



Report

IN THE U.S. SOUTHEAST, NATURAL FORESTS ARE BEING FELLED TO SEND FUEL OVERSEAS



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ABOUT NRDC

The Natural Resources Defense Council is an international nonprofit environmental organization with more than 1.4 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Montana, and Beijing. Visit us at nrdc.org.

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EXECUTIVE SUMMARY

In the ecologically rich natural forests of the southeastern United States, the buzz of tree cutting is replacing the twitter of songbirds, the rat-a-tat of woodpeckers, and the splash of fishing lines. Energy markets are driving a new and frenzied demand for trees from the region (commonly referred to as woody biomass). The epicenter of this new market demand is in Europe, where power companies are seeking alternatives to coal and other fossil fuels and increasingly turning to woody biomass in the form of pellets to fuel their power plants.¹ Europe's forests are often highly regulated, so European power companies have had to look abroad to source wood fuel, turning to the largely unregulated forests of the American South for fresh supplies. Together, eight states in the southeastern United States—Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Virginia—now make up the top exporting region for wood pellets to the European Union, with the United Kingdom, the Netherlands, and Belgium being the top importers.²

Wood pellet exports from the United States doubled from 1.6 million tons in 2012 to 3.2 million tons in 2013. They increased again, by nearly 40 percent, from 2013 to 2014 and are expected to reach 5.7 million tons in 2015.³ Wood pellet manufacturing in the region is expected to continue skyrocketing, with production estimates as high as 70 million metric tons by 2020.⁴

To manufacture wood pellets, mills in the Southeast cart in truckload after truckload of raw material harvested from the region's forests to their facilities where they compress sawdust or grind up whole trees and other large forest residuals into uniform pellets. These pellets are then loaded onto ships and transported across the Atlantic Ocean to be burned in European power stations.

Wood pellet manufacturers and their major customers claim that pellets from these mills are composed entirely of sawdust and other mill residues, tree trimmings, and diseased or "problem" trees not suitable as timber.⁵ However, studies have concluded that logging residuals alone are unlikely to meet biomass fuel market demand and that healthy, whole trees (e.g., pulpwood) will be needed.⁶ Our research, along with the research of other organizations, shows that the harvest of whole trees is already taking place—and that these trees are coming not only from plantations.^{7,8}

This report is the first to reveal the potential scale of the pressure on southeastern forests from operating and proposed pellet mill manufacturers in the region. Working with the Conservation Biology Institute, the Natural

Resources Defense Council has compiled data showing the troublesome geographic nexus between unprotected forests in the region and existing and proposed wood pellet manufacturing facilities, placing the threats to these forests in stark visual relief.

Existing and proposed pellet mills, such as those owned by U.S. pellet manufacturing giant Enviva and British utility company Drax Power, are sited not just within harvest range of plantations but within range of unprotected, natural bottomland hardwood forests. Nearly every proposed pellet plant—and several current plants—are sourcing from areas that include critical habitat for up to 25 species that are federally listed as imperiled or endangered. Seen here in totality for the first time, the pressure on forests in this region from the biomass industry is nearly ubiquitous.

WHAT'S AT STAKE BIOLOGICALLY?

The forests being impacted by wood pellet mills in the Southeast are largely the biologically rich wetland forests, also known as bottomland hardwood forests. The Southeast covers around 16 percent of the land area of the lower 48 states yet contains over 65 percent of the nation's remaining bottomland hardwood forests.⁹ They grow in stream and broad river floodplains in a mixed canopy of trees, such as towering bald cypress and swamp tupelo, red maple, green ash, American elm, and black gum, as well as numerous species of oak trees that can live for hundreds of years and are considered integral to river and coastal

wetland systems. See Appendix A for details on the forest mapping methods used in this assessment.

Nearly all of the region’s bottomland hardwood forests have been impacted ever since European settlement began. Large areas were drained and converted to agriculture that continues to this day or were devoured by urban development. It has been estimated that only around 20 percent of pre-settlement bottomland hardwood forests still remain, and because of this decline, these biologically important forests have been the focus of active restoration over recent decades.^{10,11} For the surviving bottomland hardwood forests, successive waves of logging over many decades have razed one forest after another, with slow recovery in between. As a result, what some call “old growth” forests in the region may be only 80 years old.

Rare and precious, these mature forests are the heart of the region’s natural ecosystem, supporting globally outstanding biodiversity and unique natural communities that provide a host of vital ecosystem services to the people of the region. Nurturing healthy rivers and streams meander through bald cypress and tupelo trees that tower in the beautiful river swamps. Abundant cavities in tree trunks and branches are home to woodpeckers, flying squirrels, and owls. Along blackwater rivers, Atlantic white cedar once formed extensive swamps. In the region’s bogs, carnivorous plants such as Venus flytraps and pitcher plants are now found only in small areas. These forests provide habitat for one of the highest concentrations of endangered species in North America, including numerous songbirds, Louisiana black bears, endangered bats and butterflies, and even rare varieties of synchronous fireflies, about which researchers are still learning.^{12,13}

According to the most recent forest data from the USDA Forest Service Forest Inventory and Analysis (FIA) program, there are slightly more than 24 million acres of bottomland hardwood forests in the southeastern United States but only 3 million acres (12 percent) over 80 years old, the approximate age at which a forest of this type is

considered mature. Table 1 lists total acres of bottomland hardwood forests in each state and the proportion over 80 years of age.

Even before wood pellet manufacturers set their sights on these forests, bottomland hardwoods in this region faced mounting pressure from agriculture, the traditional forest products industry (e.g., building products and pulp/paper production), and urbanization.¹⁴ The coastal Southeast is also one of the most at-risk regions in the United States for sea level rise, which will significantly encroach on bottomland hardwood forests on the coastal edge.¹⁵ As these cumulative pressures reduce or degrade forests in the region, the need for the ecosystem services these forests provide will be greater than ever.

Biodiversity

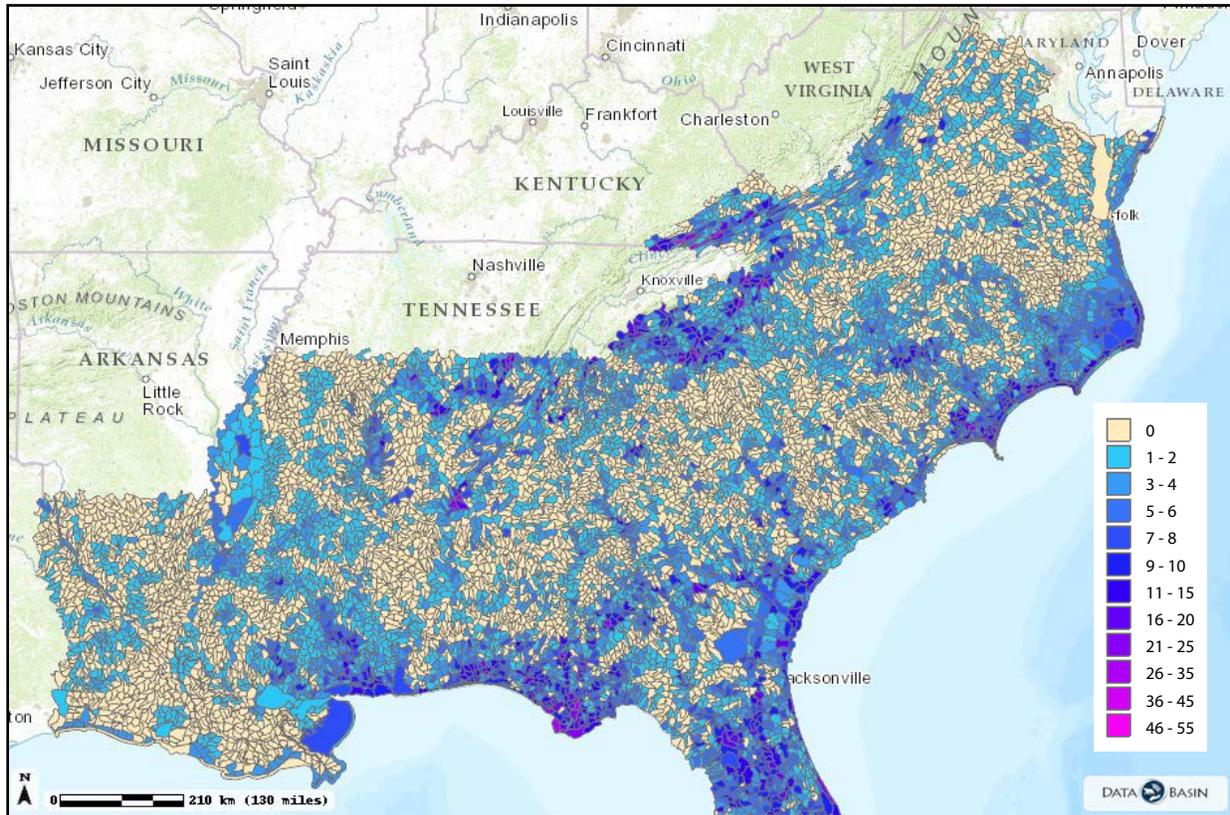
The Southeast United States is one of the most biologically rich regions in North America, supported by a mild climate, diverse geology and soils, and an abundance of water. The World Wildlife Fund calls southeastern forests “some of the most biologically important habitats in North America,” and the region has been identified as globally outstanding with respect to species richness and endemism (species found nowhere else) for salamanders, trees, land snails, fishes, mussels, and crayfishes.¹⁶ The region contains the highest concentration of valuable wetlands in all of North America, with many terrestrial and aquatic animals depending on these forests, including numerous at-risk species.

The region contains pockets with high numbers of imperiled or federally listed species and rare plant communities, many closely associated with bottomland hardwood forests (Maps 1A and 1B). Organized by watershed, the maps show concentrations of rare species and communities along the coast and inland along the major waterways, which are dominated by bottomland hardwood forests.

State	Total Acres	Old Acres	Percent Old
Alabama	2,670,224	139,201	5.21%
Florida	3,599,146	909,517	25.27%
Georgia	3,770,688	405,208	10.75%
Louisiana	4,991,000	507,393	10.17%
Mississippi	3,723,746	117,005	3.14%
North Carolina	2,349,710	354,092	15.07%
South Carolina	2,417,638	327,088	13.53%
Virginia	749,927	133,510	17.80%

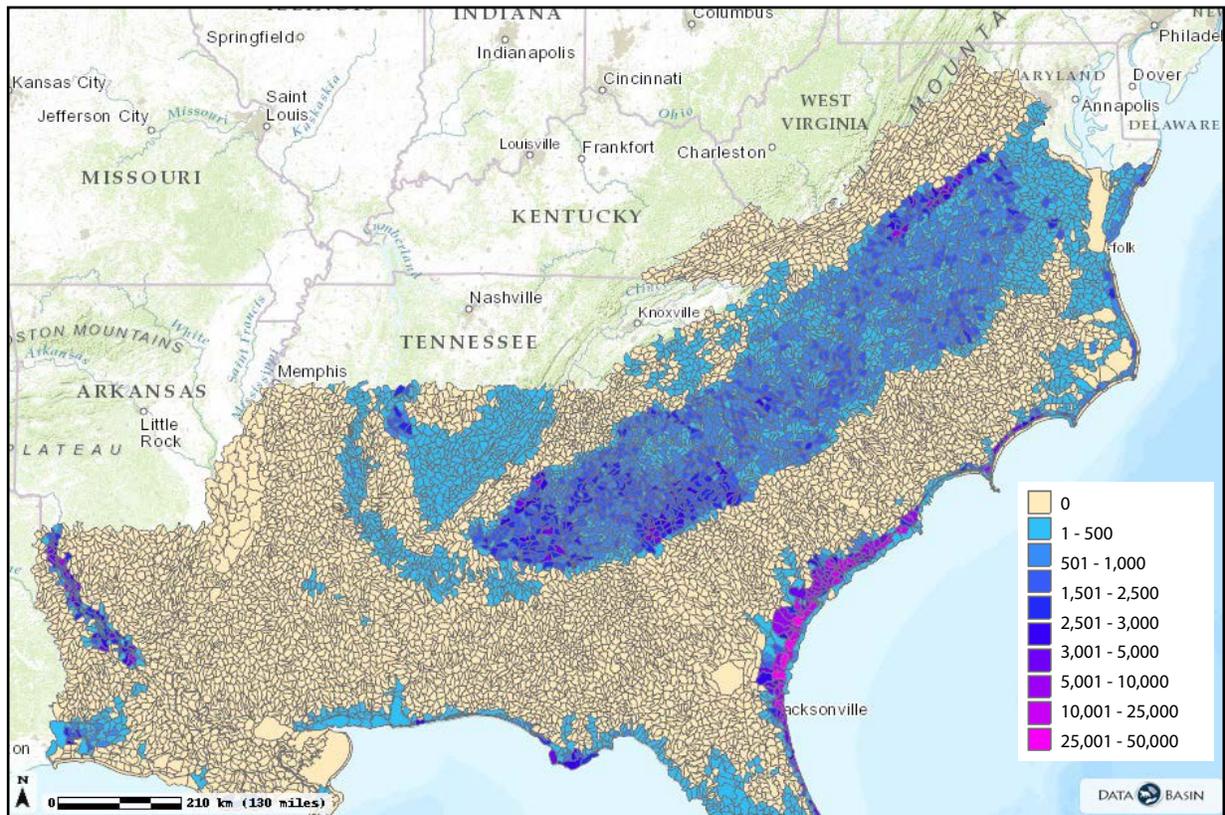
Source: USDA Forest Service FIA, October 2014

Map IA. Number of imperiled and federally endangered species, by watershed, in the U.S. Southeast



