Assessing the Impact of Ecological Considerations on Forest Biomass Projections for the Southeastern U.S.

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Executive Summary

This report evaluates the impact that administrative and ecological constraints might have on the amount of forest biomass that could be extracted for energy use in the Southeastern U.S. Using available spatial datasets, we quantified and mapped how the application of various "conservation value screens" would change previous estimates of available standing forest biomass (Blackard et al. 2008). These value screens included protected areas managed for conservation values, USDA Forest Service and Bureau of Land Management (BLM) lands, steep slopes, designated critical habitat for federally-listed threatened and endangered species, inventoried roadless areas, old-growth forests, wetlands, hydrographic (lake, stream, and coastline) buffers, and locations of threatened and endangered species (G1-G3, S1-S3).

Two alternative combinations of values were examined: in Alternative 1, all areas within value screens, including all Forest Service and BLM lands, were excluded from biomass development. In Alternative 2, Forest Service and BLM lands not afforded extra protection by such designations as wilderness or research natural areas were assumed available for biomass extraction; all other values continued to be excluded from extraction. In both alternatives, biomass located within the Wildland-Urban Interface (WUI) was assumed available for extraction regardless of conservation value screens.

The analysis was conducted at 100-m x 100-m resolution. Summary statistics were derived at three scales – entire study area, 13 states, and 24 World Wildlife Fund (WWF) ecoregions. Results were also summarized and mapped for all 1,342 counties.

Finally, we compared hydrologic datasets at two different scales (1:24,000 and 1:100,000) at multiple sample areas in the study area to evaluate how hydrologic scale might affect the delineation of riparian reserves and resulting estimates of biomass availability.

General findings:

- Total forest biomass in the Southeastern U.S. is nearly 11 billion dry tons, of which 3.8 billion tons (almost 35%) were excluded under Alternative 1 and 3.4 billion tons (31%) under Alternative 2.
- Only 3 percent of the mapped biomass was found within WUI areas.
- The states with the highest levels of excluded forest biomass were Louisiana and Florida, due largely to the large proportion of wetlands, lakes, and streams in these states.
- Proportions of excluded forest biomass vary widely among the different southeastern forest ecoregions (22% - 82% for Alternative 1 and 20% - 82% for Alternative 2).
- Ecoregions where Forest Service lands played the most important role were the Appalachian/Blue Ridge Forests, Piney Woods, and Ozark Mountains Forests.
- County map results showed that most exclusions were along the Atlantic and Gulf coasts, the Mississippi River basin, and where protected areas or Forest Service lands occurred.
- County level GIS data is detailed enough for forest biomass development planning.

Introduction

With rising energy prices and the growing concern over the environmental consequences of burning fossil fuels (most prominently climate change) alternative energy sources are being sought throughout the world. While only one percent of the world's energy consumption is derived from biomass today, it is estimated that as much as 15 percent can be achieved by 2020 (Bauen et al. 2004).

The U.S. economy uses biomass-based materials for energy in several ways. Wastes from agriculture and forestry are burned to generate heat and electricity; biomass is converted to a liquid form for use as a transportation fuel; and biomass materials are used directly in the manufacture of products (Haq 2002).

Currently, the U.S. bioelectricity industry is located primarily in the eastern states and the Pacific coast, representing a $15 billion investment and 66,000 jobs (Bauen et al. 2004). Biomass has played a small role in terms of the overall U.S. electrical energy consumption, supplying 3.2 quadrillion BTUs of energy out of a total 98.5 quadrillion BTUs of energy in 2000 (EIA 2001). Increases are expected to be minor by 2020 under a business-as-usual scenario. However, if policy and incentives continue to promote biomass as a fuel alternative, the contribution to the U.S. electrical energy by 2020 could be significant (Haq 2002).

The U.S. Department of Energy (DOE) and the Department of Agriculture (USDA) are strongly committed to developing biomass as an energy alternative. They believe that by expanding the use of biofuels the country will (1) reduce oil and gas imports, (2) enhance forestry and rural economies, and (3) promote development of new domestic industries, such as biorefineries. The R&D Technical Advisory Committee, commissioned by Congress to guide federally-funded biomass research and development, expects a 30 percent replacement of current fossil fuel consumption with domestic biofuels by 2030 (Perlack et al. 2005). In one scenario, Perlack et al. (2005) predict that the U.S. could sustainably harvest 1366 million dry tons (MDT) of biomass per year, with the larger component coming from agricultural sources (998 MDT per year) and the remainder coming from forest resources (368 MDT per year). Of this projection, 52 MDT would come from fuelwood harvesting, 145 MDT from mill residue, 47 MDT from urban wood residue and construction debris, 64 MDT from logging and sire clearing for construction, and 60 MDT from forest fuel treatments to reduce fire risk. This scenario assumed that not all forested areas would be accessible and some environmentally sensitive areas would be excluded, although no details were provided.

Although biofuels have been heralded as one of the most promising alternative energy sources for reducing greenhouse gas emissions (Farrell at al. 2006; Ragauskas et al. 2006), others have cautioned its widespread development could have significant negative consequences for biodiversity and could exacerbate a host of other environmental problems, including soil degradation and air pollution (Cook et al. 1991; Worldwatch Institute 2006; Groom et al. 2008). In a recent article in Science, Scharlemann and Laurance (2008) highlight a new study by Zah et al. (2007) who evaluated the relative merits of different types of biofuels. They found that not all biomass sources are equally beneficial to the environment. In fact, some are as damaging as

the fossil fuels they are intended to offset. "Different biofuels vary enormously in how eco-friendly they are," said Laurance. "We need to be smart and promote the right biofuels, or we won't be helping the environment much at all" (Smithsonian Tropical Research Institute 2008). Rapid development of biomass as an energy alternative without careful consideration of adverse environmental effects might help achieve some climate change abatement goals on the one hand, but could devastate important biological and ecological values on the other.

Purpose

The purpose of this report was to assess the potential effect that known and mapable conservation values could have on forest biomass development projections for the Southeastern U.S. The study area is an important timber-producing region and also supports some of the most biologically rich and diverse areas in North America. Working with the only spatial dataset on forest biomass for the U.S. (Blackard et al. 2008), we evaluated the potential limits that administrative and ecological restrictions might have on the amount of standing biomass available for biofuel development. The values we assessed included existing protected areas, Forest Service and BLM lands, steep slopes, designated critical habitat for federally listed endangered species, inventoried roadless areas, old-growth forests, wetlands, hydrographic (lake, stream, and coastline) buffers, and locations of threatened and endangered species (G1-G3, S1-S3).

Methods

Study Area

We defined the Southeastern U.S. as the 13 states from Virginia in the northeast to Texas in the southwest, as also defined by Region 8 of the U.S. Forest Service. All or part of 24 distinct World Wildlife Fund (WWF) ecoregions overlap these states (Figure 1). We compiled and summarized biomass and conservation value data for the entire Southeast region, each of the 13 states, and each ecoregion within the study area, at a resolution of 1 ha (2.47 ac). We also mapped results at the county level, which aided visualization of how conservation values might limit the distribution of biomass development throughout the study area.

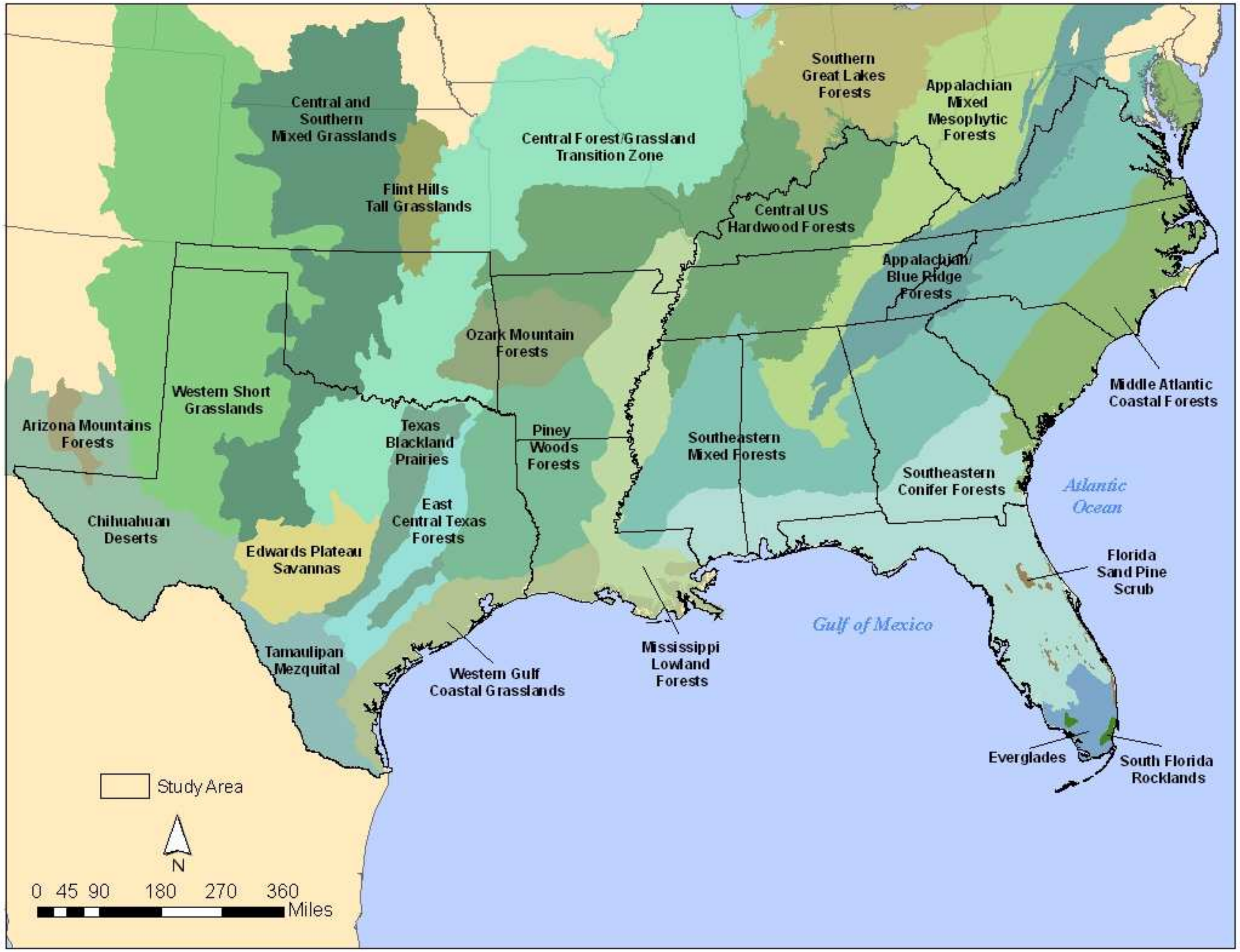

Figure 1. States and WWF ecoregions assessed in the forest biomass analysis.

Datasets

Table 1 lists datasets used to estimate biomass and to delineate potential administrative and ecological constraints on biomass extraction. These came from a variety of sources in different formats and scales. For all but three datasets, geographic extent included the entire country. The three exceptions were for threatened and endangered species data, which we obtained only for North Carolina; old-growth forest data, which we obtained only for a relatively small area in the Southern Appalachians; and hydrography (streams) data, for which we only used a sampling of 1:24,000-scale data.

