

COMPASS

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

issue 12

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Cover photo: When Hurricanes Katrina and Rita swept through in fall 2005, they left widespread damage to Gulf Coast forest resources. (Photo by Patrick Hesp, Louisiana State University Hurricane Katrina and Rita Clearinghouse Cooperative)

COMPASS

Science You Can Use!

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perspectives and tools to benefit southern forest resources

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With increased hurricane activity expected for the next 10 to 40 years, yearly damage to forests along the Gulf Coast could become the norm. (Photo by Peter L. Lorio, U.S. Forest Service, Bugwood.org)

LESSONS FROM KATRINA AND RITA

by John Stanturf

Hurricanes are a fact of life in the Southern United States. The Gulf Coast areas of Texas, Louisiana, and Mississippi are especially prone to these tropical cyclones, but coastal ecosystems are uniquely adapted to both periodic hurricanes and fire. You could say they thrive on disturbance. Unfortunately, cities and towns along the Gulf Coast—and the people who live in them—have proven to be less resilient when it comes to weathering huge storms, as most recently shown when Hurricane Ike tore through Galveston, TX. The past 10 hurricane seasons have been the most active on record. The consensus among climatologists is that increased hurricane activity could persist for another 10 to 40 years. When you add global climate change predictions to the mix, yearly damage from hurricanes could become the norm for the Gulf Coast rather than periodic occurrences.

In August and September 2005, Hurricanes Katrina and Rita caused what has been termed the most costly natural disaster in U.S. history. In addition to wind, storm surge, and flooding damage along the Gulf Coast of Louisiana, Mississippi, and Alabama, the levees that surrounded metropolitan New Orleans were undermined. Their collapse caused extensive flooding damage and loss of life. The human toll from Katrina is inestimable; property damage has been estimated in the hundreds of *billions* of dollars. The rising cost of natural disasters is a result of the increased vulnerability where human development has extended into high risk areas during periods when there were relatively few major hurricanes.


The estimated wind damage from Katrina and Rita to forest resources was between \$2 and \$3 billion, with more than 5.5 million acres of timberland affected in the States of Texas, Louisiana, Mississippi, and Alabama. Although financial estimates of timber losses provide an incomplete estimate of impacts, there is no doubt that effects from the hurricanes will linger for years to come. Many managers and landowners were caught unprepared to salvage timber quickly enough to recover value and prevent further damage from insects, invasive plants, and rot. Managing salvage while maintaining or recovering ecological values is another issue few land managers had planned for.

Hurricanes Katrina and Rita provided an opportunity to examine forest management objectives and how they could be used to reduce vulnerability to damage from future storms and to provide managers with the basis to make disaster plans. More resiliency in ecosystems and social systems is the key. A resilient system is one that can absorb recurring disturbances such as hurricanes while retaining essential structures, processes, and functions. Like the old Timex watch commercial, a resilient system can “take a lickin’ and keep on tickin’.” Southern Research Station scientists work with a wide range of partners to provide the information needed to adapt southern forests and landowners to changing conditions, whether natural disaster, climate conditions, or land use change.

In this issue of *Compass*, we don’t presume to address the depth of human suffering associated with the

2005 hurricanes, or to offer analysis of social systems. Our focus on hurricane effects on forest resources may seem at first somewhat narrow, but we believe that the importance of forests lies not only in timber values, but also in the innumerable “ecosystem services” forests provide—from habitat for myriad species, to places for people to rest and recreate, to carbon storage banks to offset climate change, to alternative sources of energy.

In this issue, we’ll go into detail about the steps landowners and homeowners can take to manage storm damage to their trees. We’ll look at how Katrina affected a long-term experiment on an experimental forest in Mississippi, including findings that longleaf pine—once the dominant tree species in coastal areas—is surprisingly hurricane-resistant when compared to other pine species. We’ll see how what we’ve learned from previous hurricanes came into play when Rita threatened red-cockaded woodpecker habitat in Texas, and how arborists across the United States responded when urban foresters along the Gulf Coast needed help saving their city trees.

Lessons learned from Katrina and Rita will not only help forest managers prepare for future hurricanes, but more readily adapt to a reality where constant and often severe natural disturbance is the norm. The future isn’t what it used to be. Managers need to focus on the extremes rather than the averages, and to expect abrupt as well as gradual change. 

John Stanturf is project leader of the SRS Center for Forest Disturbance Science in Athens, GA.

Hurricane Katrina

Natural disturbance brings human tragedy

From a natural resource perspective, Hurricane Katrina was a large-scale disturbance event. But from the human perspective, the massive storm was catastrophic, killing more than 1,800 people and displacing almost half a million.

On August 29, 2005, Katrina made landfall at Buras, LA, as a category 5 hurricane with maximum sustained winds clocked at 126 miles per hour, sending pounding waves and a mammoth storm surge onto the Gulf Coast of Louisiana, Mississippi, and Alabama. The largest storm surge recorded was 28 feet along the Mississippi coast, with surges reaching as high as 20 feet in New Orleans. The surge pushed 12 miles inland along Mississippi waterways and 6 miles along the coast.

As it roared northward, the hurricane brought 10 inches of rain to many areas and cut a wide swath of destruction that spanned southeastern Louisiana across southcentral Mississippi and western Alabama. Katrina weakened to a tropical storm as it moved inland, but not before inflicting an enormous amount of damage. Compounding the effects of Katrina were the more than 40 tornadoes the storm spawned.

Americans across the country watched as images of human tragedy and devastation flashed across their television screens. Thousands of homes and businesses were damaged or destroyed. The National Weather Service's National Hurricane Center initially estimated total damages at

around \$81 billion, which would make Katrina the costliest hurricane to hit the United States. More than 3 years after the storm pummeled the Gulf Coast, many residents are still trying to rebuild their lives.

According to research from the **SRS Forest Inventory and Analysis** unit, Hurricane Katrina damaged an estimated 4.9 million acres of coastal and inland forests. SRS economists **Jeffrey Prestemon** and **David Wear** estimated financial losses from wind damage to timber between \$1.4 and \$2.4 billion. About 90 percent of the damage was within 62 miles of the coast. More than 65 percent occurred in Mississippi alone. The majority of losses were in pine forests. Loblolly and longleaf pines, as well as hardwoods such as oaks, pecans, and other species were blown over, twisted, snapped, and damaged by salt infusion and other factors. —*SW*

Hurricane Katrina destroyed or damaged thousands of homes and businesses. (Photo by Eric Kuehler, U.S. Forest Service)



EVALUATING CHAOS

The answers are out there, even before the winds have stilled

by Bill Dockery

On August 28, 2005, **Dennis Jacobs** had just arrived at a church dinner in Knoxville, TN, when he heard that Hurricane Katrina had intensified into a category 5 storm. He knew how he would be spending the next few days.

Jacobs, research forester with the **SRS Forest Inventory and Analysis (FIA)** unit in Knoxville, has created procedures that allow him to rapidly assess damage from major storms on the forest lands of the South.

“Monday morning I began gathering data for making temporary maps and tables as the hurricane moved inland, just in case anyone wanted to see data immediately. I knew I would be able to fine tune the report after the winds tapered off.”

Only days later he would be doing the process again for Hurricane Rita, which came ashore near Port Arthur, TX, and affected forests in southwest Louisiana and east Texas.

“We’re occasionally called on by States or by the Station for quick assessments,” Jacobs says. “In the case of Hurricane Katrina, Washington officials wanted quick answers.”

Officials need damage estimates to target disaster assistance funds as well as for budgeting State and Federal funds for firefighting, insect and disease monitoring, and forest restoration efforts. Jacobs can provide them with damage estimates within 3 days of a disaster.

Jacobs relies heavily on the availability of two key types of

information: up-to-date forest inventory data and near-real-time meteorological details. The inventory data that FIA produces on an annual basis serves as the benchmark that allows the effects of catastrophic events to be measured. The increasingly sophisticated data compiled by the National Weather Service and the National Hurricane Center, immediately available on the Internet, enables Jacobs to create his rapid assessment methods. Jacobs uses data on wind patterns and speeds, rainfall totals, areas of tidal surges, and the path of the hurricane’s eye as it moves inland.

“The eye path is particularly important because the heaviest damage to forests usually occurs on the windward side of the path, where the wind has picked up speed over bodies of water before it hits the shore,” Jacobs says. “With hurricanes on the Atlantic and the gulf, that’s the right side of the eye track.”

Jacobs points out that his rapid assessment procedure is not foolproof, but must take into account variations in geography. For example, his early assessments of damage from Katrina failed to take into account that the path of the hurricane’s eyewall remained over water longer as it moved to its third landfall at the Louisiana-Mississippi border, allowing the wind speed to remain higher as the storm moved into Mississippi. Such details he takes into account in his final reports.

Storm Training

Jacobs got a chance to refine his methodology in early fall 2004, when four hurricanes hit Florida and the Gulf Coast. Hurricane Charley, a category 4 storm, came ashore on the west coast of Florida with winds clocked at 145 miles per hour. A scant 3 weeks later, while Jacobs was evaluating Charley’s effects on Florida forests, Hurricane Frances made landfall as a category 2 on the other side of the State. His office quickly assessed Frances and was returning to work on Charley when Hurricane Ivan roared ashore on September 15 at nearby Gulf Shores, AL.

For Jacobs’ purposes, Ivan proved to be the perfect storm, a model for future rapid damage assessments. The damage map he produced for Ivan shows four concentric zones that radiate outward from landfall at Gulf Shores (see map on page 7). The zone of heaviest damage, zone 4, lies immediately to the right of the landfall site. Each succeeding layer, though showing less damage, increases in size, so that even zone 1 (scattered, ≥ 1 percent light damage)—which in the case of Ivan reached almost to Huntsville in north Alabama—can represent a considerable economic impact on forest resources.

Before September 2004 was over, Hurricane Jeanne had made landfall near Stuart, FL, and followed the path of Frances up the State, crossing forests that Charley had earlier damaged and eventually covering

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terrain crossed by Ivan on the Florida Panhandle. The overlap of the damage zones made Jacobs' work even more difficult, but he was able to provide estimates for Florida and Alabama that were later validated on the ground.

Back to Ground Work

While satellite imaging, aerial photography, and other modern sensing technologies can provide important data, the technologies

themselves do not provide all the information Jacobs needs. Techniques that work well on western forests are not so accurate on forests in the South. Light detection and ranging (LiDAR) equipment, which measures tree height, works well with forests made up of large trees, open canopy, and sparse understory. Southern forests typically have smaller trees, denser understories, and more rapid change than those out West.

And to assess damage, you have to know what was there before the storm hit.

"We don't have prestorm LiDAR data on these forests," says Jacobs. "We really depend on the hard numbers we get from on-the-ground forest inventory work." 🌲

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Broken and damaged pines accounted for more than 42 miles of downed power lines in the area near Clinton, LA, surveyed by FIA crews. (Photo by Dennis Jacobs, U.S. Forest Service)



GULF COAST FORESTS HIT HARD

by Claire Payne

Hurricane Katrina blasted into Louisiana and Mississippi on August 29, 2005, with wind speeds of 140 miles per hour (mph). Less than a month later, Hurricane Rita hit Sabine Pass, TX, just west of the Texas-Louisiana border, packing wind speeds up to 120 mph. These category 5 hurricanes damaged forests that serve as sources of timber products, wildlife habitat, and recreational areas. Federal, State, and local authorities needed an assessment of damage to mitigate economic effects on communities.

The **SRS Forest Inventory and Analysis** (FIA) program, led by **Bill Burkman**, collaborated with the **Mississippi Institute for Forest Inventory** (MIFI) and the **Mississippi Forestry Commission** to provide those estimates. FIA research forester **Dennis Jacobs** had previously developed a remote sensing model that uses hurricane category, track, and rainfall amounts to map out hurricane damage zones. After Katrina hit, Jacobs used FIA data from the last Mississippi survey in 1994 and current data for Louisiana and Alabama and applied the model to the area damaged by Katrina. “The model works at a very large scale,” Burkman explained, “but it enabled us to provide a quick analysis for policymakers regarding the extent of the damage. It was close enough to meet their information needs, with the amount and level of detail they required.”

Surveying the Damage

Prior to Hurricane Katrina, the last inventory of Mississippi’s forests had been taken in 1994. In the late 1990s, the national FIA program started using an annualized inventory system; Mississippi was one of the

“As I drove to various study sites farther inland in Mississippi, I noticed time and again that although many trees were down, most forested areas were not nearly as bleak as the landscapes of homes and barns and golf courses. Forests evidently resist hurricanes better than our creations.” —Susie Adams

From: Adams, S.B. 2006. Katrina: boon or bust for freshwater fish communities? Watershed. Fall-Winter: 19–21, 23.

last Southern States to move to that process from the older 5-year cycle. “Before Katrina, there had been so many changes with the impacts of the forest industry’s disposal of their land and the onset of timber investment management organizations and real estate investment trusts,” says Burkman. “We didn’t really have a very good idea of what we had in Mississippi. Katrina provided the impetus to get started.”