Source: U.S. EPA EnviroAtlas

Map IB. Acres of rare plant communities in the U.S. Southeast



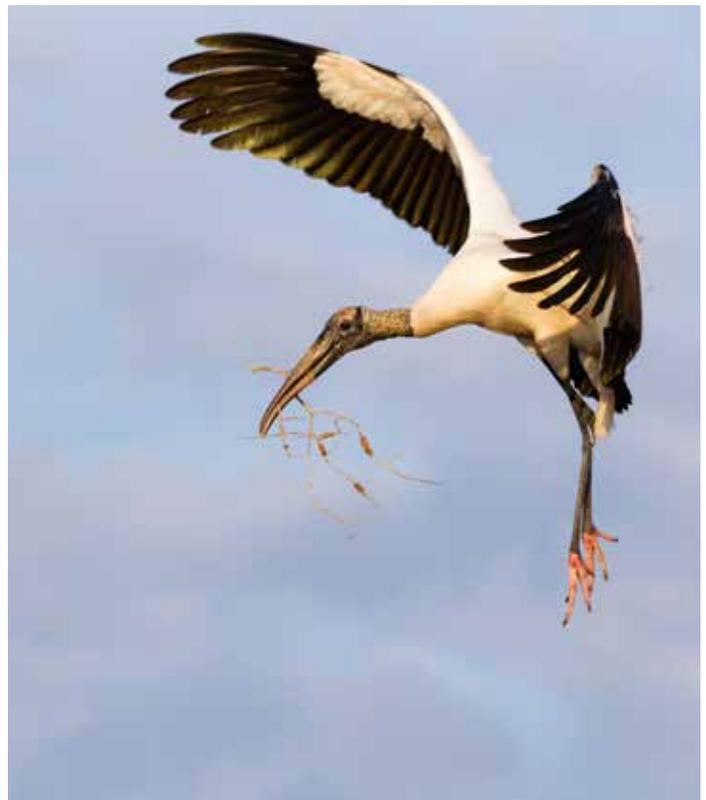
Source: U.S. EPA EnviroAtlas

Bottomland hardwood forests provide important habitat for many forest interior bird species whose numbers have declined significantly over the past decade. These birds of conservation concern include Swainson's warbler, the prothonotary warbler, and the swallow-tailed kite, birds classified as high priority by the U.S. Fish and Wildlife Service in its South Atlantic Migratory Bird Initiative (SAMBI) plan.¹⁷ Bringing more sobering news is a recent report by the Audubon Society, "Birds and Climate Change," which states that of the 588 North American bird species studied, more than half are in jeopardy.¹⁸ Audubon's models predict that 314 species will lose more than 50 percent of their current climatic range by 2080, including many species native to bottomland hardwood forests in the southeastern U.S. such as the bald eagle, wood thrush, wood duck, and American woodcock.¹⁹

Amphibians, which require freshwater for all or part of their life cycle, are a group of animals under serious threat globally from numerous factors including habitat loss and degradation, climate change, and disease.²⁰ The southeastern United States contains the highest diversity of amphibians in North America, and many species are associated with bottomland hardwood forests. In particular, the Southeast is known as globally significant for salamander diversity.²¹ Some of these species are widespread and still common; others are becoming quite rare and are found only in isolated pockets. They all rely on clean water and moist habitat for survival.²² The region also features the highest diversity of freshwater fish in the nation and is home to more freshwater mussel species than any other place on the planet.^{23,24,25} Mussels, most of which use a host fish to support the development of their larval forms, serve important ecosystem functions, including water purification and nutrient excretion, that greatly benefit other organisms and overall water quality. Unfortunately, a widespread decline in species number and abundances has compromised aquatic systems throughout the region, causing many mussel species in the region to become endangered.²⁶

BOTTOMLAND HARDWOOD FORESTS PROVIDE MANY CRITICAL ECOSYSTEM SERVICES

Bottomland hardwood forests provide critical ecosystem services for the people of the Southeast. They help filter and clean drinking water, protecting the health of an increasingly strained freshwater supply for the region's growing population, and they reduce or prevent periodic damaging floods by creating areas to hold floodwater. They provide the habitat that supports thousands of species, some of which are imperiled or on the brink of extinction. They form and protect productive soils, and they capture carbon dioxide from the atmosphere, thus making a critical contribution to tackling climate change.^{27,28}

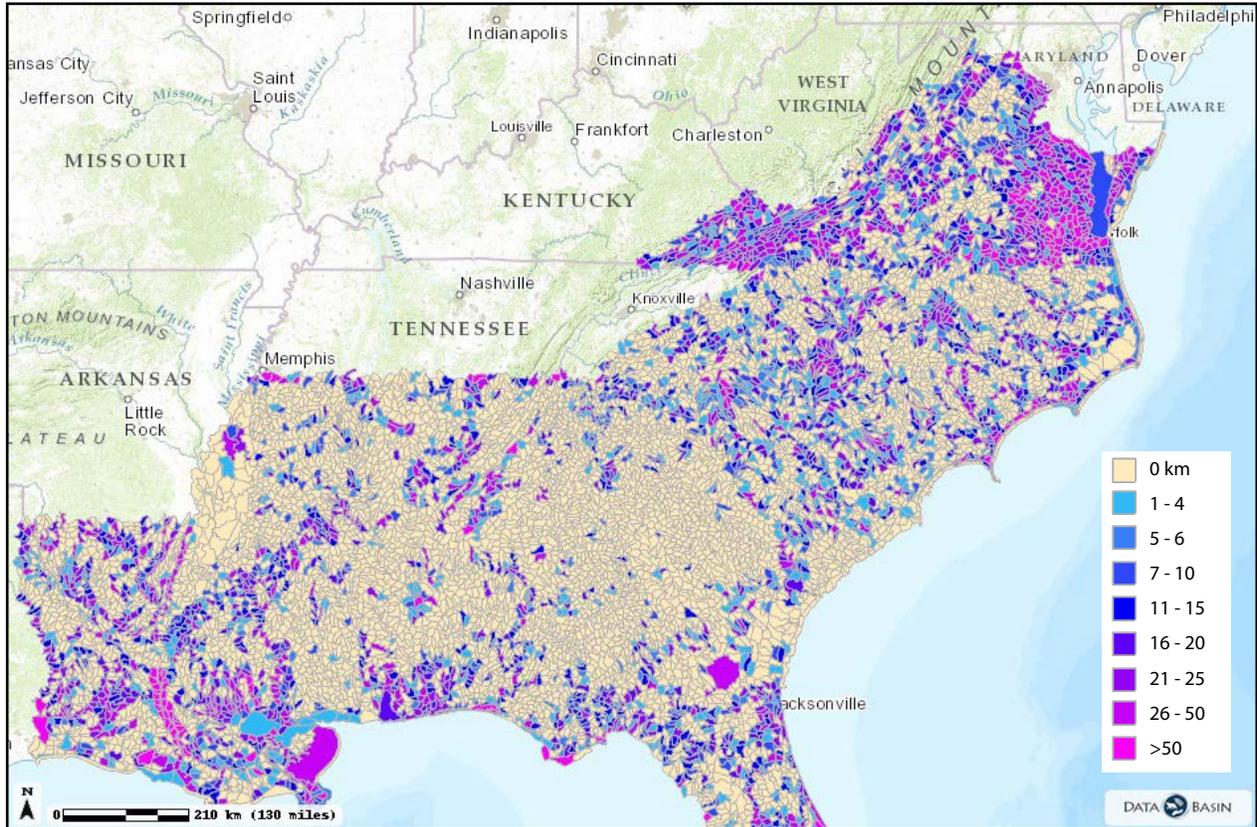


Water Quality

People and farms in the southeastern states rely on clean, plentiful water, and that supply is dwindling.²⁹ Bottomland hardwood forests purify and maintain the quality of freshwater streams and rivers in all eight states in the region, recharge groundwater, and capture and disperse sediment. Numerous scientific studies show riparian forest buffers are effective at improving water quality by intercepting pollutants (especially nitrogen), capturing sediment, and controlling water temperature fluctuations.^{30,31} For example, along the Little River in Georgia, a riparian forest has trapped 311,600 to 471,900 pounds per acre of sediment annually over the past 100 years.³²

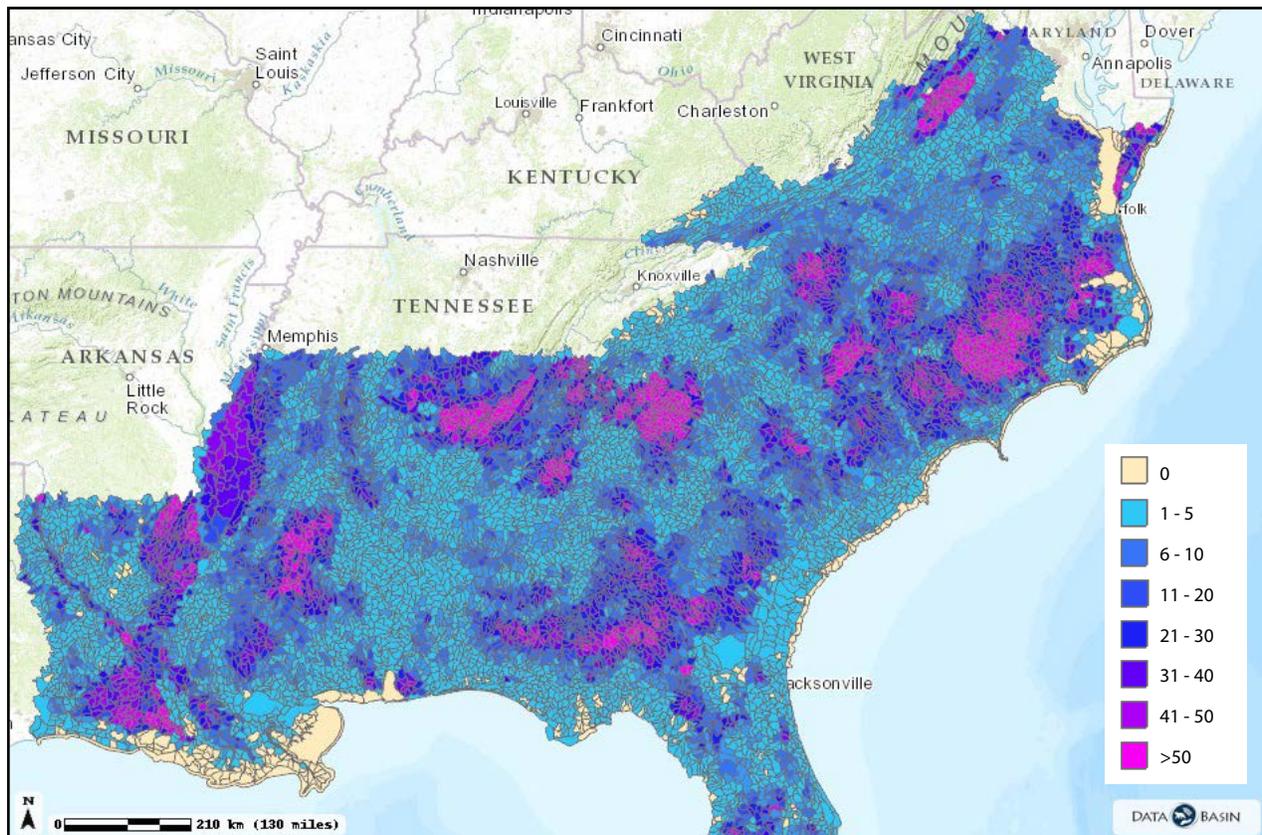
A survey of 27 water suppliers in 2002 by the Trust for Public Lands and the American Water Works Association found that in a source watershed, water treatment costs dropped by approximately 20 percent for every 10 percent increase in forest cover up to 60 percent. As much as half of water treatment costs could be explained by the amount of forest cover.³³ A 1990 study determined that the filtration benefits of the Congaree Bottomland Hardwood Swamp in South Carolina offset the need for a \$5 million wastewater treatment plant.³⁴ These natural water purification functions are especially critical in waterways already degraded by pollution (Map 2A) and loaded with excessive nutrients, such as nitrogen runoff from farming (Map 2B).

Map 2A. Length of rivers and streams listed as impaired by the U.S. EPA, by watershed



Source: U.S. EPA EnviroAtlas

Map 2B. Mean rate of annual nitrogen application on agricultural lands (kilograms per hectare), by watershed, 2006



Source: U.S. EPA EnviroAtlas

Flood Control

Bottomland hardwoods, especially in wide floodplains, deliver enormous flood control benefits, soaking up water, slowing floodwater speed, and providing areas for water to pool, thus reducing the risk of flooding in downstream communities. According to the Environmental Protection Agency (EPA), filled-in and drained bottomland hardwood forests along the Mississippi River once could store at least 60 days' worth of floodwater. Dramatically reduced in size, they now provide only 12 days' worth of water storage. In many cases, communities in the region have had to compensate for that loss of ecosystem service with expensive man-made solutions such as dredging and levees.³⁵

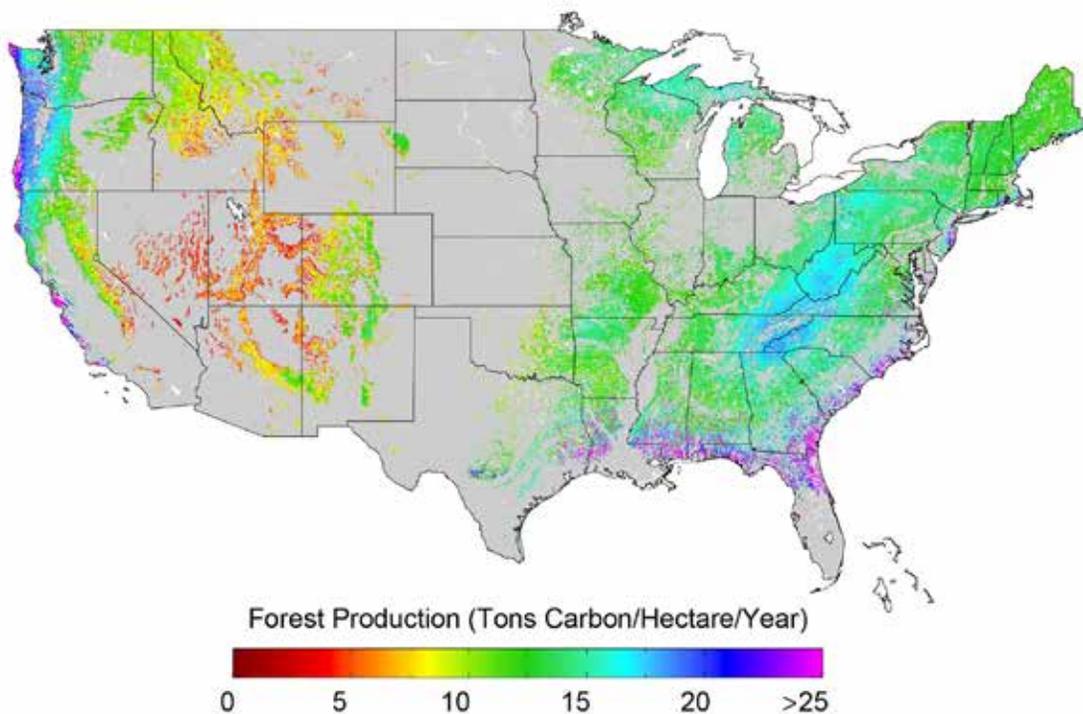
Carbon Sequestration and Storage

Forests in this region have some of the highest growth rates—and associated carbon absorption rates—of any in the United States powered by adequate water to support it (Map 3).³⁶ A recent study found that the Southeast may experience as much as a 40 percent reduction in carbon accumulation from a variety of factors.³⁷ Furthermore, growth rates are not the same thing as the amount of carbon stored in the vegetation and in the soils. Carbon stocks are higher in older forests, while younger forests take up carbon from the atmosphere at faster rates. The USDA Forest Service has mapped total forest carbon stocks for the coterminous United States, and the Southeast

region shows moderately high levels of carbon storage, especially in areas occupied by bottomland hardwoods (Map 4).³⁸ Currently, the Pacific Northwest, the Sierra-Nevada in California, and the Upper Great Lakes region show higher carbon storage values, but it is possible that increased disturbance from fires, drought, disease, and infestation of insects (such as the pine bark beetle) brought on by climate change could result in significant declines in carbon storage in these areas.³⁹ If these declines are realized, the forests in the Southeast will become even more important at the national level for carbon storage—at a time when their own capacity to store carbon could be compromised. Keeping older forests intact is a sound strategy to counter these dynamics.