The forest biomass dataset was produced by the USDA Forest Service national assessment of forest biomass resources (Blackard et al. 2008; USDA Forest Service Forest Inventory and Analysis Program 2008). They combined stand-level data from Forest Inventory and Analysis (FIA) records and other digital geographic predictor layers to model above-ground, live forest biomass at 250-meter resolution (in tons per acre) for the United States. Biomass was defined as live tree bole wood, stumps, branches, and twigs from trees larger than 1 inch in diameter. This biomass also had to be located in forest patches at least 1 acre in size with at least 10 percent stocking, a minimum canopy width of 120 feet, and containing no non-forest land uses. Predictor layers included in the modeling were 16-day Moderate Resolution Imaging Spectro-radiometer (MODIS) satellite image composites, vegetation indices, tree cover, topography, and climate data (precipitation and temperature). To accommodate the varying conditions encountered across the large national extent, separate models were developed for 65 ecologically unique mapping zones developed by Homer and Gallant (2001) for the 2001 National Land Cover Dataset. This dataset was intended to estimate forest carbon storage and net fluxes from land-use change in a spatially explicit fashion for the nation. It is the only such dataset available for this analysis.

Table 1. List of datasets used in the analysis.

Name	Type	Scale/ Resolution	Source	Year
Contiguous U.S. Biomass map	Raster	250 meter	USDA Forest Service Forest Inventory and Analysis Program. Retrieved from the Forest Service Geodata Clearinghouse.	2008
Critical Habitat (Plants, Reptiles, Mammals, Invertebrates, Fish, Birds, Amphibians)	Vector	Various	US Fish and Wildlife Service and the Conservation Biology Institute.	2008
Threatened and Endangered Species Points	Vector	None	North Carolina Department of Environment and Natural Resources.	2003
Federal Lands of the United States	Vector	1:2,000,000	National Atlas of the United States	2005
Inventoried Roadless Areas	Vector	1:24,000 - 1:126,720	USDA Forest Service Geospatial Service and Technology Center. Retrieved from the USDA Forest Service Roadless Area Conservation website.	2008
National Hydrography Dataset	Vector	1:100,000	US EPA, USGS. Retrieved from: NHDPlus; Horizon Systems Corporation.	2005
National Hydrography Dataset -- High Resolution	Vector	1:24,000	USGS, US EPA. Retrieved from USGS NHD Geodatabase.	2004
National Land Cover Dataset	Raster	30 meter	USGS. Retrieved from the Multi-Resolution Land Characteristics Consortium.	2001
National Wetlands Inventory	Vector	1:24,000/ 1:25,000	US Fish and Wildlife Service. Retrieved from: USFWS National Wetlands Inventory website.	2007
Potential Old-Growth Forest	Vector	Unknown	Southern Appalachian Man and Biosphere Project.	1996
Protected Areas Database	Vector	1:24,000 - 1:100,000	Conservation Biology Institute.	2006
SRTM Digital Elevation Data	Raster	90 meter	Jarvis et al., International Centre for Tropical Agriculture. Retrieved from CGIAR-CSI.	2006
Surface Management Agency	Vector	Unknown	Bureau of Land Management National Integrated Lands System Project.	2009
Wildland Urban Interface	Vector	1:100,000	Radeloff et al. Retrieved from: SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin, Madison.	2005

Administrative and Ecological Constraints

We evaluated how administrative and ecological constraints ("conservation value screens") might limit estimates of forest biomass available for development in the southeastern United States (Figure 2). Potentially constrained lands included Forest Service and BLM lands, designated critical habitat, inventoried roadless areas, protected areas managed for conservation values, steep slopes, wetlands, old-growth forests, and hydrographic buffer zones. Because of the spatial overlap between these screens, we also considered two alternative combinations of values.

USDA Forest Service lands were selected from the most recent CBI Protected Areas Database (2006) by extracting areas designated as "National Forest", "National Grassland", or lands where the managing agency was the USDA Forest Service. Table 2 lists national forests and grasslands within the study area.

BLM land ownership data is incomplete within the study area, and several datasets were used to create the most comprehensive coverage possible. Polygons were selected from three datasets: the most recent CBI Protected Areas Database (2006), Federal Lands of the United States (2005), and the Surface Management Area dataset (2009, unpublished).

For designated critical habitat, we used vector GIS data originally produced by the U.S. Fish and Wildlife Service for 41 species present in the Southeast, including 4 mammals, 4 birds, 2 reptiles, 2 amphibians, 10 fishes, 14 invertebrates, and 5 plants (Table 3) (U.S. Fish and Wildlife Service and Conservation Biology Institute 2008).

Roadless areas were considered one of the special designations within national forests. Roadless area polygons were obtained from the USDA Forest Service Inventoried Roadless Areas file (USDA Forest Service Geospatial Service and Technology Center 2008).

Protected areas were defined as having GAP 1 (strictly protected) or GAP 2 (moderately protected) conservation status and selected from the Conservation Biology Institute's Protected Areas Database (2006). These lands are generally managed for the protection of natural values and processes (Scott et al. 1993). Example designations considered as protected included National Wildlife Refuges, Research Natural Areas, state parks, Wilderness Areas, Special Biological Areas, Wild and Scenic Rivers, Botanic Areas, and some state Wildlife Management Areas.

Areas of steep slope were modeled from NASA Shuttle Radar Topographic Mission (SRTM) 90 meter resolution digital elevation data from CGIAR-CSI (Jarvis, Reuter et al. 2006) using the slope tool in ArcGIS 9.2. For this analysis, we considered slopes greater than 35 percent on Forest Service land, and 30 percent on private and other public land, to be steeper than ecologically desirable for the removal of forest biomass. These parameters have been used in similar studies as a reflection of timber extraction practices (California Energy Commission 2005).

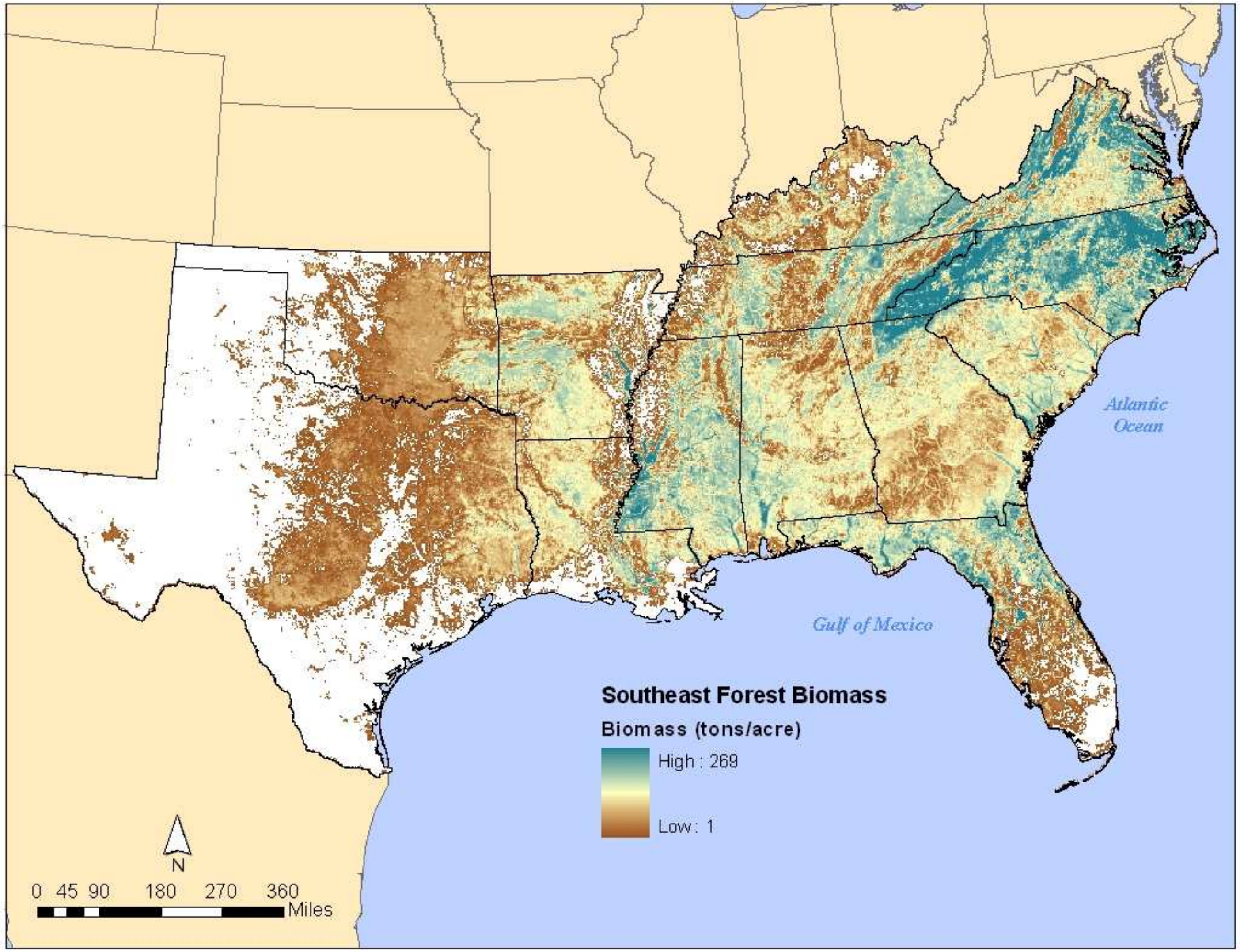

Figure 2. Southeast forest biomass (dry tons/acre) as mapped by Blackard et al. (2008).

Table 2. List of National Forests and National Grasslands within the study area.

Name	State
Conecuh National Forest	Alabama
Talladega National Forest	Alabama
Tuskegee National Forest	Alabama
William B. Bankhead National Forest	Alabama
Ozark National Forest	Arkansas
Apalachicola National Forest	Florida
Ocala National Forest	Florida
Osceola National Forest	Florida
Chattahoochee National Forest	Georgia
Oconee National Forest	Georgia
Daniel Boone National Forest	Kentucky
Kisatchie National Forest	Louisiana
Bienville National Forest	Mississippi
Delta National Forest	Mississippi
DeSoto National Forest	Mississippi
Holly Springs National Forest	Mississippi
Homochitto National Forest	Mississippi
Tombigbee National Forest	Mississippi
Croatan National Forest	North Carolina
Nantahala National Forest	North Carolina
Pisgah National Forest	North Carolina
Uwharrie National Forest	North Carolina
Black Kettle National Grassland	Oklahoma
Rita Blanca National Grassland	Oklahoma
Ouachita National Forest	Oklahoma, Arkansas
Francis Marion National Forest	South Carolina
Sumter National Forest	South Carolina
Cherokee National Forest	Tennessee
Angelina National Forest	Texas
Caddo National Grassland	Texas
David Crockett National Forest	Texas
Lyndon B. Johnson National Grassland	Texas
Sabine National Forest	Texas
Sam Houston National Forest	Texas
St. Francis National Forest	Texas
George Washington National Forest	Virginia
Jefferson National Forest	Virginia

Table 3. Species for which designated critical habitat was considered.