As soon as possible after Katrina, the Mississippi inventory began as a large cooperative effort, with a sample of 5,500 plots. Unique to the Mississippi inventory was the measurement of downed-woody material, which provides data that can be fed into fire fuel models. Normally, field crews collect data from 1/16 of the FIA plots on a large number of additional forest health

factors, including soil characteristics, vegetation structure, and diversity of all vascular plant species—and lichen diversity as a measure of climate change and air quality. For the post-Katrina inventory, the crews focused solely on basic forest inventory and tree characteristics in order to establish a new baseline.

When the next inventory begins in 2009, the other factors will be measured also. Resource analyst **Sonja Oswald**, who leads FIA efforts in Mississippi, is completing the Mississippi forest inventory report, which will include analysis of Katrina’s impacts.

Results on the Ground

Mississippi Counties Hancock, Pearl River, Harrison, Jackson, Stone, and George took a pummeling from Hurricane Katrina. Oswald and **Pat Glass**, MIFI director of operations, jointly analyzed and reported data for these six counties. Based on a sample of 1,349 plots, they found that 83 percent of measured plots sustained damage that ranged from minor to intensive. Only 34 percent of merchantable live trees (about 50 trees per acre) showed damage. Windthrow was the most common damage type, and damage levels were highest in oak-gum-cypress stands, where impacts were seen on 40 percent of basal area (the total cross-sectional area of the trees in a stand).

Sonja Oswald and FIA resource analyst **Christopher Oswald** took a special interest in how stand-level factors such as the size, density, and

(continued)

The Value of Taking Inventory

Since the 1930s, the Forest Service **Forest Inventory and Analysis** (FIA) program has been surveying public and private lands to track forest extent, health, vitality, and contributions to the national and global timber supply. The program is designed to provide data, analysis, and comprehensible information to foresters, wildlife biologists, universities, nongovernmental organizations, Federal and State agencies, forest industry, and private landowners.

SRS FIA collects data on public and private forest land in the 13 Southern

States and the U.S. territories of Puerto Rico and the U.S. Virgin Islands. Success depends on collaboration with State and private forestry agencies, the forest industry and consultants, and universities. Because wood-using industries play an important role in shaping the economic future of the Southern States, it is essential that the status and trends in forest resources be assessed and information shared in a timely manner.

For more information:
srsfia2.fs.fed.us/

Saltwater surges and flooding caused additional damage to forest resources. (Photo courtesy of NOAA)



GULF COAST FORESTS HIT HARD

species of trees present influence the likelihood of damage. They also wanted to compare the initial estimates made using remote sensing to the data they collected on the ground. In an article published earlier this year, the Oswalts state that tree species and diameter at breast height consistently affected the probability of trees suffering at least some wind-related damage in each zone of damage.

The Oswalts used the hurricane path and damage zones developed by Jacobs in his initial damage assessment. Zone numbers rose from one to five based on distance from landfall. The percentage of FIA survey plots with damage decreased as distance from landfall increased, with the exception of zone 5, the most western area, which was most likely also impacted by spinoff tornado activity. Analysis revealed that the damage figures Jacobs came up with using remotely sensed data were comparable with the Oswalts' on-the-ground inventory. Hardwood forests sustained more damage from Hurricane Katrina than softwoods, probably due to the dominance of hardwoods in forest composition rather than susceptibility to damage. The Oswalts found that, in softwoods, stand spacing and tree height were more important than species type for determining potential breakage.

The Oswalts caution, however, that trying to reduce the vulnerability of forests to hurricanes using management techniques is complicated by many variables. "We are not attempting to make recommendations for managing for a random wind event like a hurricane or tornado," says Sonja Oswalt. "While our data show that height and

diameter play a role in the probability of damage, we were unable to successfully make predictions using those variables.”

Partnerships Count

When storms subside, it helps to have partners to assess damage, come up with options, and plan for the future. After Katrina, 97 people showed up to survey in Mississippi over the course of 687 days. FIA field crews from SRS and the **Northern Research Station** and the States of Mississippi, South Carolina, Georgia, North Carolina, Texas, and Arkansas sampled plots. Burkman said of the

huge effort, “They didn’t have to come, but they came.” That response contributed significantly to what we know and continue to learn about the impacts of hurricanes on forests. 🌳

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Recommended reading:

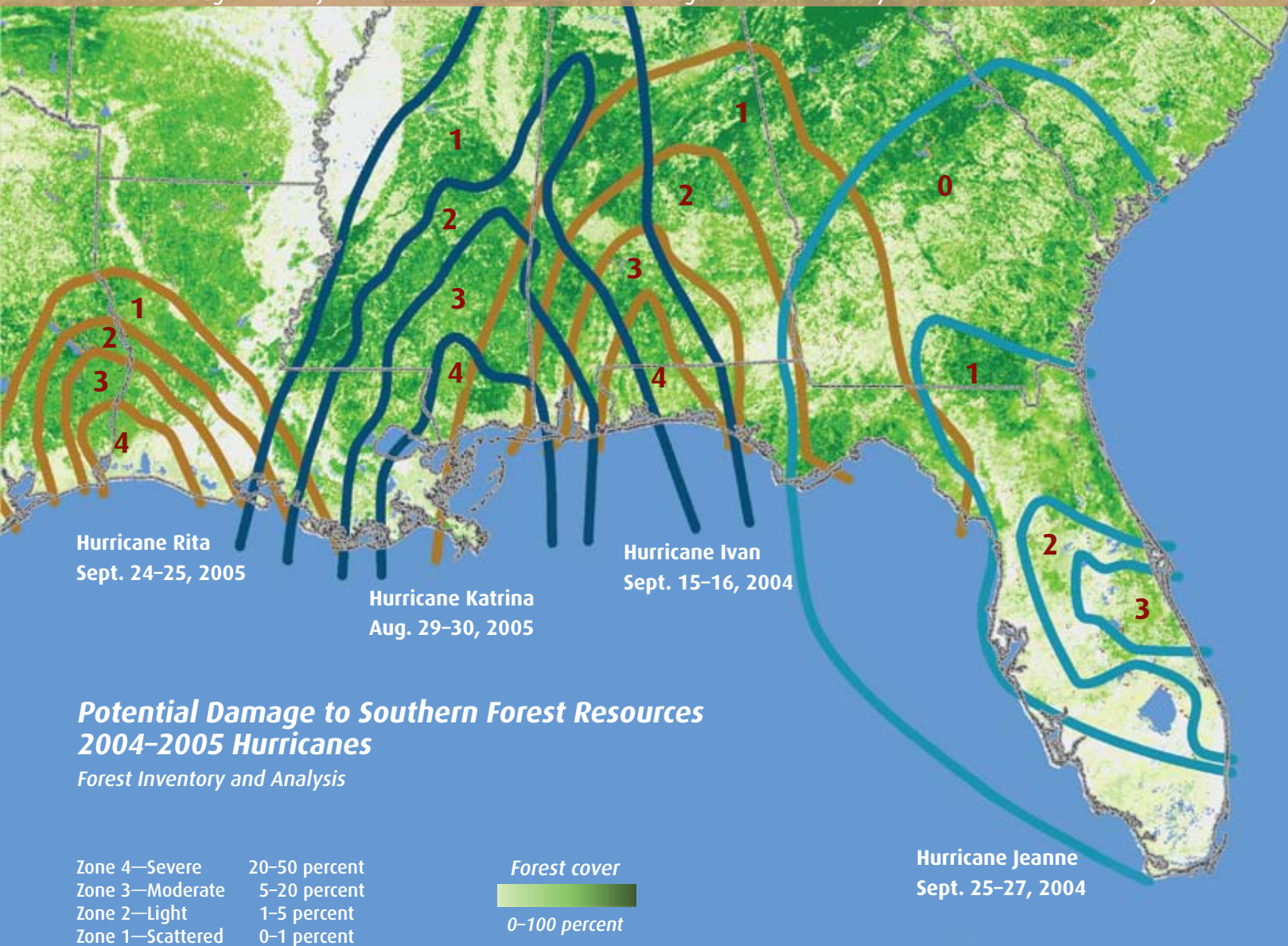
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Resource damage from major 2004 and 2005 hurricanes with damage zones estimated by SRS research forester Dennis Jacobs.



IN THE DANGER ZONE

How to Manage Forests in Hurricane Impact Zones

by Zoë Hoyle



Coastal forests are well adapted to both fire and wind, but those adaptations only go so far when hurricanes hit. (Photo by Dennis Jacobs, U.S. Forest Service)

In 2005, Hurricanes Katrina and Rita laid waste to over 5.5 million acres of forest land in Texas, Louisiana, Mississippi, and Alabama. Natural resource managers and landowners were overwhelmed by the damage. Many of them didn't have strategies or plans in place to help them get started on sometimes massive salvage operations, let alone come up with plans to make their forests more resilient when future storms strike.

"Coastal areas in the Southern United States are well adapted to disturbance from both fire and wind," says **John Stanturf**, project leader of the **SRS Center for Forest Disturbance Science** based in Athens, GA. "But those adaptations only go so

far when major hurricanes like Katrina and Rita hit. Forest owners and natural resource managers need to have strategies in place to deal with that level of damage."

In the last decade, hurricane seasons have been among the most active on record, with climatologists predicting that heightened activity could continue for at least another 10 to 40 years. The National Oceanic and Atmospheric Administration predicted above average activity for the 2008 season, with 12 to 16 storms, 6 to 9 hurricanes, and 2 to 5 major hurricanes. In the Gulf Coast area, forests are bound to be affected this year—maybe every year—so why not help landowners and managers plan ahead?

Can't Stop the Storm

With fellow disturbance center scientists—research meteorologist **Scott Goodrick** and research plant ecologist **Ken Outcalt**—Stanturf developed a conceptual approach that builds the likelihood of major disturbance into forest management. They applied their framework to a case study on the effects of Hurricanes Katrina and Rita on the coastal forests of the northern Gulf of Mexico. Their work resulted in an adaptive strategy that owners and managers can use in the short term to respond to hurricane damage, and in the long term to manage recovery efforts.

A hurricane is an unstoppable force; there's no way to divert it from its path or move forests out of its way. But

there are ways to determine the areas where the damage from hurricanes will be the most severe. The SRS scientists started by developing a threat matrix, an approach that maps out all the potential disturbances in an area, then assesses the risks of severe hurricanes in that context.

“If disturbances such as major hurricanes are in the threat matrix, policies and procedures should be in place prior to an event to manage effects,” says Stanturf. “First on the list is communication and access. Preparing and prepositioning equipment will pay dividends once a hurricane makes landfall.”

Managers and landowners also need a plan for the actions they take as soon as they have access to their land. After the storm, they’ll need a rapid assessment of damage to guide recovery efforts and mobilize the political and financial support necessary to meet both short-term and long-term needs. They’ll also need a salvage plan to recover value from downed timber and prevent damage from wildfire, insects, and disease.

Though most fires in the Southern United States are confined to relatively small areas and suppressed quickly, downed wood in hurricane damaged stands increases the potential for wildfires to burn over large areas. The risk of fire combined with the need to get salvaged timber on the market before prices go down sometimes means rushed salvage decisions that may not take into account damage to sensitive ecosystems or habitat for species of concern.

“If managers put a plan together before major disturbance, they can exempt areas where ecological values outweigh potential financial value from salvage logging,” says Stanturf. “Strict guidelines for operating in sensitive

(continued)



Quick Guide to Salvage

- Salvage pine stands first: Pines are more susceptible to pest outbreaks than broadleaves.
- Salvage promptly, in one operation, to reduce the vulnerability of remaining trees to bark beetles, borers, and fungi.
- Minimize logging damage to remaining trees, especially high-value broadleaves.
- Remove twisted trees or those with root damage, as well as all trees with major wounds. 🌲

For a more detailed guide, see the table on page 25.

IN THE DANGER ZONE

areas such as riparian zones and endangered species habitat should be set in advance.”

Damaged stands that are not salvaged will need to be monitored for up to 5 years for delayed mortality or insect or disease infestations. “After the initial flurry of cleanup and salvage logging comes the recovery period, which is a good time to look at long-term risks and restoration,” says Stanturf. “The 2005 hurricane season in the northern Gulf of Mexico provided a good opportunity to restore coastal forest ecosystems to less vulnerable conditions.”

Building Future Resiliency

The forests in the Gulf Coastal Plain area of the case study are composed mostly of pine (in the uplands) and hardwoods (in the floodplains of rivers). Though most of the upland areas were once covered with longleaf pine, they’re now dominated by loblolly pine, with numerous intensely managed industry plantations. Katrina created an opportunity for landowners and managers in areas prone to destruction by hurricanes to replace loblolly with the more resilient longleaf pine. Restoration of the longleaf pine forest that once dominated the southern Coastal Plain is popular in the region; SRS research has developed many of the methods that have made longleaf pine restoration more viable and accessible to owners and managers at multiple levels.

Forests can be made less vulnerable to future storms by converting to tree species such as longleaf that are less susceptible to wind damage, but also by controlling the structure of stands. Using information from their case study on damage from Hurricanes Katrina and Rita, Stanturf and fellow

scientists drew up nine theoretical pine stands and simulated damage to each from hurricane-strength winds.