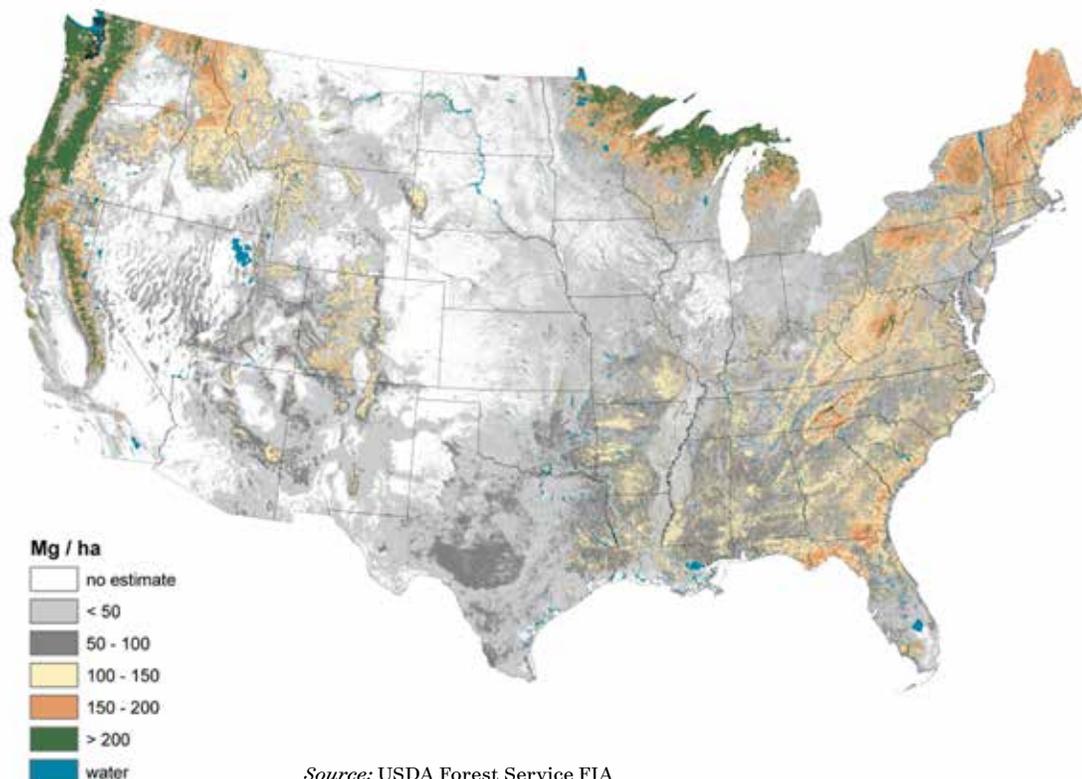
Forests help fight climate change by serving as massive carbon sinks, pulling carbon out of the atmosphere and storing it in vegetation and soil. In the United States, we count on our forests to expand each year, offsetting the carbon emissions coming from our factories, homes, and cars. In 2011, U.S. forest ecosystems and the associated wood products industry captured and stored roughly 16 percent of all carbon dioxide emitted from burning fossil fuels.⁴⁰ According to the 2014 U.S. National Climate Assessment, this important national “carbon sink could grow or shrink depending on the extent of climate change, forest management practices, policy decisions, and other factors.”⁴¹

Map 3. Annual forest growth, measured as tons of carbon per hectare, in the coterminous United States, 2000–2006



Source: Joyce, L.A. et al. 2014

Map 4. Total forest carbon stocks, in tons of carbon per hectare, in the coterminous United States



SOUTHEASTERN FORESTS ARE EXTREMELY VULNERABLE

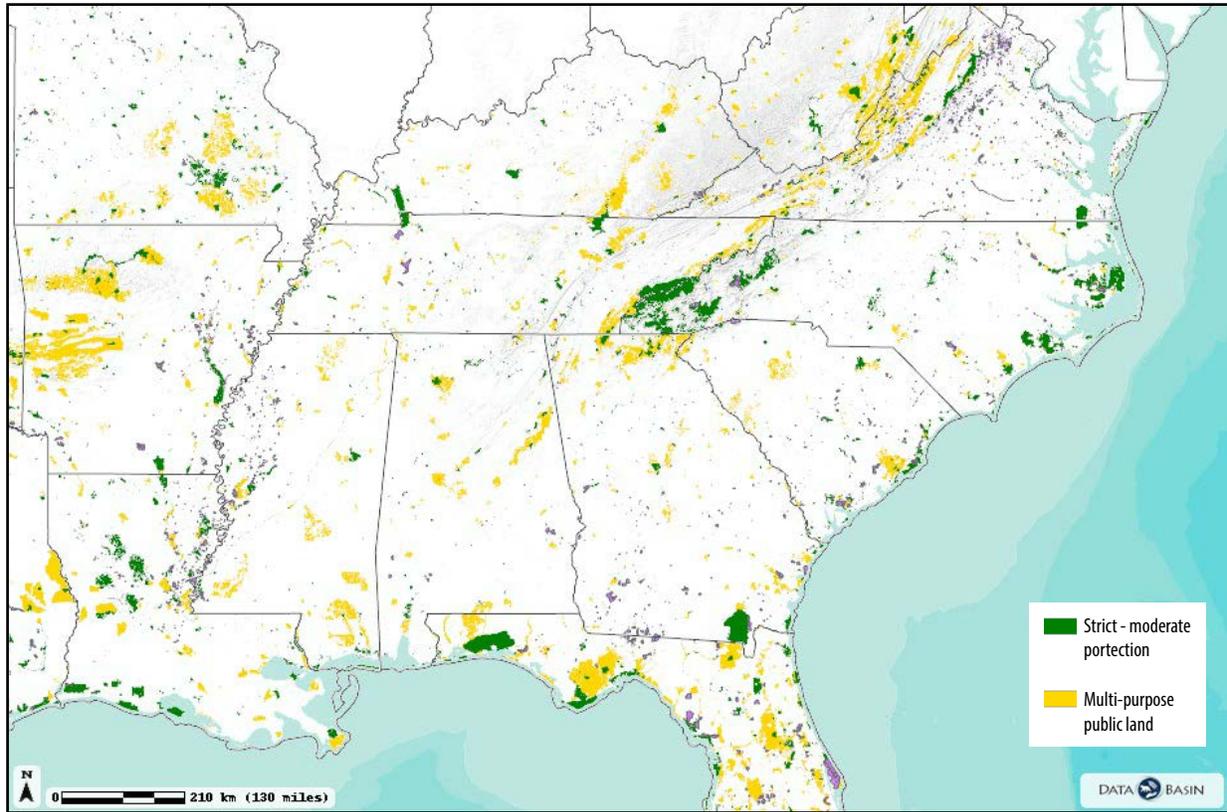
A common misconception is that forestry in the United States is strictly regulated to ensure responsible harvesting and safeguarding of sensitive ecosystems. In reality, only 10 percent of all bottomland hardwood forest in the Southeast is fully protected from commercial logging. Forestry on private land in the Southeast—which constitutes more than 80 percent of forests in the region—is conducted with few restrictions and little oversight. Practices such as large-scale clearcutting, old-growth logging, wetland logging, and the conversion of natural forests to plantations are mostly unregulated and are often practiced in sensitive habitats with little protection for species. In addition to the weak legal and regulatory environment in the region, very few forest acres are certified by any sustainability regime, and there is a disproportionate reliance on the least rigorous certification systems.⁴²

In a recent study, researchers assessed the level of protection for each of the major vegetation types as defined by the multiagency Landfire Program for the coterminous United States.⁴³ Vegetation types that were most protected were all located in the West, while three of the ten least protected types were associated with bottomland hardwood forests of the Southeast, namely Eastern Small Stream Riparian Forests, Hardwood Flats, and Sweetgum–Water

Oak Forests. Map 5 shows very little strict-moderate protection in the Southeast overall (green areas on the map), resulting in low representation of these vegetation types.

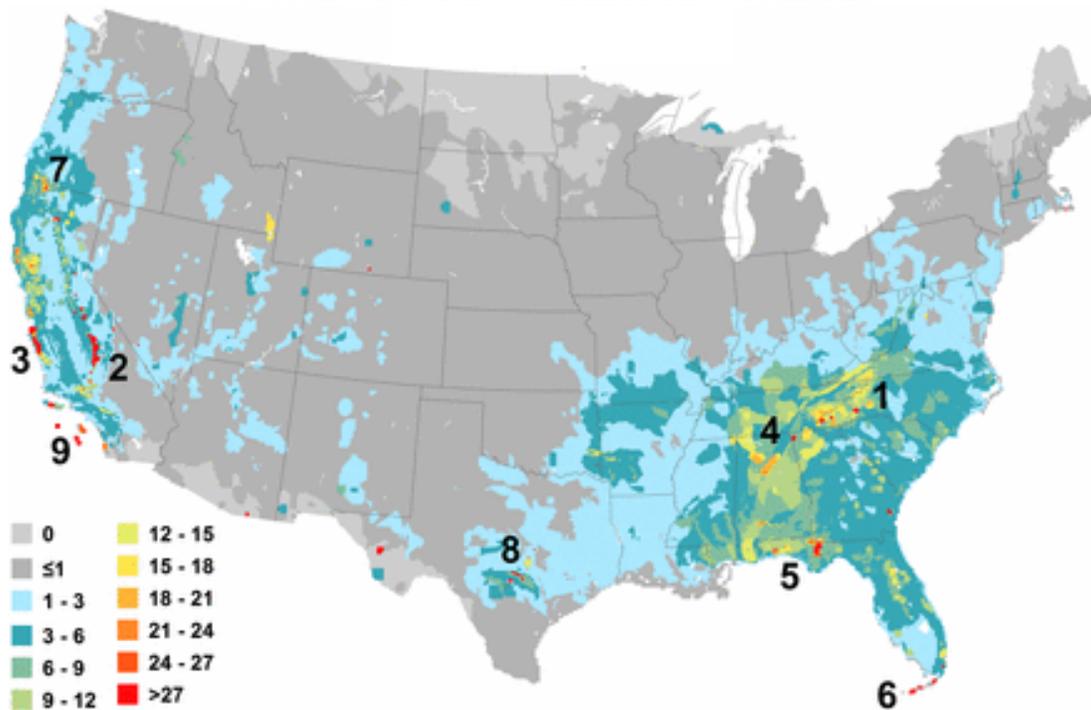


Map 5. Current land protection status for the southeastern US including private conservation easements



Source: PAD-US (CBI Edition) version 2.1, 2012, Conservation Biology Institute, databasin.org/datasets/fl0a00eff36945c9a1660fc6dc54812e

Map 6. Summed priority scores across all taxa for the coterminous United States, emphasizing areas where expanded conservation is needed: 1. Middle to southern Blue Ridge Mountains. 2. Sierra Nevada. 3. California Coast Ranges. 4. Tennessee, Alabama, and northern Georgia watersheds. 5. Florida Panhandle. 6. Florida Keys. 7. Klamath-Siskiyou. 8. South-Central Texas. 9. Channel Islands of California