Group	Common Name	Scientific Name
Amphibians	Houston toad	*Bufo houstonensis*
	San Marcos salamander	*Eurycea nana*
Birds	Cape Sable seaside sparrow	*Ammodramus maritimus mirabilis*
	Everglade snail kite	*Rostrhamus sociabilis plumbeus*
	Piping plover	*Charadrius melodus*
	Whooping crane	*Grus americana*
Fishes	Amber darter	*Percina antesella*
	Arkansas River shiner	*Notropis girardi*
	Cape Fear shiner	*Notropis mekistocholas*
	Conasauga logperch	*Percina jenkinsi*
	Fountain darter	*Etheostoma fonticola*
	Gulf sturgeon	*Acipenser oxyrinchus desotoi*
	Leon Springs pupfish	*Cyprinodon bovinus*
	Leopard darter	*Percina pantherina*
	San Marcos gambusia	*Gambusia georgei*
	Waccamaw silversides	*Menidia extensa*
Invertebrates	Appalachian elktoe	*Alasmidonta raveneliana*
	Bracken Bat Cave meshweaver	*Cicurina venii*
	Carolina heelsplitter	*Lasmigona decorata*
	Cokendolpher Cave harvestman	*Texella cokendolpheri*
	Comal Springs dryopid beetle	*Stygoparnus comalensis*
	Comal Springs riffle beetle	*Heterelmis comalensis*
	Helotes mold beetle	*Batrisodes venyivi*
	Malda Cave meshweaver	*Cicurina madla*
	Pecks Cave amphipod	*Stygobromus pecki*
	Pecos assiminea snail	*Assiminea pecos*
	Rober Baron Cave meshweaver	*Cicurina baronia*
	Spruce-fir moss spider	*Microhexura montivaga*
	Unnamed ground beetle	*Rhadine infernalis*
	Unnamed ground beetle	*Rhadine exilis*
Mammals	West Indian manatee	*Trichechus manatus*
	Choctawhatchee Beach mouse	*Speromyscus polionotus allophrys*
	Perdido Key Beach mouse	*Peromyscus polionotus trissyllepsis*
	Rice rat	*Oryzomys palustris natator*
Plants	Braun's rock-cress	*Arabis perstellata*
	Johnson's seagrass	*Halophila johnsonii*
	Mountain golden heather	*Hudsonia montana*
	Texas wild-rice	*Zizania texana*
	Zapata bladderpod	*Lesquerella thamnophila*
Reptiles	American crocodile	*Crocodylus acutus*
	Concho water snake	*Nerodia paucimaculata*

Available National Wetlands Inventory (NWI) data were provided by the US Fish and Wildlife Service (2007). Digital vector data were selected from each state geodatabase. Relevant wetland types (Estuarine and Marine, Freshwater Emergent, Freshwater Forested/Shrub, Riverine, and Other) were extracted, converted, and combined into a single raster. The decision to include "other" was based on visual comparisons to satellite data, which showed considerable wetland habitat in these areas. We supplemented the NWI data with both woody and emergent herbaceous wetlands classifications from the 2001 National Land Cover Dataset for areas where no NWI digital vector data was available.

Potential old-growth forest stands in southern Appalachian National Forests were identified by the Southern Appalachian Man and the Biosphere Program (SAMAB) (1996) using Forest Service Southern Region Continuous Inventory of Stand Condition data. Old-growth data were limited to just this one subregion.

To model hydrographic buffers, National Hydrography Dataset data was retrieved through NHDPlus (U.S. Environmental Protection Agency and U.S. Geological Survey 2005). Only natural features were selected to model buffers. From the NHDFlowline polyline shapefile, hydrographic features identified as "StreamRiver" or "Coastline" were selected. Features identified as "Rapids," "StreamRiver," or "LakePond" were selected from the NHD polygon files NHDArea and NHDWaterbody. Because of the operating resolution used in this analysis – 100m – selected polyline features were converted directly to raster format. These cells represent, in general, a buffer of 50 meters (164 feet) on each side of the stream, approximating the desired 200 foot buffer. NHD polygon data were buffered by 200 feet and then converted to raster format. All hydrographic data were then combined into a single raster layer.

Wildland Urban Interface (WUI) data were collected by state from the Silvis Lab, Department of Forest Ecology and Management, University of Wisconsin (Radeloff et al. 2005). Areas classified as high or medium density interface or intermix, based on 2000 block-scale housing density and percent vegetation, were extracted as WUI land.

We considered two alternative combinations of value screens. In Alternative 1, all potentially constrained lands, including all Forest Service and BLM lands, were excluded from biomass development. In Alternative 2, Forest Service and BLM matrix lands (those areas not provided special protection via such designations as wilderness or research natural areas) were assumed available for biomass extraction; all other values were excluded from extraction. In both alternatives, biomass located within the Wildland-Urban Interface (WUI) was assumed available for extraction regardless of location relative to conservation value screens.

Data Processing

All analyses used ArcGIS version 9.2 or 9.3 employing Model Builder programming. Datasets were projected into Albers Conical Equal Area projection, GCS North American 1927. Existing rasters were resampled to a resolution of 100m x 100m using a nearest neighbor method for categorical data and a bilinear method for continuous data. Vector shapefiles were converted to rasters with this resolution. Rasters were snapped to the resampled 100-meter-resolution forest biomass raster. The biomass for each raster cell of the conservation value screen was extracted,

and the resulting available total biomass was summarized in table and map forms at the various scales of interest.

The Effect of Scale on Hydrographic Buffers

In order to better understand the effect of scale on the lakes and stream buffer, we compared the area of buffers created from 1:100,000 hydrographic data to those created from 1:24,000 data in seventeen ecoregions. NHD high- and medium-resolution data were collected and clipped to 5x5 grids of USGS 1:24,000 Topographic Quadrangles (U.S. Geological Survey et al. 2004; U.S. Environmental Protection Agency et al. 2005). To simplify the analysis and account for discrepancies between the datasets, 200-foot buffers were created only around features classified as "StreamRiver" in the NHDFlowline and NHDArea shapefiles, and their areas were calculated and compared.

Two ecoregions deviated from this process due to significant differences in how the datasets classified feature types. In the Ozark Mountain Forests region, we excluded NHDArea features. In the Western Gulf Coastal Grasslands, we removed the southern-most row of quadrangles from analysis to remedy a discrepancy, and the analysis was performed on 20 quads, instead of 25. In both cases these data were excluded from analysis because of the difficulty of identifying the same natural features for comparison from both datasets.

Natural Heritage Data within Ecological Value Screens

Region-wide data for all threatened and endangered species were unavailable due to cost. Although congressionally mandated State Wildlife Action Plans contain a wealth of biodiversity information, we were unable to include them in our study because of the variations between states in formats, conservation priorities, management needs, and digital availability of data. To test the degree to which the other value screens we examined captured point locations (or occurrences) for rare species and communities (G1-G3 and S1-S3) we looked at just one state. For North Carolina, we calculated the number of Natural Heritage element occurrences (threatened and endangered species and communities) that fell within the boundaries of the ecological value screens. All element occurrences, including animals, plants, communities, and special animal habitats were considered (North Carolina Department of Environment and Natural Resources 2003). Element occurrence points were converted to raster data where each cell's value reflected the number of points contained within its boundaries. Summary statistics were calculated for occurrences inside and outside the various conservation value screens.

Results

Southeast Region

The total amount of standing, live biomass for the entire Southeastern U.S. is nearly 11 billion dry tons. A small amount of that biomass (approximately 336 million tons or 3 percent) is within

Wildland-Urban Interface (WUI) areas. Restricted biomass, shown in table 4, is the amount of biomass in areas potentially constrained by administrative or ecological values and not within WUI. Allowable biomass is that biomass that falls outside potentially constrained lands or within the WUI and therefore potentially available for extraction. Please note that the biomass estimates for the various land designations do not sum to the combination totals presented in Table 4, because there is considerable spatial overlap among the value screens. For example, biomass within a critical habitat area may also be on Forest Service land or within wetlands. Biomass in these overlap situations is counted only once in the totals shown in Table 4 and subsequent tables.

Forest Service lands support over 722 million tons of biomass (nearly 7%) of the total forest biomass in the region (Table 4). In Alternative 1, approximately 3.8 billion tons, or 35% of the total regional biomass would be excluded as available for development. In Alternative 2, approximately 3.4 billion tons, or 31% of the total, would be excluded.

Of all the individual administrative and ecological values considered, wetlands (many of them forested) showed the highest amount of excluded biomass, with nearly 2 billion tons (almost 18%) of the total biomass. Riparian buffers were second with 1.2 billion tons of biomass (11%). The mapped value that affected the least amount of biomass was the incomplete BLM lands data, at 112,000 tons, or 0.001% of total biomass.

Table 4. Distribution of southeast forest biomass in areas where biomass extraction may be restricted by administrative and ecological constraints versus unrestricted areas where extraction may be allowable. Note that biomass estimates for the individual value screens do not sum to the totals for the two alternatives, due to considerable spatial overlap among value screens.

	Restricted		**Allowable**	
	biomass (tons)	**% total**	**biomass (tons)**	**% total**
USFS	722,241,323	6.62	10,189,481,947	93.38
BLM	111,775	0.001	10,911,611,496	99.999
Critical Habitat	7,396,005	0.07	10,904,327,266	99.93
Roadless Areas	60,231,301	0.55	10,851,491,970	99.45
Protected Areas	466,634,033	4.28	10,445,089,238	95.72
Steep Slopes	342,072,236	3.13	10,569,651,034	96.87
Wetlands	1,933,464,093	17.72	8,978,259,178	82.28
Old-Growth Forest	75,077,144	0.69	10,836,646,126	99.31
Hydrographic Buffers	1,227,631,360	11.25	9,684,091,910	88.75
Alternative 1	3,779,790,975	34.64	7,131,932,296	65.36
Alternative 2	3,357,255,576	30.77	7,554,467,694	69.23

States

The state with the greatest amount of standing, live biomass is North Carolina, with 1.7 billion tons (Table 5). Three states (Georgia, Virginia, and Mississippi) have a little over 1 billion tons each. Not surprisingly, the state with the least amount of forest biomass is Oklahoma, with only 384 million tons. WUI-bound biomass varies from 0.85 percent in Oklahoma to 5.51 in North Carolina.

Under Alternative 1 (all Forest Service and BLM lands assumed off-limits to biomass extraction), the state with the most excluded biomass due to administrative and ecological constraints is North Carolina (549 million tons; Table 6). However, the proportion of biomass excluded due to constraints is highest in Louisiana, where nearly 58 percent of the standing biomass was excluded. Florida is second in percent of total excluded at 48 percent. The high rate of exclusion in these two states probably reflects the abundance of wetlands they contain. Florida also has more lands with high levels of protection than other states. The state with the least biomass excluded, and also the lowest percent of total, was Oklahoma.