“Our simulation of the potential of stems to break under hurricane winds was fairly simple, but we were able to show that managers potentially could manipulate stand spacing and tree height to reduce damage. We are looking into this further and plan to develop guidelines for both public and private forests,” says Stanturf. “Managers should be prepared to take advantage of the opportunities provided by severe hurricanes to make changes in composition, structure, or both.” 🌲

For more information:

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RED-COCKADED WOODPECKERS AND HURRICANES

by Zoë Hoyle

Ecologists use the term “highly specialized” to describe red-cockaded woodpeckers. Though the birds will excavate their nesting and roosting cavities in most pines, they prefer old longleaf pines—100 years old or more old. They’re also the only North American woodpeckers that dig their cavities into live trees, a process that can take up to 12 years to complete. If their habitat is removed or altered significantly, the birds disappear. By 1970, the red-cockaded woodpecker had become scarce enough to be added to the Federal list of endangered species.

The decline of red-cockaded woodpecker populations coincided with the disappearance of their primary habitat. By the 1920s, the longleaf pine forests that once covered an estimated 90 million acres across the Southeastern United States were reduced by logging and clearing to less than 3 million acres patched across a range that once stretched from Virginia to Texas. Fire suppression has also played a part; red-cockaded woodpeckers will typically abandon a cavity if other trees grow close to the cavity entrance. Without periodic fires, the historically open midstories of southern pine forests soon become choked with brush and small hardwoods.

Since the 1970s, when natural resource agencies started restoring red-cockaded woodpecker habitat, the species has made a comeback, with population numbers growing

slowly but steadily across its range. Many of the restoration areas—and the remaining stands of old longleaf pine—lie along the Atlantic and Gulf Coasts, areas susceptible to damaging weather. Strong winds, downbursts associated with thunderstorms, and tornadoes frequently uproot cavity trees or snap them at the weak points created by woodpecker nesting cavities, so the damage is usually localized. “The good news is that it’s rare for these weather events to happen more than once in many years to a particular patch of red-cockaded woodpecker habitat,” says **Craig Rudolph**, SRS research ecologist with the Nacogdoches, TX, team of the **SRS Southern Pine Ecology and Management** unit. “In general, wind events have a minimal impact on populations—as opposed to individual birds.”

Hugo’s Hard Wind

Hurricanes, however, have the potential to severely impact red-cockaded woodpecker populations. In 1989, when Hurricane Hugo hit the **Francis Marion National Forest** in South Carolina, the storm’s category 5 winds devastated the second largest population of red-cockaded woodpeckers then in existence. Before the storm, 477 groups of birds had been counted on the forest. After Hugo came through, an estimated 65 percent of the birds were dead or missing.

(continued)

A Simple Solution, But Not That Easy

Inserting artificial cavities into mature pine trees has played a major part in the restoration of red-cockaded woodpecker populations. Installation is designed to accommodate the species’ specialized lifestyle.

Each member of a red-cockaded woodpecker family group has a roosting cavity in a separate tree; the group’s cavity trees are located in “clusters.” Forest technicians install artificial cavities to supplement existing clusters or to provide cavities in a potentially new cluster site. Red-cockaded woodpeckers may occupy these new sites on their own, or birds can be translocated to the sites by biologists. The ability to provide cavities in unoccupied habitat is a powerful tool in the ongoing recovery of this species.

Artificial cavity inserts are made out of a soft wood such as cedar to minimize swelling and warping. A 10-inch tall box is built (4 inches wide, 6 inches deep) with a 1 ¾ inch entrance hole angled to prevent rain from entering the chamber. The outside of the box is coated with exterior wood putty to keep pine resin from getting into the cavity.

Technicians are lifted up 12 to 22 feet off the ground to chainsaw a rectangular hole in a living tree; to accommodate the insert, the tree must be at least 15 inches in diameter at the installation site. Since red-cockaded woodpeckers may use a cavity for as long as 20 years, a healthy tree with a large crown should be selected. After the insert is installed, the top, bottom, and sides of the hole are coated with the same wood putty applied to the outsides of the box.

When they excavate their cavities, red-cockaded woodpeckers also dig into the bark of pine trees to create resin wells. The sticky resin that streaks their cavity trees keeps predators like snakes from reaching their nests. When an artificial insert has been installed, a technician may cut resin wells to start the flow of sap.

RED-COCKADED WOODPECKERS AND HURRICANES

The storm uprooted or snapped cavity trees; of 1,765 cavities, 87 percent were destroyed. Red-cockaded woodpeckers live in groups of two to nine birds, the groups made up of a breeding pair and several male helpers. Each group member roosts in a separate cavity; the group's cavity trees are clustered together. Half of the red-cockaded woodpecker clusters on the Francis Marion were completely destroyed, as well as hundreds of acres of pine forest that served as foraging habitat for the species. The loss was stunning, both in its severity and extent.

Bob Hooper, now retired but at that time a scientist with the **Southeastern Forest Experiment Station** (SEFES) that preceded SRS, immediately got together with colleagues to start assessing the damage and come up with a plan to recover the population. Fortunately, a major technological innovation—the artificial cavity—had recently been developed by biologists **Carol Copeyon** (North Carolina State University) and **David H. Allen**, also an SEFES scientist, to help move along red-cockaded woodpecker restoration efforts.

Hooper and his colleagues realized that many of the remaining woodpeckers would not survive unless they were quickly provided with cavities. A massive effort was mounted. More than 300 cavities were artificially excavated on the Francis Marion; within a few short years, more than 60 percent of the inserts were being used for nesting or roosting, and by 1994, woodpecker populations were back to 75 percent of those before Hugo.

The experience with Hurricane Hugo led Hooper to look more closely at possible hurricane impacts on red-cockaded woodpecker populations throughout their range in the Southeastern United States. Using historical hurricane records, Hooper determined that most existing populations of the endangered species were located in areas vulnerable to catastrophic hurricanes. He suggested that management plans for red-cockaded woodpeckers include accommodations for the massive hurricane impacts that were certain to occur in the future. The Red-Cockaded Woodpecker Recovery Plan developed under the direction of the **U.S. Fish and Wildlife Service** mandated additional populations to accommodate periodic losses due to hurricanes.

Rita's Benefits

Fortunately, most hurricanes don't directly hit red-cockaded woodpecker populations; the storms usually lose power by the time they make it inland to the piney woods. In 2005, Hurricane Rita's path through Texas provided the opportunity to assess the "normal" impact of hurricanes on red-cockaded woodpeckers. By the time Rita hit the national forests the winds were fairly low, so there was less damage to trees and fewer birds lost.

In Texas, all four of the national forests—Sam Houston, Davy Crockett, Angelina, and Sabine—have red-cockaded woodpecker clusters. After Hurricane Rita came through, **Texas National Forests and Grasslands** contacted Rudolph and SRS research wildlife biologist **Dan Saenz** to help inventory damage to red-cockaded woodpecker habitat. "Craig and I were provided funds to do an assessment of the damage similar to the one Hooper did in South Carolina," says Saenz.

Though the eye of Hurricane Rita passed directly between the **Angelina** and **Sabine National Forests**, the impacts of the storm were much less than those of Hugo. Because the forests are much farther inland than the Francis Marion, Rita had lost much of its strength by the time it reached red-cockaded woodpecker habitat in Texas.

Hurricane Rita

Less than a month after Hurricane Katrina devastated the Gulf Coast, residents, emergency responders, volunteers, and others trying to rebuild the region faced another category 5 hurricane. The most intense part of the second storm—Hurricane Rita—bypassed the Big Easy and its neighbors. But residents near the Texas-Louisiana border weren't so lucky; it was their turn to experience a direct hit on September 24, 2005.

The hurricane charged into east Texas north of Houston, bringing high winds and heavy rains that ranged from 5 to 15 inches. Rita generated at least 90 tornadoes, the most ever recorded from a single weather event in that part of the country.

The threat of Rita sparked the evacuation of about 2 million people from Houston and other coastal areas. More than 60 people died as a direct or indirect result of the hurricane, which destroyed numerous homes and businesses. The National Weather Service's National

Hurricane Center estimates total damages from Hurricane Rita at \$10 billion.

Before and after the storm, **SRS Forest Inventory and Analysis** worked with the **Texas Forest Service** to assess damage in forested areas. Rita affected approximately 771,000 acres—about 6 percent of the entire timber growing stock in east Texas. The storm caused more damage to hardwood stands than pine. Experts calculated total timber damages to be more than \$800 million in Texas alone. —SW

“The documented woodpecker mortality was less than 10 total birds, and less than 7 percent of cavity trees were destroyed,” says Rudolph. “In contrast to the situation following Hurricane Hugo, the foraging habitat

was only minimally impacted, with the loss of approximately 5 percent of the pines.”

After Rita, Forest Service technicians installed 117 artificial cavities in trees in the Angelina and Sabine National

Forests. “Loss of cavity trees is never a good thing,” says Saenz. “But we found that the damage caused by hurricanes can be absorbed if there are enough trees left standing to install artificial cavities and if action is taken quickly before the birds disperse.”

Results from installing the artificial cavities once again demonstrated the genius of a relatively simple technology when applied with the right ecological knowledge. “The populations of red-cockaded woodpeckers actually rose very sharply after Hurricane Rita,” says Saenz. “There were lots of funds available to install artificial cavities all over the forests. The birds responded to the improved habitat, and we’ve seen the sharpest increase in numbers in Texas, probably ever.”

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The installation of artificial nesting cavities has significantly improved the survival of red-cockaded woodpecker populations in hurricane zones. Photo credit: Dean Elsen

SHELTER FROM THE STORM

Coastal wetlands provide essential protection

by Carol Whitlock

A recent article published in the journal *AMBIO* suggested that coastal wetlands provide invaluable protection against hurricane damage, both in terms of dollars saved and in improvements to quality of life. One example showed that the estimated 1.2 million acres of Louisiana wetlands that were lost before Hurricane Katrina represented an annual loss in storm protection of \$28.3 billion, and that coastal wetlands impacted by Katrina caused another \$1.1 billion in lost protection. Although there is little agreement about specific dollar amounts, there is growing consensus that the best way to reduce the effects of hurricanes in the Gulf Coast area is to preserve and restore coastal wetlands.

The most expansive coastal wetlands along the Gulf Coast were formed by the great rivers that drain the midsection of the United States into the Gulf of Mexico. With each flooding of the Mississippi River and its tributaries, sediment-laden water from the North seeped onto the floodplain and filtered through the river delta, rejuvenating the bottomland hardwood forests and coastal swamps and marshes of this great river system.

With European settlement came concern that the flooding which nourished the wetlands would endanger lives, destroy homes, and disrupt agricultural and commercial activity.

Hence the levees.

At first, levees were only used to protect major cities, with areas in



The continuing harvest of baldcypress in coastal swamps could hasten the loss of forested wetlands along the Gulf Coast. Photo credit: Bill Lea

between still subject to the flooding that's the lifeblood of these wetlands. But gradually the Mississippi has ceased to resemble a leaky garden hose slowly releasing nutrients into surrounding wetlands. Instead, it's turned into a canal that rushes sediments enriched with nutrients from agricultural runoff directly into the Gulf of Mexico. Diverted past bottomland forests and coastal swamps and marshes they once nourished, the nutrient-rich sediments now feed vast plumes of algae that, when they die and decompose, deplete oxygen in the water, forming "dead zones" where almost nothing can live. Meanwhile, coastal swamps and marshes, deprived of their lifeblood, have become vulnerable to more degradation and loss from other natural and anthropogenic factors.

In 2004, recognizing the problem of diminishing wetlands, Louisiana Governor **Kathleen Blanco** appointed Louisiana State University professor **Jim Chambers** to assemble natural resource experts to develop a set of recommendations for the utilization, conservation, and protection of the State's coastal forest wetlands. **Emile Gardiner**, research forester with the **SRS Center for Bottomlands Hardwood Research** in Stoneville, MS, was among 12 scientists commissioned by Governor Blanco to form the **Coastal Wetland Forest Conservation and Use Science Working Group**.

The working group found that the harvesting of baldcypress in coastal swamps could exacerbate the loss of forested wetlands already severely degraded by other factors such as canal dredging for oil and gas production, levee construction for urban and agricultural development, invasion by exotic plants and animals, rising sea levels, and land subsidence. These alterations threaten forested

wetlands by adding too much water at the wrong times, producing greater depths and durations of flooding and shortening the dry spells needed for seed germination and establishment of seedlings that become the next generation of baldcypress and water tupelo. The concern is that the current hydrologic trend is transforming cypress-tupelo forests into floating marshes and open stretches of water where no forests can grow.

Gardiner and his colleagues completed their work in the spring of 2005. In their final report, they established three wetland forest regeneration condition classes: class I, sites with potential for natural regeneration; class II, sites that can only be reforested by artificial regeneration; and class III, sites with no potential for regeneration. For class I sites, the working group recommended that the State place a priority on maintaining current hydrologic conditions. For both class I and II sites, the working group recommended that the State require management plans for all harvesting operations. And for class III sites on State managed lands, the working group recommended a halt to all harvesting.