Source: Jenkins, C.N. et al. 2015

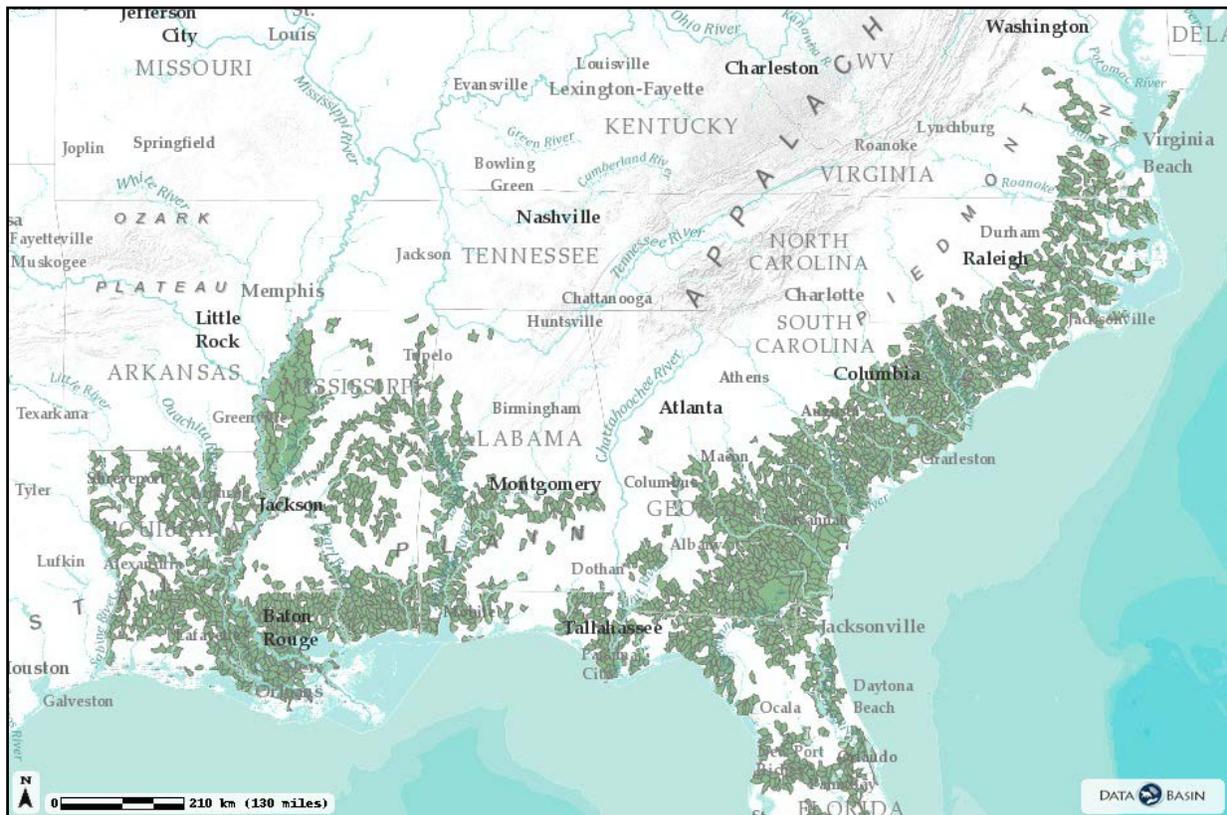
The forests in the southeastern states are extremely important biologically at global, continental, and national scales, but they are also highly vulnerable. A slightly modified bottomland hardwood forest dataset called Woody Wetlands (see Appendix A) allows for more detailed summarization with the current protected lands data. Analysis shows that only about 10 percent of this current forest type in the region is protected, leaving 90 percent

vulnerable to ongoing disturbance or conversion. The breakdown by state is provided in Table 2. Of the eight states examined, Florida is the only state that has more than 20 percent of its woody wetlands protected, totaling 832,913 acres. Five of the eight states examined have more than 90 percent of their woody wetlands at risk. Watersheds that are particularly vulnerable are shown in Map 7.

Table 2. Summary of woody wetlands, protected and vulnerable⁴⁵

State	Woody Wetlands Protected (acres)	Percent Woody Wetlands Protected	Woody Wetlands Vulnerable (acres)	Percent Woody Wetlands Vulnerable
Alabama	87,827	3.83%	2,204,072	96.17%
Florida	832,913	20.21%	3,287,520	79.79%
Georgia	462,348	9.81%	4,252,919	90.19%
Louisiana	321,645	6.06%	4,983,225	93.94%
Mississippi	173,859	4.71%	3,515,946	95.29%
North Carolina	379,500	13.62%	2,406,824	86.38%
South Carolina	198,500	6.75%	2,740,637	93.25%
Virginia	122,897	13.74%	771,710	86.26%
Total	2,579,488	9.65%	24,162,853	90.35%

Map 7. Areas in U.S. Southeast where vulnerable woody wetlands (green) are most concentrated (watersheds of >3,000 acres)



Source: Data derived from National Landcover Database, USGS GAP Land Cover, and Landfire Existing Vegetation (see Appendix A)

REGION'S LAST REMAINING MATURE FORESTS ARE IN THE CROSSHAIRS OF WOOD PELLET MANUFACTURERS

As demonstrated in the previous section, protection for these important forests in the Southeast (particularly older stands) is woefully inadequate in every state. Today millions of acres of remaining mature forests are within the sourcing radii of existing and proposed wood pellet mills. Many are on the Atlantic coast, a favorite location for pellet mills because of ease of export of pellets to European markets.

Confronted with questions about sourcing wood in sensitive ecosystems, the wood pellet industry argues that these trees will grow back. That's true, but the ecological values of a regenerating forest are far fewer than those of older stands. The complex vertical structure of a mature bottomland system, vital for the highest levels of bird diversity, for example, may never be achieved thanks to even-age management with short rotation periods (a common management practice in the U.S. South that relies on clearcutting all trees over repeated, short time frames). Furthermore, restoring bottomland hardwood forests is challenging because of the time necessary for these forests to mature and because altered flood patterns can reduce the diversity of trees and plants when a forest regenerates.

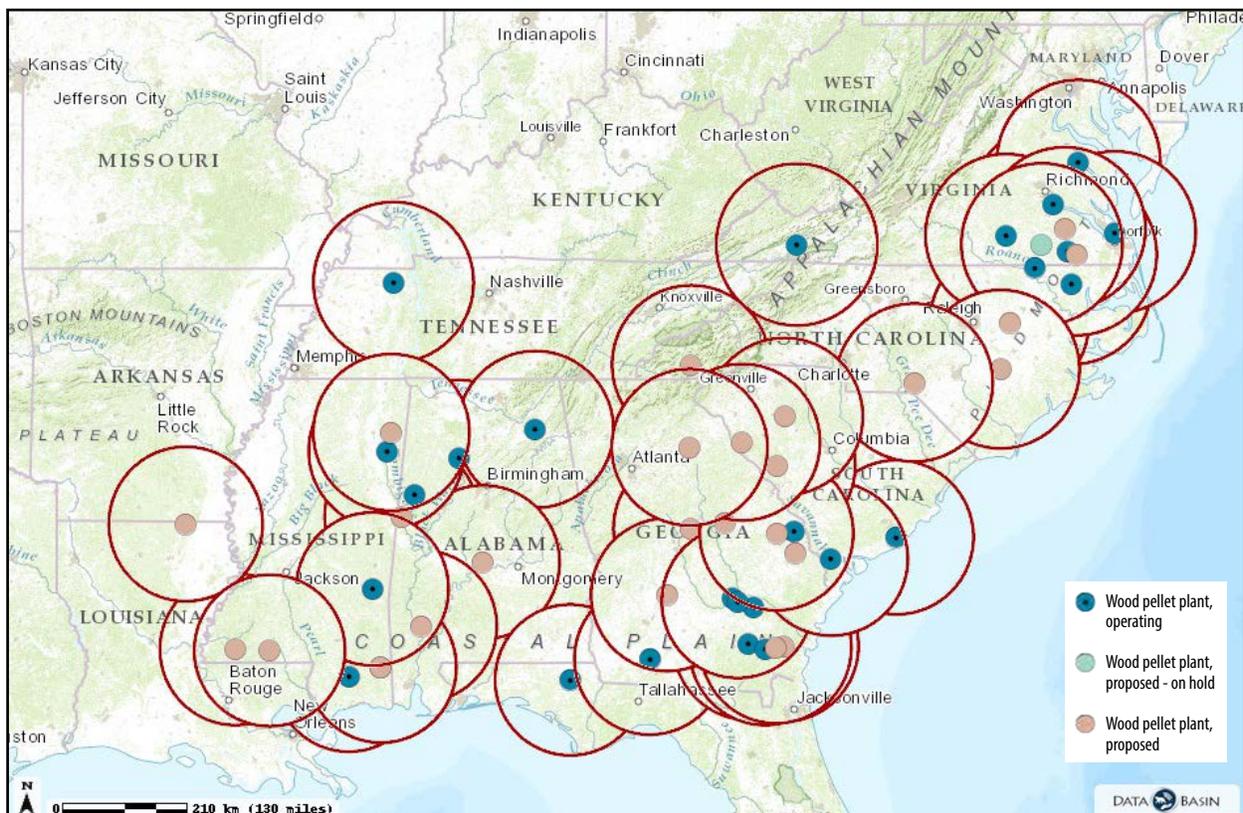
It takes an entire human lifetime to regain the values of a forest that has been cleared under the best of conditions. Even if these forests eventually do recover, in the decades-long interim, biodiversity, carbon capture, and all the other benefits of a mature forest will be forfeited and the ecological integrity of the site further compromised or in some instances completely lost.⁴⁶

BIOMASS COMPANIES ARE MOVING INTO THESE VULNERABLE AREAS

The maps in this section illustrate the existing and growing pressure on bottomland hardwood forests in the region from wood pellet facilities based on a spatial dataset compiled by the Southern Environmental Law Center.⁴⁷ Red circles on the maps show the assumed sourcing region for each facility: land within a 75-mile radius.⁴⁸ Of course, the actual sourcing distance can vary widely and is almost never uniform. However, a simple circle provides a reasonable approximation of a potential impact zone. Outside of Florida, few counties in any of the eight states examined appear to be outside the potential sourcing range of operating and proposed plants.

Map 8 shows the location of operating and proposed pellet mills and assumed sourcing distances in the southeastern United States. According to the dataset, there are 24

Map 8. Operating and proposed biomass facilities in the U.S. Southeast and approximate sourcing areas (red circles)



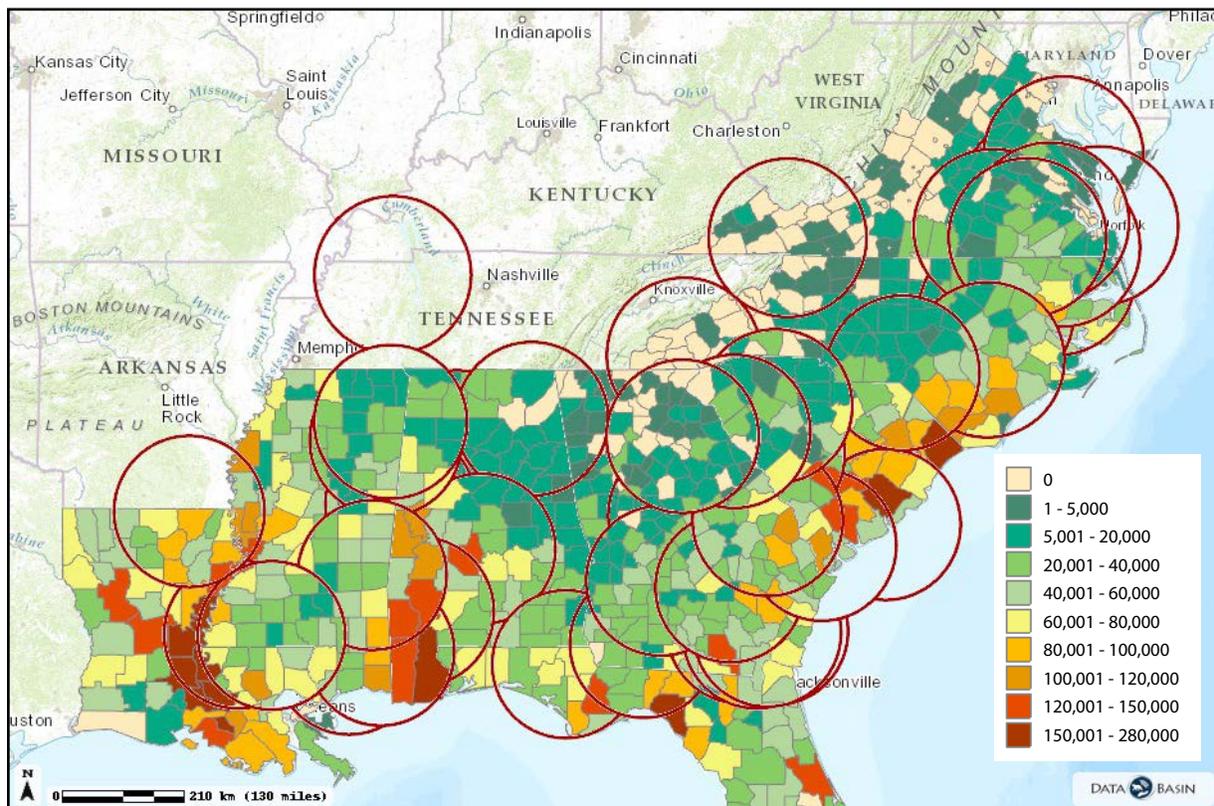
Source: Southern Environmental Law Center, 2014

operating and 27 proposed mills in the region, with some areas showing particularly high concentrations of facilities (the Virginia–North Carolina border, southeastern Georgia, and the Alabama–Mississippi border). Southern Louisiana, where there are large areas of vulnerable forest, is another region that is just beginning to be impacted. Table 3 summarizes the number of operating and proposed

pellet mills by state. Map 9 shows the assumed sourcing regions displayed over the estimated acres of vulnerable bottomland hardwoods by county. Some counties contain significant areas of forest, and pressure from the pellet industry is mounting with potentially devastating consequences.

State	Number of Operating Mills	Number of Proposed Mills	Total Number of Mills
Alabama	3	3	6
Florida	1	0	1
Georgia	7	8	15
Louisiana	0	1	1
Mississippi	3	5	8
North Carolina	2	4	6
South Carolina	2	3	5
Virginia	6	3	9
Total	24	27	51

Map 9. Acres of bottomland hardwoods per county classified as vulnerable in the U.S. Southeast



Source: USDA Forest Service FIA, 2014

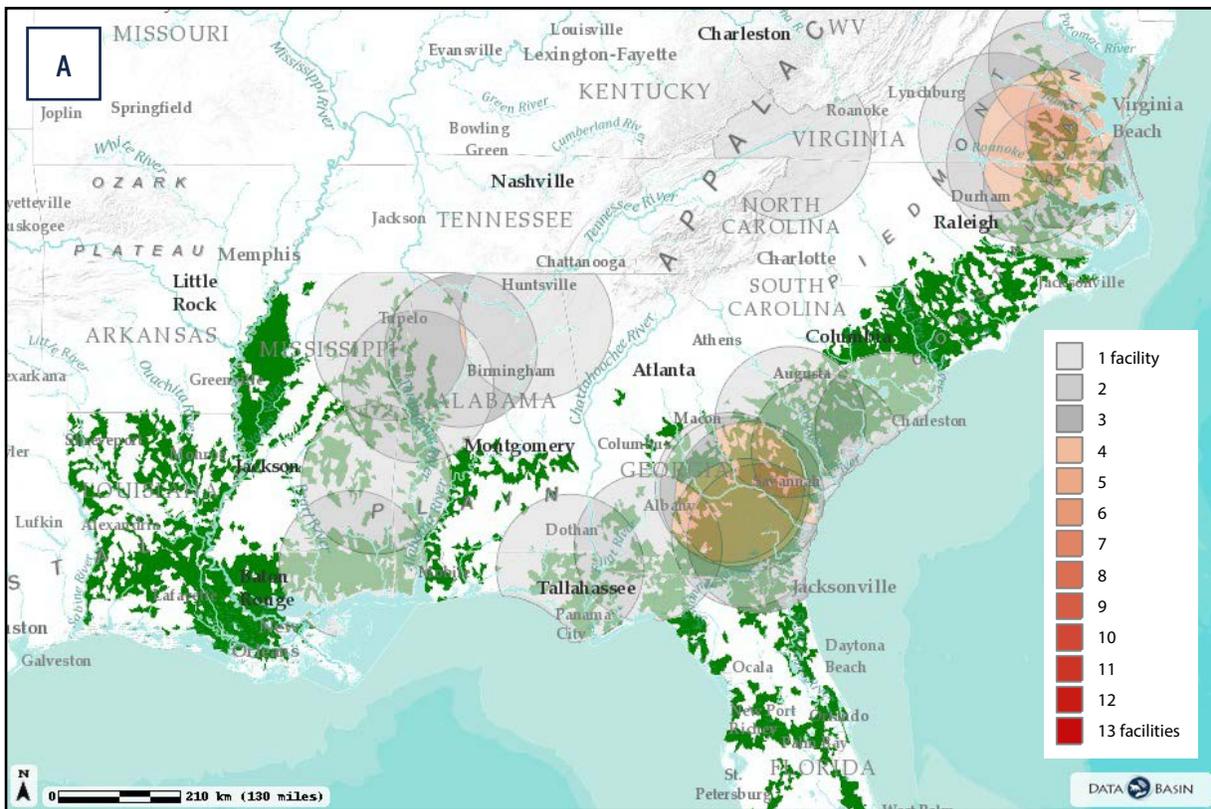
OVERLAPPING PELLET MILL SOURCING AREAS WILL CREATE HOT SPOTS

As new facilities start up, their potential sourcing areas may overlap with the assumed sourcing areas of existing wood pellet mills to create what we refer to as hot spots—areas of heavy wood sourcing. These are indicated by red and peach colors on the maps below. While a single high-production fuel pellet facility may significantly impact a bottomland hardwood forest, the potential damage is intensified if multiple facilities are sourcing from the same geographic area.

Map 10A shows the estimated intensity of sourcing by existing wood pellet mills in the region, and Map 10B adds

the proposed mills to illustrate the potential combined impact. The high-overlap areas paint a particularly bleak picture for vulnerable forests caught inside the region's growing hot spots. The maximum number of sourcing overlaps among currently operating facilities is 7—that is, up to 7 different facilities could potentially be sourcing from the same area. When proposed facilities are added, the maximum number of facilities that could source from the same area jumps to 13. Map 10B highlights two companies operating in the region. Enviva operates 6 of the 24 current facilities (25 percent) and is planning 3 more. Drax, a newcomer to the region, has proposed 4 new facilities in an emerging hot spot along the Alabama–Mississippi border and in neighboring Louisiana.

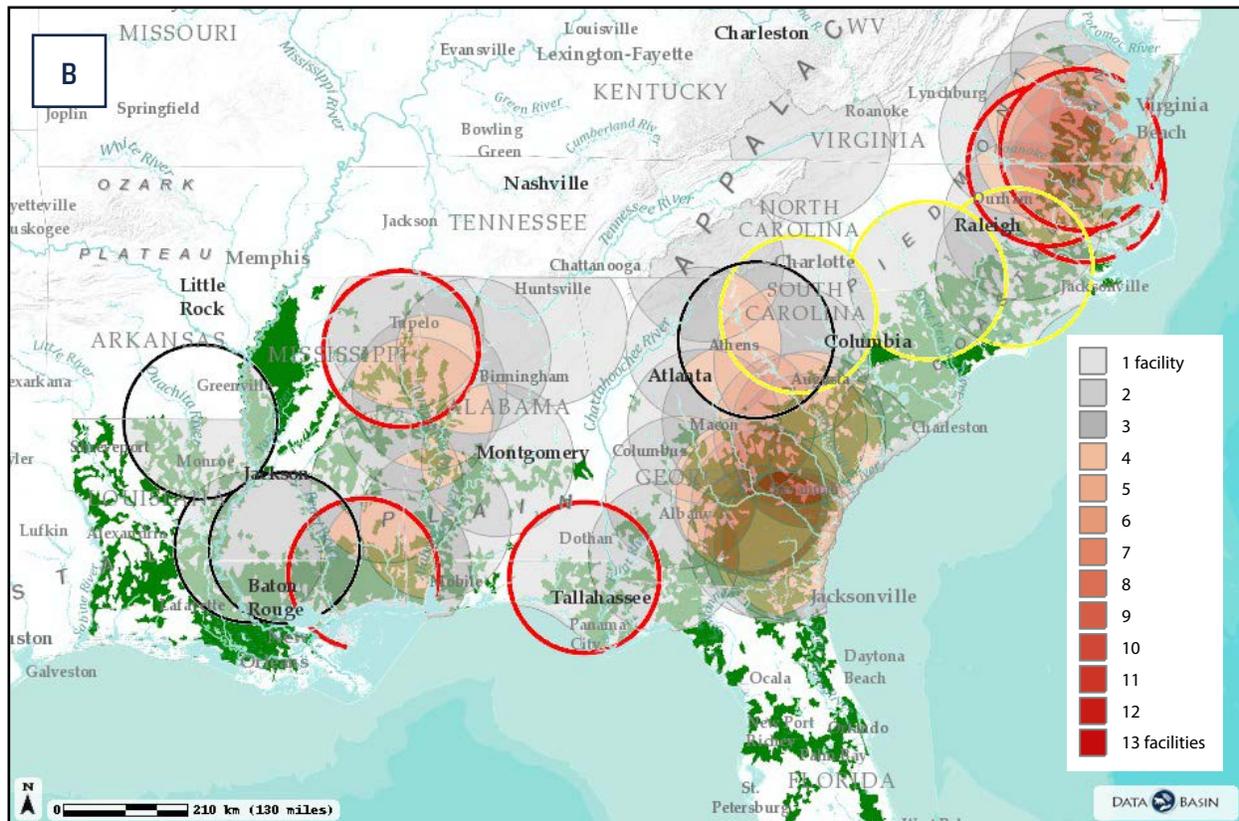
Map 10. Intensity of assumed sourcing areas from currently operating biomass processing facilities



Source: Southern Environmental Law Center, 2014; Conservation Biology Institute. See Appendix A for details. Green polygons are those watersheds containing more than 3,000 acres of woody wetlands.

Map 10. Combined operating and proposed facilities in the U.S. Southeast

(Operating Enviva facilities are outlined in red; proposed Enviva facilities in yellow; and proposed Drax facilities in black.)



Source: Southern Environmental Law Center, 2014; Conservation Biology Institute. See Appendix A for details. Green polygons are those watersheds containing more than 3,000 acres of woody wetlands.

THREE CURRENT HOT SPOTS THREATEN VULNERABLE BOTTOMLAND HARDWOOD FORESTS

While pellet mill expansion is taking place throughout the Southeast, three areas emerge as current hot spots, with the largest concentration of existing and proposed mills at the time of publication. The following section provides detailed overviews of these hot spots, including issues of particular concern and the current and potential impacts of pellet mills in each location. Growth is explosive in these locations now. Without checks on the industry, these hot spots are almost certain to grow, and new ones will likely emerge in the coming years. The focus on these three regions does not discount the need for further attention to all areas where pellet mills are moving in within sourcing range of vulnerable bottomland hardwood forests. In fact, we also discuss a potential fourth hot spot in the making, Louisiana, which has a high level of vulnerable forests and several wood pellet facilities currently being established.

Hot Spot I: Virginia–North Carolina Border

The region spanning the border between Virginia and North Carolina is already experiencing intense sourcing of wood for pellet manufacturing mills, most notably by U.S. pellet giant Enviva, which also has operations in Mississippi and Florida and another planned in South Carolina. As shown on Map 11, Enviva is the major wood pellet manufacturer in this region, operating three facilities in Southampton County, Virginia, and North Carolina’s Northampton and Hertford Counties. It also has a local port facility to move pellets overseas. The company’s operations in this region are also spreading southward. Enviva has begun planning two more facilities in North Carolina’s Richmond and Sampson Counties, intensifying the potential impact in this hot spot.

Even without additional facilities, the reach of existing pellet mills operating in Virginia extends to every bit of bottomland hardwood forest that isn’t under protection. While Virginia has the least bottomland hardwood forest acreage of all the southeastern states included in this analysis, it does contain more than 133,000 acres of bottomland hardwood forests over 80 years old, which are considered the most valuable in terms of habitat, carbon storage, and water filtration.

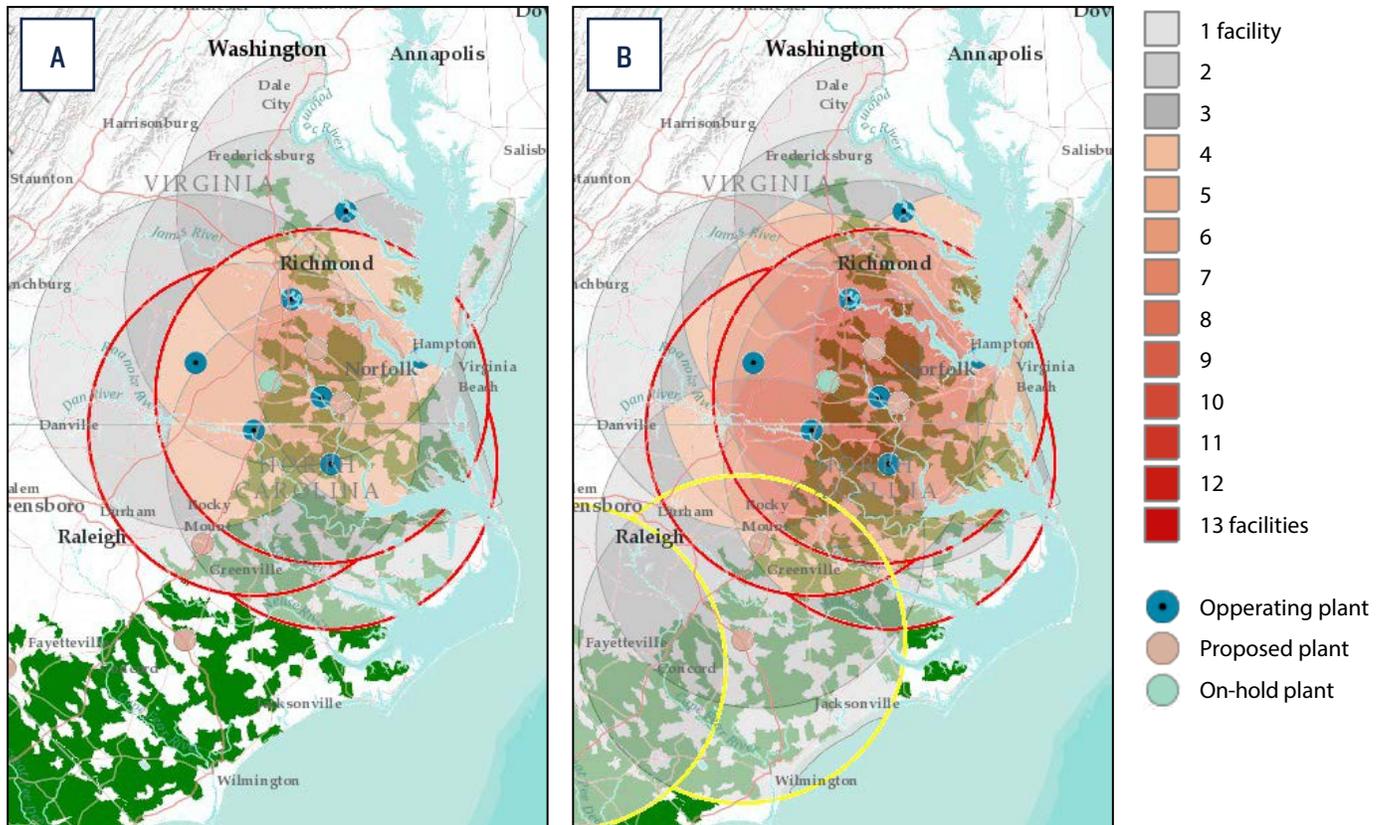
Consider the Following:

- Total estimated bottomland hardwood forest in Virginia: ~750,000 acres (~895,000 acres of woody wetlands),⁵⁰
- Total estimated mature (>80 years) bottomland hardwoods in Virginia: ~133,500 acres (18 percent of the total)
- Total estimated bottomland hardwood forest in North Carolina: ~2.3 million acres (~2.8 million acres of woody wetlands)
- Total estimated mature acres in North Carolina: ~350,000 acres (15 percent of the total)
- Approximately 86 percent of woody wetlands in the combined states are vulnerable.
- Approximately 60 percent of all vulnerable woody wetlands (537,500 acres) in Virginia and 40 percent of all vulnerable woody wetlands (1.1 million acres) in North Carolina lie within the assumed 75-mile sourcing radii of the three Enviva plants in the region.

- Existing and proposed plants could impact five primarily forested areas recognized by Audubon as being globally important habitat for the conservation of bird populations. These areas total more than 665,000 acres and encompass the Roanoke River, Chowan River, Great Dismal, Pocosin Lakes, and Palmetto Peartree. More than 60 percent of this area is currently unprotected from logging and within the assumed sourcing area for pellet facilities in this region.⁵¹
- In this region, Enviva facilities alone convert an estimated 1.45 million dry metric tons of trees and woody residuals per year into pellets. This will increase to 2.55 million dry metric tons per year if the company's two planned facilities go online as anticipated and the hot spot begins to spread to the south.⁵²
- At scheduled production levels (assumed 2.35 million dry metric tons/year, and 80 percent hardwood input), the three existing and two proposed Enviva wood pellet mills in eastern North Carolina and southeastern Virginia will require cutting approximately 30 square miles of hardwood forests in the sourcing area every year.⁵³

Map II. Virginia/North Carolina hot spot

Close-up view of the estimated intensity of operating (panel A) and operating and proposed (panel B) wood pellet facilities highlighting watersheds with >3,000 acres of vulnerable (unprotected) woody wetlands (green). These watersheds could experience significant degradation. Potential sourcing areas for the three current Enviva mills are shown in red and the two proposed mills in yellow.



Source: Southern Environmental Law Center, 2014; Conservation Biology Institute. See Appendix A of full report for details. Green polygons are those watersheds containing more than 3,000 acres of woody wetlands.



The expected production level for all companies' operating and proposed wood pellet mills in the core of this hot spot exceeds 2.6 million dry metric tons per year. Other leaders include Franklin Pellets LLC (anticipated volume is 500,000 tons of wood per year) and Wood Fuel Developers, LLC (expected volume is 300,000 tons of wood per year). With the additional two Enviva mills and one International Wood Fuels LLC mill opening just south of the existing hot spot, expected production in the region jumps to more than 4 million dry metric tons per year.⁵⁴

This area in Virginia and North Carolina is home to not only millions of people, but a rich diversity of animal and plant species, a number of which are imperiled. These species occur in the counties where the mills are located and in the dozens of counties within their sourcing ranges. Numbers of imperiled species and acres of vulnerable bottomland hardwood forest overlap in potentially disastrous ways. The red wolf, which roams the five northeastern North Carolina counties, numbers only between 50 and 75 individuals; this region is part of the U.S. Fish and Wildlife Service endangered species

recovery program.⁵⁵ The federally endangered West Indian manatee, which inhabits both freshwater and saltwater, frequents rivers and estuarine habitats within the assumed sourcing range of existing and proposed pellet mills when water temperatures are warm.⁵⁶ The critically endangered Roanoke logperch, a freshwater fish that depends on clean water associated with healthy bottomland hardwood forest habitat, is found around Enviva's Courtland plant in Southampton County.⁵⁷ Other examples of threatened and endangered species in Virginia and North Carolina counties within the assumed sourcing range of pellet plants include the rare skipper butterfly; freshwater mussels, including the dwarf wedge, yellow lance, and Atlantic pigtoe; and fishes, including the shortnose sturgeon and Carolina madtom.⁵⁸ The American alligator, near its northern range limit, occasionally can be found in the waters within the region.

Clean freshwater resources are particularly limited in this region. According to the U.S. Environmental Protection Agency, more than 8,500 miles of its rivers and streams have pollution problems.⁵⁹

Hotspot 2: Southeastern Georgia

Georgia has the third-highest number of acres of bottomland hardwood forest in the Southeast, after Louisiana and Mississippi, and the third-largest acreage of mature forest. The state is experiencing intense wood sourcing for pellet production and contains the most woody wetland acres under threat, mostly from currently operating facilities.

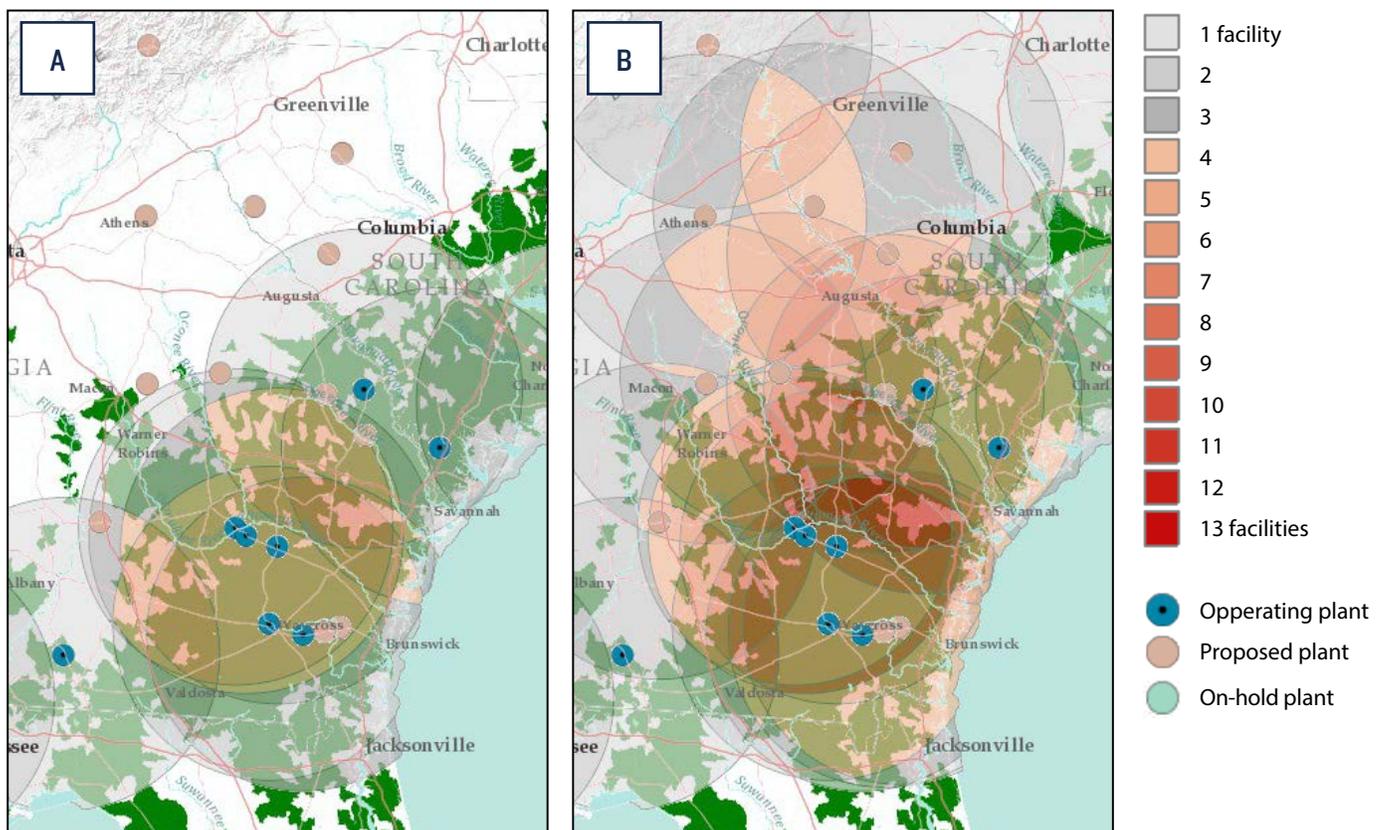
As shown in Map 12, proposed facilities in the state are spreading to the north, creating the region's largest hot spot. Some existing pellet fuel facilities in Georgia are relatively small, but not all. For example, Georgia Biomass LLC, operating in Ware County, has an output of 827,000 tons annually and is the world's largest pellet factory.⁶⁰ While Georgia Biomass currently relies heavily on pine from plantations, greater use of plantation pine is likely to incentivize conversion of the few remaining natural and seminatural forests in the region—including bottomland hardwood forests—to intensive plantations.⁶¹

Consider the Following:

- Total estimated bottomland hardwood forest in Georgia: ~3.8 million acres (~4.7 million acres of woody wetlands)^{62,63}
- Total estimated mature (>80 years) bottomland hardwoods in Georgia: ~405,000 acres (11 percent of the total)
- More than 90 percent of Georgia woody wetland acres are vulnerable.
- Multiple facilities would like to power up in this hot spot, which spreads north into South Carolina and south into Florida. Among the significant proposals are these:
 - General Biofuels proposes a plant in Washington, Georgia, to produce 440,000 tons of wood pellets per year.⁶⁴
 - Enova Energy Group LLC has proposed three plants, two in Brantley County, Georgia, and one in Wilkinson County, Georgia, producing a total of 851,000 tons of wood pellets per year.⁶⁵

Map 12. Georgia hot spot

Close-up view of estimated intensity of operating (A) and operating and proposed (B) wood pellet facilities highlighting watersheds with >3,000 acres of vulnerable (unprotected) woody wetlands (green). These watersheds could experience significant degradation.



Source: Southern Environmental Law Center, 2014; Conservation Biology Institute. See Appendix A of full report for details. Green polygons are those watersheds containing more than 3,000 acres of woody wetlands.

■ Geechee Energy LLC, proposes a pellet mill in Jenkins, Georgia, to convert 360,000 tons. According to the company, this plant is the first step in its expansion. Co-owner Marshall Deutsch told Biomass Magazine, “We think that getting into this market in a stable way will open the opportunity for us to look at other medium-sized pellet mills.”⁶⁶

Pellet plants in this region have the potential to impact a wide range of imperiled and endangered species. For example, in Ware County, Georgia, where the Georgia Biomass plant has an output of 827,000 tons annually, the state’s Department of Natural Resources lists 25 animals as being of special concern.⁶⁷

As mentioned earlier, the most globally significant area for salamander species diversity is in the Southeast. Although most of this richness is found in the southern Appalachians, a number of notable species, including the frosted flatwoods salamander and striped newt, are found in the bottomland hardwood portions of the coastal and piedmont zones of the state.⁶⁸ Among birds, the wood stork was listed as endangered in 1984 and was upgraded to threatened in 2014 by the U.S. Fish and Wildlife Service due to partial recovery of nesting adults and expansion of its inhabited range. These birds rely on mature woody wetlands for nesting and roosting.⁶⁹ Other bird species that utilize floodplain forests in the South include turkeys, woodcocks, barred and screech owls, red-shouldered hawks, bald eagles, Mississippi kites, woodpeckers, numerous waterfowl, wading birds, and songbirds. The coastal plain of Georgia has bottomland forests that provide shelter for migratory sandhill cranes and numerous songbirds such as a number of warbler species. The loss of old-growth bottomland hardwood forests contributed to the extinction of the Bachman’s warbler and the ivory-billed woodpecker.⁷⁰ A number of reptiles are at risk in the region, such as the eastern indigo snake, southern hog-nosed snake, and Barbour’s map turtle.

Several freshwater mussel species are also threatened in the region, as are a number of fish species, including the pygmy sunfish, shortnose sturgeon, bluestripe shiner, and robust redhorse, which was believed to be extinct for over 120 years.⁷¹ Then in 1991, the species was rediscovered along a 70-mile stretch of the Oconee River in Georgia.⁷² This area is now the site of three operating pellet mills.

A large number of ferns and other wetland plants are found in the region, including Georgia plume, southern Marshallia, and boykin’s lobelia.⁷³

Clean river issues are particularly important in Georgia, where the Flint River, which runs just to the west of the Georgia hot spot, was listed as the second-most endangered river in the country in 2013, after the Colorado River. The Flint River is imperiled because of heavy use, urbanization,

pollution, and drought, which have led to low water flows that critically threaten endangered fish and mussel species.⁷⁴ This river and others like it, which provide water for drinking and agriculture in southeastern states, cannot afford the loss of the protection provided by bottomland hardwood forests.

Hot Spot 3: Alabama–Mississippi Border

Bottomland hardwood forests in this region are highly vulnerable, and the wood pellet industry is moving in fast. As shown in Map 13, this hot spot is just getting started with the establishment of five proposed facilities being added to five existing ones. Two of the five operating facilities are owned by Enviva. A total of around 2.5 million acres of vulnerable woody wetlands are within the assumed sourcing area of the two Enviva facilities, including 1.7 million acres in Mississippi, 540,000 acres in Alabama, and 257,000 acres in Louisiana. Another mill, Westervelt Energy LLC, located in Pickens County, Alabama, has an annual output of 275,000 tons and can potentially source from around 1.4 million acres of vulnerable woody wetlands.⁷⁵

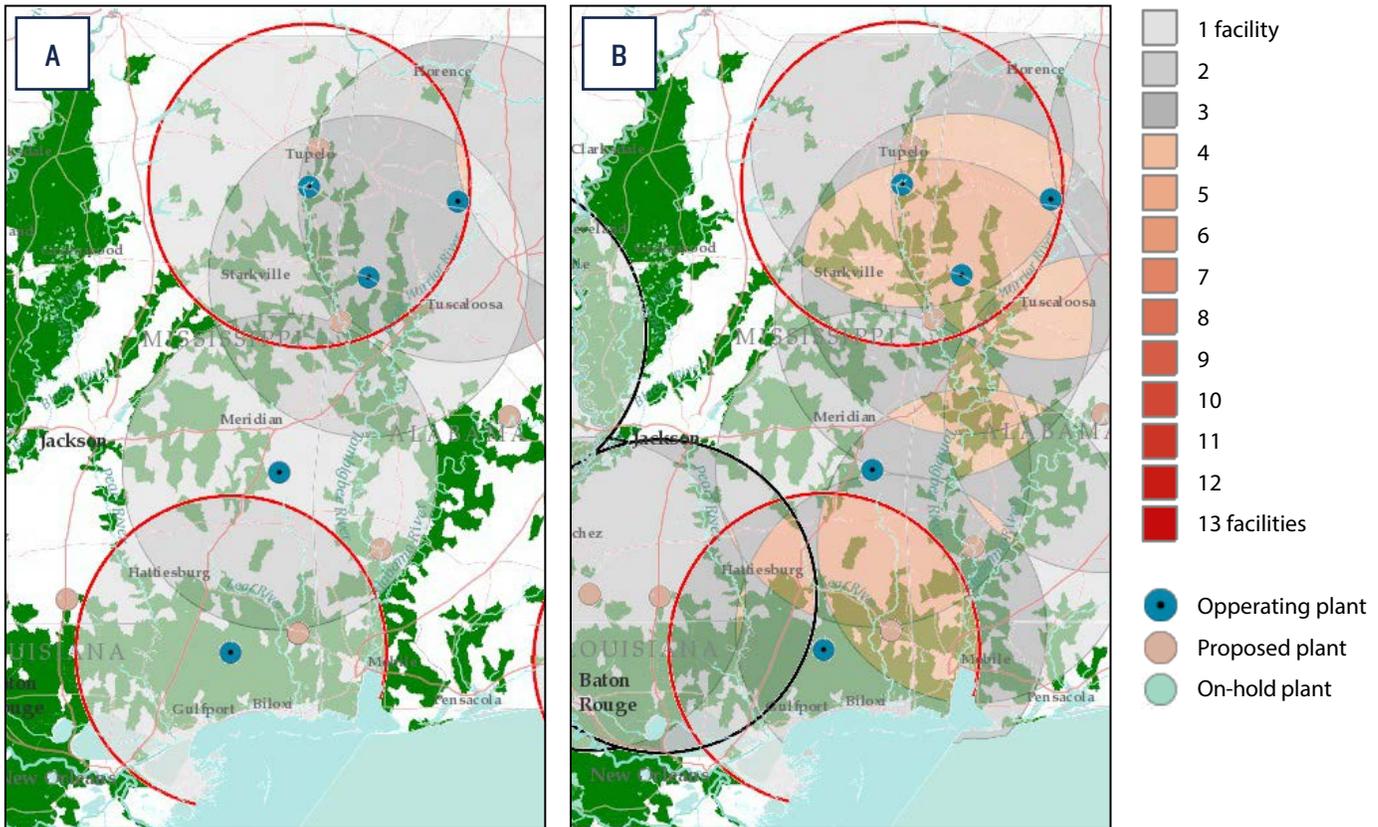
Consider the Following:

- Total estimated bottomland hardwood forest in Alabama: ~2.7 million acres (~2.3 million acres of woody wetlands).^{76,77}
- Total estimated forest in Mississippi: ~3.7 million acres (~3.7 million acres of woody wetlands).^{78,79}
- No two states have a greater percentage of vulnerable woody wetlands forest than Alabama and Mississippi: 96 percent and 95 percent, respectively.
- Proposed facilities include: Drax-Pike (450,000 metric tons/yr) in Pike County, Mississippi; International Biomass (550,000 metric tons/yr) in Clarke County, Alabama; and Gulf Coast–Lucedale (353,000 metric tons/yr) in George County, Mississippi.⁸⁰
- When all proposed facilities are in operation, a total of 2.6 million tons of wood fiber will be processed annually in this emerging hot spot.

Approximately 1.8 million acres of vulnerable woody wetlands in Mississippi, Alabama, Louisiana, and Florida lie within the assumed sourcing radii of the two proposed Lucedale, Mississippi plants—one planned by Gulf Coast Renewable Energy and the other by Green Circle Bioenergy Inc.. In addition, while these mills are likely to source from only a few counties in Florida, those Florida counties contain a high number of vulnerable acres—more than 404,000. Most of those same Florida acres would also be within the assumed sourcing range of the proposed International Biomass plant in Clarke, Alabama.

Map 13. Alabama–Mississippi hot spot

Close-up view of estimated intensity of operating and proposed wood pellet facilities highlighting watersheds with >3,000 acres of vulnerable (unprotected) woody wetlands (green). These watersheds could experience the greatest losses. Potential sourcing areas for the two current Enviva mills are shown in red and for the proposed Drax mill in black.



Source: Southern Environmental Law Center, 2014; Conservation Biology Institute. See Appendix A of full report for details. Green polygons are those watersheds containing more than 3,000 acres of woody wetlands.

Many federally threatened, endangered, and candidate species struggle in this region.⁸¹ The U.S. Fish and Wildlife Service has specifically warned about several endangered species there, including the gray bat and the Indiana bat, both in Mississippi, as well as the Louisiana black bear, federally listed as threatened, which inhabits primarily bottomland hardwood and floodplain forests along the Mississippi River in the southern portion of Louisiana and Mississippi.⁸²

Other endangered species found in counties within the assumed sourcing range of existing and proposed pellet plants—and which are specifically associated with bottomland hardwoods forests—include the American alligator; the Alabama spike mussel, delicate spike mussel, and several other mussel species; the pallid sturgeon; Alabama sturgeon; Alabama shad; Escambia map turtle; Red Hills salamander; American black bear; and numerous wetland plant species.



The Next Hot Spot: Louisiana?

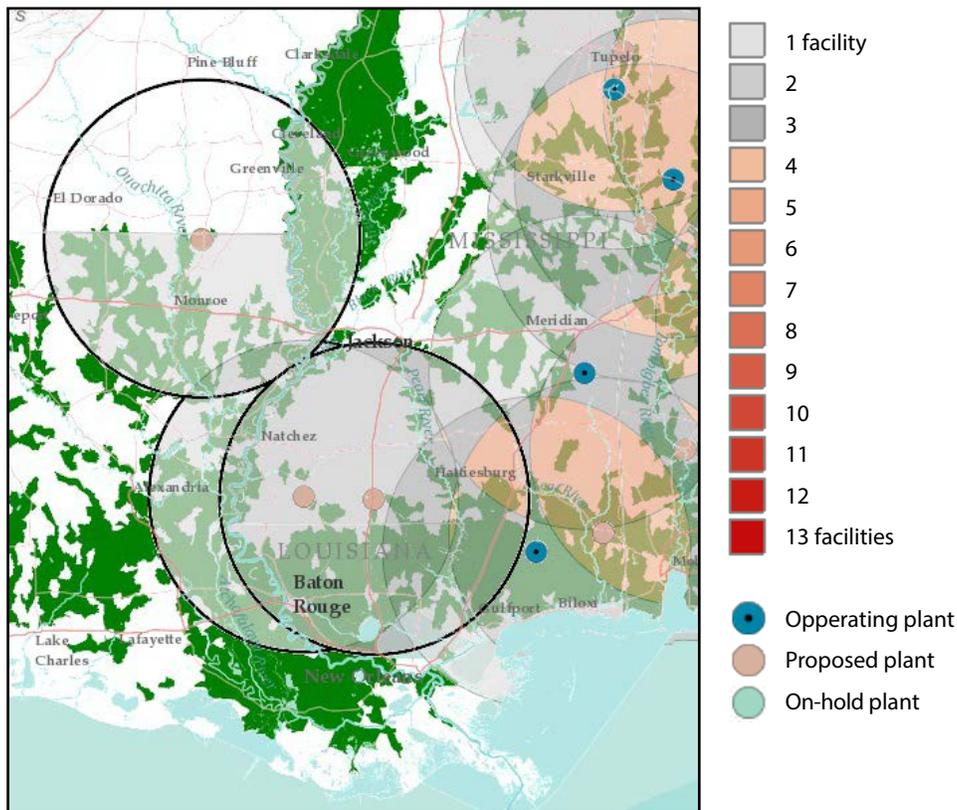
Louisiana has both the most bottomland hardwood forests of any southeastern state (5 million acres) and the highest number of vulnerable acres lacking protection from commercial logging.⁸³ Two facilities were recently opened by the U.K.'s Drax Power to supply biomass to its power plant near Leeds, England, and a third Drax plant has been proposed. Combined, these facilities would have the capacity to produce nearly 1 million short tons of wood pellets annually.⁸⁴ At the time of this writing, Drax-Morehouse Bioenergy, located in Morehouse Parish, Louisiana, and Drax-Amite Bioenergy, in Amite County, Mississippi, are already approaching their anticipated output of 450,000 metric tons/yr.⁸⁵ Map 14 highlights the proposed and newly opened Drax facilities in Louisiana and their potential sourcing areas. When all three mills are operational, they could have access to a total of 4.6 million acres of vulnerable woody wetlands (2.9 million acres in Louisiana and 1.7 million acres in Mississippi).

POLICY REFORMS ARE NEEDED TO ENSURE BIOMASS ENERGY DOESN'T POLLUTE OUR CLIMATE OR THREATEN OUR FORESTS

It is clear that the massive additional demand for biomass being driven by the bioenergy industry now threatens to destroy ecosystems that can never be replaced. A small amount of bioenergy requires a very large quantity of biomass and can drive enormous shifts in the landscape. Thus, even a limited number of conversions to bioenergy can have major impacts on the ground.

It is important to remember that the wood pellet industry has not emerged in a vacuum, but in response to specific policy incentives. Today demand for wood pellet exports out of the southeastern U.S. is being driven almost exclusively by climate and energy policies in the U.K. and European Union. However, it is imperative that policymakers in both the EU and the United States implement key policy reforms and avoid making specific policy errors with respect to bioenergy.

Map 14. Close-up view of Drax wood pellet facilities' assumed sourcing areas in Louisiana and Mississippi, highlighting watersheds with >3,000 acres of vulnerable (unprotected) woody wetlands (green). These watersheds could experience the greatest losses.



Source: Southern Environmental Law Center, 2014; Conservation Biology Institute. See Appendix A of full report for details. Green polygons are those watersheds containing more than 3,000 acres of woody wetlands.

First and foremost, policymakers must ensure that sustainability standards are paired with sound carbon accounting. It is critical that policymakers reject the assumption that all biomass is carbon-neutral and restrict public subsidies and other support mechanisms to sources of biomass fuel that demonstrably reduce carbon emissions within a time frame relevant to tackling climate change. Recent science and our own modeling show that wood pellets made in part of whole trees from bottomland hardwoods in the Atlantic plain of the U.S. Southeast—even in relatively small proportions—will emit carbon pollution comparable to or in excess of fossil fuels for approximately five decades.⁸⁶ This five-decade time period is significant: climate policy imperatives require dramatic short-term reductions in greenhouse gas emissions, and emissions from these pellets will persist in the atmosphere well past the time that significant reductions are needed. Under the right circumstances, true wood waste could serve as a lower-carbon option for producing pellets. For example, sawdust and chips from sawmills that would otherwise quickly decompose and release carbon anyway can be a low-carbon source.

When it comes to sustainability standards, as noted earlier, very few forest acres in the Southeast are certified by any sustainability regime. There is also a disproportionate use of the least rigorous certification options, such as the Sustainable Forestry Initiative (SFI) and American Tree Farm System (ATFS). These systems allow the conversion of natural forests with high biodiversity and high carbon values to low-biodiversity forests with low carbon storage value, industrial tree plantations, or development. Both also fail to ensure adequate protection for the habitats of

endangered and threatened species and for special, rare, or disappearing ecosystems.⁸⁷ Of the region's certified forests, only a tiny fraction is certified with the Forest Stewardship Council (FSC), the strongest certification system. It is important to note, however, that even the FSC does not currently include specific requirements for protecting forest carbon storage capacity.

Studies have concluded that true wood waste alone will likely be unable to meet bioenergy demands in the southern region.⁸⁸ Given that lower-carbon biomass sources are limited in supply, it is equally important that a cap be imposed on the use of biomass at levels that can be sustainably sourced (taking into consideration other competing uses—the existing traditional forest products industry—and the pressing need to increase protected areas for sensitive forest types). Getting this policy signal right is critical to steering the industry away from high-carbon, ecologically damaging sources of biomass and ensuring that bioenergy projects do not adversely impact forests, carbon sinks, soil, wildlife habitat, biodiversity, and water resources. It will also help direct both public resources and private investments toward energy efficiency and truly clean technologies such as wind, solar, and geothermal.

Getting the right policies in place will mean the difference between a bioenergy industry that could help us reduce the carbon emissions driving dangerous climate change and one that makes climate change worse. Failure to do so risks distorting the marketplace toward greater use of unsustainable and high-carbon sources of biomass, with significant risks to our climate, forests, and the valuable ecosystem services they provide.

APPENDIX A. MAPPING BOTTOMLAND HARDWOOD FORESTS VERSUS WOODY WETLANDS

This report’s primary source for specific bottomland hardwood data (organized by county) was the USDA Forest Service’s Forest Inventory and Analysis (FIA) program, which was downloaded from its online data management system, called FIDO (apps.fs.fed.us/fia/fido/index.html).

Data were searched and downloaded for each county according to forest type (i.e., bottomland hardwood forest), stand age class, and reserved status. Using these data, we created spatial representations of bottomland hardwoods for each county in each state.

In order to map land cover at a finer spatial resolution, we used the National Landcover Database (NLCD, USGS, 2011), choosing woody wetlands as the initial land-cover class to approximate bottomland hardwood forests; neither NLCD nor any other wall-to-wall map product of forest type used “bottomland hardwood forest” as a specific class. We further refined this dataset by erasing all non-forest cover types from the most recent U.S. Geological Survey GAP Land Cover data, reducing the amount of woody wetlands. For Florida, South Carolina, and Virginia, we also erased all non-forest land cover types using Landfire Existing

Vegetation Type (USFS, 2010). Comparison between FIA bottomland hardwood forests and woody wetlands yielded reasonable agreement in total acres by state (see Table A1 below). For all but two states, the woody wetlands cover was greater than the amount of bottomland hardwood forest class from FIA, suggesting that the woody wetlands class is a bit more inclusive in defining these forests. Alabama and Mississippi were the two exceptions. Percent differences ranged from <1 percent (Mississippi) to 22 percent (South Carolina), with an average difference of 10 percent for the entire study region.

Age data were not available at this level of spatial resolution. However, we did gain more accurate spatial cover information and higher accuracy regarding level of protection, which was based on the latest PADUS (CBI Edition, 2012) for each state. For this exercise, protected was defined as GAP Status 1 & 2 lands plus all military lands and conservation easements. The composite woody wetlands dataset was intersected with the combined fee protected lands and easements as described above and summarized by state and sixth level (12-digit) HUC watersheds. Vulnerable woody wetland forests were calculated as the inverse of the protection totals.

Table A1. Bottomland Hardwoods Versus Woody Wetlands Classifications

State	Bottomland Hardwoods (acres)	Reported FIDO Error	Woody Wetlands (acres)	Difference (acres)	Percent Difference
Alabama	2,670,224	25 to 50%	2,291,899	378,325	-14.20%
Florida	3,599,146	25 to 50%	4,120,433	-521,287	14.40%
Georgia	3,770,688	25 to 50% +	4,715,266	-944,578	25%
Louisiana	4,991,000	25 to 50% +	5,304,870	-313,870	6.30%
Mississippi	3,723,746	25 to 50%	3,689,805	33,941	-0.91%
North Carolina	2,349,710	25 to 50% +	2,786,324	-436,614	18.60%
South Carolina	2,417,638	+/- 25%	2,939,137	-521,499	21.60%
Virginia	749,927	25 to 50% +	894,607	-144,680	19.30%
Total	24,272,079	25 to 50% +	26,742,341		10.20%

ENDNOTES

- 1 Tom Zeller Jr., “Wood Pellets Are Big Business (and for Some, a Big Worry,” *Forbes*, February 1, 2015, www.forbes.com/sites/tomzeller/2015/02/01/wood-pellets-are-big-business-and-for-some-a-big-worry/.
- 2 U.S. Department of Commerce, International Trade Administration, “Renewable Energy Top Markets for U.S. Exports 2014–2015,” February 26, 2014.
- 3 Danielle Lowenthal-Savy, “UK’s Renewable Energy Targets Drive Increases in U.S. Wood Pellet Exports,” U.S. Energy Information Administration, April 22, 2015, www.eia.gov/todayinenergy/detail.cfm?id=20912.
- 4 Wood Resources International LLC, “Global Timber and Wood Products Market Update,” news brief, October 11, 2012.
- 5 See, for instance, Enviva company website, www.envivabiomass.com/biomass-products/enviva-wood-pellets/ (accessed September 17, 2015).
- 6 Christopher S. Galik, Robert C. Abt, and Yun Wu, “Forest Biomass Supply in the Southeastern United States: Implications for Industrial Roundwood and Bioenergy Production,” *Journal of Forestry* 107, no. 2 (March 2009): 69–77.
- 7 Natural Resources Defense Council (NRDC), “Wood Pellet Feedstock Investigation in Ahoskie, North Carolina: December, 2014,” www.nrdc.org/land/files/wood-pellet-feedstock-investigation.pdf.
- 8 Thomas Buchholz and John Gunn, “Carbon Emission Estimates for Drax Biomass Power Plants in the UK Sourcing from Enviva Pellet Mills in U.S. Southeastern Hardwoods Using BEAC Model,” Southern Environmental Law Center, May 27, 2015, www.southernenvironment.org/uploads/audio/2015-05-27_BEAC_calculations_SE_hardwoods.pdf.
- 9 Reed F. Noss et al., “Endangered Ecosystems of the United States,” (1995).
- 10 Michael J. Mac et al., “Status and Trends of the Nation’s Biological Resources,” U.S. Geological Survey (USGS), 1998.
- 11 David N. Wear and John G. Greis, Southern Forest Resource Assessment, USDA Forest Service, 2002.
- 12 The U.S. Fish and Wildlife Service proposed on May 20, 2015, that the Louisiana black bear be removed from Endangered Species Act (ESA) protection due to its recovery. See www.wlf.louisiana.gov/black-bear-delisting (accessed September 1, 2015).
- 13 Dr. Frank Henning, Dr. David C. Shelley and Dr. Jonathan Copeland, “Synchronic Firefly Research at Congaree National Park,” National Park Service, Old-Growth Bottomland Forest Research and Education Center. www.nps.gov/rlc/ogbfrec/research.htm (accessed September 17, 2015).
- 14 World Wildlife Fund, “Middle Atlantic Coastal Forests,” www.worldwildlife.org/ecoregions/na0517 (accessed September 17, 2015). citation is missing publication date. No publication date available.
- 15 U.S. Environmental Protection Agency (EPA), “Climate Change: Climate Impacts in the Southeast,” www3.epa.gov/climatechange/impacts/southeast.html#impactecosystem (accessed September 17, 2015).
- 16 T. Ricketts et al., *Terrestrial Ecoregions of North America: A Conservation Assessment* Washington D.C. (City: Island Press, June, 1999), 33–59xx-xx.
- 17 SAMBI is a multistate/multi-partner conservation planning and implementation effort providing the biological foundation to secure the future for waterfowl, songbird, shorebird, wading bird, and other vulnerable bird populations through an integrated approach to protect, restore, and manage avian coastal plain habitat in the South Atlantic region.
- 18 Audubon South Carolina, “Bird Friendly Bottomland Hardwood Forest Management: Project Need,” draft, February 2013.
- 19 Audubon, “Birds and Climate Report,” September 9, 2014, www.audubon.org (accessed June 12, 2015).
- 20 Amphibian Redlist Authority, www.globalamphibians.org.
- 21 T. Ricketts, et al., *Terrestrial Ecoregions*, 33–59xx-xx.
- 22 North Carolina Wildlife Resources Commission, “Green Salamander,” fact sheet, 2005, www.ncwildlife.org/portals/0/Conserving/documents/FactSheets/nongame_greensalamander_lores.pdf.
- 23 C. Lydeard and R. Mayden, “A Diverse and Endangered Aquatic Ecosystem of the Southeast United States,” *Conservation Biology* 9, no. 4 (August 1995): 800–805.
- 24 J.D. Williams, M.L. Warren, Jr., K.S. Cummings, J.L. Harris and R.J. Neves, “Conservation Status of Freshwater Mussels of the United States and Canada,” *The Mussel Project*, University of Wisconsin, 1993, Fisheries 18(9): 6–22, mussel-project.uwsp.edu.
- 25 R. A. Abell et al., *Freshwater Ecoregions of North America: A Conservation Assessment* (Washington D.C. City: Island Press, 2000), 25–48xx-xx.
- 26 The Catena Group, “Freshwater Mussel Surveys,” www.thecatenagroup.com/freshwater-mussel-surveys (accessed September 17, 2015).
- 27 World Wildlife Fund, “Middle Atlantic Coastal Forests,” www.worldwildlife.org/ecoregions/na0517 (accessed September 17, 2015).
- 28 Louisiana Wildlife and Fisheries, “Natural Communities of Louisiana: Bottomland Hardwood Forest,” www.wlf.louisiana.gov/sites/default/files/pdf/fact_sheet_community/32338-Bottomland%20Hardwood%20Forest/bottomland_hardwood_forest.pdf (accessed September 17, 2015).
- 29 National Wildlife Federation, “More Variable and Uncertain Water Supply: Global Warming’s Wake-Up Call for the Southeastern United States,” 2008, www.nwf.org/~media/PDFs/Global-Warming/Reports/NWF_SEWaterSupply_FINAL2.pdf (accessed September 17, 2015).
- 30 North Carolina State University, “Riparian Buffers: What Are They and How Do They Work?” www.soil.ncsu.edu/publications/BMPs/buffers.html, (accessed September 17, 2015).
- 31 P. Lee et al. 2004. Quantitative Review of Riparian Buffer Width Guidelines from Canada and the U.S.,” *Journal of Environmental Management* 70, no. 2 (February, 2004): 165–180.
- 32 Julia C. Klapproth and James E. Johnson, “Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality,” Virginia Cooperative Extension, May 1, 2009.
- 33 C. Ernst, “Protecting the Source: Land Conservation and the Future of America’s Drinking Water,” Water Protection Series, published by Trust for Public Land and American Water Works Association, 2004.
- 34 EPA, “Wetlands and People,” water.epa.gov/type/wetlands/people.cfm. (accessed September 17, 2015).
- 35 Ibid.
- 36 L.A. Joyce et al., *Climate Change Impacts in the United States: The Third National Climate Assessment*, J.M. Melillo, T.C. Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program, 2014, nca2014.globalchange.gov/report/sector/forests.
- 37 J. Coulson et al. 2015. “Complex Forest Dynamics Indicate Potential for Slowing Carbon Accumulation in the Southeastern United States,” 2015, www.treesearch.fs.fed.us/pubs/47451. Published on-line January 23, 2015.
- 38 Forest Carbon Estimation, USDA Forest Service, Forest Inventory and Analysis National Program, www.fia.fs.us/Forest%20Carbon/default.index (accessed September 19, 2015).
- 39 B. Law and R. Warring, “Carbon Implications of Current and Future Effects of Drought, Fire and Management on Pacific Northwest Forests,” *Forest Ecology and Management*, in press.
- 40 L.A. Joyce et al., *Climate Change Impacts*, Ch. 7: “Forests,” 175–194.
- 41 Ibid.
- 42 NRDC, “The Truth About the Biomass Industry: How Wood Pellet Exports Pollute Our Climate and Damage Our Forests,” fact sheet, August 2014, www.nrdc.org/energy/files/wood-pellet-biomass-pollution-FS.pdf.
- 43 K. Foster et al., “Protecting Natural Vegetation: Comparative Analysis of Land Protection Mechanisms,” final report to the USDA Forest Service, Conservation Biology Institute, 2014.
- 44 C.N. Jenkins et al., 2015. “US Protected Lands Mismatch Biodiversity Priorities,” *PNAS* 112, no. 16 (April 21, 2015): 5081–5086.
- 45 Note: Woody wetland acreage totals are slightly different from those for bottomland hardwood forests. See Appendix A for details.
- 46 Michael P. Schafale, “Nonriverine Wet Hardwood Forests in North Carolina: Status and Trends,” N.C. Natural Heritage Program, March 1999.
- 47 Southern Environmental Law Center, “Biomass Energy in the South,” www.southernenvironment.org/cases-and-projects/biomass-energy-in-the-south. Map and data updated July 2015.

- 48 Seventy-five miles is the distance generally considered to be economical for transporting logs to processing facilities. This sourcing radius is the area from which facilities can source fiber.
- 49 USDA Forest Service, Forest Inventory and Analysis, October 2014.
- 50 See Appendix A for details.
- 51 Personal communication with Curtis Smalling, director of land bird conservation, Audubon North Carolina, via email, August 31, 2015.
- 52 Bioenergy Database, *Forisk Research Quarterly*, Q1 2015.
- 53 Southern Environmental Law Center, “Wood Pellet Industry Destroys Forests and Harms Birds of Conservation Concern,” July 18, 2014.
- 54 Ibid.
- 55 US Fish and Wildlife Service, www.fws.gov/redwolf/redwolfrecovery.html. September 23, 2015.
- 56 West Indian Manatee, US Fish and Wildlife Service, www.fws.gov/verobeach/MSRPPDFs/WestIndianManatee.pdf.
- 57 NatureServe county aggregation of threatened and endangered species reported locations.
- 58 Ibid.
- 59 EPA, www.databasin.org/datasets/53f72f00668848f48e6ebfd7d99ad05b.
- 60 Bioenergy Database, *Forisk Research Quarterly*, Q1 2015.
- 61 J.M. Evans et al., *Forestry Bioenergy in the Southeast United States: Implications for Wildlife Habitat and Biodiversity* (Merrifield, VA: National Wildlife Federation, 2013), 45-73xx-xx? www.nwf.org/pdf/Conservation/NWF_Biomass_Biodiversity_Final.pdf (accessed August 31, 2015).
- 62 USDA Forest Service, Forest Inventory and Analysis, 2014.
- 63 See Appendix A for details.
- 64 Southern Environmental Law Center, “Wood Pellet Industry Destroys Forests.”
- 65 Ibid.
- 66 Erin Voegelé, “Geechee Energy Announces Georgia Pellet Project,” *Biomass Magazine*, March 26, 2014, www.biomassmagazine.com/articles/10205/geechee-energy-announces-georgia-pellet-project (accessed September 15, 2015).
- 67 Georgia Department of Natural Resources, Wildlife Division. www.georgiawildlife.com/sites/default/files/uploads/wildlife/nongame/text/html/cnty_eos/ware.html.
- 68 T. Ricketts et al., *Terrestrial Ecoregions*, xx-xx.
- 69 Known occurrences of special concern plants, animals and natural communities U.S. Fish and Wildlife Service, ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B060.
- 70 Leslie Edwards, Jonathan Ambrose, and L. Katherine Kirkman, eds., *The Natural Communities of Georgia (Athens) CITY*: University of Georgia Press, 2013), 480.
- 71 NatureServe county aggregation of threatened and endangered species reported locations.
- 72 Warm Springs National Fish Hatchery, “Robust Redhorse,” U.S. Fish and Wildlife Service, www.fws.gov/warmsprings/FishHatchery/species/robustredhorse.html.
- 73 NatureServe county aggregation of threatened and endangered species reported locations.
- 74 American Rivers, “America’s Most Endangered Rivers for 2013: Flint River,” www.americanrivers.org/endangered-rivers/2013-report/flint/.
- 75 Bioenergy Database, *Forisk Research Quarterly*, Q1 2015.
- 76 USDA Forest Service, Forest Inventory and Analysis, October 2014.
- 77 See Appendix A for details.
- 78 USDA Forest Service, Forest Inventory and Analysis, October 2014.
- 79 See Appendix A for details.
- 80 Southern Environmental Law Center, “Wood Pellet Industry Destroys Forests.”
- 81 U.S. Fish and Wildlife Service, Mississippi, “List of Federally Threatened and Endangered Species by County,” 2010, www.fws.gov/mississippiES/pdf/SpeciesbyCounty.pdf.
- 82 U.S. Fish and Wildlife Service, Mississippi Field Office, “Federally Threatened, Endangered, and Candidate Species in Mississippi,” February 2013, www.fws.gov/mississippiES/pdf/MS_Species_Habitat_Descriptions_2013.pdf.
- 83 USDA Forest Service, Forest Inventory and Analysis, October 2014.
- 84 U.S. Energy Information Administration, “UK’s Renewable Energy Targets Drive Increases in U.S. Wood Pellet Exports,” *Today in Energy*, April 22, 2015, www.eia.gov/todayinenergy/detail.cfm?id=20912 (accessed September 10, 2015).
- 85 Katie Fletcher, “Drax Biomass’ First Vessel Sails from Port of Baton Rouge,” *Biomass Magazine*, April 20, 2015, www.biomassmagazine.com/articles/11835/drax-biomass-first-vessel-sails-from-port-of-baton-rouge.
- 86 NRDC, “Think Wood Pellets are Green? Think Again,” issue brief, May 2015, www.nrdc.org/land/files/bioenergy-modelling-IB.pdf.
- 87 “On the Ground 2011: The Controversies of PEFC and SFI,” published by Climate for Ideas (United Kingdom), Forests of the World (Denmark), Dogwood Alliance (United States), Hnutí DUHA (Friends of the Earth Czech Republic), Les Amis de la Terre (Friends of the Earth France), Greenpeace, Sierra Club of British Columbia, Suomen Luonnonsuojeluliitto (Finnish Association for Nature Conservation), Netherlands Centre for Indigenous Peoples, September 2011.
- 88 Christopher S. Galik, Robert C. Abt, and Yun Wu, “Forest Biomass Supply in the Southeastern United States.”