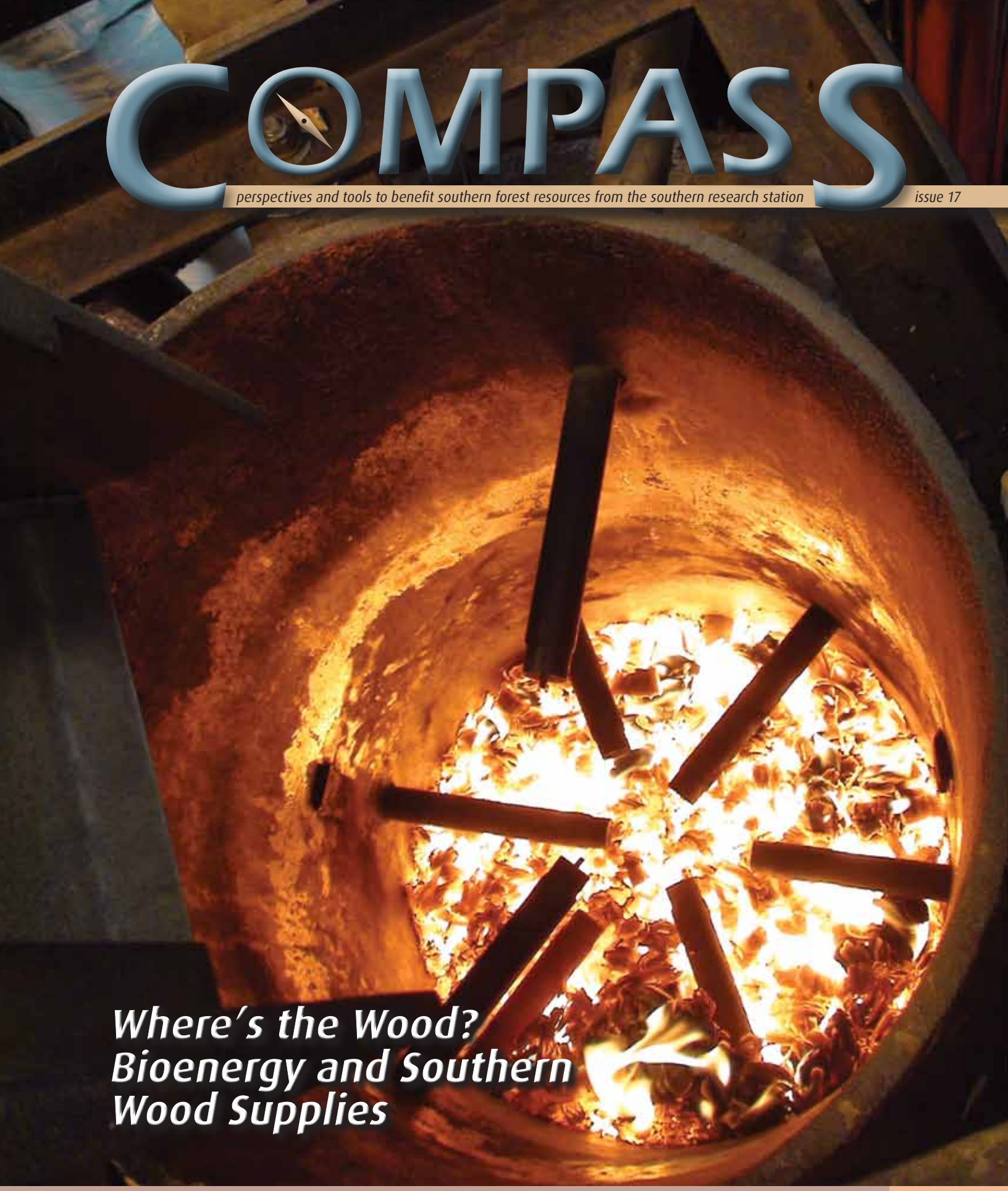
COMPASS

perspectives and tools to benefit southern forest resources from the southern research station

issue 17



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On the cover: A wood-to-energy gasifier converts wood chips directly into electricity to power the Winn Ranger District office on the Kisatchie National Forest. (photo by Tom Elder, USDA Forest Service)

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COMPASS

Science You Can Use!

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perspectives and tools to benefit southern forest resources

COMPASS is published by the Science Delivery Group (SDG) of the Southern Research Station (SRS), Forest Service, U.S. Department of Agriculture. As part of the Nation's largest forestry research organization—Forest Service Research and Development—SRS serves 13 southern states and beyond. The Station's 130 scientists work at more than 20 units located across the region at Federal laboratories, universities, and experimental forests.

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"We envision a future where biomass and bioenergy utilization from southern forests is part of a dynamic and sustainable forest sector that includes private landowners, forest managers and resource professionals, forest industry, forest-based enterprise, and energy producers."

– SRS Bioenergy Science Team, May 2010.

(image by Robert Pace, Allen Wayne, Ltd.)

Where's the Wood?

Bioenergy and Southern Wood Supplies

by Zoë Hoyle

Just a century and a half ago, Americans relied on wood for structural materials and energy so heavily that they almost stripped the country of its forests, leaving a devastation of soil and water. This near disaster prompted the formation of the Forest Service and began a century of research that has resulted in the restoration of the Nation's forest ecosystems and the innumerable benefits they provide.

The 1800s also brought the shift to fossil fuels that led us to another era of crisis. As concerns grow about the effects of global climate change and American dependence on foreign oil, so has interest in using woody biomass to produce transportation fuels and electricity. If it pans out, using wood for energy could usher in the most important new phase for forestry in a century.

The long-term research studies from the Southern Research Station (SRS) that established the best practices for planting and managing forests in the South also underlie the best management practices needed to harvest and grow wood for energy. SRS forest operations research is already showing landowners how to economically and sustainably harvest small-diameter wood for energy feedstocks, while agroforestry scientists design systems that protect water resources while providing the capacity to grow bioenergy crops as part of a portfolio of forest products.

Markets and incentives will determine how growing wood for energy affects the landscapes and people of the South. SRS economics research, combined with forest and inventory analysis data, provides the input needed by planners at multiple levels to balance the needs of a burgeoning wood-to-energy market with those of more traditional forest industries, and with the full range of benefits—ecological, practical, aesthetic, and spiritual—provided by southern forests.

Woody biomass serves as an alternative fuel for producing electricity. (photo by Warren Gretz, National Renewable Energy Laboratory)

A New Boom or a Bust?

The South, with its productive climate and forest industry, is uniquely poised to benefit from a new market for wood. Often called the "Nation's wood basket," the South produces an estimated 60 percent of the U.S. timber supply. Of the 214 million acres of forest land in the southern region, 89 percent are owned by private landowners. About 19 percent of these forests are planted, some intensely managed; a long history of forest industry has provided the South with a readymade infrastructure for moving and processing wood for energy.

Through the 20th century, total acres of timberland in the South remained stable except for a 5-percent reduction in the 1970s due to agricultural expansion. Meanwhile, acres of planted pine forests increased since the 1960s to some 39 million acres, more than any other country in the world. Plantation forests can produce up to three times as much fiber as naturally regenerated forests and seem a natural fit for energy—or more likely, mixed use—production.

This all sounds rosy, but as with any human endeavor, there are always unintended consequences.

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Where's the Wood

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Concerns about the new wood boom include environmental impacts and siting issues, but some of the most pressing—and closely related—are about supply. Just exactly where will all the wood for energy come from if aggressive renewable energy policies are adopted? Will we end up with more pine plantations in the South? Will natural forests be cut for energy? Will timber prices get so high that other forest industries are driven out of business?

Early studies assumed that the fiber for bioenergy would come almost exclusively from residues—wood debris from timber or mill processes. The South is rich in logging residues, with about half of the total national supply. But as more and more biomass-based facilities enter the planning phase, it's become apparent that residues will probably not be enough, that some energy feedstocks will have to come from plantations and even from natural forests. These same resources support southern pulp, paper, and sawtimber markets, which could be adversely affected by demand for bioenergy markets.

It all comes down to markets, how demand will affect future supply and ultimately, the sustainability of southern forest resources.

How Can We Tell If There's Enough?

SRS tracks forest industry trends through its **Forest Inventory and Analysis** (FIA) unit in Knoxville, TN, and its **Forest Economics Research** unit in Research Triangle Park, NC. FIA timber output and harvest and utilization studies pinpoint exactly what's happening in the South's forest industries, including the closings of the pulp and paper mills that bioenergy industries will compete with.

Interior of generating plant using wood fuel. (photo courtesy of the National Renewable Energy Laboratory)

Led by research forest economist **David Wear**, scientists in the SRS economics unit work with a range of university and other cooperators to look into the future of forest industry in the South. It's no easy task; in many cases, they're creating the tools they need from scratch and making the first forecasts and analyses for an economy where markets can turn on a dime, often driven by perception rather than actual data.

Wear and his fellow researchers provide ways to outline tradeoffs and effects as the market for biomass moves in different directions, using forecasting methods that can be checked and modified over time. With **John Greis**, a resource specialist with the Forest Service regional office, Wear currently leads a collaborative analysis of the response of southern forests to future scenarios that include climate change, population growth, and the development of markets for bioenergy feedstocks. A major goal of the **Southern Forest Futures Project**, due out in 2011, is to develop scenarios planners can use to evaluate their decisions in response to a range of new situations, whether they're threats or opportunities.

In the case of bioenergy, this growing market for southern wood is bound to have mixed—and for a few decades, at least—uncertain results.

"Demand for southern timber has declined, and pulpwood production fell off between 1997 and 2006. At the same time timber supply kept expanding, so prices declined," says Wear. "Projections show supply continuing to expand in much of the South over the next two decades. Feedstocks for bioenergy could provide a replacement for reduced demand from the paper

Wood chipper preparing material for biofuel production. (photo by Warren Gretz, National Renewable Energy Laboratory)

and pulpwood industries, but the bioenergy industry will directly compete with the other industries, raising raw material prices."

As part of the futures project, Wear and unit scientists developed a framework based on detailed FIA data for analyzing the harvest choices of private landowners, who own some 68 percent of the South's forest lands—and who provided 97 percent of the region's timber harvest in 2006. The framework will allow researchers to not only estimate timber supply but also project how land use and forest conditions will affect biomass supplies in the future.

Supply, Demand, and Policy

SRS research economist **Karen Abt** has a long history of studying the behavior of private landowners in southern timber markets and how the individual decisions they make aggregate to the regional level. For a recent study, she and husband and coresearcher **Robert Abt, North Carolina State University** professor, used a model of aggregate timber supply and demand, the Subregional Timber Supply model, to set up scenarios to evaluate the effects of demand for woody biomass for energy on both timber markets and the sustainability of forest resources in the South. The Abts included standing timber inventories in their scenarios, acknowledging the probability that residues will not adequately supply growing bioenergy markets.

"Most studies on the sustainability of using wood for energy have focused on using residues from logging and manufacturing," says SRS researcher Karen Abt. "If woody biomass supply is limited to residues—thus to the production level of current industry—the impact on the forest resource will be small. If standing inventory is included, the energy potential from wood increases, but so do the effects on existing industry and on forest resources."

The wider adoption in the South of renewable energy portfolio standards (RPS) and state regulations that establish how much energy must come from alternative sources will also affect demand on woody biomass for energy, as will definitions of the

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Biofuels from Wood, Still in the Works

In 2004, Congress asked the U.S. Department of Energy (DOE) to look at the feasibility of using fuels made from biomass—corn, switchgrass, wood, and others—to reduce the dependency of U.S. transportation on imported oil by 30 percent by 2030. DOE, with help from the U.S. Department of Agriculture, found that there were 1.3 billion dry tons of biomass from forests and farmlands available each year, more than enough to produce 30 percent of U.S. transportation fuels. But what's often called the "billion ton study" did not take into account the increasing demand for woody biomass for producing renewable electricity. The wood resources needed to help reach renewable portfolio standards in states that have them must come from the same billion tons that would be available for biofuels production.