It's an understatement to say that the efforts of Gardiner and his colleagues were overtaken by events on the ground. The double-fisted punch of two major hurricanes a few months after the release of their report both underscored the value of wetlands and compromised the State's ability to carry on the important wetlands work in the face of urgent infrastructure needs.

Despite enormous recovery challenges in the years following Hurricanes Katrina and Rita, Louisiana has continued to place emphasis on finding solutions to the loss of forested wetlands, including the establishment

of Interim Best Management Practices and the identification of research priorities for coastal forest regeneration. Clearly, there will be steep challenges in the effort to safeguard and restore Gulf Coast forested wetlands while maintaining the ability to use forest products, protect communities, and extract mineral energy. 🌳

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In 2000, Emile Gardiner won the Forest Service Early Career Scientist award and then went on to win a Presidential Award in the same category. The award is the highest honor bestowed by the U.S. Government on young professionals at the beginning of their Forest Service research careers.



*SRS fisheries research scientist Susie Adams and collaborators surveyed the Pascagoula River area in southeast Mississippi shortly after Hurricane Katrina. Adams shown here with smallmouth buffalo fish (*Ictiobus bubalus*). (U.S. Forest Service photo)*

HOW FISH FARE

by Zoë Hoyle

Saltwater surges from Hurricane Katrina pushed up into sections of the large and medium-size rivers closest to the Gulf Coast; meanwhile the flooding of wetlands may have flushed water low in oxygen into the rivers. Saltwater surges, water depleted of oxygen, and large inputs of small organic material can have immediate adverse effects on fishes and other aquatic organisms in lowland, coastal areas. Over a longer timeframe, dramatic increases in large and small downed wood indirectly affect fishes in small streams by changing the habitats and functions of streams and rivers.

When Hurricane Katrina came through, **Susan Adams**, fisheries research scientist with the **SRS Center for Bottomland Hardwoods Research**, was working on an ongoing research project on Alabama shad funded by the **FishAmerica Foundation**, **NOAA Fisheries**, the **Mississippi Museum of Natural Science**, the **University of Southern Mississippi** (USM), and the Forest Service.

Adams, with USM cooperators **Jake Schaefer**, **Paul Mickle**, and **Brian Kreiser**, had been collecting data on fish communities, habitat, and migration in the Pascagoula River drainage in southeast Mississippi. The researchers had been surveying at 10 large river sites: 4 sites each in the Leaf and Chickasawhay Rivers that merge to form the Pascagoula, and 2 sites in the Pascagoula River itself. Schaefer and graduate students had additional historic and recent data from small and medium streams in the area.

On August 29, 2005, Hurricane Katrina made landfall about 70 miles west of the mouth of the Pascagoula River. Adams and her colleagues had to delay the sampling trip they had planned for September 2005.

“When we finally returned to the Leaf and Chickasawhay in October, I was surprised to find the rivers looking essentially the same as they did in August, before the hurricane,” says Adams. “The sand bars had rearranged a bit, but the channels weren’t choked with wood, nor the trees toppled. More importantly, the fish community was essentially unchanged.”

But when the researchers got to the downstream site on the Pascagoula River, they caught only 10 fish where they had normally caught 140, and local fishermen and residents reported fish kills all the way up the mainstem of the river. Similar affects were seen in the Pearl River as well. “The presumed cause of fish death on the Pascagoula River was a combination of salt water and low oxygen,” says Adams. “The huge tidal surge forced salt water much further up the river than normal. Salt water overlaid with anoxic (low in oxygen) freshwater flushed from wetlands could have killed most of the fish in the river.”

The good news is that most of the fish deaths were the result of a short-duration “pulse disturbance.” Habitat and water-quality conditions quickly returned to within a normal range, and fish populations began to recover immediately.

When they compared poststorm and prestorm data, the researchers found that short-term effects on the fish community were greater in areas closest to the Gulf of Mexico. Adverse effects were short-lived for most fish species, with species composition recovering within 1 to 2 years, and fish size structure taking longer to recover. Long-term benefits from the addition of downed wood were expected in smaller streams and rivers.

“The long-term impact of the storm in smaller streams was from the addition of rootwads and fallen trees—an integral component of stream and river ecosystems—to streams and smaller rivers,” says Adams. “Large dead wood helps retain sediment and organic matter, helps stabilize some stream channels, and creates complex habitats such as pools and side channels.” Fish community data collection is ongoing, and the researchers expect to assess some longer term results of the storm within the next year. One important question that remains unanswered is how such a storm affects slow-growing, long-lived species such as Gulf sturgeon.

As a natural disturbance, Katrina is expected to have positive long-term impacts on river and stream habitats and their aquatic inhabitants. For Adams, the more interesting question is how the long-term impacts and recovery processes have played out. “The answer to that question depends not so much on the degree of impact which the hurricanes had on ecosystems as on how humans altered ecosystems prior to the storm and how humans respond to posthurricane conditions.” —ZH


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“Extensive damage to loblolly pine stands from Katrina reduced the value of the area’s forests due to initial timber losses and increased susceptibility to insects, disease, and fire. Our findings suggest that longleaf pine may be more resilient than the other two pines, particularly loblolly pine.” –Kurt Johnsen

Just 25 miles north of Gulfport, MS, an experiment installed almost 50 years ago in the **Harrison Experimental Forest** (HEF) is providing resource managers with ideas about managing for the hurricanes and storms that regularly visit the Gulf Coast.

The 4,111-acre experimental forest was established on the **Desoto National Forest** near Saucier, MS, in 1934. By that time, vast stretches of southern pines, mostly longleaf pine, had been cut from the estimated 31 million acres that once made up the

EXPERIMENTAL FORESTS

teach us about resiliency to future storms?

Harrison Experimental Forest near the Gulf Coast

southern Coastal Plain forest. In many areas, there weren’t enough pine trees left to provide a reliable seed source. More often than not, any seedlings that sprouted naturally were eaten by cattle or feral hogs—or lost out to fire, invasive plants, insects, or disease.

Seed for a Barren Land

Problems with planting and growing southern pine trees and reestablishing forests soon became the primary focus of research at the HEF. The southern pine seed-source study was started on the experimental forest and other sites throughout the Southeastern United States to match regeneration sites with seed sources and to determine how far seeds could be moved without jeopardizing regeneration.

Although longleaf pine had dominated coastal forests before the great timber runs of the 19th and 20th centuries, loblolly pine grew back

Harrison Experimental Forest plot after Hurricane Katrina. Loblolly pines on left show more crown damage than longleaf pines on right. (Photo by John Butnor, U.S. Forest Service)

in greater numbers, and because of its fast growth, became the favored pine species for timber. Though industry quickly adopted loblolly pine, the Forest Service and others were still interested in studying how to reestablish multiple species of southern pine on cutover Coastal Plain sites.

In 1961, researchers set out experimental plots on the HEF to test responses to fertilization in three different southern pine species—longleaf, loblolly, and slash. For the experiment, 120 plots were laid out in a grid with 100 seedlings planted in each plot. In the second year of the project, five treatments were applied to the plots including three different levels of fertilization. Regardless of species, trees in fertilized plots showed a much greater and more sustained response than expected, with effects persisting over 45 years without additional applications of fertilizer.

As the experiment moved into its fourth decade, it yielded new and unexpected results that have important implications for forest restoration in the 21st century. Though longleaf pine grew slower than both loblolly and slash the first 10 years of the experiment, it caught up with both species by age 25 years. In 1999, at age 39, mean timber volume per acre was actually greatest in the longleaf pine plots.

“These are surprising results that wouldn’t have turned up in 20- or even 35-year studies,” says **Kurt Johnsen**, SRS research physiologist. “These data show that longleaf pine catches up with loblolly as rotation length increases. We’re also seeing that it’s more resilient to hurricanes.”

Katrina: A Test of Pine Mettle

Historically, hurricanes and wildfires disturbed the ecologies of the Southeastern United States on a regular basis; longleaf pine, unlike loblolly and slash pine, thrives in areas where there is frequent fire.

Some evidence suggests that longleaf pine may also be more tolerant to high winds. In August 2005, when Hurricane Katrina hit the HEF as a category 3 hurricane, the experimental plots took a beating. Trees were knocked over and uprooted; limbs broken; and boles twisted, bent, and snapped in two.

In 2006, researchers measured all the trees left on the experimental plots and rated them in terms of wind damage, using as comparison data measurements taken on all trees in 1999. Results showed that damage from Katrina was over 30 percent greater in loblolly pine plots than in those of longleaf and slash pines. “We found that longleaf pine suffered the least damage, although it was only significantly less than loblolly,” said Johnsen.

“Loblolly pine is still the most planted species along the Gulf Coast,” says Johnsen. “Extensive damage to loblolly pine stands from Katrina reduced the value of the area’s forests due to initial timber losses and increased susceptibility to insects, disease, and fire. Our findings suggest that longleaf pine may be more resilient than the other two pines, particularly loblolly pine.”

Seed for Change

Since 1956, the HEF has also been home to the **Southern Institute of Forest Genetics (SIFG)**. For over a half century, the institute’s research on the inheritance of growth, form, and pest resistance of forest trees has guided tree improvement programs across the South. When SRS reorganized into science areas in 2006, the SIFG, now a team, was joined with the **Southern Institute of Forest Ecosystems Biology** team in Research Triangle Park, NC, led by Johnsen, to form the **SRS Forest Genetics and Ecosystems Biology** unit led by research geneticist **Dana Nelson**.

The new combination of expertise in genetics and productivity research has

revitalized the pine study on the HEF. This spring, researchers from Research Triangle Park drove over to Mississippi to map tree roots and measure soil respiration for research on the differences in carbon storage among the pine species. These data will allow them to quantify the total amount of above- and below-ground carbon sequestered in the plots since 1960. At the same time they’re designing and preparing a new companion study. Set out on a nearby site, the new study will be replanted with both native seeds harvested from trees in the old study and state-of-the-art genetically improved seedlings grown under varied fertilization and prescribed fire treatments.

Instruments that measure carbon efflux will also be installed on the plots, allowing scientists to study how the interplay of genetics, fertilizer, and fire affect stand productivity and carbon sequestration—as well as forest resilience. These two studies, the old and the new, will provide land managers the knowledge they need to manage Coastal Plain forests in response to climate change and the more intense storms predicted for the future.

In March 2008, researchers from the new combined unit met with national foresters from the **FS Southern Region** (Region 8) to get input on the new study. “The national forests are very interested in coming up with descriptions for what southern forests should be in the future, and then allowing managers to decide how best to get there,” says Nelson. “Factors to consider for future Gulf Coast forests include climate change and longleaf pine restoration. Our new study is planned to give managers some answers about how to manage for a resilient productive forest.”—ZH 🌲

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Why Longleaf?

Hurricanes and major storms cause billions of dollars of damage to southern timber resources. If you add the increased risk of wildfire and insect and disease damage that comes with downed wood, you have millions of acres of forests vulnerable to major damage.


One idea for reducing the vulnerability of forests to disturbance involves recreating the ecosystems that existed before they were replaced by plantation loblolly pine forests. In areas where hurricanes occur, this often means planting longleaf pine, which once covered over 90 million acres in the Southeastern United States, but now occupies less than 3 percent of its original range. It has even been suggested that managers

and landowners take advantage of the damage caused by hurricanes to advance conversions on sites that have been planted with loblolly pine for generations.

Loblolly pine historically grew in moister areas without much fire, but was widely planted in early reforestation efforts on drier and more fire-vulnerable sites where longleaf pine—better adapted to fire—once dominated. Longleaf pine has also been found to be more resistant to damage from southern pine beetle, a native insect that has inflicted over \$1.5 billion in damages over the past decade. One strategy currently promoted by the Forest Service is to replant longleaf pine in areas where southern pine beetle has destroyed loblolly and other pines.

In response to the growing need for information about longleaf pine

ecosystems, SRS established the **Restoring and Managing Longleaf Pine Ecosystems** unit. Directed by project leader **Kris Connor**, the unit includes scientists with expertise in plant physiology, ecology, silviculture, and biometrics. Unit scientists contribute long-term research findings and practical information on both natural and artificial regeneration of longleaf pine and on restoring the understory plants that play an essential role in longleaf pine ecosystems.

To find out more about longleaf pine, the unique ecosystems the species harbors, and the SRS research that supports current restoration efforts, see the summer 2005 issue of *Compass*, available online at <http://www.srs.fs.usda.gov/compass/summer2005/> or in hardcopy by order through pubrequest@fs.fed.us. 



Replanting longleaf pine within the species' historical range may help reduce vulnerability to hurricane damage. (Photo by John Butnor, U.S. Forest Service)

HOW MUCH FOREST CARBON IS LOST AFTER A MAJOR HURRICANE?

by Stephanie Worley Firley

Near the end of the 20th century, many scientists began to realize the importance of forests as a sink for storing, or sequestering, the carbon dioxide that continues to increase in the Earth's atmosphere, estimating that U.S. forests sequester approximately 200 million metric tons of carbon each year. These calculations were based on models of forest growth and productivity, but disturbance effects from hurricanes such as Katrina were not taken into account. **Steve McNulty**, SRS Southern Global Change Program team leader, saw this omission—and seized a research opportunity.