Under Alternative 2 (Forest Service and BLM lands lacking special protection designations included as allowable) showed a similar pattern, albeit with somewhat lower exclusion totals (Table 7).

Table 5. Forest biomass totals (in dry tons) per state within the study area and the amount of that biomass contained within the Wildland-Urban Interface.

State	Total Biomass (tons)	WUI-Bound Biomass (tons)	% Biomass in WUI
Alabama	964,874,758	19,442,711	2.02
Arkansas	792,239,169	7,349,201	0.93
Florida	821,167,128	33,132,377	4.03
Georgia	1,069,722,783	57,014,491	5.33
Kentucky	598,502,410	7,728,294	1.29
Louisiana	563,487,999	8,532,363	1.51
Mississippi	1,015,963,038	10,567,836	1.04
North Carolina	1,702,235,527	93,725,052	5.51
Oklahoma	384,104,664	3,280,775	0.85
South Carolina	653,768,929	29,781,417	4.56
Tennessee	745,114,101	18,820,330	2.53
Texas	548,912,087	8,166,479	1.49
Virginia	1,051,630,678	38,056,992	3.62

Table 6. Forest biomass totals for Alternative 1 by state.

State	Total Biomass (tons)	Alternative 1			
		Total Excluded Biomass		Total Allowable Biomass	
		tons	% of total	tons	% of total
Alabama	964,874,758	283,437,240	29.38	681,437,518	70.62
Arkansas	792,239,169	329,585,043	41.60	462,654,127	58.40
Florida	821,167,128	397,320,665	48.38	423,846,462	51.62
Georgia	1,069,722,783	313,253,484	29.28	756,469,299	70.72
Kentucky	598,502,410	174,640,767	29.18	423,861,643	70.82
Louisiana	563,487,999	326,488,280	57.94	236,999,718	42.06
Mississippi	1,015,963,038	386,018,795	38.00	629,944,243	62.00
North Carolina	1,702,235,527	548,792,541	32.24	1,153,442,986	67.76
Oklahoma	384,104,664	70,647,792	18.39	313,456,872	81.61
South Carolina	653,768,929	209,056,801	31.98	444,712,128	68.02
Tennessee	745,114,101	217,853,192	29.24	527,260,909	70.76
Texas	548,912,087	209,470,484	38.16	339,441,603	61.84
Virginia	1,051,630,678	313,225,889	29.78	738,404,788	70.22

Table 7. Forest biomass totals for Alternative 2 by state.

State	Total Biomass (tons)	Alternative 2			
		Total Excluded Biomass		Total Allowable Biomass	
		tons	% of total	tons	% of total
Alabama	964,874,758	262,211,191	27.18	702,663,567	72.82
Arkansas	792,239,169	238,552,590	30.11	553,686,579	69.89
Florida	821,167,128	369,207,997	44.96	451,959,130	55.04
Georgia	1,069,722,783	285,798,762	26.72	783,924,021	73.28
Kentucky	598,502,410	143,412,977	23.96	455,089,433	76.04
Louisiana	563,487,999	311,280,562	55.24	252,207,437	44.76
Mississippi	1,015,963,038	340,029,033	33.47	675,934,005	66.53
North Carolina	1,702,235,527	508,030,835	29.84	1,194,204,692	70.16
Oklahoma	384,104,664	63,915,738	16.64	320,188,926	83.36
South Carolina	653,768,929	190,651,497	29.16	463,117,432	70.84
Tennessee	745,114,101	195,242,802	26.20	549,871,299	73.80
Texas	548,912,087	179,131,096	32.63	369,780,990	67.37
Virginia	1,051,630,678	269,790,495	25.65	781,840,183	74.35

Ecoregions

Twenty-four WWF ecoregions are included in the 13-state study area (Figure 1). Some are entirely contained in the study area (e.g., Southeastern Conifer Forest), but a number only slightly overlap the study area (e.g., the Southern Great Lakes Forests ecoregion just touches Kentucky and the Arizona Mountains Forests ecoregion just touches west Texas). Other ecoregions are not dominated by forest at all (e.g., Chihuahuan Desert, Western Short Grasslands, and South Florida Rocklands), but small levels of forest biomass occur in these ecoregions and are reported in Table 8.

Table 8. Forest biomass totals (in dry tons) per ecoregion within the study area and the amount of that biomass contained within the Wildland-Urban Interface. Forested ecoregions are shaded in gray and forested ecoregions contained predominantly within the Southeast study area are in bold text.

Ecoregion	Total Biomass (tons)	WUI-Bound Biomass (tons)	% Total Biomass in WUI
Appalachian Mixed Mesophytic Forests	767,085,670	13,975,966	1.82
Appalachian/Blue Ridge Forests	**1,188,481,630**	**40,248,299**	**3.39**
Arizona Mountains Forests	69,133	0	-
Central Forest/Grassland Transition Zone	283,201,987	3,370,821	1.19
Central US Hardwood Forests	816,567,699	12,019,662	1.47
Central and Southern Mixed Grasslands	29,034,566	149,457	0.51
Chihuahuan Desert	1,608,118	210	0.01
East Central Texas Forests	**57,117,510**	**452,879**	**0.79**
Edwards Plateau Savannas	99,215,422	1,680,381	1.69
Everglades	7,156,472	526,720	7.36
Flint Hills Tall Grasslands	2,252,880	279	0.01
Florida Sand Pine Scrub	19,531,972	1,560,502	7.99
Middle Atlantic Coastal Forests	**1,190,223,393**	**37,856,786**	**3.18**
Mississippi Lowland Forests	**326,406,854**	**4,638,482**	**1.42**
Ozark Mountain Forests	**455,550,510**	**2,833,552**	**0.62**
Piney Woods Forests	**846,011,991**	**9,925,811**	**1.17**
South Florida Rocklands	391,927	34,195	8.72
Southeastern Conifer Forests	**1,595,137,164**	**44,226,091**	**2.77**
Southeastern Mixed Forests	**3,144,548,765**	**158,596,141**	**5.04**
Southern Great Lakes Forests	414,740	90,051	21.71
Tamaulipan Mezquital	930,577	1,371	0.15
Texas Blackland Prairies	28,078,392	469,041	1.67
Western Gulf Coastal Grasslands	37,156,289	1,333,714	3.59
Western Short Grasslands	3,527,133	2,413	0.07

The Southeastern Mixed Forests ecoregion contained the greatest amount of forest biomass (over 3 billion tons) followed by Southeastern Conifer Forests, Middle Atlantic Coastal Forests, and the Appalachian/Blue Ridge Forests – all with over 1 billion tons.

WUI-bound biomass totals varied considerably more for ecoregions (0 – 22%) than for the states due to the wide range in areal extents contained within the study area and the delineation of very different natural vegetation types, including forests, grasslands, and deserts.

Under Alternative 1, the ecoregion with the largest amount of exclusions was the Southeastern Conifer Forests (over 700 million tons) followed closely by the Southeastern Mixed Forests ecoregion (682 million tons; Table 9). For percent of total forest biomass (considering only the dominant forested ecoregions in the southeast), the most heavily affected ecoregion was the Mississippi Lowland Forests with 82 percent of the potentially available forest biomass excluded, predominantly due to wetland values. The lowest percentage in forest-dominated ecoregions was observed for the Southeastern Mixed Forests (22%) with all of the others ranging from 39 to 48 percent.

Under Alternative 2, the ecoregion with the largest amount of exclusions remained the Southeastern Conifer Forests (around 660 million tons) followed closely by the Southeastern Mixed Forests ecoregion (630 million tons; Table 10). For percent of total forest biomass (considering only the dominant forested ecoregions in the southeast), the same pattern as Alternative 1 was observed, with a few notable exceptions. The Appalachian/Blue Ridge Forests experienced a drop of approximately ten percentage points, the Piney Woods Forests ecoregion dropped by 5 percentage points, and the Ozark Mountains Forests ecoregion dropped from 40 percent under Alternative 1 to 20 percent under Alternative 2.

Counties

Although we compiled summary statistics for all 1,342 counties in the study area, for this scale of our analysis we provide a series of maps showing the distribution of excluded biomass under the two alternatives rather than providing lengthy tables. Figure 3 shows the total forest biomass excluded from what is potentially available for biomass development under Alternative 1, and Figure 4 shows the proportion of biomass excluded. The counties with the most excluded biomass tend to be along the coast, or contain abundant national forest land or major rivers with extensive wetlands. Some counties are heavily affected (as much as 100%) by the exclusions while other counties are affected little or not at all (Figure 4). Figures 5 and 6 show companion graphics for Alternative 2. The results are very similar although there are notable changes in a few locations – the Ozarks, northern Florida, and some areas of the Appalachians.

Table 9. Forest biomass totals for ecoregions in the study area under Alternative 1. Forested ecoregions are shaded in gray and forested ecoregions contained predominantly in the Southeast study area are in bold text.

Ecoregions	Total Biomass (tons)	Alternative 1			
		Total Excluded Biomass		Total Allowable Biomass	
		tons	% of total	tons	% of total
Appalachian Mixed Mesophytic Forests	767,085,670	245,263,197	31.97	521,822,473	68.03
Appalachian/Blue Ridge Forests	**1,188,481,630**	**570,110,874**	**47.97**	**618,370,757**	**52.03**
Arizona Mountains Forests	69,133	69,133	100.00	0	-
Central Forest/Grassland Transition Zone	283,201,987	40,615,482	14.34	242,586,505	85.66
Central US Hardwood Forests	816,567,699	156,765,170	19.20	659,802,529	80.80
Central and Southern Mixed Grasslands	29,034,566	4,464,498	15.38	24,570,068	84.62
Chihuahuan Deserts	1,608,118	779,087	48.45	829,031	51.55
East Central Texas Forests	**57,117,510**	**23,766,836**	**41.61**	**33,350,674**	**58.39**
Edwards Plateau Savannas	99,215,422	11,823,858	11.92	87,391,564	88.08
Everglades	7,156,472	5,461,254	76.31	1,695,218	23.69
Flint Hills Tall Grasslands	2,252,880	432,670	19.21	1,820,210	80.79
Florida Sand Pine Scrub	19,531,972	13,611,086	69.69	5,920,886	30.31
Middle Atlantic Coastal Forests	**1,190,223,393**	**461,393,298**	**38.77**	**728,830,095**	**61.23**
Mississippi Lowland Forests	**326,406,854**	**267,943,300**	**82.09**	**58,463,554**	**17.91**
Ozark Mountain Forests	**455,550,510**	**181,136,232**	**39.76**	**274,414,278**	**60.24**
Piney Woods Forests	**846,011,991**	**377,882,215**	**44.67**	**468,129,776**	**55.33**
South Florida Rocklands	391,927	337,572	86.13	54,355	13.87
Southeastern Conifer Forests	**1,595,137,164**	**700,793,631**	**43.93**	**894,343,533**	**56.07**
Southeastern Mixed Forests	**3,144,548,765**	**682,875,241**	**21.72**	**2,461,673,524**	**78.28**
Southern Great Lakes Forests	414,740	53,258	12.84	361,482	87.16
Tamaulipan Mezquital	930,577	309,227	33.23	621,351	66.77
Texas Blackland Prairies	28,078,392	6,067,767	21.61	22,010,624	78.39
Western Gulf Coastal Grasslands	37,156,289	21,026,016	56.59	16,130,273	43.41
Western Short Grasslands	3,527,133	586,240	16.62	2,940,893	83.38

Table 10. Forest biomass totals for ecoregions in the study area under Alternative 2. Forested ecoregions are shaded in gray and forested ecoregions contained predominantly within the Southeast study area are in bold text.