In 2007, the DOE looked at what would happen nationwide if both a Renewable Electricity Standard of 25x25 (25 percent by 2025) and a Renewable Fuel Standard of 25x25 were adopted at the same time. Results showed that the woody biomass needed to achieve both goals would mean doubling the current level of harvesting in the United States—with significant economic effects and potential impacts on soil and water, biodiversity, and other resources.

It takes about 2 green tons of wood to make 86 gallons of cellulosic ethanol. A biofuels plant producing cellulosic ethanol would need approximately 1.2 million green tons of wood a year. Although these plants were once expected to get some of their supply from local wood waste and residues from forest management, as capacity increases more of the supply will have to come from wood grown for this purpose. With forest stocking typical of the South, it would take clearing an estimated 28,000 acres of forest a year to supply one biofuels plant.

From:
Pinchot Institute for Conservation; The H. John Heinz III Center for Science, Economics and the Environment. 2010. **Forest sustainability in the development of wood bioenergy in the U.S.** Washington, DC: Pinchot Institute. 52 p.

Where's the Wood

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wood sources that can be used to satisfy the standards.

Another factor is the adoption of a national RPS, which would set a nationwide standard, e.g., 25 percent by 2025, for the amount of U.S. electricity coming from alternative sources. A strong Federal-level RPS would cause a dramatic increase in the use of wood for energy across the United States; eventually an annual gap in supply would develop that would exceed the current demand for pulpwood in the South, opening up competition with all types of wood markets.

In their scenarios, the Abts looked at the use of woody biomass for renewable energy under high- and low-initial contribution levels for RPS. Factors that could affect wood demand include beginning and target years, definitions of eligible woody biomass, and incentives. The researchers varied the demand for woody biomass and the use of residues for electricity production to look at impacts over time on the pine pulpwood and sawtimber markets and on the underlying forest resource.

"In all of our scenarios, energy markets compete with existing industry, which increases income for forest landowners," says Karen Abt. "As larger harvests reduce inventories, higher prices encourage more planting, which increases forest acres in the long term."

None of these projections are written in stone. What SRS research economists have to offer is a perspective that comes from outside the markets themselves; if there's a vested interest it's in sustaining southern forest resources for the full range of services they provide.

"We can't really give you definitive answers," says Karen Abt. "Our job is to outline tradeoffs as policy and the markets interact. We understand that this job never ends. As the market changes, so do supplies, and new tradeoffs develop. But we'll be there to try to gauge what's happening and offer our perspectives."

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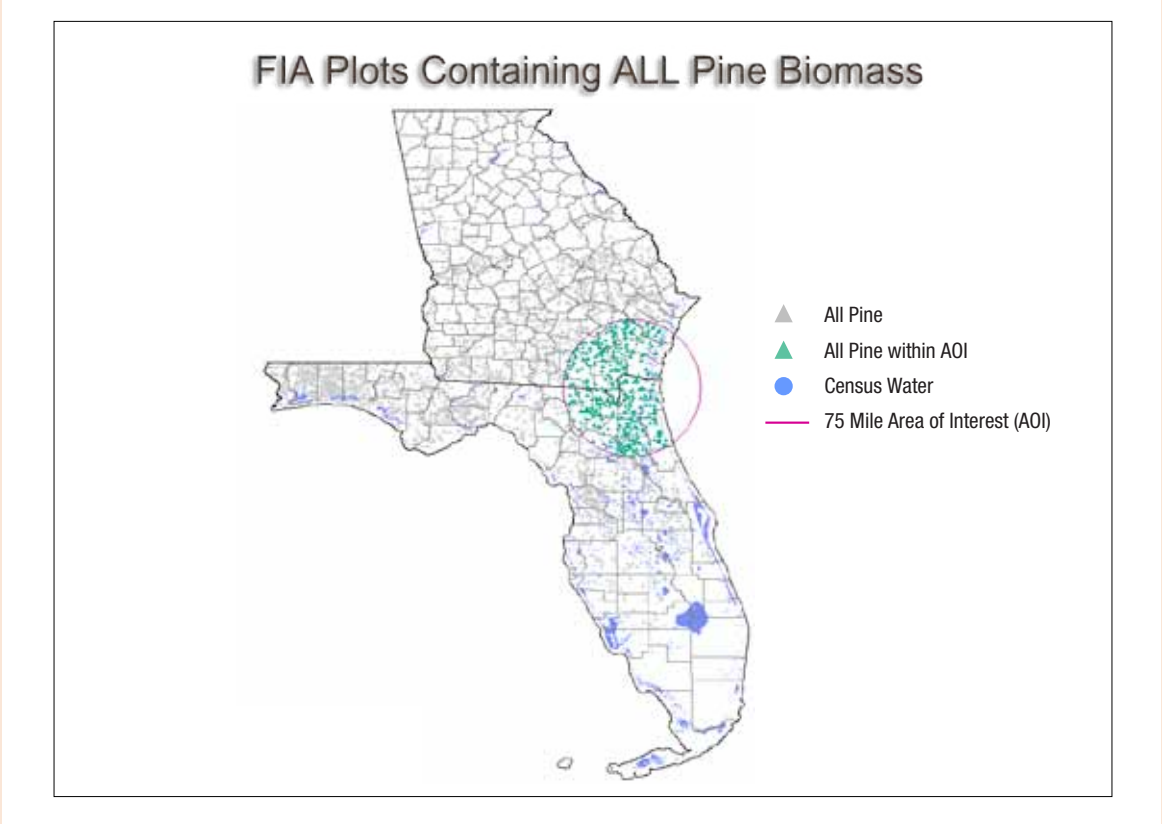
Recommended reading:

Abt, R.C.; Abt, K.L. **Potential impact of bioenergy demand on the sustainability of the southern forest resource.** Manuscript available from authors.

Abt, R.C.; Cubbage, F.W.; Abt, K.L. 2009. **Projecting southern timber supply for multiple products by subregion.** Forest Products Journal. 59(7/8): 7–16.

Wear, D.; Abt, R.C.; Alavalapati, J. [and others]. 2009. **The South's outlook for sustainable forest bioenergy and biofuels production.** 20 p. Unpublished report. [Presentation for Pinchot Institute Regional Workshop, Raleigh, NC]. Available online: www.srs.fs.fed.us/pubs/ja/2010/ja_2010_wear_001.pdf.



The SRS Forest Inventory and Analysis (FIA) unit generated the above map to help site planning for a pellet mill.

Bioenergy and Climate Change
Wood vs. Fossil Fuels

Fossil fuels—coal, oil, and natural gas—come from ancient deposits that formed millions of years ago beneath the Earth's surface. These deposits are not being replenished. When these nonrenewable fuels are burned, greenhouse gases—including carbon dioxide (CO_2)—are released into the Earth's atmosphere, where they trap heat and contribute to global climate change.

Burning wood also releases CO_2 and greenhouse gases to the atmosphere, but living trees are constantly removing carbon from the atmosphere and storing it in their stems and roots. As long as we're planting and growing as many or more trees than we're burning, using woody biomass for energy can be considered *carbon neutral*.

Sandbags prop up a receding shoreline in South Carolina. (photo by Zoë Hoyle, USDA Forest Service)

In reality, there will still be CO_2 emissions from the machines used to harvest, process, and transport biomass feedstock, but these can be kept relatively low. The **SRS Forest Operations Research** unit conducts research that helps landowners cut both the emissions and costs of biomass harvest and removal by evaluating machines and processes for efficiency and sustainability.

Another advantage of using biomass as fuel is the reduction in air pollution from sulfur and nitrous oxides that result from burning fossil fuels. Wood has less than 50 percent the nitrogen content of coal, and the sulfur content is negligible.

Using thinnings from forests for bioenergy could help reduce the "megafires" of the last few years, which release massive amounts of CO_2 into the atmosphere, affect air quality globally, and contribute to climate change. Using forest residues and thinnings for fuel also prevents that wood from being burned in open air with no pollution controls.

Using urban wood waste that usually ends up in landfills also reduces the amount of methane released into the atmosphere.

Growing trees for bioenergy feedstock provides additional incentive for landowners to keep their land in forests. Deforestation from land conversion contributes to global climate change by reducing the number of trees available to absorb and store CO_2. *–ZH*

Wood to Energy
Points to Ponder

- Demand for the South's timber has declined from a peak in the late 1990s to levels comparable to the early 1990s, with pulpwood production falling by 15 percent between 1997 and 2006. At the same time, investment in timber growing continued until 2000, expanding the timber supply. New demand for wood for bioenergy could provide a "replacement" for reduced demand from the pulp and paper industry, but would also drive up prices for the softwoods used in those industries.
- Commercial forest landowners in the South have shown themselves to be very responsive to expanded demands for timber by harvesting more in the short run and by increasing investment in production in the long run. Timing—when growers start investing in response to demand for bioenergy—will affect how long prices for bioenergy feedstocks continue to rise.
- Land use and forest ownership changes raise uncertainty about wood supplies for bioenergy, especially where these supplies will be grown. Transporting feedstocks more than 45 miles adds prohibitive transportation costs.
- Key drivers for bioenergy development in the South will be the adoption of policies to encourage the use of renewable sources for energy, and the development of the technologies needed to make the commercial-level production of cellulose-based liquid biofuels truly feasible. Renewable energy policies such as state-level renewable portfolio standards will probably have the greatest effect on the wood for bioenergy market in the short to medium run.
- The growing use of wood for bioenergy will compete with the existing wood products industry; how much depends on the policies adopted for renewable energy. At the same time new demands for wood should encourage forest landowners to invest in expanding supplies, a long-term response.
- In addition to "clean" feedstocks, liquid biofuels require large supplies of water, which may prove a limiting factor in developing commercial-scale biofuels plants in the same way that water organized and limited the siting of pulp and paper plants in the South. This may also become another area of competition with existing wood products industries.
- Forests provide a wide range of services beyond the production of fiber. A shift towards more intensive management for bioenergy feedstocks could affect water quality, wildlife habitat, and other services. A specific area of concern, for example, is the southeastern Coastal Plain, where wetland forests are already stressed and several amphibian species already imperiled.

Adapted from:
Wear, D.; Abt, R.C.; Alavalapati, J. [and others]. 2009. **The South's outlook for sustainable forest bioenergy and biofuels production.** 20 p. Unpublished report. [Presentation for Pinchot Institute Regional Workshop, Raleigh, NC]. Available online: www.srs.fs.fed.us/pubs/ja/2010/ja_2010_wear_001.pdf.

Coffee roasted using wood chips. (photo by David Parsons, National Renewable Energy Laboratory)

Do the Math

How much energy can you get from a ton of wood?

A dry ton of wood will produce around 17 million British thermal units or 1 megawatt hour (MWh). It takes 2 tons of green uncured wood to produce 1 MWh. A typical pine plantation under low-intensity management can produce about 1.7 dry tons per acre per year.

How many homes will a ton of wood power?

An average home uses about 10,000 kilowatt hours (kWh) a year. If a dry ton of wood generates 1 MWh (1,000 kWhs), you would need 10 dry tons to power one house for a year. Or, if one home needs 1 kWh of energy for 1 hour, then 1 MWh can sustain 1,000 houses for 1 hour.

Where Does It Come From?

The principal sources of woody biomass in the South are:

- Harvest residues
- Mill residues
- Trees damaged by wildfire, insects, diseases, or weather
- Short-rotation woody crops

Logging residues are branches, tops, stumps, and other debris left over—and usually left behind—after commercial harvest. Logging residues constitute about 40 million dry tons of woody biomass for the United States as a whole. The South produces 20 million dry tons or half of that total.

Small-diameter wood thinned to improve forest health has been traditionally used as pulpwood, but declining markets have made this source more available for bioenergy. An estimated 2.7 billion tons of this wood is available nationally from both public and private lands; but due to accessibility, recovery limits, and use of the material for higher value products, only about 20 million tons are actually available for removal, with 85 percent coming from the South.

Mill waste is the most desirable source for bioenergy because it's clean, concentrated, uniform, and low in moisture; but in the South about 97 percent of mill waste is used for energy by industries themselves, all together the largest consumers of wood-based biofuels in the region.

In the South, forest industries use their mill waste to power their operations. (photo courtesy of the National Renewable Energy Laboratory)

Urban wood waste. (photo by Rod Kindlund, USDA Forest Service, retired)

In the South, wood waste from threats and disasters is another source for bioenergy, on the average, 1.36 million dry tons a year from southern pine beetle alone. In 2005, hurricanes generated more than 800 million tons of wood waste.

Urban wood waste—the woody part of municipal waste, construction, demolition, and landscape waste—could contribute an estimated 10.1 million dry tons of biomass each year. *–ZH*

Adapted from:
Hubbard, W.; Biles, L.; Mayfield, C.; Ashton, S., eds. 2007. **Sustainable forestry for bioenergy and bio-based products: trainers curriculum notebook.** Athens, GA: Southern Forest Research Partnership, Inc. 316 p. [Available in pdf format at www.forestbioenergy.net/].

North Carolina: A Case Study

by Zoë Hoyle

State and Federal policies on renewable energy will, to a great extent, drive demand for wood-to-energy biomass feedstocks. Across the United States, 29 states and the District of Columbia have adopted renewable portfolio standards (RPS) mandating that a certain percent of the state's energy come from renewable sources by a certain date.

In the South, only North Carolina and Texas have adopted RPS. One of the questions that comes with RPS—and with a proposed national renewable electricity standard—is how the increased demand created by these policies will affect local timber markets and underlying forest resources.

SRS research economist **Karen Abt** and **North Carolina State University** cooperators used the North Carolina RPS as a case study to simulate the impacts of increased demand for woody biomass as a result of renewable energy policies.

"In the South especially, limited infrastructure to use solar, wind, and other renewable sources puts the focus on biomass as a key renewable feedstock," says Abt. "At the same time, a decade of reduced forest planting and the current recession reduce the amount of residues available for bioenergy in the short run, and the supply of pulpwood in the long run."

Many studies on wood supply for bioenergy have assumed that timber and mill residues would make up most of the feedstocks; in the South, residues are already widely used as energy sources by the industries that produce them, significantly reducing the amount actually available for other facilities. The focus on residues has minimized concerns about the impacts of wood-based energy on other forest industries using pulpwood, generally defined as trees not large enough or of good enough quality for sawtimber.

Pine chips from an onsite chipping operation. (photo by David J. Moorhead, University of Georgia, courtesy of Bugwood.org)

North Carolina's RPS requires that a certain amount of a utility's energy sales come from renewable resources. As renewable standards go, North Carolina's is both complicated and relatively modest; after 2020, 12.5 percent of a utility's 2020 retail sales must come from a combination of renewable resources and energy-saving measures. Even at this level, the policy could affect the forest industries that play a major part in the state's economy.

For their study, Abt and her colleagues estimated how much of renewable demand would probably be met by woody biomass, and modeled the effects of the already enacted RPS on wood prices and traditional forest industry in the state. They did not consider the impacts of national renewable electricity or fuel standards on North Carolina in this study.

"The role of pulpwood sources in meeting the RPS depends on how renewable biomass is defined," says Abt. The researchers found that residues alone would not be enough to fulfill the RPS demand even in the first year of the requirement, and that prices for pulpwood would start to increase in 2012 as bioenergy demands increase. Increased demand for pulpwood reduces the amount of timber allowed to grow to sawtimber size, which in turn raises sawtimber

Loblolly pine flower. (photo by Erich G. Vallery, USDA Forest Service, courtesy of Bugwood.org)

prices and affects another sector of traditional forest industry.

"These price increases could mean major changes for forest landowners and traditional wood users," says Abt. "Increase in demand will mean higher incomes for landowners and lead to greater investments in planting and forest management, but they'll also have adverse effects on traditional forest industry and drive up the prices for those products."

Abt and her cooperators caution that their analysis is limited by lack of data and forecasts related to biomass demand and supply responses. "We also assume in this analysis that North Carolina will allow the use of pulpwood for bioenergy," says Abt. "Indeed, our analysis suggests that the use of pulpwood is essential for the state to reach its RPS goals."

The North Carolina Utilities Commission agreed with this assessment in their recent decision on how to define the wood sources that can be used to meet the state RPS, stating that "…primary wood harvest products, including woodchips from whole trees, are biomass resources and renewable energy resources." This ruling, favored by landowner advocates who hope for increased income and energy suppliers who must meet the RPS requirements, continues to be strongly opposed by some concerned with the sustainability of the forests as well as current wood products firms.

By focusing on the early years of the RPS policy, the researchers illuminate factors—policy timing, market characteristics, structure of the current forest resource, and long-term response of supply—that must be taken into account in the assessment of any wood-to-energy policy.

North Carolina hardwood forest. (photo courtesy of USDA Forest Service)

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Recommended reading:

Abt, R.C.; Abt, K.L.; Cubbage, F.W.; Henderson, J.D. 2010. **Effect of policy-based bioenergy demand on southern timber markets: a case study of North Carolina.** Biomass and Bioenergy. 34(12): 1679–1686.

Funding for this research was provided by North Carolina State University, the Southern Forest Resource Assessment Consortium, the Forest Service, and the U.S. Department of Transportation Sun Grant.

Glossary

Bioenergy. Energy derived from organic matter.

Biofuels. Mostly liquid transportation fuels produced from biomass. Examples include ethanol, methanol, and biodiesel.

Biomass. Any organic matter available on a renewable basis.

Biomass gasification. The process that converts biomass into gas using high temperatures in an oxygen-controlled environment.

Dry ton. Two thousand pounds of material dried to a constant weight.

Green ton. Two thousand pounds of freshly cut, undried biomass.

Pulpwood. Timber stocks that are cut for paper production. In the logging of mixed forest stands, the better trees are cut for sawlogs for lumber production.

Renewable energy portfolio standards (RPS). Regulations requiring the increased production of energy from renewable energy sources, such as wind, solar, biomass, and geothermal. Also called **renewable electricity standards (RES)**.

Renewable fuel standards (RFS). Policies requiring that a certain amount of the transportation fuel come from renewable fuels.

Residues. Wood not harvested for bioenergy purposes, such as leftovers from timber or pulp processes.

Woody biomass. Accumulated mass, above- and belowground, of trees and woody shrubs, including roots, wood, bark, branches, and leaves.

Showing Potential in South Carolina

In South Carolina, a recent survey showed great potential for sustaining industry based on woody biomass. (photo by David J. Moorhead, University of Georgia, courtesy of Bugwood.org)

In 2008, the **SRS Forest Inventory and Analysis** (FIA) unit and the **South Carolina Forestry Commission** (SCFC) completed a cooperative effort to assess the potential for developing a sustainable woody biomass energy industry in South Carolina. The assessment also gave FIA an opportunity to develop a focused report highlighting the use of their data in the context of a bioenergy or biomass availability issue.

Sources of woody biomass vary, but typically include wood residue from both tree harvesting and mill operations, volume from residual forest inventory including poor quality and small-diameter trees, and woody material from urban waste. Assessing biomass availability from these varied sources required synthesizing data from FIA's Timber Products Output database, annual forest resource inventories, and SCFC-provided estimates of the urban wood waste entering commercial landfills.

In addition, SCFC surveyed South Carolina loggers and timber producers to determine the range of prices per delivered ton needed to make the harvest, processing, and transportation of logging residue and residual trees economically viable. The timber producers also provided estimates of the amount of biomass they could potentially produce at different prices per ton.

A range of $20 to $30 per ton was established as the range of prices needed from responses to timber producer surveys. The estimates of potential available biomass from all sources distributed across these price points ranged from 4.8 to a maximum of 16.5 million tons per year for the state of South Carolina.

Study results showed that while 7.7 million tons of the potential maximum were currently committed to other uses, 8.8 million tons of unutilized material produced annually could be used to sustain new wood-based bioenergy facilities without increasing current harvest levels and without overly impacting the state's existing forest industries.

Reliance on Forest Inventory and Analysis Data

The models used by SRS research economist **Karen Abt** and fellow researchers to project timber supply and demand for the South rely on the **Forest Inventory and Analysis** (FIA) dataset of inventory, growth, removals, and acreage by forest type, private ownership category, species group, and age class. The data are collected annually and are available through the FIA Web site at srsfia1.fia.srs.fs.fed.us/.

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Recommended reading:

Conner, R.C.; Adams, T.O.; Johnson, T.G. 2009. **Assessing the potential for biomass energy development in South Carolina.** Res. Pap. SRS–46. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 19 p.

New Ways to Operate

by Kayla Burton and Zoë Hoyle

New biomass baling system removes shrubs and small trees, preparing an area for prescribed fire. (photo courtesy of USDA Forest Service)

When serious discussions about energy from wood first started, the costs of harvesting and hauling the small-diameter wood and residues proposed as feedstocks were a major barrier to making the market work. Over a decade ago, scientists at the **SRS Forest Operations Research** unit in Auburn, AL, were already field testing machines and processes for harvesting and transporting fuels for bioenergy, working to make the new industry more efficient and sustainable. The foremost in their field, they're now involved in projects with a range of owners on multiple locations.

And there's no one-size-fits-all when it comes to bioenergy operations.

"We're trying to determine which set of tools are needed to work in each particular type of forest," says **Bob Rummer**, project leader of the forest operations research unit. "When looking at harvesting for bioenergy, landowners need to know which equipment will fit their specific needs, how much it will cost to operate that equipment, and what the environmental impacts are."

A Hundred Million Tons a Year

That's an estimate for how much wood for bioenergy could be produced from half the current acreage of southern pine plantations if they're planted more intensively. But more intensive planting for bioenergy means major changes in how wood is harvested, processed, and hauled.

In 2009, SRS forest operations research scientists joined with **Auburn University, Corley Land Service**, and **Tigercat**® to develop a new mechanized system for harvesting on pine plantations planted for bioenergy. With funding from the **U.S. Department of Energy**, the partners started a 3-year program of testing, development, and commercialization.

"A bioenergy pine plantation presents several unique features that affect harvesting operations," says Rummer. "With more trees per acre, there are more machine movements, and you're adding an additional processing step to reduce the wood to bioenergy feedstock specifications."

The project will test refinements of felling, skidding, and processing at the field level. Researchers will also look at the cost savings of reducing moisture content before hauling and using completely mechanized systems for harvesting. At the same time, scientists will take field measurements to monitor the effects of removals, trafficking, and soil exposure on water quality and wildlife habitat.

"At the end of this project we'd like to have a new technology ready for commercialization," says Rummer. "We should be able to provide landowners with a clear understanding of what they can expect if they decide to intensely manage pine for bioenergy."