The Damage Done

Intense hurricanes occur often enough in the Eastern United States—2 out of 3 years on average—to have significant effects on forest carbon sequestration. A single storm can do a lot of damage to a forest, but size alone doesn't determine how much live tree mass ends up as debris. High winds and heavy rainfall followed by flooding are the key factors responsible for the most severe storm damage.

These intense hurricanes cause direct and immediate forest carbon loss. First, because downed wood resulting from a hurricane is often difficult or impossible to access—and the wood's quality may be compromised—relatively little is salvaged following a catastrophic storm. The carbon tied up in those trees is released into the atmosphere as the trees decompose rather than being stored in wood products

originating from the salvaged wood. Additionally, the trees left standing may take 5 to 10 years to recover the prehurricane growth rates and leaf area required for healthy levels of photosynthesis and full carbon sequestration capacity. Forest carbon can also be lost over time following a major hurricane as damaged trees become more susceptible to insect attacks. Dead, dry wood can also fuel wildfires that release even more carbon into the atmosphere.

A New Carbon Source

In 2000, McNulty set out to estimate the potential changes in forest carbon sequestration due to these direct and indirect losses of forest carbon. "I began by looking at forest damage estimates from hurricanes making landfall in the United States since the 1920s," says McNulty, who notes that very little forest damage information is available prior to that decade.

Many Federal and State agencies now track hurricane-caused forest damage using a variety of methods including field surveys, aerial photography, and remote sensing imaging. Damage estimates are typically expressed in economic terms based on board or cubic feet of timber and cords of wood lost. To determine the impacts on carbon sequestration following a storm event, McNulty used timber data to estimate carbon lost from tree leaves, roots, and stems. Carbon losses vary by species, age, and region.

"Hurricanes are indeed a major source of regional carbon loss as well as a significant factor in the reduction

of short-term carbon storage in U.S. forests," says McNulty. He concluded in a 2002 study that a single storm can convert the equivalent of 10 percent of the total annual carbon sequestered by forests across the United States into dead and downed biomass.

"Hurricane Katrina may have caused a loss of 40 million metric tons of forest carbon. That's 20 percent of annual forest carbon sequestration capacity lost," according to McNulty, whose most recent assessment used data derived from post-Katrina ground crew measurements of forest damage as well as aerial photography available from the Alabama and Mississippi Forestry Commissions. "Forest lost to Hurricane Katrina will be a carbon source to the atmosphere for years to come," he says.

Add Climate Change to the Mix

McNulty believes that carbon sequestration in U.S. forests has been overestimated in the past. He has found that carbon sequestration has generally been decreasing in recent decades as a result of storms and a range of other factors: wildfires, forest loss due to land use change, increasing fuel loads, and climate change effects. "Most carbon sequestration models assume a constant forest mortality rate of approximately 0.5 percent each year. This rate is definitely not constant because it is dependent on many disturbance factors," says McNulty, who has developed new forest carbon sequestration equations incorporating longer term, episodic forest disturbance rates.

(continued)

HOW MUCH FOREST CARBON IS LOST AFTER A MAJOR HURRICANE?

Several climate scenarios predict that the Southern United States will be warmer and dryer in the future. “Even if the South receives more rain in the future than predicted, higher air temperatures will probably lead to more drying in forests, and, therefore, greater wildfire risks, more insect generations, and ultimately even less carbon sequestration capacity,” says McNulty. Higher air temperatures are already warming the oceans. Since hurricanes are born out of warm ocean water, some predict that hurricanes will be even more intense in coming years.

Filling the Carbon Sink

McNulty’s research on disturbance effects and forest carbon sequestration in the United States will help land managers develop strategies for keeping carbon in forests given a future of changing conditions. McNulty plans to continue examining forest carbon loss scenarios by building his carbon sequestration equations into process models such as those used to examine forest water use and growth.

“Managing our forests so that they are able to capture and store more carbon—and increase the net amount of carbon sequestered—is going to be part of the solution to global climate change. If we understand how carbon sequestration is impacted by major

hurricanes and other disturbances, we can anticipate and respond to these impacts. In other words, we can manage our forests so that they can be resilient in the face of disturbance,” says McNulty. 🌲

For more information:

Steve McNulty at 919-515-9489 or smcnulty@fs.fed.us

Recommended reading:

McNulty, S.G. 2002. **Hurricane impacts on U.S. forest carbon sequestration.** *Environmental Pollution*. 116 (Suppl. 1): S17-S24.

Stephanie Worley-Firley is communications assistant with the SRS Eastern Forest Environmental Threat Assessment Center in Asheville, NC.

Aerial view of downed trees after Hurricane Katrina. (Photo courtesy of NOAA)



WINNERS AND LOSERS, DEPRESSION AND REBOUND

Two economists explore the complex impacts of Hurricane Hugo on timber markets

by Bill Dockery

The hurricane-rich years of 2004 and 2005 brought into sharp focus the destructive power these giant storms can throw at the southern part of the United States. Four hurricanes, notably including Ivan and Frances, affected Florida and Alabama in 2004; and in 2005, New Orleans, as well as portions of Mississippi and east Texas, took the brunt of Katrina and then Rita.

Although there is considerable uncertainty about the reasons, hurricanes in the Atlantic Basin have become more frequent and severe over the past decade. More certain is the devastation these storms can bring to people's lives and businesses.

The human toll associated with hurricanes usually overshadows the impact these storms have on the forests of the region. But their effects have not been lost on SRS researchers **Jeffrey Prestemon** and **Thomas Holmes**, who have developed an economic model that describes the effects of such catastrophes on the region's forest resources and the market environment in which timber producers and consumers operate.

From Hugo, A New Perspective

To understand how timber markets respond to meteorological catastrophes, Holmes and Prestemon, both research foresters with the **SRS Forest Economics and Policy** unit, went back to study the aftermath of Hurricane Hugo, which made landfall near Charleston, SC, in 1989 and affected forests from the coast all the way up to the mountains of western

North Carolina. Hugo damaged some 1.3 billion cubic feet of hardwood and softwood timber worth an estimated \$630 million in 2005 dollars.

"What we find is that there is almost always a price depression immediately after a major event like a hurricane, because people are salvaging timber," says Prestemon. "While this depression had been familiar to market analysts and landowners, what we found—which was new—in looking at Hugo was that the forest losses that occur can actually lead the market to settle at a higher equilibrium price after the depression dissipates. Higher prices can persist over several years."

The pair's research indicates a three-stage pattern. Immediately after the catastrophe, local prices for logs and pulpwood go down as damaged timber is salvaged and enters the market, offering a surplus of timber. Then, as the salvaged wood clears the market, prices rebound, typically going higher than prestorm prices. The price rebound slowly subsides as timber inventories are replenished by the regeneration and growth of forests. The model assumes that salvaged timber clears the market in a year and that the best quality of salvage hits the market early in that year.

Prestemon and Holmes found that, during the price-drop phase, the market value of timber, both pulpwood and sawtimber, fell an average of 30 percent. The price during the rebound phase could exceed prestorm prices by 10 to 30 percent.

The model indicated that, absent other economic forces and

catastrophic events, timber markets would return to pre-Hugo levels in a little less than 25 years. The rate of return to prestorm prices can be as short as a decade for pulpwood and for softwoods, which regrow more quickly, while the effect of the storm may take more than two decades to dissipate for larger diameter timber products and slow-growing hardwoods.

Weathering the Economic Aftermath

For owners of forested lands damaged by storms, Prestemon and Holmes suggest harvesting damaged wood—especially the sawtimber—as soon as possible, before factors like humidity and air temperature can bring on wood decay. For owners whose timberlands have escaped storm damage, they suggest postponing harvest until the damaged timber has cleared the market and the rebound has started.

"Consumer well-being increases briefly after a hurricane because of lower prices and greater quantity consumed," says Prestemon. "But consumers are harmed over the long term, and damaged producers lose in the long term. While there are short-term losses for timber producers not affected by the storm, this group can ultimately gain over longer periods because of the persistently higher prices they may receive."

The Hugo study did not examine storm impacts in terms of the size of timber holdings, but owners of

(continued)

What Gulfport Lost

Putting a monetary value on ecosystem services

In May 2007, **American Forests** released the results of a 30,000-square-mile regional assessment on the impacts on tree canopy of Hurricane Katrina. Sponsored by the Forest Service, the study compared land cover in Louisiana and Mississippi from 2001 to 2006.

The most evident changes in tree canopy could be seen in the city of Gulfport, MS, which lost 13 percent of its tree canopy and gained 12 percent shrub cover—while gaining only 4 percent urban area. These changes indicate that hurricane damage rather than development caused the majority of the land cover changes.

American Forests estimated that the loss of tree canopy meant an additional 305,000 cubic feet of stormwater management for the city of Gulfport, valued in 2007 at \$610,500. The loss of canopy also resulted in 28,000 pounds lost in air pollution control, valued at \$68,000; and a 10,700-ton loss of carbon storage annually.

For more information on the study:

<http://www.urbanforestrysouth.org/resources/press/post-katrina-study-assesses-new-gulf-coast-region2019s-ecological-impacts-and-fire-risks/>

American Forests, the nation's oldest nonprofit citizens' conservation organization, is a world leader in planting trees for environmental restoration, a pioneer in the science and practice of urban forestry, and a primary communicator of the benefits of trees and forests.

For more information:

www.amfor.org/

WINNERS AND LOSERS, DEPRESSION AND REBOUND

large forest tracts can minimize their financial risks by diversifying the locations of their lands across the Southeast. Prestemon and Holmes suggest that owners holding properties farther from the Atlantic and Gulf Coasts may suffer less damage, and owners of softwood timber may face greater economic risks than owners of hardwood timber, though these suppositions will need further research for confirmation.

Property owners at risk of damage from hurricanes should consider having the value of their timber assessed periodically so that credible casualty losses can be estimated after catastrophic events, the study concludes.

The methodology used in the Hugo study originated in research Holmes conducted on damages from the southern pine beetle. "In evaluating large-scale catastrophic damages, the methodology up to that point was inadequate," he said. "I realized that we had better economic tools available to measure impacts."

Impacts of hurricanes prove to be distinctly local. Because timber is expensive to move very far, most of the mills and other first-level consumers are located close to the forests where it is cut, and there's not a lot of impact in adjacent market areas.

"The timber mills are the first-level consumers," Holmes says. "We really don't know how far up the chain the price impacts go, whether they actually reach the final consumers. We don't know much about market adjustments made above the mill level."

The study of the timber market after Hugo marks the first time that economists have tackled the economic dynamics of a hurricane.

"No one had ever thought of looking for this phenomenon," Prestemon said. "We suspected it, but this is the first time it was found." 🌲

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Jeffrey Prestemon at 919-549-4033 or jprestemon@fs.fed.us

Bill Dockery is a freelance science writer based in Knoxville, TN.

Recommended reading:

Holmes, T.P. 1991. **Price and welfare effects of catastrophic forest damage from southern pine beetle epidemics.** *Forest Science*. 37(2): 500-516.

Prestemon, J.P.; Holmes, T.P. 2000. **Timber price dynamics following a natural catastrophe.** *American Journal of Agricultural Economics*. 82(1): 145-160.

Prestemon, J.P.; Holmes, T.P. 2004. **Market dynamics and optimal timber salvage after a natural catastrophe.** *Forest Science*. 50(4): 495-511.

Prestemon, J.P.; Holmes, T.P. 2008. **Timber salvage economics.** In: Holmes, T.P.; Prestemon, J.P.; Abt, K.L., eds. *The economics of forest disturbances: wildfires, storms, and invasive species.* For. Sci. Series, XIV. [Unknown]: Springer. pp. 167-190. Vol. 79.

Prestemon, J.P.; Pye, J.M.; Holmes, T.P. 2001. **Timber economics of natural catastrophes.** In: Pelkki, M., ed. *Proceedings of the 2000 Southern Forest Economics Workshop.* Lexington, KY: [Publisher unknown]: 132-141.