Ecoregion	Total Biomass (tons)	Alternative 2			
		Total Excluded Biomass		Total Allowable Biomass	
		tons	% of total	tons	% of total
Appalachian Mixed Mesophytic Forests	767,085,670	202,128,172	26.35	564,957,498	73.65
Appalachian/Blue Ridge Forests	**1,188,481,630**	**448,094,736**	**37.70**	**740,386,894**	**62.30**
Arizona Mountains Forests	69,133	69,133	100.00	0	-
Central Forest/Grassland Transition Zone	283,201,987	39,636,275	14.00	243,565,712	86.00
Central US Hardwood Forests	816,567,699	146,321,990	17.92	670,245,709	82.08
Central and Southern Mixed Grasslands	29,034,566	4,437,676	15.28	24,596,890	84.72
Chihuahuan Deserts	1,608,118	779,087	48.45	829,031	51.55
East Central Texas Forests	**57,117,510**	**23,579,670**	**41.28**	**33,537,840**	**58.72**
Edwards Plateau Savannas	99,215,422	11,824,606	11.92	87,390,816	88.08
Everglades	7,156,472	5,461,244	76.31	1,695,228	23.69
Flint Hills Tall Grasslands	2,252,880	432,635	19.20	1,820,244	80.80
Florida Sand Pine Scrub	19,531,972	5,654,344	28.95	13,877,628	71.05
Middle Atlantic Coastal Forests	**1,190,223,393**	**454,092,057**	**38.15**	**736,131,336**	**61.85**
Mississippi Lowland Forests	**326,406,854**	**267,022,272**	**81.81**	**59,384,582**	**18.19**
Ozark Mountain Forests	**455,550,510**	**89,200,036**	**19.58**	**366,350,474**	**80.42**
Piney Woods Forests	**846,011,991**	**333,661,323**	**39.44**	**512,350,667**	**60.56**
South Florida Rocklands	391,927	337,572	86.13	54,355	13.87
Southeastern Conifer Forests	**1,595,137,164**	**660,601,700**	**41.41**	**934,535,464**	**58.59**
Southeastern Mixed Forests	**3,144,548,765**	**629,922,801**	**20.03**	**2,514,625,964**	**79.97**
Southern Great Lakes Forests	414,740	53,258	12.84	361,482	87.16
Tamaulipan Mezquital	930,577	309,083	33.21	621,494	66.79
Texas Blackland Prairies	28,078,392	5,900,702	21.02	22,177,690	78.98
Western Gulf Coastal Grasslands	37,156,289	21,020,179	56.57	16,136,110	43.43
Western Short Grasslands	3,527,133	575,236	16.31	2,951,897	83.69

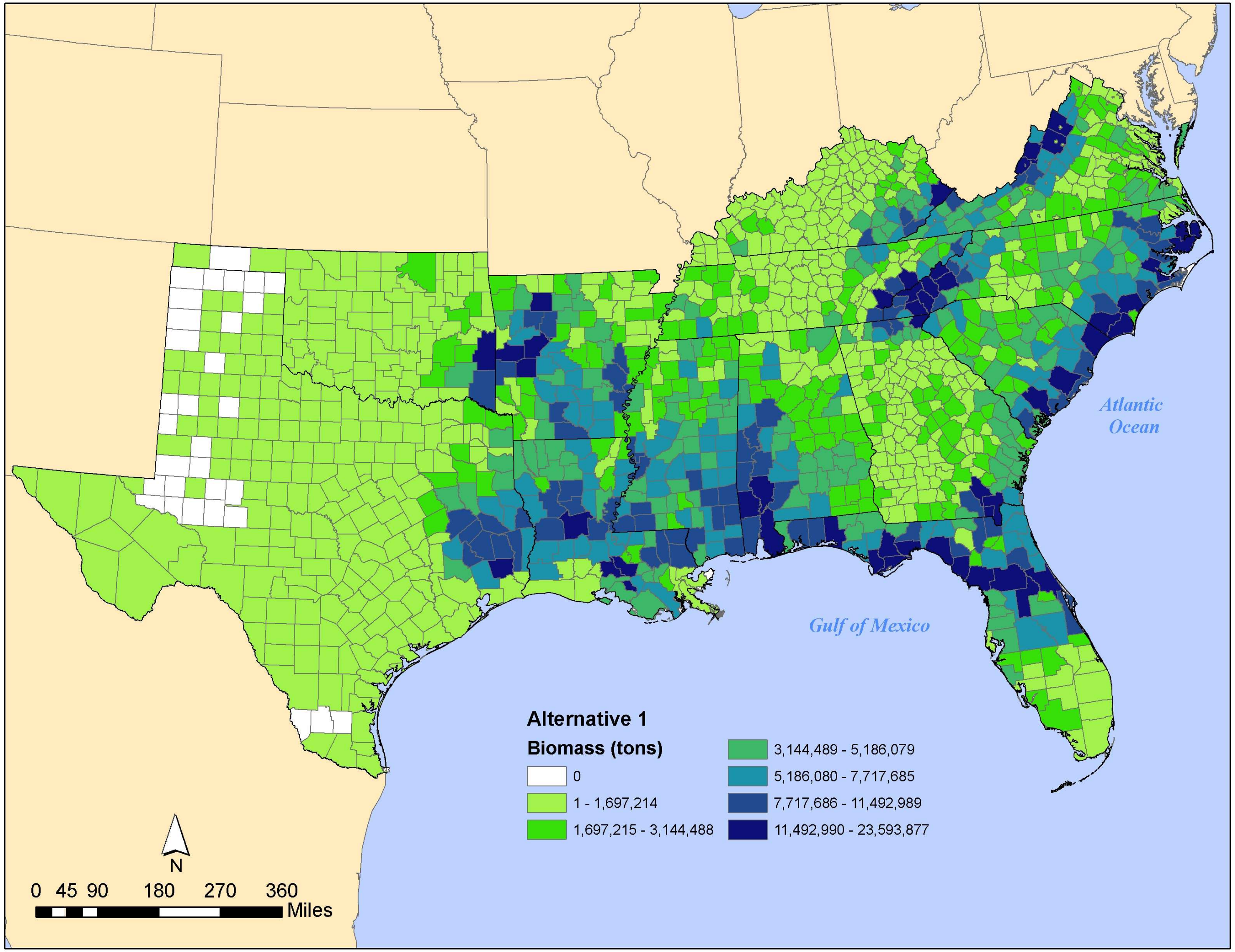

Figure 3. Forest biomass (in dry tons) excluded from extraction under Alternative 1, by county.

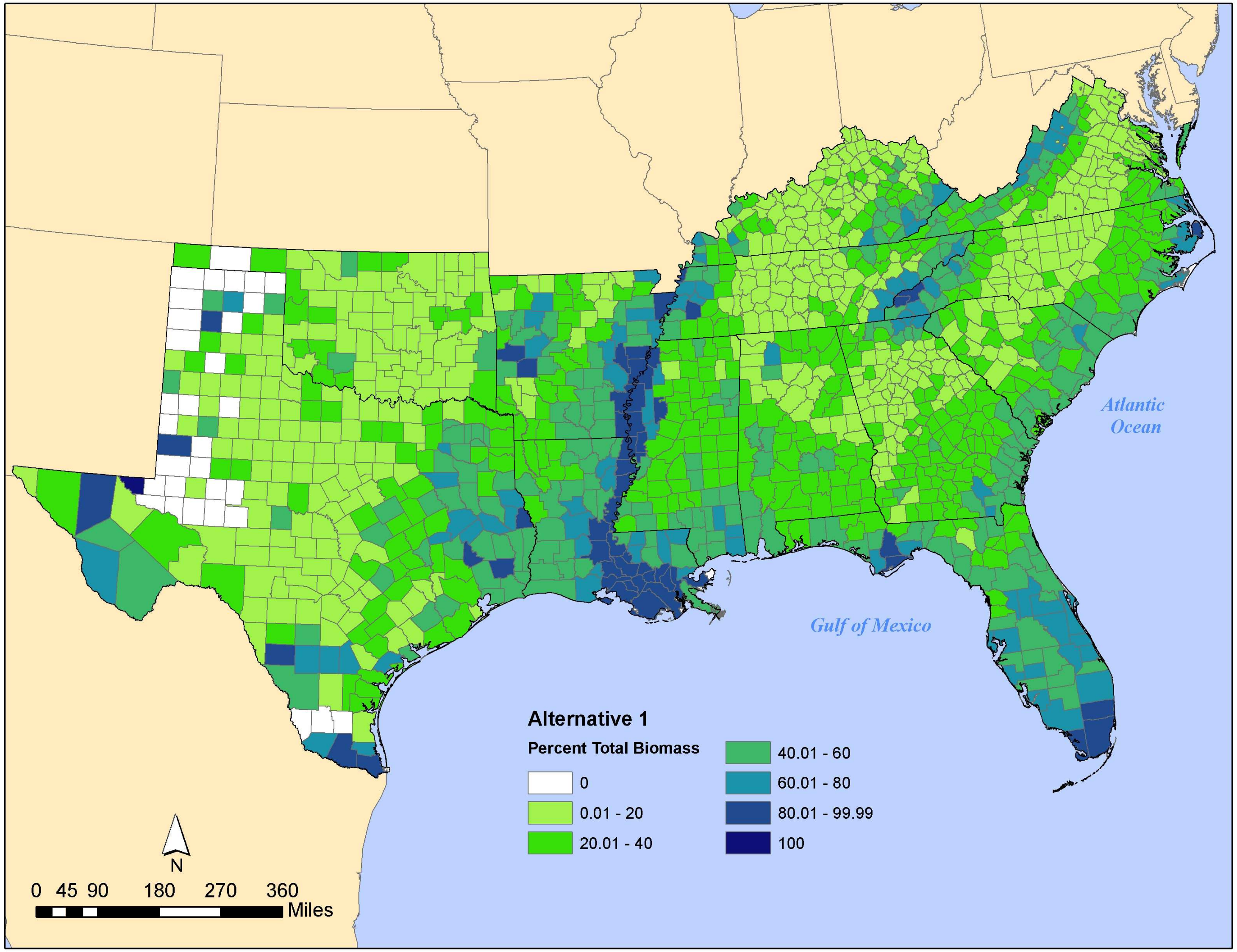

Figure 4. Percent of total forest biomass excluded from extraction under Alternative 1, by county.

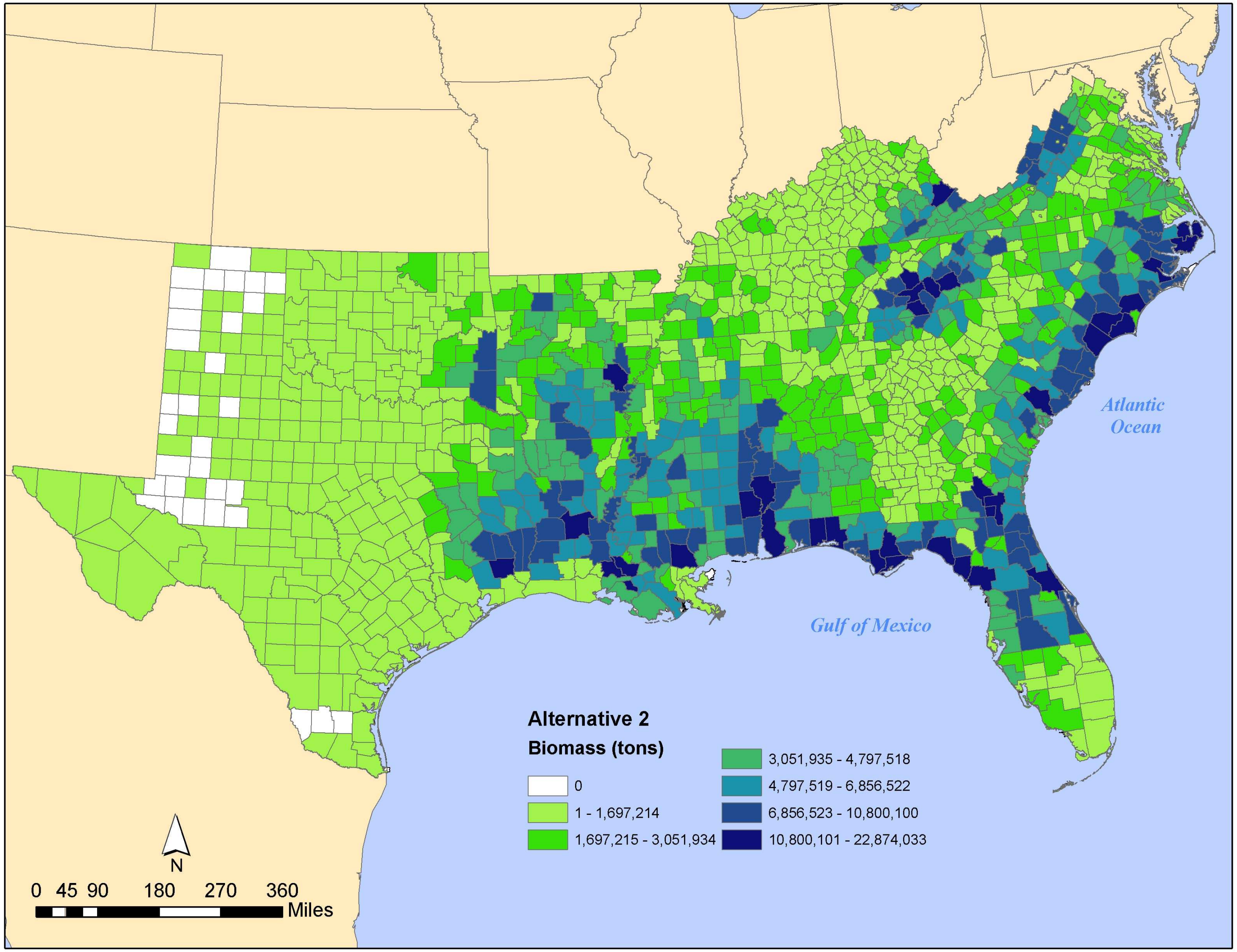

Figure 5. Forest Biomass (in dry tons) excluded from extraction under Alternative 2, by county.

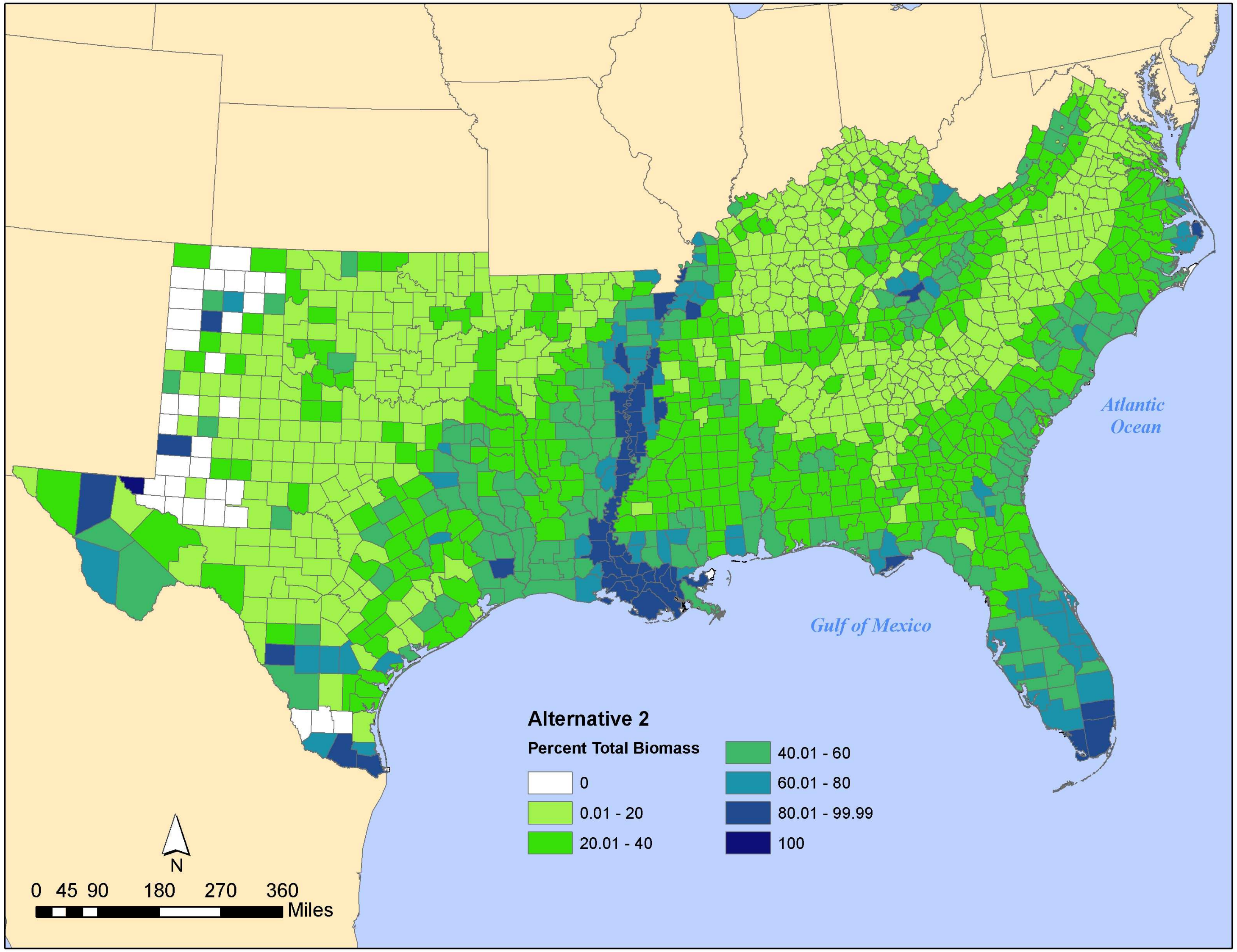

Figure 6. Percent of forest biomass excluded from extraction under Alternative 2, by county.

To illustrate the range of variability among counties, we provide two examples – Graham County, North Carolina (Figure 7) and Franklin County, Alabama (Figure 8). Approximately 62 percent of forest biomass in Graham County, NC is located within the Nantahala National Forest (Table 11). Under Alternative 1, 80 percent of the forest biomass in the county would be excluded from biomass development; under Alternative 2, 56 percent of the county's forest biomass would be excluded. Franklin County, Alabama, contains very little national forest land and few mapped ecological values. Only about 16 percent of the potential forest biomass would be excluded in this county under either alternative. The database we created allows for the query of detailed summaries for each value as well as the composite for each county.

Table 11. Summary exclusion results for two sample counties.

Graham County, NC	**Totals by restricted biomass**		**Totals by allowable biomass**	
Total Biomass: 14,071,699 tons	**tons**	**% of total**	**tons**	**% of total**
USFS	8,707,118	61.88	5,364,581	38.12
BLM	0	-	14,071,699	100.00
Critical Habitat	6,091	0.04	14,065,608	99.96
Roadless Areas	981,652	6.98	13,090,047	93.02
Protected Areas	1,051,872	7.48	13,019,827	92.52
Steep Slopes	4,947,644	35.16	9,124,055	64.84
Wetlands	22,472	0.16	14,049,227	99.84
Old Growth	2,233,564	15.87	11,838,135	84.13
Freshwater Buffers	1,641,685	11.67	12,430,014	88.33
Alternative 1	11,258,660	80.01	2,813,039	19.99
Alternative 2	7,867,284	55.91	6,204,415	44.09
Franklin County, Alabama	**Totals by restricted biomass**		**Totals by allowable biomass**	
Total Biomass: 10,786,779 tons	**tons**	**% of total**	**tons**	**% of total**
USFS	73,055	0.68	10,713,724	99.32
BLM	0	-	10,786,779	100.00
Critical Habitat	0	-	10,786,779	100.00
Roadless Areas	0	-	10,786,779	100.00
Protected Areas	0	-	10,786,779	100.00
Steep Slopes	410	0.00	10,786,369	100.00
Wetlands	373,645	3.48	10,413,134	96.54
Old Growth	0	-	10,786,779	100.00
Freshwater Buffers	1,467,483	13.71	9,319,296	86.40
Alternative 1	1,733,434	16.19	9,053,345	83.93
Alternative 2	1,673,544	15.63	9,113,235	84.49

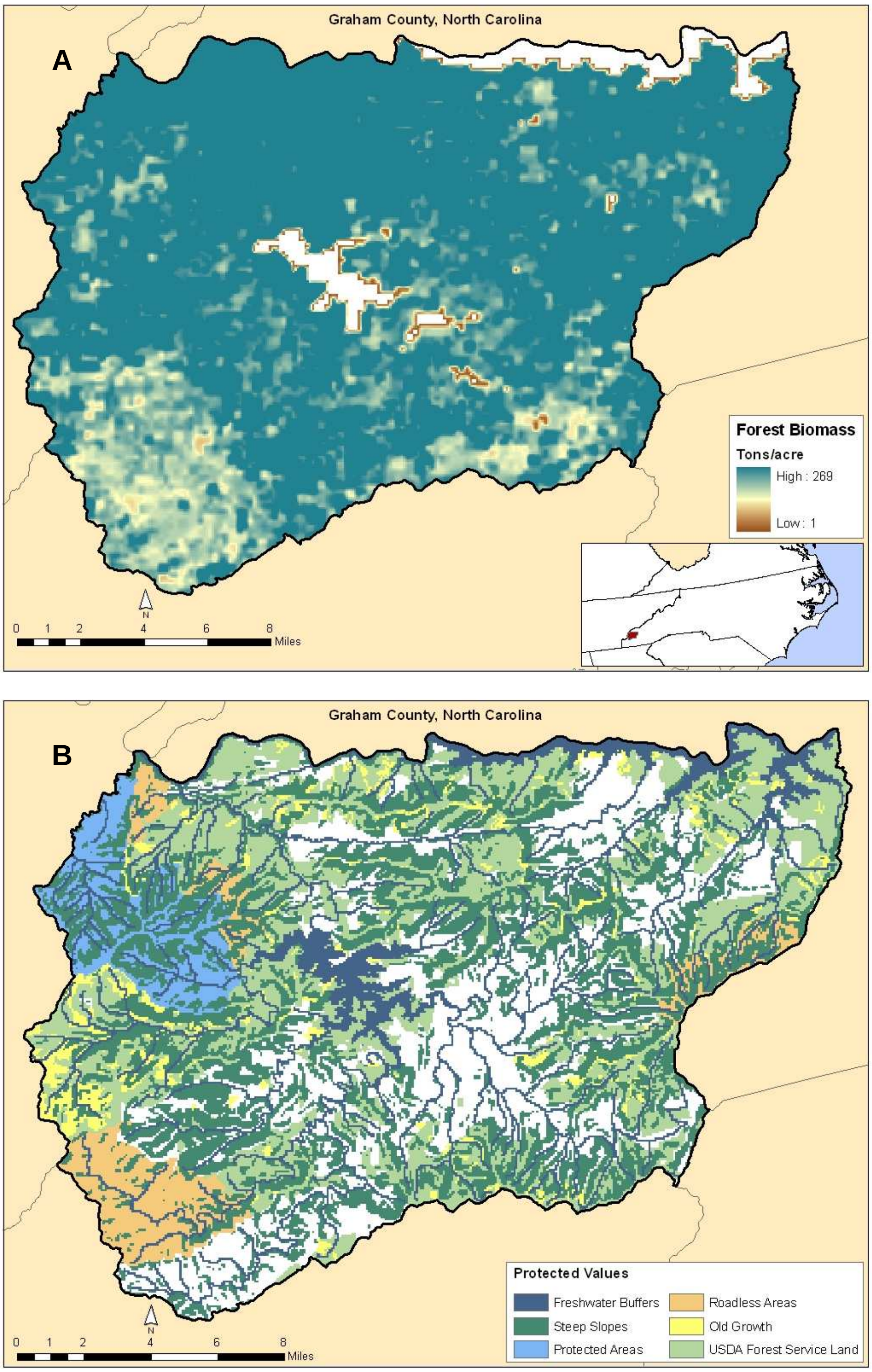

Figure 7. Forest biomass totals mapped at 100-meter resolution for Graham County, NC (A) and area occupied by mapped administrative and ecological values (B).

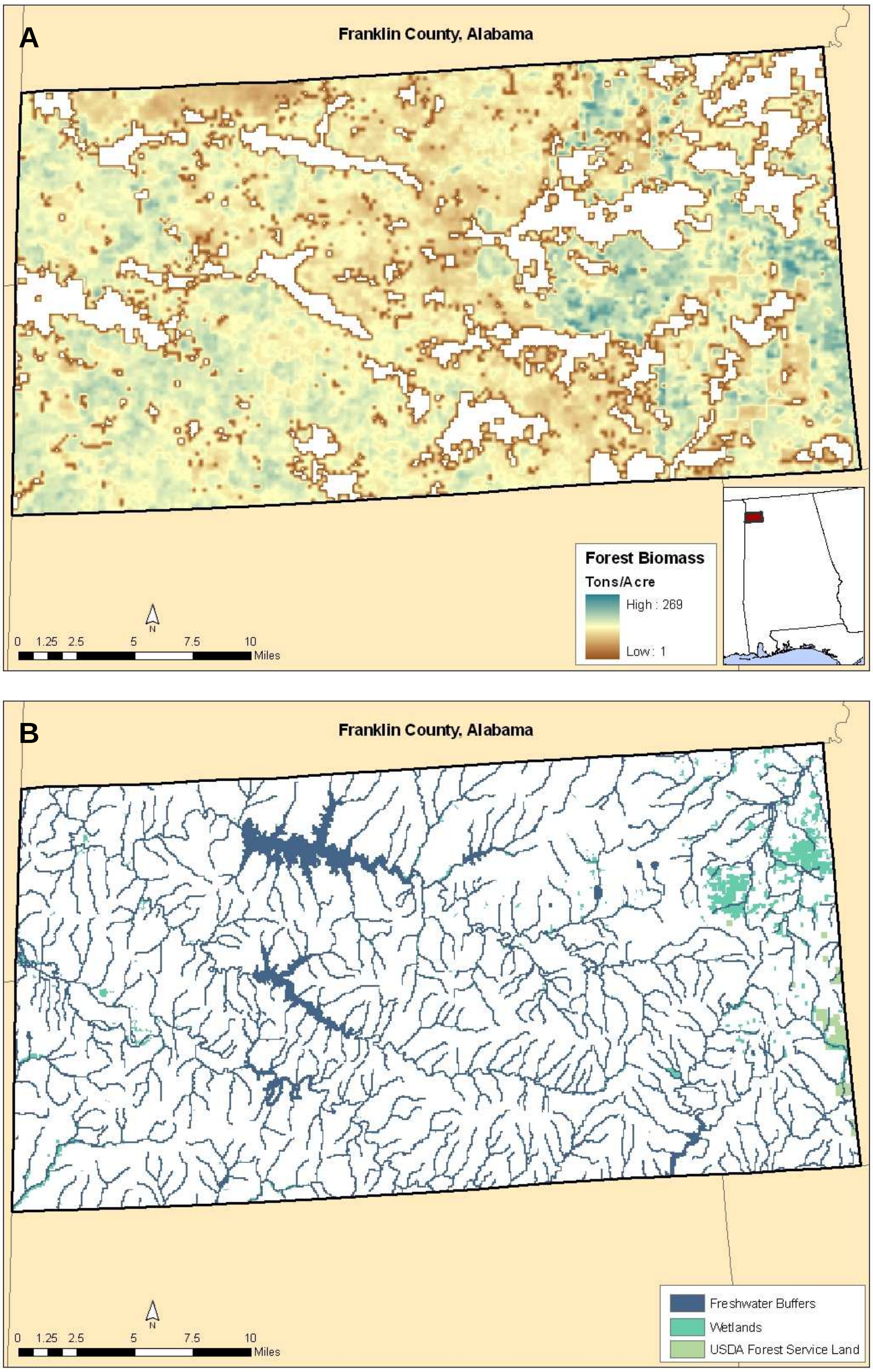

Figure 8. Forest biomass totals mapped at 100-meter resolution for Franklin County, Alabama (A) and area occupied by mapped administrative and ecological values (B).

The Effect of Scale on Hydrographic Buffers

The scale of datasets matters a great deal in geospatial analyses. It is accepted practice for regional analyses to rely heavily on middle-scale data (1:100,000), but if land management decisions are made from these studies, it is common to see discrepancies once management is implemented at finer spatial scale.

The comparison of two scales of hydrographic data in a sampling of the predominant ecoregions in the study area showed significant increases in buffer area using the finer resolution (1:24,000) dataset than using the 1:100,000 dataset (Table 11). The total area of excluded forest biomass nearly doubled at the finer scale. All of the summary tables in this report used the 1:100,000-scale hydrographic data, and lake and stream buffers accounted for approximately 11 percent of the excluded forest biomass in the region. However, this scale comparison illustrates that if lake and stream buffers were excluded from biomass development at the finer operational scale, more biomass would be excluded than is currently predicted in our summaries. It is impossible to predict exactly how much more forest biomass would be unavailable (the results presented in Table 12 are just a sample), but it would significantly more – perhaps as much as 5-8 percent more of the total forest biomass in the study area.

Table 12. Hydrographic buffer area comparison between 1:24,000 and 1:100,000 scale data.

Ecoregions	**Area (square miles)**		**Difference (square miles)**
	100k	**24k**	
Appalachian/Blue Ridge Forests	**171**	**306**	**+135**
Appalachian Mixed Mesophytic Forests	148	232	+84
Central Forest Grassland Transition Zone	137	318	+181
Chihuahuan Deserts	94	230	+136
Central and Southern Mixed Grasslands	77	221	+144
Central US Hardwood Forests	153	246	+93
Edwards Plateau Savannas	110	286	+176
Middle Atlantic Coastal Forests	**127**	**230**	**+103**
Ozark Mountain Forests	**164**	**245**	**+81**
Piney Woods Forests	**186**	**243**	**+57**
Southeastern Conifer Forests	**166**	**232**	**+66**
Southeastern Mixed Forests	**158**	**297**	**+139**
Tamaulipan Mezquital	100	198	+98
East Central Texas Forests and Texas Blackland Prairies	120	288	+168
Western Gulf Coastal Grasslands	68	233	+165
Western Short Grasslands	28	67	+39
Total	**2,007**	**3,872**	**+1,865**

Natural Heritage Data within Ecological Value Screens

Because we were unable to obtain a complete set of natural heritage element occurrences for the entire study area, we wanted to test the hypothesis that most locations of rare species would be contained within the administrative and ecological features we did map. Examining only those species and communities that were ranked as G1-G3 or S1-S3 for the entire State of North Carolina, we found that 12,196 out of 20,123 records (61%) were within our mapped conservation value screens. Of the 7,927 record locations outside these exclusion areas 1,062 points or 13% were red-cockaded woodpecker (*Picoides borealis*) locations – a bird species that lives in mature, open pine stands. Only 351 red-cockaded woodpecker occurrences, or 25% of all the species' records, were captured by Alternative 1. The overwhelming majority of all other records (including 29 different plant species, 5 birds, 5 reptiles, and 9 natural communities) were upland (mostly dry) sites. The important communities not well-represented in the existing administrative and ecological screens included Pine/Scrub Oak Sandhill, Xeric Sandhill Seep, Dry-Mesic Oak-Hickory Forest, and Granitic Flatrock, as well as some of the species unique to these habitat types. Therefore, the exclusion screens applied to the Southeastern U.S. do not represent these habitats well, and further refinement is needed although no region-wide datasets for these shortfalls are currently available.

Discussion

Data Deficiencies

USFS Forest Biomass Error

The USFS Forest Biomass layer is the best available dataset describing the distribution of live, aboveground forest biomass across the United States. The dataset is comprehensive, well-documented, and available. Because of the inherent limitations of modeling biomass on such a scale, the data may not accurately reflect ground conditions, and this variation must be taken into account to understand the limitations of our analysis.

Blackard et al. (2008) calculated several measures of accuracy for the forest biomass data. As a whole, the USFS forest biomass model tended to narrow the range of biomass variability by over-predicting biomass in low-biomass areas and under-predicting them in high-biomass areas. The accuracy of predicted pixel-level values of forest biomass varied by region, and our study area was identified as having a relatively high probability of error compared to other regions of the country.

The authors identified three possible sources of error. First, the limitations of remote sensing can cause misleading results. For example, forests continue to accumulate biomass that is less readily detectable after the canopy has closed. Second, the spatial mismatch between plot size and raster resolution (FIA plots range from 0.67 to 2.5 ha, while 250 meter pixels cover 6.25 ha) can increase error in areas where there is greater variability in existing forest biomass. Third, errors in identifying forest land and non-forest land, particularly near and below the predicted

probability of forest threshold (0.5), may also poorly reflect actual biomass in sparsely forested areas.

In addition, the different modeling methods and data quality between mapping zones led to discrepancies that can be seen in the biomass and error maps as distinct lines between zones. Many mapping zones had data deficiencies: For example, Texas and Oklahoma were missing data, and much of the southeast was inhibited by poor FIA plot coordinates and out-of-date data in an area of rapid land-use change. But by far, the two states that contain the greatest error are North Carolina and Florida (note the orange areas in Figure 9). Therefore the summary results for these states need to be moderated to take into account these high levels of error.

Despite these concerns over the accuracy of biomass totals provided by this dataset, it is unique in its presentation of the national distribution of forest biomass, and we consider the forest biomass exclusion summaries reasonably accurate by region, state, and ecoregion. The county-level data and maps may be less accurate in some areas than in others, but it is the relative degree to which changes occur that matters more than absolute values. Please note that this analysis examined current standing biomass. We were unable to predict annual forest biomass yields from these numbers. Rather, our study presents relative availability on a per county basis.

Bureau of Land Management Land

The BLM land ownership data were incomplete in our study area, largely due to the limited presence of BLM in the region. Although the BLM is currently compiling a dataset with all BLM-owned land in the region, none is currently available. Because of this, the biomass we found to be contained within BLM land is extremely small.

Compared with the western states, where BLM has a large land presence, the Bureau manages very little land east of the Mississippi. Our data contained all of the BLM area in Texas (11,800 acres) and Virginia (805 acres), although the area in Texas contained no forest biomass. Six other states contain BLM land (Alabama, Arkansas, Florida, Louisiana, Mississippi, and Oklahoma), but our data showed only 0 - 3% of the actual area of BLM land ownership in these states (BLM 2002 and 2008). Our BLM-contained biomass estimates therefore do not accurately reflect existing biomass in those areas. These estimates should be updated once BLM coverage data in the southeast is fully available.

Ecological Considerations

The data used to map ecological considerations and calculate their effect on forest biomass availability came from different sources, were created at different times and under varying standards, and exist in different forms, projections, and scales. Some of these differences may lead to spatial and attribute inaccuracies, and some detail was invariably lost in the preparation of the data, as shapefiles were converted to 100-meter rasters and existing rasters were resampled to higher or lower resolutions. These factors should always be taken into account, but the results presented in this study are reasonable estimates and well within accepted practices.

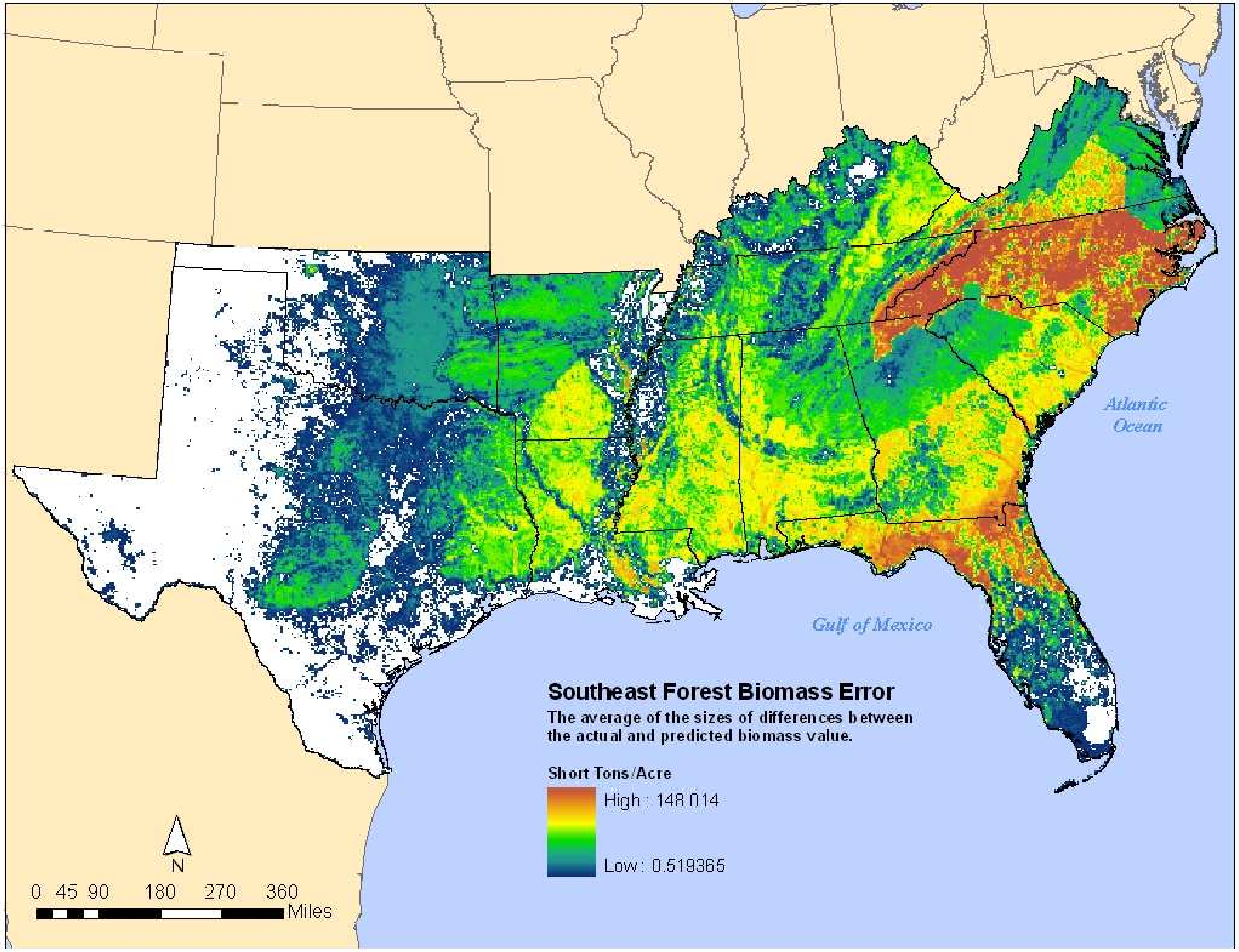

Figure 9. Forest biomass error as provided by Blackard et al. (2008) [orange = high error, blue = low error].

Data for some ecological considerations were not complete for the entire study area. For example, the only available old-growth forest dataset was created in 1996 and restricted to Southern Appalachian Forest Service lands. Critical habitat data from the US Fish and Wildlife Service are not available for all listed species, so the critical habitat that is mapped in our study is incomplete.

In mapping wetlands across the region, we combined available National Wetlands Inventory vector digital data at a 1:24,000 scale with 2001 National Land Cover Dataset 30-meter raster data. These datasets convey similar information but were created using very different methods: the NWI uses a classification system based on ecological indicators, while the NLCD largely relies on remote sensing. As such, areas identified by the NLCD may need refinement.

We used the National Hydrography dataset to create buffers around freshwater lakes, streams, and coastlines. The NHD Feature Type attribute was used to select the natural features that such buffers are meant to protect. Because of the complexity of hydrographic systems and the multiple shapefiles used to describe them, the final network may differ in some areas from the natural features that would be the focus of protection on the ground. We included the most clearly identifiable natural features, which may have excluded waterways in urban areas, man-made features, and engineered connections between natural features.

The discrepancies in the ecological considerations are relatively minor relative to the scale of analysis. Examinations of forest biomass at more local scales would require more geographically specific and complete datasets and/or on-the-ground knowledge.

Wildland-Urban Interface

The amount of Wildland-Urban Interface (WUI) was relatively low (3%) for the Southeast region, with some modest variability observed when considering subregional scales. For example, the amount of total forest biomass contained within WUI at the state level ranged from 1 to 5.5 percent. Ecoregion results showed greater variability (0 – 22%), which is due to the wide variety of sizes and dominant vegetation types of these areas. In general, WUI appears to be a relatively minor factor affecting the amount of allowable biomass extraction in the Southeastern U.S.

Forest Biomass Exclusions

The administrative and ecological restrictions we examined provide a solid approximation of the impact these factors may have on forest biomass development in the Southeastern U.S. Roughly a third of the potential forest biomass currently standing was found to be unavailable for biomass development region-wide. Wetlands and hydrographic buffer zones accounted for the majority of the forest biomass exclusion, 18 percent and 11 percent respectively. Note that there is considerable overlap of these two features, so the amounts are not additive. Based on the scale comparison, it is highly likely that more biomass would be excluded by wetland considerations than reported here, as the scale of the analysis and scale of implementation differ. The results also show that dry upland habitat types and associated species were not well-represented in mapped conservation value screens, so these values would have to be accounted for at the

operational scale. If it were important to have these data incorporated at one of the scales of this assessment, the appropriate datasets could be obtained.

Forest Service lands contained almost 7 percent of the regional forest biomass, but the difference between excluding all USDA Forest lands from extraction and excluding only the special designated areas (e.g., wilderness areas, roadless areas, and research natural areas) was only 4 percent. Considering the results by subregion (state and ecoregion), the impact of excluding Forest Service land is more pronounced. For example, the difference between the two alternatives tested was nearly 12 percent for Arkansas but only 2 percent for Alabama. Likewise, the ecoregion summaries showed little difference between alternatives in some cases, but fairly large differences in others. For example, the Appalachian/Blue Ridge Forests showed a difference of 10 percent and the Ozark Mountain Forests, 20 percent. The difference between the two alternatives observed at the county level was even more pronounced, with most counties not changing at all, but other counties changing as much as 50 percent. These changes may appear subtle when looking at the entire study area at the county level, but closer examination illustrates the difference quite markedly.

Protected areas are mapped consistently across the entire study area and account for over 4 percent of the forest biomass exclusion totals. Steep slopes reduced available biomass by approximately 3 percent, with the other values affecting only 0.001 – 0.69 percent of available biomass. There is very little old-growth forest remaining in the Southeastern U.S. Although most remaining old growth is on the public lands in the Southern Appalachians where we obtained the data, there are other old-growth locations that would likely be excluded from biomass development. We predict this area to be very small, but locally significant. For example, we learned of old growth data from east Texas and portions of Arkansas and Louisiana, but were unable to acquire it. Some county exclusion summaries would undoubtedly increase with these data.

Designated critical habitat accounted for the least amount of biomass exclusion. It is important to note that critical habitat has not been designated or mapped for many federally listed species. For the most part, the federally endangered species in the Southeast region that have designated critical habitat have very limited distributions – often associated with unique or unusual habitats that may not have anything to do with forests (e.g., beach dunes, caves, and scrublands).

Expanded Use of the Results

The summaries provided at the study area, state, and ecoregional scales provide an important overview of the potential impact of imposing administrative and ecological restrictions on future biomass development in the Southeastern U.S. The county maps provided in this report show a much more detailed picture of not only where there are the most exclusions, but also where there are possible biomass development opportunities. The dataset generated from this study could be routinely accessed and queried to address a wide range of forest biomass development planning issues.

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