Baling for Fuel Reduction

The SRS forest operations research unit has tested baling and bundling technologies for years, comparing effectiveness and costs with those of chipping onsite. For a recent study, they evaluated a relatively new technology that uses a round baler to harvest standing biomass. By removing shrubs and small

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New Ways to Operate

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trees in the understory, the method could be used to prep an area for prescribed fire and to improve wildlife habitat while preparing the material for bioenergy use.

"What prompted this research were the recent rises in oil prices," says Rummer. "Harvesting forest biomass into large round bales has potential for reduced energy costs when compared to other harvesting and handling schemes such as chipping."

Rummer and SRS engineer **John Klepac** evaluated the performance of an understory biomass baling system in a 28-year-old loblolly pine stand near Valdosta, GA. Test bales from the site were processed in a grinder and sent to an advanced material development center for analyses of bulk density, moisture content, and size distribution.

"The machine we tested was successful in producing bales from an understory that was filled with flatwoods shrubs such as gallberry," says Rummer. "Our findings suggest that the heat content of the bales is similar to that of pine stemwood, even though the bales contained a lot of nonwoody material."

The project demonstrates how harvesting for biofuel can be successfully combined with treating the forest understory to reduce wildfire risk and improve wildlife habitat.

"One factor to consider is the timing of applications," cautions Rummer. "If you rebale every 3 years to control growth, you won't get the same volume you got the first time, so your costs per ton of biofuel will be higher. But if you don't bale often enough, you'll lose the benefits of thinning. These sorts of questions are critical to understanding which stand conditions are best for baling treatments."

Bio-oil for the Military

Wood can be converted to liquid fuel by pyrolysis. In the bioenergy world, pyrolysis means burning an organic material—in this case, wood—at a very high temperature in the absence of oxygen. This produces gas and liquid fuel and a highly concentrated charcoal residue called biochar. A more efficient process called "fast pyrolysis" heats more finely processed feedstocks at even higher temperatures, between 660 and 930°F, for less than 2 seconds. This fast pyrolysis technology can yield roughly 120 gallons of bio-oil, 500 pounds of charcoal, and 300 pounds of combustible "synthesis" gas from 1 ton of dry wood.

In 2008, the **U.S. Department of Defense** (DOD) started a research project to validate the performance of an infield fast pyrolysis unit that uses wood waste to produce bio-oil, synthesis gas, and biochar. The resulting bio-oil is similar to number 2 fuel oil; the military will evaluate its use as fuel for boilers and steam generators on installations as well as testing a blend of bio-oil and diesel for a liquid transportation fuel. The synthesis gas will be used as fuel for the fast pyrolysis unit itself, adding to self-sufficiency. The biochar can either be combined into a fuel product or used separately as a soil amendment.

Harvesting small-diameter wood. (photo by Trice Megginson, courtesy of USDA Forest Service)

The SRS forest operations research unit is working on the project with DOD, **Auburn University**, and **Renewable Oil International**®, which produced a prototype fast pyrolysis unit for the project. The project will determine the economic and technical feasibility of using forest residues for bio-oil production and will include assessments of emissions and life-cycle impacts of the process.

The primary feedstocks for the project come from typical woody residues available at military installations including forest residues, wood packaging, paper, and cardboard.

Rummer's unit is evaluating equipment for processing residues from site clearing and forest-thinning operations into material that meets the needs for fast pyrolysis conversion to bio-oil. "Feedstock material for fast pyrolysis needs to be much finer and more uniform than the chips destined for power plants," says Rummer. "Right now we're in the process of figuring out what kind of field equipment will produce the feedstock most effectively."

For more information:

Bob Rummer at 334–826–8700, x 22 or rrummer@fs.fed.us

Recommended reading:

Klepac, J.; Rummer, B. 2010. **Harvesting understory biomass with a baler.** In: Proceedings of 2010 COFE: 33rd annual meeting of the Council on Forest Engineering. Auburn, AL, COFE: 1-11.

Kayla Burton is a graduate student studying mass communications at Murray State University and worked for SRS as a student intern during the summer of 2010.

BCAP Recap

Part of the 2008 Farm Bill, the **Biomass Crop Assistance Program** (BCAP) was designed to support the planting and harvesting of eligible bioenergy crops in selected areas, and to help agricultural and forest landowners and operators supply eligible material to biomass conversion facilities. In February 2010, financial assistance from BCAP was placed on hold until the final rule was established.

On October 21, 2010, **USDA Secretary Tom Vilsack** announced the October 27th publication of the final rule to implement BCAP and the resumption of payments to eligible producers.

BCAP uses a two-pronged approach to support the production of renewable energy. First, the program provides assistance for establishing and producing eligible biomass crops within specified project areas, with qualified producers receiving up to 75 percent of the establishment cost. Producers of woody crops can receive payments for up to 15 years. The **USDA Farm Service Agency** (FSA) is now accepting project area proposals; when these have been approved, eligible producers in these areas can participate by enrolling at their FSA county offices.

Bioenergy pine plantations, with more intensive planting, require new harvesting systems and processes. (photo courtesy of USDA Forest Service)

Willow and poplar show great promise as biomass feedstocks. (photo courtesy of the National Renewable Energy Laboratory)

Second, BCAP assists forest landowners and operators by providing matching payments for collection, harvest, storage, and transportation of eligible materials to qualified facilities that convert the materials into heat, power, biobased products, or advanced fuels. The rule just released makes new specifications about eligible woody materials.

The new rule specifies that wood or wood waste from contract land must be harvested and collected directly from the land. If separated from a higher value product, the bioenergy material must be separated at the harvest site before being transported. Materials must also be harvested in compliance with an approved conservation, stewardship, or similar plan to protect soil and water quality and future productivity.

The specifications are stricter for noncontract land that lies outside of established program areas. For biomass harvested from noncontract acres, matching payments will only be made for woody biomass if the material has been removed to reduce hazardous fuels, reduce or contain disease or insect infestation, or restore ecosystem health.

For the latest information about financial assistance from BCAP: www.apfo.usda.gov/FSA/webapp?area=home&subject=ener&topic=bcap.

Help with BCAP Conversion

Under BCAP, payments to material growers are made on a dry-ton basis, while many traditional forest markets use green (wet) weight in their calculations. This has resulted in some confusion in calculating matching payments for transportation of materials to eligible facilities.

Scientists at the **SRS Forest Operations Research** unit have investigated various methods of calculating and sampling woody biomass materials towards simplifying participation in BCAP. This year, the unit partnered with the **Smallwood Utilization Network** (SUN) to develop a spreadsheet-based tool that provides exact conversions between green and dry-ton cost and between green and dry-ton weight. The converter includes charts that can be used for quick reference. SUN distributed the initial version of the converter; user feedback will be used to develop an improved version.

For more information:
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Adding Bioenergy to the Agroforestry Mix

by Sarah Farmer

The **USDA National Agroforestry Center** (NAC), a partnership between SRS, **Forest Service State and Private Forestry**, and the **USDA Natural Resources Conservation Service**, studies how *Working Trees* (also called agroforestry), can be put to work on farms, ranches, and in communities doing important tasks such as improving water quality, controlling soil erosion, increasing sustainable agricultural production, providing wildlife habitat, and sequestering carbon. Scientists at the NAC investigate the economic and ecological payoffs associated with agroforestry practices and offer tools and training to natural resource professionals so that they in turn can help landowners get the most out of their land. **Michele Schoeneberger**, NAC research project leader, also examines how these same practices, be they windbreaks, riparian forest buffers, or alley cropping systems, can contribute to bioenergy production while providing multiple other services.

Bioenergy is in the spotlight these days, with much interest in identifying alternative biofuel feedstock sources. Fast-growing, energy-rich perennial grasses such as switchgrass—grown as part of an agroforestry system—show particular promise as feedstocks for the next generation of biofuels. Efficient production of transportation fuel from wood is still a ways off, but short-rotation woody crops have been grown in dedicated plantations and used for electric power generation for over a decade, especially in states with renewable portfolio standards in place. Wood can also be cofired in existing coal-powered plants or serve as the primary fuel in the smaller combined heat and power (CHP) and advanced wood combustion (AWC) plants that are popular in Europe and gaining increasing interest in the United States as providing a more local solution.

Working Trees is all about local solutions. "With *Working Trees*

Switchgrass, which can be grown as part of an agroforestry system, shows promise as a feedstock for the next generation of biofuels. (photo by Steve Jurvetson, courtesy of Wikimedia)

practices, you have a system that can do 'double duty,' providing the added conservation services, especially for water-quality protection, needed to make monoculture biomass (both grain and cellulose-based) production more sustainable," says Schoeneberger. "That crop (trees) can also serve as an additional source of biomass for energy use, be it in CHP systems for on-farm, schools or other local use, cofiring, or production of transportation fuels."

Several agroforestry practices lend themselves to this double duty, such as windbreaks planted with fast-growing woody species and riparian forest buffers planted with both perennial herbaceous and fast-growing woody species in the outer zones. This last agroforestry approach expands the benefits that riparian forest buffers already provide by improving soil and water qualities. Working with several other university partners, NAC scientists are evaluating which species combinations and management strategies optimize both the production of biomass and environmental services.

Since windbreaks and riparian forest buffers generally make up only a small part of a farm operation, integrating biomass production into new or existing agroforestry plots could serve as a means for landowners to transition into a cellulosic-based bioenergy production system while minimizing the risk of investing solely in a new production arena. Alley cropping or silvopasture practices provide landowners the opportunity to establish a system that provides revenue from established markets that can be converted to produce biomass feedstocks when the technology is available and markets are favorable.

"Shifts in farm policy, programs, and markets will be necessary to the make adoption of agroforestry practices for bioenergy production more attractive to landowners," says Schoeneberger. One such program, **USDA's Biomass Crop Assistance Program** (BCAP), provides funding for landowners who sell eligible biomass to approved conversion facilities that generate heat, power or biofuels. Through BCAP, eligible producers of qualified renewable crops can receive up to 75 percent of start-up costs, plus annual payments.

Armed with knowledge from agroforestry research, land managers can choose species and practice designs based on their ability to improve water quality, enhance biodiversity, or other purposes.

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Riparian buffers act as "living filters" to protect water quality. (photo by Lynn Betts, courtesy of USDA Natural Resources Conservation Service)

Native grasses in a conservation buffer. (photo by Lynn Betts, courtesy of USDA Natural Resources Conservation Service)

Adding Bioenergy

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Including biofuel production in the mix will require investigating the bioenergy properties, biomass yield, plant resilience, and potential for invasiveness of biofuel crops. The need for renewable fuel sources is real and here to stay, and woody biomass as part of a larger portfolio of renewable resources offers landowners another way to make money while improving the value of their land. Generating bioenergy from local wood sources can also stimulate local economies, especially when materials are transported less than 50 miles.

Agroforestry practices offer an array of economic, ecological and esthetic rewards. Each day, *Working Trees* show us what they can do—reclaiming soil and water, producing an alternative energy source, providing landowners an additional income source, and improving our quality of life by connecting the landscape with green infrastructure.

For more information:

Michele Schoeneberger at 402-437-5178, x 4021 or mschoeneberger@fs.fed.us

Learn more about *Working Trees* from the USDA National Agroforestry Center: www.unl.edu/nac

Recommended reading:

Bentrup, G. 2008. **Conservation buffers: design guidelines for buffers, corridors, and greenways.** Gen. Tech. Rep. SRS-109. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 110 p.

Schoeneberger, M.; Bentrup, G.; Current, D. [and others]. 2008. **Building bigger better buffers for bioenergy.** Water Resources Impact. 10(3): 22–25.

Sarah Farmer is studying biology, chemistry and writing at Asheville-Buncombe Technical Community College.

The Advantages of Agroforestry

by Chris Fargo-Masuda

The **USDA National Agroforesty Center**, headquartered in Lincoln, NE, develops and delivers technology on a broad suite of agroforestry practices and associated technologies to improve their economic, environmental, and social benefits and increase the use of agroforestry in the United States.

Agroforestry, the blending of agriculture and forestry practices, allows landowners to realize maximum profit from their land. By using a few simple agroforestry practices landowners can realize economic benefits while simultaneously enhancing the sustainability and productivity of their land.

Agroforestry can be grouped into five basic practices:

- **Silvopasture** is the practice of combining forest or timber crops with grazing areas for livestock. Rows of trees are sparsely planted to allow livestock to graze on the grass which grows between. The timber crop is harvested when trees reach maturity.
- **Alley cropping** uses similar practices, with agricultural crops taking the place of livestock between rows of harvestable trees. Crops of corn or soybeans planted between rows of black walnut trees are examples of alley cropping.
- **Riparian forests** and upland buffers are trees and shrubs planted along the banks of streams and bodies of water. These "living filters" protect the health and quality of the waterways by capturing excess nutrients from fertilizers, reducing erosion, and providing food and cover for native wildlife.
- **Windbreaks** use trees as protective barriers for wind-sensitive crops and livestock. Windbreaks reduce erosion, decrease animal mortality by reducing stress, and provide shade. Through the choice of trees, windbreaks can also serve as an income-producing crop by themselves.
- **Forest farming** is the emerging practice of cultivating high-value crops such as ginseng, shitake mushrooms, and decorative ferns in maintained-forests environments. These crops can provide a short-term income while high-quality wood products mature.

In addition to the proven economic benefits of agroforestry practices emerging markets may open a wide array of opportunities. As the effects of climate change create new markets like carbon offsets and demand for biomass energy, agroforestry is poised to benefit.

For more information:

www.unl.edu/nac/

Chris Fargo-Masuda is a researcher for the Blue Ridge Sustainability Institute in Asheville, NC.

Wood Powers Forest Service District Office

by Stevin Westcott

A wood-to-energy gasification project by the Forest Service in Louisiana is proving that it's possible to produce electricity from forest biomass and promote forest health at the same time.

The gasification system directly converts chips from woody materials such as small-diameter trees into electricity. In this case, the electricity produced powers the Winn Ranger District office on the **Kisatchie National Forest**. The **SRS Utilization of Southern Forest Resources** unit in Pineville, LA, purchased and operates the gasification unit in collaboration with the Kisatchie National Forest and **Forest Service State and Private Forestry** (SP&F). The **Community Power Corporation**, from Littleton, CO, constructed the system.

Installed 2 years ago, the state-of-the-art unit converts wood into electricity. The system dries woodchips in two bins that hold a combined 1,400 pounds. The chips are then sorted by size and transported by an auger to the gasifier. Operating at temperatures ranging from 800 to 900 °C, the gasifier converts the chips into a combustible gas. The gas is cooled, filtered, and used to fuel a modified 6-cylinder, internal combustion engine that turns an electrical generator.

The system produces up to 25 kWs of electricity—enough electricity to power the 4,000-square-foot district office. On average, the Forest Service operates the system for a total of 20 hours a week. When operating at full capacity, the wood-using generator produces approximately 10 kWs of surplus electricity which is returned to the local electricity provider for credit. The Forest Service will soon install an 11-kW solar array that will provide enough additional electricity to make the Winn Ranger Station completely electricity independent. This is due in part to a geothermal system used to heat and cool the district office.

The Winn Ranger District eventually plans to supply much of its energy needs from woodchips. In addition, the Forest Service is evaluating the feasibility of adding a special module to convert gas produced by the gasification unit into synthetic diesel for use in district vehicles.

Woodchips supplied to the unit come from a myriad of research projects, among which are

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This wood-fueled gasifier supplies electric power to the Winn Ranger District office in Louisiana. (photo by Tom Elder, USDA Forest Service)

Wood Powers

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understory removal for wildfire fuels reduction as well as restoring habitat in longleaf pine forests that are home to the federally listed red cockaded woodpecker.

The Agency's SP&F uses the unit as a demonstration project for thinning forests for southern pine beetle control and to demonstrate to landowners how trees removed from thinning can be used as a feedstock for bioenergy production and/or biofuel.

The overall goal of the project is to stimulate the development of a bioenergy industry that increases the demand for sustainably produced woody biomass and introduces a market for small-diameter trees and wood residue that's just starting to emerge in the South.

"We're using the system to conduct biomass-to-bioenergy research in an effort to determine the most effective use of our renewable resources while restoring forest health and improving forest resiliency," said **Les Groom**, project leader of the SRS Pineville unit. "This project is just one piece of the Station's larger wood-to-energy program."

View a presentation about the gasification unit at www.srs.fs.usda.gov/usfr/.

For more information:

Les Groom at 318–473–7267
or lgroom@fs.fed.us

Local Heat and Power

The promise of CHP and AWC

Keeping a biomass-burning electric power plant going will require a steady supply of wood from a relatively close area. Trying to determine whether that supply will be available at a reasonable cost for the 30- to 40-year life of the plant—which could very well come to compete with other major electricity or biofuel-producing plants in the same area—could be daunting and downright scary. If the plant is cofiring with coal—likely for major utilities complying with state renewable energy standards—the wood is burned much less efficiently than is now possible with smaller, more localized facilities.

Communities with forest products industries or located near national lands have the resources to consider using smaller, more manageable combined heat and power (CHP) facilities. CHP facilities are more efficient because they are designed primarily to produce heat, with the ability to generate electricity as an extra. Since they're usually built on a small-to-medium scale and are more efficient than larger technologies designed to generate electricity, CHPs require much less biomass. Communities near forest resources might be better served by several smaller CHPs rather than one 50- to 100-MW power plant that might require 1.2 million tons of wood a year to run.

When burning wood, the highest level of efficiency is achieved by the advanced wood combustion (AWC) technologies. Thousands (1,200 or so in Austria alone) of small-scale (10 MWs or less) AWC power plants have been installed over the last two decades across Europe to provide heating, cooling, and electricity in both urban and rural settings. AWC plants are automated, up to 90 percent efficient, and produce minimal amounts of pollution and greenhouse gases. Most AWCs are installed in districts—college campuses, hospital complexes, downtown areas—where they provide heat, cooling, and sometimes electric power. At their small scale, AWC plants can be easily supplied from sustainably managed local forests and urban wood waste.

Though increasingly popular in Europe, AWC has yet to be adopted in the United States, mostly due to lack of knowledge about how it works, though some states have proposed AWC for "Fuels for Schools" programs. **Duke University's Daniel Richter** has estimated that if North Carolina built one AWC facility a year in each of its 100 counties over a 5-year period, the initial $500 million investment over the 5 years would generate fuel savings of $180 million a year and reduce emissions of greenhouse gases by up to a million tons annually. In a recent study, analysts estimated that this program would only require about 20 percent of the state's estimated energy-wood supply.

Recommended reading:

Richter, D. [and others]. 2009. **Wood energy in America. Science.** 323: 1432–1433.

science

You Can Use!

The Biomass Site Assessment Tool (BioSAT)

As new bioenergy markets emerge, one of the greatest challenges is balancing technological, political, environmental, and economic forces.

In 2007, SRS and the **Southeastern Sun Grant Center** at the **University of Tennessee** (UT) formed a partnership to provide research, policy, and business practitioners with innovative biomass to energy research that takes into account regional differences in available biomass supplies, infrastructure capacities, and environmental impacts.

This partnership gave rise to the **Biomass Site Assessment Tool** (BioSAT), a dynamic and durable data delivery system that enables users to compare, map, and display a variety of data and information by zip code for the 33 Eastern states.

"BioSAT grew from the idea that the stability of biomass markets hinges on improved methods to display the risk and cost of supply and logistics from farms and forests to collection or conversion facilities," says **Jim Perdue**, SRS biological scientist working on biomass and energy issues based at UT in Knoxville, TN.

"BioSAT makes use of data fusion to turn information into knowledge for biobased industries," says **Timothy Young**, professor at the **UT Center for Renewable Carbon** and a principal collaborator on the project.

The tool integrates contemporary Web-based information technology, e.g. Microsoft®Virtual Earth, with existing **Forest Inventory and Analysis** data as well as with U.S. Department of Agriculture agricultural and Forest Service harvesting and transportation data.

BioSAT provides the user a unique opportunity to obtain business analyses of the marketplace. With a focus on supply chain components, the system maps and displays up-to-date baseline data for public and business leaders, assesses the economic availability of woody and agricultural-derived biomass, and identifies local market conditions. This reduces screening time to locate sites favorable for biomass businesses.

BioSAT will assist in answering business and economic questions such as:

- *Where is the biomass?*
- *What are the biomass supply options and costs?*
- *Have I chosen the right location?*
- *What are the biomass location opportunities or constraints?*
- *What are my delivered resource supply costs?*

BioSAT estimates the total costs, average total costs, and marginal cost (dollars per dry ton) of biomass at the mill gate. The cost of the resource, harvesting cost, and transportation cost are included in the estimate.

"This information provides a framework for economic decisionmaking for both agricultural and forestry biomass," says Perdue. "The system has realtime update capabilities combined with additional research targeted to continuously adding innovation."

In June 2009, BioSAT received a 2009 Innovator Award from The Southern Growth Policies Board for innovative research vital to "The Future of Southern Energy."

BioSAT is funded by the Forest Service and the Southeastern Sun Grant Center. Additional partners include: North Carolina State University; Oak Ridge National Laboratory; U.S. Department of Energy; U.S. Department of Transportation; and U.S. Endowment for Forestry & Communities, Inc.

The BioSAT Web-modeling framework will be publicly available upon completion at www.biosat.net/. *–TJ*

For more information:

Jim Perdue at 865–946–1123 or jperdue@fs.fed.us

around the STATION...

Experimental Forests

1	Bent Creek	NC
2	Blue Valley	NC
3	Coweeta	NC
4	John C. Calhoun	SC
5	Santee	SC
6	Scull Shoals	GA
7	Hitchiti	GA
8	Olustee	FL
9	Chipola	FL
10	Escambia	AL
11	Tallahatchee	MS
12	Delta	MS
13	Harrison	MS
14	Palustris	LA
15	Stephen F. Austin	TX
16	Crossett	AR
17	Alum Creek	AR
18	Sylamore	AR
19	Henry F. Koen	AR

Dr. Rob Doudrick Named New SRS Director

On December 3, 2010, **Forest Service Chief Tom Tidwell** announced **Dr. Rob Doudrick** as the new director for SRS. Doudrick will report to his new position in Asheville, NC, early in 2011.

Doudrick is an accomplished plant pathologist, geneticist, and mycologist who published extensively on conifer rusts and pine genetics. He started his Forest Service career in 1991 at SRS with the Southern Institute of Pine Genetics in Saucier, MS, where he later served as project leader. In 1998, he came to Asheville to serve as Assistant Director for Planning and Applications.

Doudrick most recently served as Director of Resource Use Science in the Forest Service Office of the Deputy Chief for Research and Development (R&D) in Washington, DC. Previously he served in the Chief's Office as Ecosystems Service Coordinator; other recent assignments include Acting Station Director for the North Central Research Station, Budget Coordinator for R&D, and Legislative Fellow with Congressman Charles Taylor of North Carolina.

Doudrick is also a past board member of the American Chestnut Foundation and received a USDA Secretary's Honor Award for Research for his work on American chestnut genetics.

Reaves Appointed to Top Research Position in Forest Service

SRS Director **Jim Reaves** has accepted the position of Deputy Chief of **Forest Service Research and Development** (R&D) in Washington, DC. In his new role, Reaves leads the largest natural resource research organization in the world, comprised of about 500 scientists and 1,500 professional and administrative employees.

Jim Reaves, new Deputy Chief of Forest Service R&D. (photo by Stevin Westcott, USDA Forest Service)

Reaves served as SRS Director from January 2008 to November

2010. **Forest Service Chief Tom Tidwell** offered Reaves the position of Deputy Chief September 2010. Though Reaves said he had planned to retire in Asheville, he was "surprised, humbled and honored," to be offered the position.

"I accepted the job because I felt it was my duty to serve the Agency when asked. I've worked as a civil servant for many years, and this is an opportunity to sustain the nation's forest resources," said Reaves. "I'll miss Asheville and the dedicated and talented staff at the Southern Research Station. At the same time, I look forward to this new and exciting chapter in my life."

As SRS Director, Reaves oversaw more than 120 scientists and several hundred support staff. From 2000 to 2007, he served in Washington, DC, as Associate Deputy Chief for R&D, and prior to that was a senior staff member to the Forest Service Deputy Chief for R&D. Before working in Washington, Reaves served as Assistant Director for Budget and Planning at SRS.

New Research and Training Center at Bent Creek

Bent Creek Experimental Forest has a new "green" building that gives foresters and scientists the space they need to share information about upland hardwood forest ecology and management. On October 13, 2010, local leaders and partners joined SRS and other Forest Service officials for a ribbon-cutting ceremony for the new **Bent Creek Research and Training Center**.

The center provides space for conferences, workshops, and research meetings as well as office space for Forest Service employees. The facility was designed to meet U.S. Green Building Council's Leadership in Energy and Environmental Design standards.

The facility is 16 percent more efficient than average buildings, with heating, ventilating, and air conditioning split systems; a reflective roof system; increased window and door insulation; energy-efficient light fixtures; and lighting systems equipped with daylight and occupancy sensors. Water consumption is lessened by using low-flow plumbing fixtures and native plants that do not require irrigation. Site disturbance was minimized to cut down on erosion, stormwater runoff, and sedimentation in nearby streams.

Established in 1925, Bent Creek Experimental Forest is the oldest experimental forest east of the Mississippi River and the third oldest managed by the Forest Service.

Chair caning material produced by machine invented by Boggs Collective co-owner Brian Boggs. (photo by Zoë Hoyle, USDA Forest Service)

SRS Initiative Boosts Business in Western North Carolina

This fall, local partners joined Forest Service and other Federal officials for a tour of **The Boggs Collective** in Asheville, NC, to see an example of how the **American Recovery and Reinvestment Act** (Recovery Act) is helping the local economy.

Boggs Collective co-owners Melanie Moeller and Brian Boggs conducted the late August tour, which was sponsored by SRS and the **Land-of-Sky Regional Council** (Land-of-Sky).

The Boggs Collective received a grant of nearly $100,000 from the Land-of-Sky **Western North Carolina Forest Products Cooperative Marketing Project**, which is funded by the Recovery Act through SRS. The Boggs Collective is using the grant to create an infrastructure for a cooperative workshop, woodshed, woodworking school, and virtual gallery to support local craftspeople and forest producers. The grant will also help the company hire six full-time employees.

SRS received nearly $2 million in Recovery Act funds to put people to work and boost the economy of the region. SRS awarded the Recovery Act funds to Land-of-Sky through a competitive selection process; the council's marketing cooperative provided grants for about 14 projects. Land-of-Sky officials estimate the cooperative marketing project is putting at least 140 people to work across western North Carolina. *–SF*

Southern Research Station headquarters in Asheville, NC. (photo by Rod Kindlund, USDA Forest Service, retired)

NEW PRODUCTS *from the Southern Research Station...*

Forest Ecosystem Restoration and Management

1 Greenberg, C.H.; Forrest, T.G.; Waldrop, T. 2010. **Short-term response of ground-dwelling arthropods to prescribed fire and mechanical fuel reduction in a Southern Appalachian upland hardwood forest.** Forest Science. 56(1): 112–121.

As part of the National Fire and Fire Surrogate Study, we used drift fences with pitfall traps to determine how three fuel reduction treatments affected ground-dwelling macroarthropods in the Southern Appalachian Mountains of North Carolina. Four experimental units were contained within each of three replicate blocks. Treatments were: (1) prescribed burning, (2) mechanical felling of shrubs and small trees, (3) mechanical felling burning, and (4) untreated controls. Mechanical understory felling was conducted in winter 2001 to 2002, and prescribed burning was conducted in March 2003. Mechanical felling burning resulted in greater canopy openness compared with the other treatments as a result of hotter fires and elevated levels of subsequent tree mortality. Burning reduced leaf litter depth in both burned treatments by 80 percent. We found no differences among treatments in the relative abundance or dry biomass of total ground-dwelling macroarthropods or within most orders; Hymenoptera (predominantly Formicidae) dry biomass was greater with mechanical felling burning than with mechanical felling. Total relative abundance and dry biomass were low in spring and higher in late summer. Our results indicate that prescribed burning and mechanical fuel reduction treatments conducted in winter or early spring have little impact on the community composition, relative abundance, or biomass of total arthropods or most arthropod orders and families, at least in the short term.

2 Nelson, C.D.; Kubisiak, T.L.; Amerson, H.V. 2010. **Unravelling and managing fusiform rust disease: a model approach for coevolved forest tree pathosystems.** Forest Pathology. 40: 64–72.

Fusiform rust disease remains the most destructive disease in pine plantations in the Southern United States. Our ongoing research is designed to identify, map, and clone the interacting genes of the host and pathogen. Several resistance (R) genes have been identified and genetically mapped using informative pine families and single-spore isolate inoculations. In addition, we are mapping the first of many expected corresponding avirulence (Avr) genes in the fungal pathogen. The Avr genes condition avirulence / virulence and avirulence is required for an incompatible reaction, i.e., no-gall development, to take place within an inoculated tree that carries resistance at the corresponding R gene. We provide an overview of our methodology for identifying and mapping R and Avr genes, an update of our current progress, and a brief discussion of two approaches for predicting R gene genotypes of uncharacterized parental trees and for estimating the efficacy of specific pine genotypes at various planting locations.

3 Saenz, D.; Kavanagh, B.T.; Kwiatkowski, M.A. 2010. ***Batrachochytrium dendrobatidis* detected in amphibians from national forests in eastern Texas, USA.** Herpetological Review. 41(1): 47–49.

The amphibian disease chytridiomycosis, caused by the pathogenic fungus *Batrachochytrium dendrobatidis* (Bd) is well known as a major threat to amphibians resulting in mass die-offs and population declines throughout the world. Bd has been detected on amphibians from sites across North America and appears to be most prevalent in the Western and the Northeastern United States. Whereas infected anurans also have been found throughout the Southeastern United States, there have been no reports of Bd from amphibians in eastern Texas, a broad area encompassing 10 000 000 ha. We sampled amphibians for the presence of Bd in four national forests in eastern Texas (approximately 31°N. latitude).

4 Sanchez, F.G.; Eaton, R.J. 2010. **Site establishment practices influence loblolly pine mortality throughout the stand rotation.** Res. Pap. SRS–50. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 6 p.

During a rotation, land managers need to estimate yields, update inventories, and evaluate stand dynamics. All of these factors are heavily influenced by tree mortality, which is in turn influenced by management practices from the inception of the stand throughout the rotation. We describe the impact of organic matter removal and soil compaction during stand establishment on loblolly pine (*Pinus taeda* L.) through mortality over the course of 15 years. We also describe the impact of understory control throughout the study on tree mortality. In this study, soil compaction did not impact tree mortality at any time. Removal of surface organic matter impacted tree mortality, with the least intensive practices (bole only removal) resulting in the greatest tree mortality. This effect, observed very early in the rotation, was probably due to immobilization of essential nutrients. Control of the understory became a significant factor to tree mortality late in the rotation as intraspecific competition for light became an important consideration. Site amelioration, via regional Best Management Practices, negated the impact of competition control on mortality.

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5 Scott, D.A.; Messina, M.G. 2010. **Soil properties in 35 y old pine and hardwood plantations after conversion from mixed pine-hardwood forest.** The American Midland Naturalist. 163: 197–211.

Past management practices have changed much of the native mixed pine-hardwood forests of the western Gulf Coastal Plain to either pine monocultures or hardwood stands. Changes in dominant tree species can alter soil properties and processes, thereby changing soil attributes, and ultimately, soil functions. Restoring these forests may be slow or difficult if soil function is altered appreciably. We studied the soil properties and processes in pine or hardwood-dominated stands after 35 y since conversion from a mixed pine-hardwood stand. The pine forest floor biomass was about twice as great as that of the oak stands, the oak soils were 20 to 30 percent wetter than the pine soils throughout the sampling period, and the oak soils released more CO2 through respiration and had higher rates of N mineralization in the summer. This study supports the hypothesis that pine- or hardwood-only stands create functionally different soils on these site types after 35 y.

6 Sword Sayer, M.; Haywood, J.D.; Sung, S.S. 2009. **Cavity size and copper root pruning affect production and establishment of container-grown longleaf pine seedlings.** Forest Science. 55(5): 377–390.

With six container types, we tested the effects of cavity size, i.e., 60, 93, and 170 ml, and copper root pruning on the root system development of longleaf pine (*Pinus palustris* Mill.) seedlings grown in a greenhouse. We then evaluated root egress during a root growth potential test and assessed seedling morphology and root system development 1 year after planting in central Louisiana, USA. Seedling size was increased by copper root pruning in small cavities but was unaffected by this treatment in larger cavities. Before planting, copper root pruning increased taproot and secondary lateral root dry weights at the expense of primary lateral root dry weight and increased root growth potential in the top 5 cm of the root

plug. Across treatments, survival was 97 percent, and all seedlings were in the grass stage. Of the lateral root dry weight that elongated during the first year after planting, 33 percent more occurred in the upper 5 cm of soil when seedlings were treated with copper. Within each cavity size, copper root pruning did not affect the general morphology of 1-year-old seedlings. However, relationships between root-collar diameter and root egress by depth indicated that this treatment has the potential to increase the range of cavity sizes used for seedling production.

Forest Values, Uses, and Policies

7 Abt, R.C.; Abt, K.L.; Cubbage, F.W.; Henderson, J.D. 2010. **Effect of policy-based bioenergy demand on southern timber markets: a case study of North Carolina.** Biomass and Bioenergy. 34(12): 1679–1686.

Key factors driving renewable energy demand are State and Federal policies requiring the use of renewable feedstocks to produce energy and liquid fuels. However, over the next decade, the infrastructure for renewable energy supplies is unlikely to develop as fast as renewable energy demands. The ability to supply wood over the next decade is a function of the residual utilization, age-class structure, and competition from traditional wood users. Using the North Carolina Renewable Portfolio Standard (RPS) as a case study, we simulate the impacts of increased woody biomass demand on timber markets, focusing on the interaction between short-run demand changes and long-term supply responses. We conclude that logging residuals alone may be unable to meet bioenergy demands from North Carolina's RPS. Thus, small roundwood (pulpwood) may be used to meet remaining bioenergy demands, resulting in increased timber prices and removals; displacement of traditional products; higher forest landowner incomes; and changes in the structure of the forest resource.

8 Abt, R.C.; Cubbage, F.W.; Abt, K.L. 2009. **Projecting southern timber supply for multiple products by subregion.** Forest Products Journal. 59(7/8): 7–16.

While timber supply modeling has been of importance in the wood-producing regions of the United States for decades, it is only more recently that the technology and data have allowed disaggregation of supply and demand to sub-State regions, including product specific breakdowns and endogenous land use and plantation changes. Using southwide data and an economic supply and demand framework, the Subregional Timber Supply model was used to project timber inventory, removals, and price for subregions of the 12 Southern States through 2030. Two hypothetical demand scenarios were modeled to reflect current recessionary impacts and potential for added bioenergy demands: (1) constant demands based on average 2002 to 2007 removals, and (2) a 30-percent recession reduction (2006 to 2009) and rebound by the same percentage (2010 to 2013) followed by a 0.5-percent per year demand increase for all products.

9 Holmes, T.P. 2010. **Confronting challenges to economic analysis of biological invasions in forests.** New Zealand Journal of Forestry Science. 40: 105–116.

Biological invasions of forests by nonindigenous organisms present a complex, persistent, and largely irreversible threat to forest ecosystems around the globe. Rigorous assessments of the economic impacts of introduced species, at a national scale, are needed to provide credible information to policymakers. It is proposed here that microeconomic models of damage due to specific invading organisms be aggregated across the forest landscape by considering the rate at which acute, short-run economic impacts accumulate over time and space. By estimating the economic costs and damages associated with the most consequential pests within each pest guild and each sector of the forest economy, a better indication of the economic consequences of biological invasions can be obtained and used to inform policy analysis.

10 Prestemon, J.P.; Butry, D.T.; Abt, K.L.; Sutphen, R. 2010. **Net benefits of wildfire prevention education efforts.** Forest Science. 56(2): 181–192.

Wildfire prevention education efforts involve a variety of methods, including airing public service announcements, distributing brochures, and making presentations, which are intended to reduce the occurrence of certain kinds of wildfires. A Poisson model of preventable Florida wildfires from 2002 to 2007 by fire management region was developed. Controlling for potential simultaneity biases, this model indicated that wildfire prevention education efforts have statistically significant and negative effects on the numbers of wildfires ignited by debris burning, campfire escapes, smoking, and children. Evaluating the expected reductions in wildfire damages given a change in wildfire prevention education efforts from current levels showed that marginal benefits exceed marginal costs statewide by an average of 35-fold. The benefits exceeded costs in the fire management regions by 10- to 99-fold, depending on assumptions about how wildfire prevention education spending is allocated to these regions.

11 White, R.H.; Zipperer, W.C. 2010. T**esting and classification of individual plants for fire behaviour: plant selection for the wildland–urban interface.** International Journal of Wildland Fire. 19: 213–227.

Knowledge of how species differ in their flammability characteristics is needed to develop more reliable lists of plants recommended for landscaping homes in the wildland–urban interface (WUI). The flammability of vegetation is often described as having four components (ignitability, combustibility, sustainability and consumability). No standards or generally recognised test procedures exist for evaluating these components in plants. Some measurements of flammability include times for ignition, rate of flame spread, flame height, and heat release rate. Often, the fire behaviour characteristics of a plant are derived from its physical and chemical characteristics. Thermogravimetric analysis and other thermal analyses of ground samples have long been used to characterise the thermal degradation of vegetation. More recently, researchers have used the oxygen consumption methodology to measure the heat released due to combustion of the vegetation.

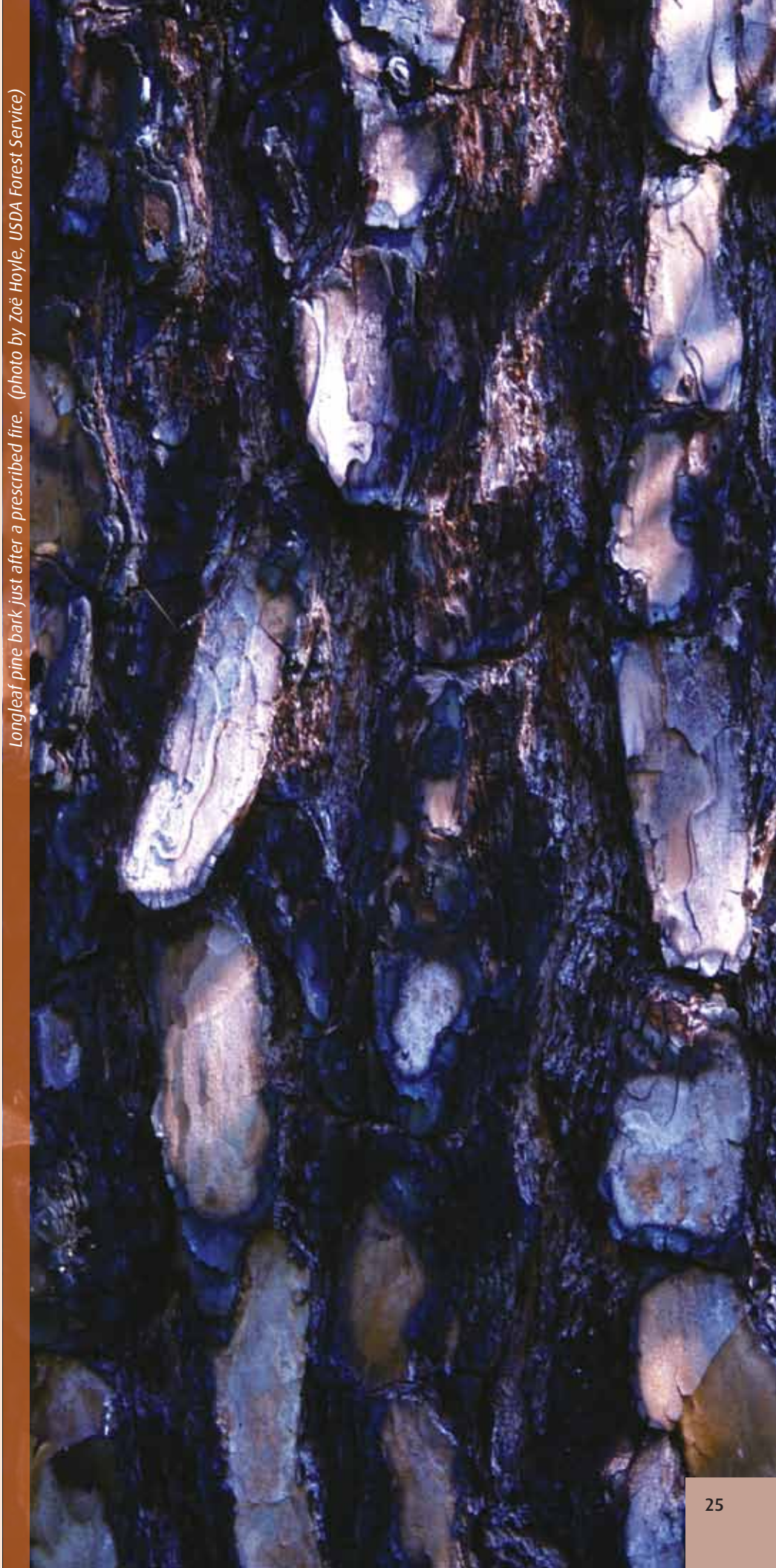
Forest Watershed Science

12 Adams, S.B.; Taylor, C.A.; Lukhaup, C. 2010. **Crayfish fauna of the Tennessee River drainage in Mississippi, including new State species records.** Southeastern Naturalist. 9(3): 521–528.

We present new State records for three crayfish species in the Tennessee River basin in Mississippi, and the first drainage-specific distributional information in the State for a fourth. The species—*Cambarus girardianus, Cambarus rusticiformis, Orconectes spinosus*, and *Orconectes wright*—are all known from the Tennessee River basin in Tennessee, while all but *O. wright* are also known from Alabama. We also expand the distribution of *Procambarus viaeviridis* in the State to include the Tennessee River drainage in Alcorn and Tishomingo Counties, MS. We briefly discuss taxonomic issues involving *C. girardianus* and *O. spinosus*. Based on their distributions in neighboring States, we suspect that several other species may occur in the Mississippi portion of the basin.

13 Clinton, B.D.; Vose, J.M.; Fowler, D.L. 2010. **Flat Branch monitoring project: stream water temperature and sediment responses to forest cutting in the riparian zone.** Res. Pap. SRS–51. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 8 p.

Streamwater protection during timber-harvesting activities is of primary interest to forest managers. In this study, we examine the potential impacts of riparian zone tree cutting on water temperature and total suspended solids. We monitored streamwater temperature and total suspended solids before and after timber harvesting along a second-order tributary of the Coleman River in northeastern Georgia, where logging with rubber-tired skidders was conducted in the riparian area along alternating 60-m stream reaches on the east side of the stream. We monitored temperature above the management unit (reference), at a location within the cut area (within cut), and at a third site 150 m below the cut area (below cut). We measured total suspended solids during baseflow and stormflow, taking weekly streamwater



Longleaf pine bark just after a prescribed fire. (photo by Zoë Hoyle, USDA Forest Service)

grab samples above the site and above and below each riparian area, for a total of six sampling locations. We found that streamwater temperature following harvest increased within the cut area relative to the reference but decreased at the below sample site back to reference conditions. Overall, total suspended solids responses were minimal or nonexistent during base- and stormflows within the cut relative to the reference site, and temperature responses were minimal.

14 Ford, C.R.; Reynolds, B.C.; Vose, J. 2010. **Xylem transport models optimize effectiveness of systemic insecticide applications for controlling hemlock woolly adelgid (*Adelges tsugae*).** Gen. Tech. Rep. SRS–120. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 8 p.

The hemlock woolly adelgid [HWA (*Adelges tsugae* Annand)] is causing widespread decline and mortality of eastern hemlock trees [*Tsuga Canadensis* (L.) Carr.]. Stem injection of insecticide is widely used as a control measure, but its effectiveness depends on individual tree hydraulic characteristics. In this study we modeled daily water use for 20 eastern hemlock trees across a range of diameters. Based on expected daily water use and, thus, potential xylem transport of insecticide, we applied a dosage of imidacloprid estimated to achieve a lethal and uniform xylem sap concentration to half the trees (xylem transport treatment), and treated the remaining half based on the manufacturer-recommended dosage (MFR treatment), which is a linear function of tree diameter. At 4 and 56 weeks after treatment, we assessed all trees for new shoot growth and live HWA population density. We found that both treatment dosages significantly reduced live HWA populations; however, 4 weeks after treatment, live HWA population density was 32 percent lower on xylem transport treatment trees compared with MFR treatment trees. Both treatment dosages also significantly increased the proportion of new shoot growth; however, over time xylem transport treatment trees had a significantly greater increase in new shoot production compared with MFR treatment trees. We conclude that dosages based on a xylem transport model not only significantly improved tree health, but also caused greater reductions in the live HWA population.

15 Hawkins, T.S.; Skojac, D.A.; Schiff, N.M.; Leininger, T. 2010. **Floristic composition and potential competitors in *Lindera melissifolia* (Lauraceae) colonies in Mississippi with reference to hydrologic regime.** Journal of the Botanical Research Institute of Texas. 4(1): 381–390.

Lindera melissifolia is a federally endangered shrub endemic to the Southeastern United States. Hydrologic regime and floristic composition within individual *L. melissifolia* colonies in three disjunct populations in Mississippi were monitored for 3 years. Sixty-nine vascular plant species were identified growing within *L. melissifolia* colonies. Although number of flooding events and flood duration varied among the three populations, floristic composition and the ratio of *L. melissifolia* to other plants in the colonies remained relatively constant during the study period. In Mississippi, Smilax spp. and Vitis spp. have the greatest potential to become strong competitors of *L. melissifolia*.

16 Kilgo, J.C.; Ray, H.S.; Ruth, C.; Miller, K.V. 2009. **Can coyotes affect deer populations in Southeastern North America?** Journal of Wildlife Management. 74(5): 929–933.

The coyote (*Canis latrans*) is a recent addition to the fauna of Eastern North America, and in many areas coyote populations have been established for only a decade or two. Although coyotes are known predators of white-tailed deer (*Odocoileus virginianus*) in their historic range, effects this new predator may have on eastern deer populations have received little attention. We speculated that in the Southeastern United States, coyotes may be affecting deer recruitment, and we present five lines of evidence that suggest this possibility. First, the statewide deer population in South Carolina has declined coincident with the establishment and increase in the coyote population. Second, datasets from the Savannah River Site (SRS) in South Carolina indicate a new mortality source affecting the deer population concurrent with the increase in coyotes. Third, an index of deer recruitment at SRS declined during the period of increase in coyotes. Fourth, food habits data from SRS indicate that fawns are an important food item for coyotes during summer. Finally, recent research from Alabama documented significant coyote predation on fawns there. Although this evidence does not establish cause and effect between coyotes and observed declines in deer recruitment, we argue that additional research should proactively address this topic in the region. We identified several important questions on the nature of the deer-to-coyote relationship in the East.

Natural Resources Inventory and Monitoring

17 Ambrose, M.J.; Conkling, B.L. 2009. **Forest health monitoring: 2006 national technical report.** Gen. Tech. Rep. SRS–117. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 118 p.

The Forest Health Monitoring Program's annual national technical report presents results of forest health analyses from a national perspective using data from a variety of sources. The report is organized according to the Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests of the Santiago Declaration. Drought in 2005 is presented, and drought over the decade 1996 to 2005 is compared with the historical average. National air pollution data are used to estimate the exposure of forests to ozone, wet sulfate deposition, and wet deposition of inorganic nitrogen. Aerial survey data are used to identify hotspots of insect and disease activity based on the relative exposure to defoliation- and mortality-causing agents. Marine cargo data are analyzed to identify locations where exotic insect pests are likely to be introduced. Forest Inventory and Analysis crown condition data are analyzed to identify spatial clusters of plots where trees have relatively poor crowns, which might indicate forest health problems.

18 Bentley, J.W.; Johnson, T.G. 2009. **Florida harvest and utilization study, 2008.** Resour. Bull. SRS–162. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 27 p.

In 2008, a harvest and utilization study was conducted on 82 operations throughout Florida. There were 2,114 total trees measured: 1,670 or 79 percent were softwood, while 444 or 21 percent were hardwood. Results from this study showed that 85 percent of the total softwood volume measured was utilized for a product, and 15 percent was left as logging residue. Seventy-four percent of the total hardwood volume measured was utilized for a product, while 26 percent was left as logging residue.

19 Conner, R.C.; Adams, T.O.; Johnson, T.G. 2009. **Assessing the potential for biomass energy development in South Carolina.** Res. Pap. SRS–46. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 19 p.

An assessment of the potential for developing a sustainable biomass energy industry in South Carolina was conducted. Biomass as defined by Forest Inventory and Analysis is the aboveground dry weight of wood in the bole and limbs of live trees ≥1-inch diameter at breast height, and excludes tree foliage, seedlings, and understory vegetation. Several possible sources of biomass were analyzed: unutilized logging residue and standing residual inventory trees on acres with tree harvesting, commercial thinning, precommercial thinning on overstocked natural sapling/seedling stands, mill residue, and urban wood waste. A range of prices from $20 to $30 per ton was established by surveys sent to South Carolina's timber producers. Prices reflect 2008 market conditions. The estimates of potential biomass distributed across these price points rose from 4.8 million tons to a total of 16.5 million tons annually. Nearly 7.7 million tons are currently being utilized. New facilities that use wood to produce energy could capitalize on the 8.8 million annual tons of unutilized biomass and operate without overly impacting existing forest industries or increasing harvest levels above 2006 estimates.

20 Johnson, T.G.; Steppleton, C.D.; Bentley, J.W. 2010. **Southern pulpwood production, 2008.** Resour. Bull. SRS–165. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 42 p.

The South's production of pulpwood increased from 65.7 million cords in 2007 to 67.0 million cords in 2008. Roundwood production increased by 1.2 million cords to 48.8 million cords and accounted for 73 percent of the South's total pulpwood production. The use of wood residue remained stable at 18.2 million cords. Georgia led the South in total production, with 11.6 million cords. In 2008, 86 mills were operating and drawing wood from the 13 Southern States. Pulping capacity of southern mills declined from 125,565 tons per day in 2007 to 124,679 tons per day in 2008, but still accounted for >70 percent of the Nation's pulping capacity.

21 Rosson, J.F.; Rose, A.K. 2010. **Arkansas' forests, 2005.** Resour. Bull. SRS–166. Asheville, NC: U.S.

Longleaf pine stand in Brosnan Forest after spring burn. (photo by Zoë Hoyle, USDA Forest Service)

Forest operations. (photo by Trice Megginson, courtesy of USDA Forest Service)

Department of Agriculture Forest Service, Southern Research Station. 126 p.

The principal findings of the eighth forest survey of Arkansas are presented. This survey marks a major change in the Forest Inventory and Analysis sampling protocol from a periodic prism sample to an annualized fixed-plot sample. Topics examined include forest area; ownership; forest-type groups; stand structure; basal area; timber volume; growth, removals, and mortality; crown characteristics; ozone levels; soil characteristics; and invasive species.

Threats to Forest Health

22 Goodrick, S.L.; Shea, D.; Blake, J. 2010. **Estimating fuel consumption for the upper Coastal Plain of South Carolina.** Southern Journal Applied Forestry. 34: 5–12.

Recent changes in air quality regulations present a potential obstacle to continued use of prescribed fire as a land management tool. Lowering the acceptable daily concentration of particulate matter will bring much closer scrutiny of prescribed burning practices from the air quality community. To work within this narrow window, land managers need simple tools to estimate their potential emissions and examine trade-offs between continued use of prescribed fire and other means of fuels management. A critical part of the emissions estimation process is determining the amount of fuel consumed during the burn. This study combines results from studies along the upper Coastal Plain of South Carolina to arrive at a simple means of estimating total fuel consumption on prescribed fires. The result is a simple linear relationship that determines the total fuel consumed as a function of the product of the preburn fuel load and the burning index of the National Fire Danger Rating System.

23 Hanula, J.; Horn, S.; Taylor, J.W. 2010. **Chinese privet (*Ligustrum sinense*) removal and its effect on native plant communities of riparian forests.** Plant Science and Management. 2: 292–300.

Chinese privet (*Ligustrum sinense*) is a major invasive shrub within riparian zones throughout the Southeastern United States. We removed privet shrubs from four riparian forests in October 2005

Loading logs for transport. (photo by Trice Megginson, courtesy of USDA Forest Service)

with a mulching machine or by hand felling with chainsaws and machetes to determine how well these treatments controlled privet and how they affected plant community recovery. One year after shrub removal a foliar application of 2 percent glyphosate was applied to privet remaining in the herbaceous layer. Both methods completely removed privet from the shrub layer without reducing nonprivet shrub cover and diversity below levels on the untreated control plots, resulted in higher nonprivet plant cover than the untreated controls, and created open streamside forests usable for recreation and other human activities.

24 O'Brien, J.J.; Mordecai, K.A.; Wolcott, L. 2010. **Fire managers field guide: hazardous fuels management in subtropical pine flatwoods and tropical pine rocklands.** Gen. Tech. Rep. SRS–123. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 55 p.

This publication is a field guide to tactics and techniques for dealing with hazardous fuels in subtropical pine flatwoods and tropical pine rocklands. The guide covers prescribed fire, mechanical, chemical, and other means for reducing and managing wildland fuels in these systems. Also, a list of exotic plants that contribute to hazardous fuel problems is included with recommendations on their control.

25 Qian, H.; Guo, Q. 2010. **Linking biotic homogenization to habitat type, invasiveness and growth form of naturalized alien plants in North America.** Diversity and Distributions. 16: 119–125.

Biotic homogenization is a growing phenomenon and has recently attracted much attention. Here, we analyse a large dataset of native and alien plants in North America to examine whether biotic homogenization is related to several ecological and biological attributes. We assembled species lists of native and alien vascular plants for each of the 64 State- and province-level geographical units in North America. Each alien species was characterized with respect to habitat (wetland versus upland), invasiveness (invasive versus noninvasive), life cycle (annual/biennial versus perennial), and habit (herbaceous versus woody). We calculated a Jaccard similarity index separately for native, alien, and for native and alien species. We used the average of Jaccard dissimilarity index (1 – Jaccard index) of all paired localities as a measure of the mean beta diversity of alien species for each set of localities examined in an analysis. We used a homogenization index to quantify the effect of homogenization or differentiation.

26 Waldrop, T.; Phillips, R.J.; Simon, D.A. 2010. **Fuels and predicted fire behavior in the Southern Appalachian Mountains and fire and fire surrogate treatments.** Forest Science. 56(1): 32–45.

This study tested the success of fuel reduction treatments for mitigating wildfire behavior in the Southern Appalachian Mountains. A secondary objective of treatments was to restore the community to an open woodland condition. Three blocks of four treatments were installed in a mature hardwood forest in western North Carolina. Fuel reduction treatments included chainsaw felling of small trees and shrubs (mechanical treatment), two prescribed fires 3 years apart, a combination of mechanical and burning treatments, and an untreated control. Mechanical treatment eliminated vertical fuels but without prescribed burning; the mechanical treatment added litter and woody fuels that increased several measures of BehavePlus4-simulated fire behavior (rate of spread, flame length, spread distance, and area burned) for 5 years. Prescribed burning reduced litter mass by 80 percent and reduced all simulated fire behavior variables for 1 year but had no residual effect by the third year. The combined mechanical and burning treatments had hot prescribed fires during the first burn that killed some overstory trees, resulting in increased amounts of woody fuels on the forest floor. All active treatments (fire, mechanical, and combined) reduced simulated wildfire behavior, even after a severe ice storm added fine fuels. Prescribed burning in combination with the mechanical treatment was the most effective in reducing all measures of fire behavior and advancing restoration objectives.

Loblolly pine stand. (photo by David J. Moorhead, University of Georgia, courtesy of Bugwood.org)

Research Work Units

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Forest Ecosystem Restoration and Management		
Asheville, NC Katie Greenberg	Upland Hardwood Ecology and Management www.srs.fs.usda.gov/bentcreek	828-667-5261
Auburn, AL Kris Connor	Restoring and Managing Longleaf Pine Ecosystems www.srs.fs.usda.gov/4111	334-826-8700
Monticello, AR James Guldin	Southern Pine Ecology and Management www.srs.fs.usda.gov/4106	870-367-3464
Saucier, MS Dana Nelson	Forest Genetics and Ecosystems Biology www.srs.fs.usda.gov/organization/unit/mississippi.htm#SRS-4153	228-832-2747
Forest Values, Uses, and Policies		
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Auburn, AL Bob Rummer	Forest Operations www.srs.fs.usda.gov/forestops/	334-826-8700
Pineville, LA Les Groom	Utilization of Southern Forest Resources www.srs.fs.usda.gov/4701	318-473-7268
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Natural Resources Inventory and Monitoring		
Knoxville, TN Bill Burkman	Forest Inventory and Analysis www.srsfia2.fs.fed.us	865-862-2000

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The Earth from above.
(photo courtesy of National Aeronautics & Space Administration)