Managing hurricane-damaged forests in the Gulf Coastal Plain may require immediate salvage to recover value and control secondary insect and disease problems

Damage type	Pines			Hardwoods		
	Salvage immediately	Monitor 1 year	Monitor 1 to 5 years	Salvage immediately	Monitor 1 year	Monitor 1 to 5 years
Breakage	Salvage if tops are gone or three or fewer large limbs remain	Monitor for bark-beetles, sanitation removal if retained trees infested	Monitor for pest activity: yellow needles, pitch tubes on bark, boring dust around base, bark-beetle infestation	Broken tops and lost limbs more likely to result in value loss than mortality, salvage highest value trees now	Harvest lesser valued hardwoods with broken tops or large limb (>10 cm) damage	Harvest lesser valued hardwoods with broken tops or large limb (>10 cm) damage
Twisting	Salvage if damage obvious or pitch flow evident	Salvage if pitch flow evident or if bark-beetle infested		Significant value loss, retain for future harvest	Harvest damaged trees for pulpwood, fuelwood	Harvest damaged trees for pulpwood, fuelwood
Bending	Salvage older trees or if pitch flow evident	Salvage if pitch flow evident or if bark-beetle infested		Harvest bent trees over 4 m tall	Trees with sap flow from cracks indicating internal damage (ring shake, splintering) should be harvested for pulpwood or fuelwood	Trees with sap flow from cracks indicating internal damage (ring shake, splintering) should be harvested for pulpwood or fuelwood
Root damage	Uprooting less likely for most pines, salvage if root sprung	Salvage if pitch flow evident or if bark-beetle infested		Windthrow more likely than breakage, salvage windthrown and root sprung trees as soon as possible	Root sprung trees will decline over several years, harvest as soon as possible	Root sprung trees will decline over several years, harvest as soon as possible
Wounds	Salvage if major wounds are on lower bole or large roots	Salvage if pitch flow evident or if bark-beetle infested		Entry sites for stain and decay fungi, salvage high-value trees as soon as possible	Harvest wounded trees in next scheduled harvest	Harvest wounded trees in next scheduled harvest, monitor for pest activity, yellow leaves, boring dust around base
Salt damage	May lose needles, if no evidence of other damage or bark-beetles, can be retained	Salvage if retained trees do not refoliate or if bark-beetle infested		Defoliated crowns or burned leaves do not indicate mortality, crowns should refoliate	If new leaves do not form may indicate saltwater intrusion, stressed trees may die	Monitor for pest activity, yellow leaves, boring dust around base

Monitoring may be needed for 1 to 5 years, depending on species and damage type.

Sources: Barry and others (1993), Conner and Wilkinson (1982), Conner and others (1989, 1997)

From: Stanturf, J.A.; Goodrick, S.L.; Outcalt, K.W. 2007. Disturbance and coastal forests: a strategic approach to forest management in hurricane impact zones. Forest Ecology and Management. 250 (1-2): 119-135.

LAST TREES STANDING

by Zoë Hoyle

Hurricane Katrina hit the town of Gulfport, MS, hard. Winds up to 145 miles per hour wrapped trees in debris, while 30-foot storm surges pushed some 400 tractor trailers through urban neighborhoods. Hundreds of trees that had been planted along Gulfport's "Emerald Coast" were swept away—all but 24 live oaks. A few days into the posthurricane cleanup those live oaks were gone, too, bulldozed down as part of debris removal. Losing these survivors just seemed like the final straw to some.

Ironically, Gulfport had measures in place to evaluate storm damage to urban trees before the storm hit. In 2001, the Forest Service (FS) developed the Initial Storm-Damage Assessment Protocol (SDAP) to help storm damaged communities project debris cleanup volumes and costs for trees along public rights-of-way after major storms. SDAP is now part of i-Tree, a suite of Web-based urban forest assessment and management tools developed by the Forest Service.

Gulfport was one of the only communities along the Gulf Coast to implement the protocol; urban foresters had established sample plots (street segments) and completed an inventory of trees. The plots were resurveyed after Katrina and a plan formed to assess still living trees, but the plan was not carried out by the contractors who came in to do debris removal. It was simply easier, faster, and more lucrative to bulldoze down

live trees than to assess or prune them.

What happened to urban trees in Gulfport and other communities along the Gulf Coast during the cleanup after Katrina caught the attention of **Ed Macie**, director of urban forestry for the **FS Southern Region**. Hundreds of thousands of urban trees were killed or

"When we first arrived, residents were still trying to get things in order and really didn't have time to be concerned about urban trees. Most of the trees we saw were severely damaged except for live oak. At that time, the magnolias hadn't died, though eventually, they were pretty much lost. Live oak and cypress were the species that best withstood the wind, flooding, and tidal surge along the coast." —Dudley Hartel

badly damaged by Katrina's winds and storm surge. Municipalities needed a way to assess how much money it would take to remove thousands of downed trees, but they also needed to know how to save those left standing.

Around the same time, arborists attending the **Society of Municipal Arborists** (SMA) meeting in Windsor, Ontario, expressed interest in volunteering their services to communities along the Gulf Coast to help assess damage to urban trees. "The storm had just happened before their annual meeting and they were ready to go," says **Dudley Hartel**, center manager with **SRS Urban Forestry South** in Athens, GA.

On the Ground

At the regional office, Macie began assembling a partnership of agencies and organizations interested in

providing professional assistance to the Gulf Coast. Initially, these included the SMA, the **International Society of Arboriculture**, **Davey Resource Group** (DRG), and the FS Southern Region.

Hartel and SRS technology transfer specialist **Eric Kuehler** worked with DRG to develop a rapid assessment protocol for damaged trees. Working with the **Mississippi Forestry Commission**, the partners developed and tested protocols that winter and then set off for Biloxi, MS, with an initial six volunteers in January 2006. In Biloxi, the **Land Trust for the Mississippi Coastal Plain** arranged for volunteer housing.

In mid-February, work moved to the New Orleans area, and **Katie Armstrong** (FS Northern Area) began a 1-month detail to lead additional volunteer teams, with Hartel and Kuehler rotating training and planning over the next 3 months as they worked their way along the Gulf Coast communities of Mississippi and Louisiana.

"When we first arrived, residents were still trying to get things in order and really didn't have time to be concerned about urban trees," says Hartel. "Most of the trees we saw were severely damaged except for live oak. At that time, the magnolias hadn't died, though eventually, they were pretty much lost. Live oak and cypress were the species that best withstood the wind, flooding, and tidal surge along the coast."

The main goal of the arborist teams was to provide cities with a list of priority removals and pruning and other storm related actions. Between January and May, the teams assessed urban trees in 10 communities affected by Katrina. They trained and coordinated 35 professional volunteers, and assessed more than 7,500 trees, providing information for interim plans for tree removal and pruning. Most importantly at the time, they provided the information municipalities needed to request funding from the Federal Emergency Management Agency (FEMA) for hazardous tree removal and to provide specifications for contractor work.

“We learned the importance of timing right away,” says Hartel. “In some places, we got there too early, before the community was ready for us. In other cases, we got there too late, after everything had been cleaned up. We learned that it’s best to get there right after the initial emergency clearing has been done.”

Even in communities that had been cleaned up, the teams found hazardous trees still standing. “We saw many instances where trees that should have been saved were removed and dangerous ones left standing,” says Hartel. “We saw the benefit of

having people on the ground with the background, training, and experience to assess trees.”

Urban Forest Recovery

The Mississippi Forestry Commission initially estimated that 200,000 urban trees had been damaged in that State alone, with foresters estimating an equal number in Louisiana. Many trees that could have survived the damage were cleaned up before they could be assessed by arborists or urban foresters.

“This project helped us to understand how tree cleanup efforts are handled by FEMA and the Army Corps of Engineers and how these impact the urban forest,” says Hartel. “We’ve since developed an urban tree assessment protocol that is flexible enough to be used by communities across the southern region for any type of disaster.”

But it’s about more than debris removal and lessening the risk of damage from falling limbs. The trees that survive are the foundation for restoring urban forests and their benefits. In spite of the high winds and saltwater storm surge from Katrina and Rita, many urban trees stayed alive, or could have been saved by professional management.

“Damage to urban forests threatens public safety and, in the short term, creates economic burdens to local and State governments,” says Hartel. “It also means loss of important ecosystem services such as energy, stormwater control, air quality, and habitat. By retaining as many trees as possible, a community can use these trees as the foundation for recovery of these vital services.” 🌳

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**Urban Forestry South:
www.urbanforestrysouth.org**

**Gulf Coast Tree Assessment:
www.daveyresourcegroup.com/gcta/default.htm**

**Urban Forest Strike Teams:
www.UFST.org**

i-Tree: www.itreetools.org

Cooperators on Gulf Coast Tree Assessment Project: Davey Resource Group, Environmental Systems Research Institute, International Society of Arboriculture, Mississippi Forestry Commission, Louisiana Department of Agriculture and Forestry, Mississippi State Cooperative Extension Service, Geospatial Information and Technology Association, Society of Municipal Arborists, Forest Service Southern Region, SRS Urban Forestry South.

After Hurricane Katrina, the Mississippi Forestry Commission initially estimated that 200,000 urban trees were damaged in that State alone. (U.S. Forest Service photo)



Strike While the Harm is Hot

The work done in 2006 by the Katrina tree assessment teams led by **Dudley Hartel** and **Eric Kuehler** sparked interest in urban foresters in other States. In 2007, **Urban and Community Forestry (UC&F) Program** coordinators **Leslie Moorman** in North Carolina and **Paul Revell** in Virginia asked Hartel, center manager for **SRS Urban Forestry South**, to help set up a training program for State-employed certified arborists.

Held in August 2007 in Kinston, NC, the meeting included training on how to estimate tree debris volume following a disaster, assess the risk associated with trees remaining after initial cleanup, and evaluate tree plantings needed to restore the urban forest. Arborists attending the training became the first members of a new **Urban Forest Strike Team (UFST)** designed to provide postdisaster tree assessment assistance to State UC&F Programs and communities in the southern region.

“Training and procedures are being developed to be compatible with the Incident Command System developed by the Forest Service for mobilizing personnel to fight wildfires,” says Hartel. “Working within State emergency management programs, qualified arborists on strike teams will be available to provide assistance following disasters that affect urban trees.”

Put to the Test in Tulsa

On December 10, 2007, a massive ice storm hit eastcentral Oklahoma, knocking out power to hundreds of thousands of homes and businesses. The sounds of crashing trees and snapping limbs reverberated throughout the neighborhoods of Oklahoma City and Tulsa. People were advised to stay in their homes to avoid harm from falling limbs.

At the request of **Mark Bays**, Oklahoma U&CF coordinator, and Oklahoma State Forester **John Burwell**, Hartel and Revell headed out to Tulsa in mid-January 2008 to assess the damage before sending out a team of arborists.

“I went out thinking there probably wasn’t that much of a problem,” says Hartel. “I couldn’t have imagined how bad it was. There were tens of thousands of trees down or damaged. We concentrated on the urbanized areas of Bixby, Tulsa, Nichols Hills, and Edmond where assistance had been requested.”

Working with **Oklahoma Forestry Services**, Hartel and Revell revised the assessment and data collection protocol for ice storm damage and took teams out to the Tulsa area the first of February. Over the next month, strike teams provided detailed risk assessments and debris estimates to help communities apply to the Federal Emergency Management Agency (FEMA) under a pilot program that provided funding for debris removal prior to cleanup rather than after.

Four UFST arborists worked for a week on Mohawk Park in Tulsa. At 2,806 acres, Mohawk Park is one of the largest municipal parks in the United States. In one day alone, crews assessed over 500 trees along trails and heavily used areas in the park, resulting in recommendations for 217 tree removals, 254 tree prunings to remove broken and hanging limbs, and restoration pruning for 75 trees.

Because they had taken a recent, predisaster inventory of trees in most of the city parks, **Tulsa Parks and Recreation** was able to demonstrate to the FEMA debris management team that debris estimates could be easily calculated from existing data. “I refer to this as the ‘Tulsa Model,’ where a city has a recent and accurate management inventory that can be used for reference after a disaster,” says Hartel. “UFST arborists helped the City of Tulsa by completing the inventory in the remaining parks, including Mohawk. The data we

recorded—location, genus, diameter, and disaster related assessments—provided enough information for Tulsa Parks to make recommendations for removal and restoration. The same system could be easily applied to street trees.” For Tulsa, this information was also the basis for the calculating debris contracts with FEMA.

Strike Team Network Spreads

In July 2008, additional UFST arborists and 12 team leaders completed a training held in Providence Forge, VA. For now, the emphasis is on training certified arborists who are State forestry agency employees, but trainers are also receiving requests from municipal arborists. Hartel and Kuehler help develop the trainings and act as interim leaders of teams, but what started with a group of arborists after Katrina is quickly gaining support from the State Foresters and spreading to other regions. At the Virginia training, five representatives from the **Forest Service Northeastern Area** attended with the intent of beginning a similar program in their region.

“Eventually we hope to have a whole network of disaster response arborists available to work on strike teams wherever urban trees are affected,” says Hartel. “The goal of the UFST program is to reduce risk in communities following a disaster, and to protect viable trees that can be managed to reestablish urban forests and the environmental services they provide.” —ZH

For more information:

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Urban and Community Forestry (UCF) is a cooperative Forest Service program that focuses on the stewardship of urban natural resources. UCF provides technical, financial, research, and educational services to local government, nonprofit organizations, community groups, educational institutions, and tribal governments. The program is delivered through the State forestry agencies.



You Can Use!

Homeowners Guide: How to Handle Trees Damaged by Hurricanes

Hurricanes bring winds that can exceed 125 miles per hour, heavy rain, and flooding—any or all of which can damage trees. Although some damage can be seen immediately, some effects of structural damage to trees may not become apparent for years. On the other hand, what may initially seem like mortal damage—all the leaves blown off—may be just temporary. Leaves saturated with salt water turn brown and look like they've been burned. If not hazardous, these trees should be monitored for 6 to 12 months before deciding to cut them.

Hazard Trees

Downed or weakened trees can be hazardous to people, buildings, and power lines. Storm damaged trees should be assessed for risk as soon as possible after a hurricane or other major storm. Signs that a tree could be a hazard include:

- New cracks in the lower trunk or large stems split from the tree

- Major roots severed or broken, tree partially uprooted
- Noticeable tree lean attributable to the storm
- Large limbs broken; most of crown damaged

If one or more of these conditions are present, consult with a professional arborist as soon as possible. Until the tree damage is addressed, stay clear and keep vehicles and other moveable assets out of range.

Some Tips When Hiring a Tree Service

Beware of scams—unsolicited offers, bargain deals, and out-of-State companies with offers too good to be true. Use a qualified arborist; unqualified workers could get hurt on your property or cause irreparable damage to trees.

Ask for certificates and proof of liability insurance and workmen's compensation. Contact the insurance company to confirm that policies are current.

Ask for references and check them.

Do not use any company that recommends topping.

Sign a written agreement before the work. Never pay in advance.

You can find a qualified arborist using your local phone directory or on the Web at <http://www.isa-arbor.com/findarborist/findarborist.aspx>.

Compensation for Loss of Landscape Value

Insurance, tax credits, and other assistance may be available depending

on your circumstances. To qualify for possible assistance:

- Photograph damage.
- Document estimates, descriptions, remedial tree maintenance following the storm, and other pertinent information.
- Stay in touch with local, State, and Federal Agency representatives, as well as insurance companies and relief organizations.

Timber Salvage Guidelines

Landowners with larger stands of trees will need to develop a plan for salvaging damaged timber. Guidelines for conducting surveys, evaluating damage, and prioritizing salvage can be found online at www.forestpests.org/storm/ or in the table on page 25.

Recommended reading:

Gilman, E.F.; Duryea, M.L.; Kampf, E.; Partin, T.J. [and others]. 2006. **Assessing damage and restoring trees after a hurricane.** ENH1036. Gainesville, FL: Urban Forest Hurricane Recovery Program, School of Forest Resources and Conservation, University of Florida. 13 p. edis.ifas.ufl.edu/pdf/EP/EP29100.pdf [Date accessed: July 1, 2008].

Stanturf, J.A.; Goodrick, S.L.; Outcalt, K.W. 2007. **Disturbance and coastal forests: a strategic approach to forest management in hurricane impact zones.** Forest Ecology and Management. 250 (1–2): 119–135.

Adapted from: Mississippi Homeowners Guide: Working with Trees Affected by Hurricane Katrina. Mississippi Forestry Commission, Mississippi State Extension Service, SRS Urban Forestry South. Jackson, MS: Mississippi Forestry Association, International Society of Arborists. 2 p. Available from www.mfc.state.ms.us/publications.htm.

On the Bookshelf...

Holmes, T. P.; Prestemon, J. P.; Abt, K. L., eds. 2008. **The economics of forest disturbances: wildfires, storms, and invasive species.** For. Sci. Series, XIV. 422 p. Vol. 79.

Thomas Holmes, Jeffrey Prestemon, and Karen Abt, scientists with the **SRS Forest Economics and Policy** unit in Research Triangle Park, NC, edited this compilation of research that addresses the foundations of the most pressing forest policy questions.

Much of today's forest management and protection is by necessity organized around forest disturbance. Public land managers focus on managing forests to alter fuel loads and reduce damages in the face of evolving fire regimes. A national debate swirls around funding for fuel reductions and fire fighting. Private forest managers must account for

multiple risks as they make forest investment decisions, and efforts to restore forested ecosystems must take into account disturbance patterns.

"It's fair to say that just about every decision made now regarding forest management or protection must account for forest disturbances," according to **Dave Wear**, project leader for the Forest Economics and Policy unit. "This book defines the state of the science in natural resource economics regarding forest decision making in the context of all types of disturbances."

The book is divided into sections that address the structure of disturbance processes, the economic impacts of disturbances, and decisionmaking in response to disturbances. Issues covered include the effects of climate on wildfire, social relationships driving wildland arson, timber salvage economics, and the effects of fire on residential property

values. Other chapters examine the tradeoffs between fuels management, suppression and damages, and the regulatory environment addressing wildfire mitigation. Most of the work presented was funded by the National Fire Plan.

The book is the culmination of years of research led by the Forest Economics and Policy Unit. "Because of its breadth and rigor, this body of work sets the agenda for research in this area, including our own, for many years to come," Wear says.—CP 🌲

The Economics of Forest Disturbances: Wildfires, Storms, and Invasive Species is available at amazon.com.

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Hanula Receives Hopkins Award

Jim Hanula, entomologist with the **SRS Insects, Diseases, and Invasive Plants of Southern Forests** unit, has been named the 2008 winner of the A.D. Hopkins Award, the most distinguished prize given to a forest entomologist in the South. The award is one of only two such honors nationwide that recognize the contributions of entomologists studying forest insects.

Hanula received the award during the 51st annual Southern Forest Insect Work Conference held August 4-7 in Chattanooga, TN. The group presents the A.D. Hopkins Award to an individual with an outstanding record of service to southern forest

entomology. Scientists receive the award only in years when five of the seven award committee members concur. Peers nominated Hanula in recognition of significant and lasting contributions to the study of forest entomology in the Southern United States and his outstanding career conducting practical, service-oriented science. Hanula's recent contributions to understanding and controlling new invasive species are especially noteworthy.

During his 16-year career with the Forest Service, Hanula and his students have conducted a wide range of research ranging from analyzing prey of the endangered red-cockaded woodpecker in various forest conditions to the effects natural and manmade disturbances have on insect communities. Currently, he is analyzing the decline of insect

pollinators in relation to the invasion of nonnative plant species such as Chinese privet. Hanula is also developing attractants to trap the invasive redbay ambrosia beetle, which spreads a fungus responsible for killing redbay and other trees in the Coastal Plains of northeastern Florida, Georgia, and South Carolina.—SW 🌲



Jim Hanula (U.S. Forest Service photo)

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 |

New Laboratory Receives Green Certification

The U.S. Green Building Council recently awarded the **SRS Savannah River Forestry Sciences Laboratory** with a Leadership in Energy and Environmental Design (LEED) Silver certification.

The LEED® Green Building Rating System is a third-party certification program administered by the nonprofit Green Building Council for the design, construction, and operation of high performance, sustainable buildings.

The 4,200-square-foot laboratory and office building is located in New Ellenton, SC, just outside the Savannah River Site on the **Warner Savannah River Research Campus**. The facility is home to eight SRS scientists and technicians who conduct ecological research on the forests of the Savannah River Site, which is owned by the **U.S. Department of Energy**.

The Savannah River Forestry Sciences Laboratory is 33 percent more energy efficient than a standard building. It incorporates numerous sustainable and energy efficient features including a geothermal heating and air conditioning system, highly efficient light fixtures and windows to reduce energy use, and building materials made from recycled

waste products, just to name a few. The facility includes other savings and benefits that are more difficult to measure, such as increased employee productivity because of enhanced natural lighting and improved indoor air quality. Energy models estimate that SRS is saving close to \$2,000 a year through sustainable building practices at the laboratory. 🌲

Savannah River Forestry Sciences Laboratory, New Ellenton, SC (U.S. Forest Service photo)



Honors, Awards, and More

SRS researcher emeritus **John Moser** has honored fellow entomologist and project leader **Kier Klepzig** by naming a new mite after him—one of two new mite species unveiled by Moser and Ukrainian taxonomist **Alexander Khaustov** in a paper recently published in the *International Journal of Acarology* (vol. 34, no. 2). Moser named *Caesarodispus klepzig* (Microdispidae) after Klepzig; the second mite *Petalomium hofstetteri* (Neopygmephoridae) was named in honor of **Northern Arizona University** researcher **Rich Hofstetter**. Moser named the mites in tribute to the contributions Klepzig and Hofstetter have made to understanding the complex symbiotic interactions among insects, fungi, and mites.

Moser actually discovered the mites,



Caesarodispus klepzig (Photo by Stacy Blomquist, U.S. Forest Service)

which were attached to flying fire ants, in his own backyard in Pineville, LA. Last year, he discovered three other new mite species. The “retired” entomologist said he may have close to 20 additional new species to describe in the near future.

Jim Miller, research ecologist with the **SRS Diseases and Plants Team**, received an award from the **Alabama Invasive Plant Council** recognizing

him as a charter member and in Appreciation of Expert and Steadfast Leadership of the Council, at the Alabama Invasive Plant Council’s 6th Annual Conference, Columbiana, AL.

Eastern Forest Environmental Threat Assessment Center (EFETAC) ecologist **William Hargrove** was among the scientists who won the People’s Choice Awards gold medal at the 2008 Atmospheric Radiation Measurement (ARM) Science Team Meeting in Norfolk, VA. The award honored Hargrove and scientific partners for developing the poster, *A Cluster Analysis Approach to Comparing Atmospheric Radiation Measurement Data and Global Climate Model Results*. The People’s Choice Awards, new to this year’s meeting, were awarded based on votes from ARM scientists attending the meeting. The poster, along with the second and third place winners, can be viewed at stm.arm.gov/2008/winning_posters_pc.stm.

EFETAC research hydrologist **Ge Sun** has been elected president of the Sino-Ecologists Association Overseas (Sino-Eco) for its 2008 to 2010 term. Sun assumed his presidential responsibilities May 1, 2008. Sino-Eco is a nonprofit academic organization established in 1988 to encourage the exchange of ideas and knowledge among Chinese ecologists in China and around the world.



Ge Sun (Photo by Erika Cohen, U.S. Forest Service)

Josephine Falcone, a master’s biology student at Western Carolina University, joins EFETAC as a Student Temporary Employment Program biological science technician working with SRS ecologist **Qinfeng Guo**. Falcone is helping to develop and populate Guo’s invasive and exotic plants database, a comprehensive catalog of nonnative plants in North America used for continent-scale ecological analyses of these key threats to native ecosystems.



Josephine Falcone (Photo by Mike Falcone)

Thomas Eberhardt, research scientist with the **SRS Utilization of Southern Forest Resources** unit in Pineville, LA, was recently honored as the third speaker in the Elvin T. Choong Memorial Lecture Series at Louisiana State University School of Renewable Natural Resources. Eberhardt delivered a presentation on May 13 titled *Southern Pine Bark Quality: Impact on the Living Tree and the Utilization of Available Biomass Resources*.

SRS Center for Forested Wetlands team leader **Carl Trettin** hosted three Chinese researchers as part of a wetland restoration field tour of the United States. During their April trip, the trio toured SRS wetland research at the **Santee Experimental Forest** in South Carolina, **Coweeta Hydrologic Laboratory** in North Carolina, and **Center for Bottomland Hardwoods Research** in Mississippi. 



NEW PRODUCTS

from the Southern Research Station...

Natural Resources Inventory and Monitoring

1 Bentley, James W.; Cartwright, Walter E.; Hendricks, Brian. 2008. **Alabama's timber industry—an assessment of timber product output and use, 2005.** Resour. Bull. SRS-128. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 32 p.

In 2005, roundwood output from Alabama's forests totaled 1.14 billion cubic feet. Mill byproducts generated from primary manufacturers amounted to 432 million cubic feet. Almost all plant residues were used primarily for fuel and fiber products. Pulpwood was the leading roundwood product at 563 million cubic feet; saw logs ranked second at 425 million cubic feet; veneer logs were third at 93 million cubic feet. The number of primary processing plants was 145. Total receipts amounted to 1.18 billion cubic feet.

2 Bentley, James W.; Howell, Michael; Johnson, Tony G. 2008. **Arkansas's timber industry—an assessment of timber product output and use, 2005.** Resour. Bull. SRS-132. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 31 p.

In 2005, roundwood output from Arkansas's forests totaled 749 million cubic feet. Mill byproducts generated from primary manufacturers were 354 million cubic feet. Almost all plant residues were used, primarily for fuel and fiber products. Saw logs were the leading roundwood product at 390 million cubic feet; pulpwood ranked second at 235 million cubic feet; and veneer logs were third at 95 million cubic feet. The number of primary processing plants was 156 in 2005. Receipts for those mills totaled 814 million cubic feet.

Southern Research Station headquarters in spring 2007. (Photo by Rodney Kindlund, U.S. Forest Service)

3 Bentley, James W.; Howell, Michael; Johnson, Tony G. 2008. **Louisiana's timber industry—an assessment of timber product output and use, 2005.** Resour. Bull. SRS-130. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 32 p.

In 2005, industrial roundwood output from Louisiana's forests totaled 866 million cubic feet, 20 percent more than in 2002. Mill byproducts generated from primary manufacturers increased 17 percent to 321 million cubic feet. Almost all plant residues were used primarily for fuel and fiber products. Saw logs were the leading roundwood product at 343 million cubic feet; pulpwood ranked second at 337 million cubic feet; veneer logs were third at 146 million cubic feet. The number of primary processing plants increased from 60 in 2002 to 62 in 2005. Total receipts increased 18 percent to 936 million cubic feet.

4 Bentley, James W.; Howell, Michael; Johnson, Tony G. 2008. **Mississippi's timber industry—an assessment of timber product output and use, 2005.** Resour. Bull. SRS-131. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 32 p.

In 2005, industrial roundwood output from Mississippi's forests totaled 1.03 billion cubic feet, 11 percent more than in 2002. Mill byproducts generated from primary manufacturers decreased 1 percent to 385 million cubic feet. Almost all plant residues were used primarily for fuel and fiber products. Saw logs were the leading roundwood product at 543 million cubic feet; pulpwood ranked second at 366 million cubic feet; veneer logs were third at 78 million cubic feet. The number of primary processing plants remained at 116 in 2005. Total receipts increased 2 percent to 908 million cubic feet.

5 Johnson, Tony G.; Bentley, James W.; Howell, Michael. 2008. **Florida's timber industry—an assessment of timber product output and use, 2005.** Resour. Bull. SRS-133. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 31 p.

In 2005, volume of industrial roundwood output from Florida's forests totaled 445 million cubic feet, 13 percent less

than in 2003. Mill byproducts generated from primary manufacturers declined to 146 million cubic feet. Almost all plant residues were used primarily for fuel and fiber products. Pulpwood was the leading roundwood product at 214 million cubic feet; saw logs ranked second at 167 million cubic feet; veneer logs were third at 26 million cubic feet. Total receipts declined 5 percent to 460 million cubic feet. The number of primary processing plants totaled 93 in 2005.

6 Johnson, Tony G.; Bentley, James W.; Howell, Michael. 2008. **The South's timber industry—an assessment of timber product output and use, 2005.** Resour. Bull. SRS-135. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 52 p.

In 2005, industrial roundwood output from the South's forests totaled 8.7 billion cubic feet, 6 percent more than in 2003. Mill byproducts generated from primary manufacturers increased 1 percent to 3.2 billion cubic feet. Almost all plant residues were used primarily for fuel and fiber products. Saw logs were the leading roundwood product at 3.9 billion cubic feet; pulpwood ranked second at 3.5 billion cubic feet; veneer logs were third at 846 million cubic feet. The number of primary processing plants declined from 2,281 in 2003 to 2,028 in 2005. Total receipts increased 5 percent to 8.7 billion cubic feet.

7 Johnson, Tony G.; Stepleton, Carolyn D. 2008. **Southern pulpwood production, 2006.** Resour. Bull. SRS-134. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 42 p.

The South's production of pulpwood increased from 64.0 million cords in 2005 to 64.7 million cords in 2006. Roundwood production increased 123,300 cords to 46.3 million cords and accounted for 72 percent of the total pulpwood production. The use of wood residue increased 3 percent to 18.3 million cords. Alabama led the South in total production at 10.5 million cords. In 2006, 87 mills were operating and drawing wood from the 13 Southern States. Pulping capacity of southern mills increased from 124,567 tons per day in 2005 to 125,093 tons per day, and still accounts for more than 70 percent of the Nation's pulping capacity.

8 Oswalt, Sonja N.; Oswalt, Christopher; Turner, Jeffrey. 2008. **Hurricane Katrina impacts on Mississippi forests.** Southern Journal of Applied Forestry. 32(3): 139-141.

Hurricane Katrina triggered public interest and concern for forests in Mississippi that required rapid responses from the scientific community. A uniform systematic sample of 3,590 ground plots were established and measured in 687 days immediately after the impact of Hurricane Katrina on the Gulf Coast. The hurricane damaged an estimated 521 million trees with more than 2.5-cm d.b.h. and killed approximately 54 million trees statewide. Sixty-nine percent of tree mortality occurred in 17 counties in southeastern Mississippi, and 45 percent of trees killed were loblolly pine trees. Total tree mortality was less than 1 percent of the statewide population.

9 Roesch, Francis A. 2008. **An alternative view of continuous forest inventories.** Forest Science. 54(4): 455-464.

In this publication, continuous forest inventories are conceptualized as being a sample drawn from a population in three dimensions: two dimensions in land area and the third in time. The sample units result from carving the three-dimensional volume into pieces like a three-dimensional jigsaw puzzle. Forest inventory is often described as a random sample drawn from the land area; however, the third dimension becomes necessary when the time of observation is also random. As with two-dimensional sampling, this three-dimensional concept results in a finite number of sample units, each of which is selected independently with a known probability, allowing the formulation of unbiased estimators.

10 Rose, Anita K. 2007. **Virginia's forests, 2001.** Resour. Bull. SRS-120. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 140 p.

Between 1997 and 2001, the Forest Service's Forest Inventory and Analysis (FIA) Program conducted the seventh inventory of the forests of Virginia. About 15,844,000 acres, or 62 percent, of Virginia was forested. Red maple and loblolly pine dominated in terms of number of live stems (1.5 billion and .96 billion, respectively). Yellow-poplar dominated the live-tree volume with 5.5 billion cubic feet. Loblolly

pine was second, with 4.7 billion cubic feet. FIA is the only program that conducts forest assessments across the United States. Increasing demands on the resource and anthropogenic-related impacts on forests have intensified the need to conduct these ecosystem-based inventories.

11 Turner, Jeffrey A.; Oswalt, Christopher M.; Chamberlain, James L. [and others]. 2008. **Kentucky's forests, 2004**. Resour. Bull. SRS-129. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 101 p. [Editor's note: Southern Research Station scientists Roger C. Conner, Tony G. Johnson, Sonja N. Oswalt, and Kadonna C. Randolph co-authored this publication.]

Forest land area in the Commonwealth of Kentucky amounted to 11.97 million acres, including 11.6 million acres of timberland. Over 110 different species, mostly hardwoods, account for an estimated 21.2 billion cubic feet of all live- tree volume. Hardwood forest types occupy 85 percent of Kentucky's timberland, and oak-hickory is the dominant forest-type group, accounting for about 8.4 million acres. About 78 percent of timberland in Kentucky is owned by nonindustrial private forest landowners. Forest industry owns about 2 percent of the timberland in the Commonwealth, while Federal, State, and local government agencies manage about 11 percent or 1.03 million acres. In 2003 more than 21,500 individuals were directly employed at wood processing mills, with a total annual payroll of over 700 million dollars. Many nontimber forest products are harvested in Kentucky, which ranks second in the southern region in terms of the number of nontimber forest product enterprises.

Forest Ecosystem Restoration and Management

12 Bragg, Don C. 2008. **An improved tree height measurement technique tested on mature southern pines**. Southern Journal of Applied Forestry. 32(1): 38-43.

Virtually all techniques for tree height determination follow one of two principles: similar triangles or the tangent method. Most people apply the latter approach, which uses the tangents of the angles to the top and bottom and a true

horizontal distance to the subject tree. However, few adjust this method for ground slope, tree lean, crown shape, and crown configuration, making errors commonplace. Given documented discrepancies exceeding 30 percent with current methods, a reevaluation of height measurement is in order. The sine method is an alternative that measures a real point in the crown. Hence, it is not subject to the same assumptions as the similar triangle and tangent approaches. In addition, the sine method is insensitive to distance from tree or observer position and cannot overestimate tree height. The advantages of the sine approach are shown with mature southern pines from Arkansas.

13 Bragg, Don C. 2008. **The prominence of pine in the Upper Gulf Coastal Plain during historical times**. In: Hardy, Laurence M., ed. Freeman and Custis Red River expedition of 1806: two hundred years later. Bull. of Museum of Life Sciences, 13. Shreveport, LA: Louisiana State University: 29-54.

Jeffersonian explorers Thomas Freeman and Peter Custis passed through the Upper West Gulf Coastal Plain (UWGCP) during their 1806 Red River expedition, but provided only rudimentary descriptions of upland forests. This paper cites dozens of references to better account for the dominance of pine in these forests prior to their development. While pine was a prominent species, it was rarely found in pure stands over much of the study area. Rather, it appears pine mixed with hardwoods dominated the UWGCP, with only localized areas of very high pine concentration resulting from factors such as soil conditions or disturbances. Over the last two centuries, Euroamericans have dramatically impacted most of this area, and have noticeably altered the prominence of pine.

14 Darling, O.H. "Doogie"; Bragg, Don C. 2008. **The early mills, railroads, and logging camps of the Crossett Lumber Company**. Arkansas Historical Quarterly. 67(2): 107-140.

From the earliest small-scale logging and milling operations to the multinational conglomerates of today, the timber industry has long shaped the social and economic history of the Southern United States. Nowhere is this more true than

in Crossett, AR. Born of the axe and saw, oxen and steam engines, and nurtured by the railroad during its infancy, Crossett was transformed from a remote and virtually unknown tract of rolling pine into one of the leading forest products centers in the United States, yielding enormous quantities of dimensional lumber, paneling, paper and related products, and wood-based chemicals. The story of Crossett through its first 45 years rests almost exclusively on a single institution—the Crossett Lumber Company—and the cast of characters responsible for its founding and survival.

15 Greenberg, Cathryn H.; Waldrop, Thomas A. 2008. **Short-term response of reptiles and amphibians to prescribed fire and mechanical fuel reduction in a Southern Appalachian upland hardwood forest**. Forest Ecology and Management. 255(7): 2883-2893.

We compared effects of three fuel reduction techniques and a control on relative abundance and richness of reptiles and amphibians using drift fence arrays with pitfall and funnel traps. Treatments were prescribed burn (B); mechanical understory reduction (M); mechanical + burn (MB); and controls (C). Hot fires in MB killed about 25 percent of the trees, increasing canopy openness relative to controls. Leaf litter depth was reduced in B and MB after burning, but increased in M due to the addition of dead leaves during understory felling. We captured 1,308 amphibians of 13 species, and 335 reptiles of 13 species. Relative abundance of total salamanders, common salamander species, and total amphibians was not changed by fuel reduction treatments. Total frogs and toads (anurans) and *Bufo americanus* were most abundant in B and MB; however, proximity of breeding sites likely affected results. Total reptile abundance and *Sceloporus undulatus* abundance were highest in MB after burning, but differed significantly only from B. Results indicate a single application of fuel reduction methods studied will not negatively affect amphibian or reptile abundance or diversity in Southern Appalachian upland hardwood forest. Our study further suggests that high-intensity burning with heavy tree kill, as in MB, can be used as a management tool to increase reptile abundance— particularly lizards—with no negative impact on amphibians, at least in the short term.

16 King, N.T.; Seiler, J.R.; Fox, T.R.; Johnsen, K.H. 2008. **Post-fertilization physiology and growth performance of loblolly pine clones.** *Tree Physiology*. 28(5): 703-711.

Clones are distinct genotypes whose genetic expression results in distinct phenotypes. Clones can respond differentially to forest management practices. We studied growth and leaf physiology of eight loblolly pine clones in response to fertilization. The eight genotypes displayed diverse responses to fertilization. Some grew substantially more with fertilization but did so with varying performances of a suite of traits, including growth, leaf photosynthetic traits, crown size, and crown efficiency. Fast growing clones can use different strategies for achieving their fast growth rate, and such diversity may be important for making decisions for deploying them in the field.

17 Loeb, Susan C.; Waldrop, Thomas A. 2008. **Bat activity in relation to fire and fire surrogate treatments in southern pine stands.** *Forest Ecology and Management*. 255: 3185-3192.

Bats are important components of forested ecosystems, but little is known about the effects of forest management on their populations. We used acoustic bat detectors to determine relative bat activity in three replicates of four experimental treatment plots in the Piedmont of South Carolina: (1) control, (2) thinned, (3) burned, and (4) thinned and burned. Overall bat activity was greater in the treated stands than in the control stands in both years. Activity of the larger big brown bats and red bats was also greater in the treated stands, whereas the treatments did not affect activity of the smallest species, the eastern pipistrelle. Our results suggest that treatments that reduce clutter, particularly thinning, increase the suitability of pine stands for bats' foraging and commuting activity in the Piedmont region. Thus, use of these practices may help to preserve the biodiversity of managed pine forests in the South.

18 Ludovici, Kim H. 2008. **Compacting Coastal Plain soils changes midrotation loblolly pine allometry by reducing root biomass.** *Canadian Journal of Forest Research*. 38: 2169-2176.

Factorial combinations of soil compaction and organic matter removal were replicated at the long-term site productivity study in the Croatan National Forest, near New Bern, NC, USA. Ten years after planting, 18 preselected loblolly pine (*Pinus taeda* L.) trees were destructively harvested to quantify treatment effects on total above- and belowground tree biomass and to detect any changes in the absolute and relative allocation patterns. Stem volume at year 10 was not affected by compaction treatments, even though the ultisols on these sites continued to have higher bulk densities than noncompacted plots. However, even when site preparation treatments were undetectable aboveground, the treatments significantly altered absolute root growth and tree biomass allocation patterns. Soil compaction decreased taproot production and significantly increased the ratio of aboveground to belowground biomass. Decreased root production will decrease carbon and nutrient stores belowground, which may impact future site productivity.

19 Marqués, Livia; Payne, Claire. 2008. **Hardwood regeneration helps wildlife.** *Forest Landowner*. 67(2): 23-25.

This article summarizes two research projects impacting wildlife habitat. The importance of creating openings in mature forest stands to enhance fruit production is demonstrated by the work of SRS scientists Cathryn Greenberg and David Loftis and Douglas J. Levey, University of Florida. