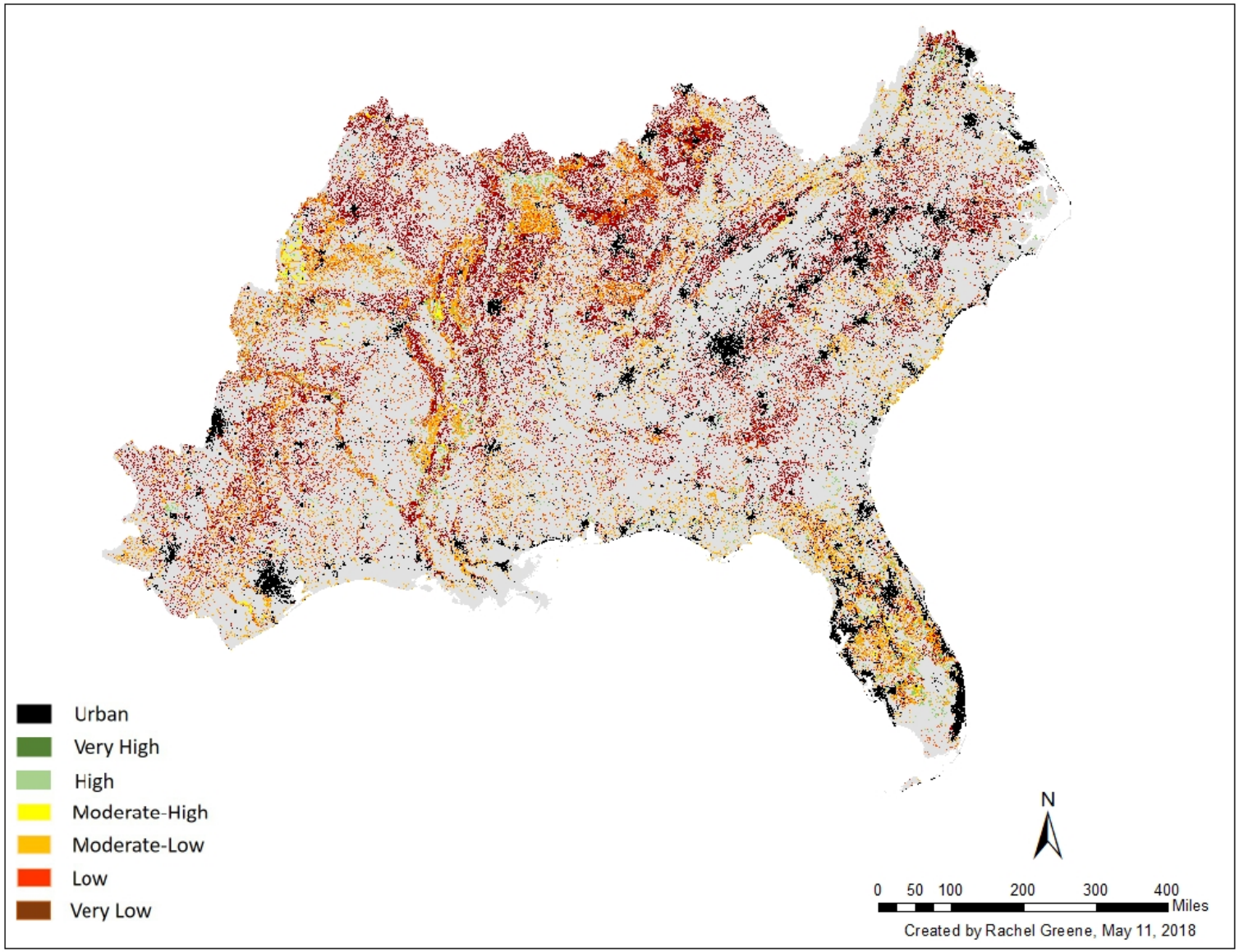

Figure 7. Potential forestlands of the southeastern United States stratified by Potential Reforestation Index class at year 2060.

Gap Analysis: Biodiversity

All Forest Retention Index (FRI) classes captured highly biodiverse areas, which total 9.4 million acres across the Southern States. Nearly 3 million acres having high biodiversity are already protected (Very High), but may be vulnerable to multi-use designations (Table 3, Figure 8). Class High captures 4 million acres, or 43%, of highly biodiverse areas. In the Southern Appalachians, Florida panhandle, central Florida peninsula, and Arkansas, biodiverse areas in High tend to be located near biodiverse areas currently protected (Very High), creating an opportunity for landscape conservation planners to identify biodiverse corridors amongst protected and Tier 1 Priority patches. Class Very Low captures roughly 770,000 acres, or 8%, of highly biodiverse areas

Table 3. Highly biodiverse areas (in millions of acres) stratified by Forest Retention Index class at year 2060.

	Very High	**High**	**Moderate-High**	**Moderate-Low**	**Low**	**Very Low**
High Biodiversity (ac)	2.96	4.03	1.31	0.31	0.01	0.77
FRI Class (ac)	36.28	111.41	49.92	21.87	0.44	17.66

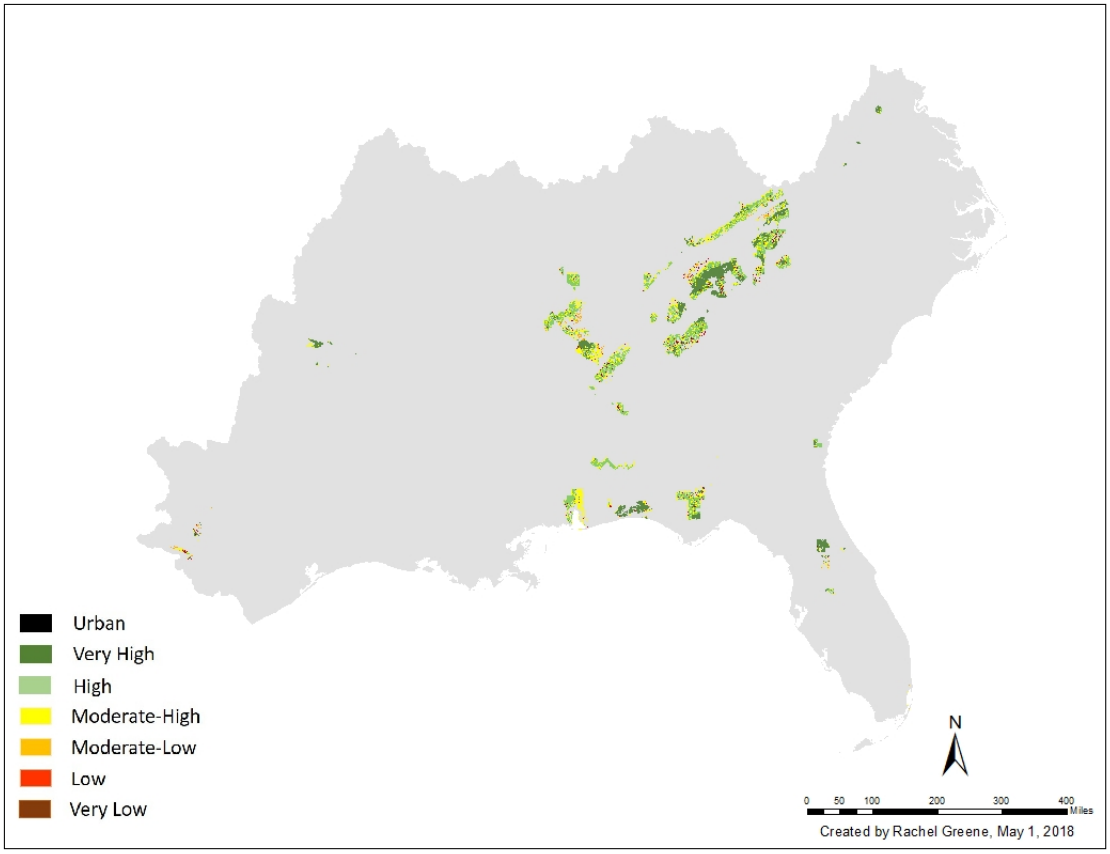

Figure 8. Highly biodiverse areas stratified by Forest Retention Index classes for year 2060.

CONCLUSIONS

The Mapping the South's Forests of the Future builds upon the work of the USFS Southern Forest Futures Project to identify areas of existing, planned and prioritized forest retention and reforestation in the Southern U.S. Much like any other planning effort, it is important to use tools like this to identify areas to target forest retention efforts, particularly as landscapes are subject to rapid conversion to development and volatility in timber markets increases risk in private forestland timber production. This tool provides a collaborative, transparent, and defensible mapping product that can aid in identification of key watershed areas where retaining forests is critical to ecological and socioeconomic integrity in the South. Other initiatives, such as the Keeping Forests as Forests Initiative and the Partnership for Southern Forestland Conservation, can further build upon this tool in their collaborative planning efforts. Moreover, other conservation planning efforts, such as the Southeastern Conservation Adaptation Strategy, may find this tool complimentary to their efforts to identify the most sustainable network of lands and waters to target for conservation efforts in the future.

Through this data compilation effort and qualitative set of indices we suggest 147.7 million acres of forest are projected to be retained, and 4.6 million acres are projected to be reforested with high and very high likelihood out to 2060. Our estimates of future forest loss (Forest Retention Index Low and Very Low) are similar to forecasts from the Southern Forest Futures Project (Wear and Greis 2013). Our analysis indicates that nearly 18 million acres of current forest are very likely to be lost by 2060. Most of this loss will be attributable to continued urbanization associated with human population growth in the region, though other factors such as energy development and sea level rise will impact parts of the region as well. Further, lands currently identified as protected or planned for protection remain at risk to ownership changes and conversion depending on protection status. Of particular concern are public protected lands with multi-use designations that may be at risk for forest loss to energy development. Future research should aim to assess risk of forest loss in designated multi-use protected lands.

This project also represents an unprecedented effort to inventory and compile planned and prioritized areas for land protection, which is not readily available in a single data source at the regional scale. Our team worked directly with 50 organizations and agencies to compile Tier 1 planned areas and Tier 2 prioritized areas for forest protection. While we attempted to be as inclusive and comprehensive as possible, we undoubtedly have inadvertently missed many smaller conservation efforts that aim to protect forestlands in some areas of the Southern U.S. (e.g., urban forests and greenways). Additionally, some conservation organizations we contacted were engaged in dialogue about future forestland conservation, but did not have spatially-defined priorities at this time (e.g., Shortleaf Pine Initiative). Thus, local projects referencing the Mapping the South's Forests of the Future data layers need to evaluate whether all conservation efforts in their area have been included and adjust accordingly.

The data we have compiled here are coalesced to a HUC12 watershed scale to protect proprietary information on planned and protected lands not publicly available, as well as to reduce data processing time, and provide outputs at a scale matching other conservation planning efforts (e.g., KFAF, SECAS). We recommend the data be used to inform decision making at no finer scale than the HUC12 watershed. We intend our map outputs to be useful to large-scale (e.g., regional or state-level) forest retention and conservation planning efforts. However, application to existing watershed-based planning efforts may also be relevant. For instance, timber investment organizations or watershed-based land conservancies may be able to utilize this data to identify key watersheds for forest retention efforts.

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APPENDIX A

Conservation Partners

Listed below are all conservation partners that have contributed to the Mapping the South's Forests of the Future project by providing essential protected priority area data, engaging in dialogue as the project developed its decision tree process, and/or reviewing mapping products.

Alabama Forestry Commission

America's Longleaf Restoration Initiative

Arkansas Agriculture Department

The Conservation Fund

Department of Defense, Readiness and Environmental Protection Integration Program

Florida Department of Agriculture and Consumer Services

Florida Department of Environmental Protection

Florida Fish and Wildlife Resource Commission

Florida Natural Areas Inventory (Florida's Natural Heritage Program)

Georgia Department of Natural Resources

Georgia Forestry Commission

Gulf Coast Joint Venture

Illinois Department of Natural Resources

Keeping Forests as Forests

Kentucky Department of Fish and Wildlife Resources

Kentucky Division of Forestry

Land Trust Alliance

The Longleaf Alliance

Louisiana Department of Wildlife and Fisheries

Lower Mississippi River Conservation Committee

Lower Mississippi Valley Joint Venture

Mississippi Forestry Commission

Mississippi River Trust

Mississippi Wildlife, Fisheries, and Parks

Missouri Department of Conservation

National Council for Air and Stream Improvement, Inc.

Natural Resources Conservation Service

The Nature Conservancy

North Carolina Division of Marine Fisheries

North Carolina Wildlife Resources Commission

Oklahoma Department of Wildlife Conservation

Open Space Institute

Para la Naturaleza

Partnership for Gulf Coast Land Conservation

Partnership for Southern Forestland Conservation

Resource Management Service

Shortleaf Pine Initiative

South Carolina Department of Natural Resources

Southeast Conservation Adaptation Strategy

Southeastern Partnership for Forests and Water

Tall Timbers Research Station and Land Conservancy

Tennessee Department of Agriculture, Division of Forestry

Tennessee Wildlife Resources Agency

Texas Parks and Wildlife

The Trust for Public Land

United States Fish and Wildlife Service

United States Forest Service

United States Geological Survey

Virginia Department of Forestry

Virginia Department of Game and Inland Fisheries

APPENDIX B

Priority Layers

Because conservation partners are at various stages in their prioritization and acquisition processes, we divided priority data into two groups: Tier 1 and Tier 2 Priority Areas. Tier 1 Priority Areas are defined as lands which are forested, or have the capacity to become forested, which are strategically planned for protection, usually associated with a formal acquisition program and designated at the parcel spatial scale (Table 1). In contrast, Tier 2 Priority Areas are regional conservation priorities, typically designated at broad spatial scales and whose acquisition has varying degrees of certainty and may be more opportunistic in nature (Table 2).

Table 1. Tier 1 priority data layers used to identify areas highly prioritized for conservation action in Forest Retention Index and Potential Reforestation Index maps. Tier 1 priorities are defined as lands which are forested, or have the capacity to become forested, which are strategically planned for protection, usually associated with a formal acquisition program designated at the parcel spatial scale.

Layer	Source	Coverage	Format	Citation
Florida Forever Board of Trustees Projects	Florida Natural Areas Inventory	Florida	Vector	Florida Natural Areas Inventory. Florida Forever Board of Trustees Projects, December 2017.
Land, Water, & Conservation Fund Purchase Areas	Land, Water, & Conservation Fund	Southeast	Vector	USDA Forest Service. Land, Water, and Conservation Fund: Proposed Land Purchases, October 2017
Longleaf Priority Protection Areas	The Nature Conservancy	Southeast	Vector	The Nature Conservancy, December 2014
Rural and Family Lands Protection Program	Florida Department of Agriculture & Consumer Services	Florida	Vector	Florida Department of Agriculture and Consumer Services, November 2017
United States Fish & Wildlife Service Approved Acquisition Boundaries	United States Fish & Wildlife Service	Southeast	Vector	United States Fish & Wildlife Service, 2017
United States Forest Service Approved Acquisition Boundaries	United States Forest Service	Southeast	Vector	USDA Forest Service, November 2017

Table 2. Tier 2 priority data layers used to identify areas prioritized for conservation action in Forest Retention Index and Potential Reforestation Index maps. Tier 2 priorities are defined as lands which are forested, or have the capacity to become forested, which are identified as regional conservation priorities, typically designated at broad spatial scales, whose acquisition has varying degrees of certainty and may be opportunistic in nature.

Layer	Source	Coverage	Format	Citation
Alabama Forest Legacy Program, Priority 1[a]	Alabama Forestry Commission[b]	Alabama	Vector	Alabama Forestry Commission, 2002
Alabama Strategic Habitat Units (SHUs)	U.S. Fish & Wildlife Service, Geologic Survey of Alabama	Alabama, Florida, Georgia, Mississippi, Tennessee	Vector	U.S. Fish and Wildlife Service Alabama Department of Conservation and Natural Resources, Geological Survey of Alabama, and Alabama Clean Water Partnership, 2015
Arkansas Forest Legacy Areas[a]	Arkansas Agriculture Department	Arkansas	Vector	Arkansas Agriculture Department, 2017
Arkansas Pine Focal Area: AR-LA Open Pine Merge	U.S. Fish & Wildlife Service	Arkansas, Louisiana	Vector	U.S. Fish and Wildlife Service, Partners for Fish and Wildlife Program, 2017.
Arkansas Pine Focal Area: Ozark Shortleaf Open Pine Woodland	U.S. Fish & Wildlife Service	Arkansas	Vector	U.S. Fish and Wildlife Service, Partners for Fish and Wildlife Program, 2017.
Arkansas Pine Focal Area: WGCP Shortleaf	U.S. Fish & Wildlife Service	Arkansas	Vector	U.S. Fish and Wildlife Service, Partners for Fish and Wildlife Program, 2017.
Arkansas Wetland Focal Areas	U.S. Fish & Wildlife Service	Arkansas	Vector	U.S. Fish and Wildlife Service, Partners for Fish and Wildlife Program, 2017.
Arkansas-Louisiana West Gulf Coastal Plain Conservation Delivery Network	Lower Mississippi Valley Joint Venture	Arkansas, Louisiana	Vector	Lower Mississippi Valley Joint Venture, 2016
Arkansas-Mississippi Alluvial Valley Conservation Delivery Network	Lower Mississippi Valley Joint Venture	Arkansas, Mississippi	Vector	Lower Mississippi Valley Joint Venture, June 2017
Critical Lands & Waters Identification Project: Aggregated	Florida Fish & Wildlife Resource Commission	Florida	Vector & Raster	Florida Fish & Wildlife Resource Commission, Florida Natural Areas Inventory, Critical Lands & Waters Identification

Resource Priorities, Rank 4 & 5[a]				Project, version 4, August 2016
Florida Springs Priority Focus Areas[a]	Florida Department of Environmental Protection	Florida	Vector	Florida Department of Environmental Protection, September 2016
Georgia Conservation Opportunity Areas[a]	Georgia Department of Natural Resources, Wildlife Resources Division	Georgia	Vector	Georgia Department of Natural Resources, Wildlife Resources Division, 2008
Georgia Forest Legacy Areas[a]	Georgia Forestry Commission[b]	Georgia	Vector	Georgia Forestry Commission, October 2016
Illinois Conservation Opportunity Areas[a]	Illinois Department of Natural Resources	Illinois	Vector	Illinois Department of Natural Resources, 2013
Kentucky Forest Legacy Areas[a]	Kentucky Division of Forestry	Kentucky	Vector	Kentucky Division of Forestry, February 2018
Kentucky Tier 1 Conservation Areas[a]	Kentucky Department of Fish & Wildlife Resources	Kentucky	Vector	Kentucky Department of Fish & Wildlife Resources, 2015
Longleaf Pine Local Implementation Team Target Regions	America's Longleaf Restoration Initiative	Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas, Virginia	Vector	America's Longleaf Restoration Initiative, Longleaf Pine Local Implementation Teams, 2014
Louisiana Conservation Opportunity Areas[a]	Louisiana Department of Wildlife & Fisheries	Louisiana	Vector	Louisiana Department of Wildlife & Fisheries, August 2015
Louisiana-Mississippi Conservation Delivery Network	Lower Mississippi Valley Joint Venture	Louisiana, Mississippi	Vector	Lower Mississippi Valley Joint Venture, 2013
Mississippi Conservation Opportunity Areas[a]	Mississippi Wildlife, Fisheries, & Parks	Alabama, Mississippi	Vector	Mississippi Wildlife, Fisheries, & Parks, 2015

Mississippi Forest Legacy Areas[a]	Mississippi Forestry Commission	Mississippi	Vector	Mississippi Forestry Commission, 2007
Missouri Forest & Woodland Conservation Opportunity Areas[a]	Missouri Department of Conservation	Missouri	Vector	Missouri Department of Conservation, 2015
Missouri Priority Geographies 2016[a]	Missouri Department of Conservation	Missouri	Vector	Missouri Department of Conservation, 2016
North Carolina Strategic Habitat Areas, Region 1	North Carolina Division of Marine Fisheries	North Carolina	Vector	North Carolina Division of Marine Fisheries, 2009
North Carolina Strategic Habitat Areas, Region 2	North Carolina Division of Marine Fisheries	North Carolina	Vector	North Carolina Division of Marine Fisheries, 2011
North Carolina Wildlife Action Plan Priority[a]	North Carolina Wildlife Resources Commission	North Carolina	Vector	North Carolina Wildlife Resources Commission, 2015
Northeast Texas Conservation Delivery Network	Lower Mississippi Valley Joint Venture	Texas	Vector	Lower Mississippi Valley Joint Venture, 2017
Oklahoma Conservation Priority Areas[a]	Oklahoma Department of Wildlife Conservation	Oklahoma	Vector	Oklahoma Department of Wildlife Conservation, August 2013
Partnership for Gulf Coast Land Conservation's Conservation Vision	Partnership for Gulf Coast Land Conservation	Alabama, Florida, Georgia, Louisiana, Mississippi, Texas	Vector	Partnership for Gulf Coast Land Conservation, 2014
Priority Protection Areas for Migratory Landbirds in the Gulf Coast JV	Gulf Coast Joint Venture	Alabama, Louisiana, Mississippi, Texas	Vector	Gulf Coast Joint Venture, 2014
Priority Watersheds in the Edwards Plateau Region[a]	Texas Parks and Wildlife	Texas	Vector	Texas Parks and Wildlife, 2013
Resilient and Connected Landscapes: Prioritized Network	The Nature Conservancy	East of Mississippi River (AL, FL, GA, KY, MS, NC, SC, TN, VA)	Raster	The Nature Conservancy, January 2017

South Carolina Wildlife Priority Focus Area[a]	South Carolina Department of Natural Resources	South Carolina	Vector	South Carolina Department of Natural Resources, 2015
Southeast Conservation Adaptation Strategy Blueprint, v.2	Southeast Conservation Adaptation Strategy	Southeast	Raster	Southeast Conservation Adaptation Strategy, December 2017
Tennessee Proposed Forest Legacy Properties[a]	Tennessee Department of Agriculture, Division of Forestry	Tennessee	Vector	Tennessee Department of Agriculture, Division of Forestry, 2010
Tennessee Terrestrial Priority Habitat: Very High and High[a]	Tennessee Wildlife Resources Agency	Tennessee	Vector	Tennessee Wildlife Resources Agency, 2015
Virginia Forest Legacy Areas[a]	Virginia Department of Forestry	Virginia	Vector	Virginia Department of Forestry, 2007
Virginia Priority Wildlife Diversity Conservation Areas[a]	Virginia Department of Game & Inland Fisheries	Virginia	Vector & Raster	Virginia Department of Game & Inland Fisheries, 2009

[a] Data associated with a state agency, usually attached to a wildlife or forest action plan

[b] Provided non-spatial data; spatial data created by Mapping the South's Forests of the Future project

APPENDIX C

Data Collection

Protected Lands and Priority Areas

We collected datasets of currently protected and land prioritized for protection from August 2017 through March 2018. Protected Areas Database-U.S. and National Conservation Easement Database are national, publicly-available datasets providing data about protected, fee simple and easement properties held privately or in public trust. We searched databases maintained by states to capture recent transactions of protected land and priority areas identified in State Wildlife Action Plans, Forest Resource Assessments and Strategies, and Forest Action Plans. When such data were not available for download online, we contacted the appropriate agencies and organizations to obtain datasets. We contacted numerous non-governmental organizations for protected land and priority area datasets including but not limited to The Nature Conservancy, The Conservation Fund, Open Space Institute, Longleaf Pine Initiative partners, Shortleaf Pine Initiative, Partnership for Gulf Coast Land Conservation, Lower Mississippi Valley Joint Venture, Gulf Coast Joint Venture, SECAS, and all Landscape Conservation Cooperatives within the MFF area. In addition, we attempted to include data from federal programs such as U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program and Department of Defense's Readiness and Environmental Protection Integration. All data were converted to North American 1983 datum and Albers projection, and clipped to the MFF geographic area.

Threats to Forest Retention

Urbanization is a primary threat to forests in the southeastern U.S. and presents a challenge for long-term conservation strategies and landscape planning. To capture the potential extent of future urbanization, we used SLEUTH models, so named for the input models (Slope, Land use, Excluded, Urban, Transportation, and Hillshade) for years 2030, 2040, 2050, and 2060. The SLEUTH model was initially developed by Dr. Keith C. Clarke at the University of California, Santa Barbara, modified by David I Doato of the U.S. Geological Survey Eastern Geographic Science Center, and further modified and implemented for the Southeast by the Biodiversity and Spatial Information Center at North Carolina State University (Jantz et al. 2009, NCGIA 2011; for further information, visit www.basic.ncsu.edu/dsl/urb.html). For each decade of interest, we classified SLEUTH's probability of urbanization (P_U) into three classes: high ($P_U \geq 90\%$), moderate ($P_U \geq 50\%$ and $< 90\%$), and low ($P_U < 50\%$).

Climate change can directly and indirectly affect the extent, type, and health of the Southeast's forests due to alterations in rainfall and temperature patterns, ranges of pests and disease, and wildfire risk, among other factors (McNab et al. 2014, USDA Forest Service 2016). Because Mapping the South's Forests of the Future does not discriminate among forest types or condition classes, we limited our evaluation of the effects of climate change to coastal forests, where inundation from sea level rise and the associated inward migration of wetlands and forests can result in forest loss along the Southeast's extensive coast line (Williams et al. 1999, DeSantis et al. 2007, Doyle et al. 2010, Florida Oceans and Coastal Council 2010). We used datasets of

inundation extent from National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center which projects potential inundation of coastal areas above current mean higher high water conditions. These datasets use a modified bathtub approach that attempts to account for local and regional tidal variability as well as hydrological connectivity. For decades 2030 through 2060, we implemented an inundation model of one-foot rise in sea level by 2100.

Because inundation data does not capture coastal forest migration, we used Sea Level Rise Transition Areas, which reflects transition of ecosystems as well as complete loss of land projected to occur by 2050 for the Atlantic coast and Florida's Gulf coast line (South Atlantic LCC 2015). For the Gulf Coast, we used Tidal Saline Wetland Migration, which projects migration of mangrove forests, salt marshes, and salt flats based on alternative sea level rise scenarios for years 2030, 2040, 2050, and 2060 (Enwright et al. 2015). Tidal Saline Wetland Migration includes five sea level rise scenarios (0.5-, 1.0-, 1.2-, 1.5-, and 2.0-meter rise by 2100) and the option of including physical barriers to migration. We chose 0.5-meter rise (approximately corresponding to 1-foot sea level rise in NOAA data) and inclusion of physical barriers. We used Sea Level Rise Transition Areas data for years 2050 and 2060. We used Tidal Saline Wetland Migration for all years of analysis.

The final threat to forest retention that we examined is forest loss to energy development in the Southern Appalachian Mountains. The Appalachians are extensively forested, containing important remnants of Temperate Conifer and Broadleaf forests (Dunscomb et al. 2014). The area is biologically rich, housing two of the Southeast's five biodiversity hotspots (Jenkins et al. 2015) and numerous imperiled species (Chaplin et al. 2000) and provides vital ecosystem services, including the provision of clean drinking water to 22 million people (Dunscomb et al. 2014, Caldwell et al. 2016). The Appalachians have long been mined for coal and, more recently, shale gas extraction. With broad southwest-to-northeast tending ridges, the Appalachian Mountains extending from western Pennsylvania to eastern West Virginia contain some of the windiest areas east of the Mississippi River, making it prime real estate for wind energy development that could assist Eastern states in meeting renewable energy standards (Dunscomb et al. 2014). The Appalachian Landscape Conservation Cooperative (LCC) and The Nature Conservancy partnered to develop a risk assessment for future energy development to quantify potential impacts on forest and aquatic resources across 146 million acres in 15 states. The analysis determined that nearly 7.6 million acres, 71% of which is forested, within the Appalachian LCC geography have a high (< 90%) probability of energy development from one or more sources. Areas at high risk are concentrated on the Allegheny and Cumberland plateaus, and 10% of areas at high risk are intact patches of interior forest habitat (Dunscomb et al. 2014). While we acknowledge that energy development and extraction activities occur in other areas of the South, we were unable to obtain a satisfactory dataset that qualified risk of forests in areas outside the Appalachian LCC.

Socio-Economic Value

We also examined socio-economic value of forests as they relate to timber markets and surface drinking water. To determine areas of high timber value, we used the Timber Products Output dataset from the U.S. Forest Service's Forest Inventory and Analysis program. Timber Products

Output details the amount of timber processed at mills for all categories of timber products (e.g., saw logs, veneer logs, pulpwood, composite, post) for every county in the Southeast. For this analysis, we used the summation of all products (measured in million cubic feet) and divided the dataset into five quantiles. In our quantile analysis, data is ordered from least to greatest, and divided such that each quantile contains 20% of data. We determined the highest two quantiles (i.e., top 40% of timber-producing counties) to have high socio-economic value based on timber production.

Forests are also critical to providing clean drinking water, and forest conservation is utilized as a method of maintaining water quality for urban areas while reducing the need for costly water filtration facilities. To determine areas of high value to surface drinking water, we used the U.S. Forest Service's Forests to Faucets project output "Forest Importance to Surface Drinking Water." The underlying model includes surface drinking water intake locations and population, mean annual water supply, land cover and ownership information, and forest threats (i.e., wildland fire potential, insect and disease risk, and expected increase in housing density; Weidner and Todd 2011). The resulting index ranges from 0 to 100 and is summarized for 12-digit hydrologic units (HUCs). We divided the dataset into five quantiles and determined the highest two quantiles to have high socio-economic value based on contributions to surface drinking water.

We combined quantile analysis outputs for Timber Products Output and Forests to Faucets data into a single layer. Thus, a location may be determined to have high socio-economic value if it is located in the top two quantile of Timber Products Output or Forests to Faucets. Because Timber Products Output and Forests to Faucets output are inherently forest-based, these datasets were used to determine socio-economic value only for areas currently in forest land cover.

Reforestation Opportunities

We used two datasets to determine areas currently occupied by agriculture that may be most conducive to reforestation efforts: National Commodity Crop Productivity Index (NCCPI) and Potentially Restorable Wetlands on Agriculture Land (PRWAg). The NCCPI is available from USDA Natural Resources Conservation Service as part of Gridded Soil Survey Geographic (gSSURGO) Database's National Value Added Look Up (Valu1) Table (gSSURGO Version 2.2; NRCS 2016). Index values are available for corn/soybeans, small grains, and cotton crop with low index values indicating low productivity and high index values indicating high productivity. We used NCCPI to identify marginal agriculture land, defined as an index value of less than 0.4 for the highest-valued crop category. The PRWAg dataset was developed from three layers: 1) 2011 National Land Cover Data classes pasture/hay and cultivated crops; 2) poorly- and very poorly-drained soils identified from NRCS's Soil Survey, and; 3) Composite Topographic Index (CTI 2012), a wetness index. PRWAg has four classes of wetland restoration potential: unsuitable, low, moderate, and high summarized by 12-digit HUC. We included low, moderate, and high classes in our analysis.

Land Cover Classifications

We used the 2011 National Land Cover Database (NLCD; U.S. Geological Survey, GAP 2011) to determine current land cover status. The NLCD uses a many-tiered classification system. We re-classified NLCD into two classes: Forest and Non-Forest. Forest includes deciduous forest (value=41), evergreen forest (42), mixed forest (43), shrub/scrub (52), and woody wetlands (90). All other classes were re-classified as Non-Forest.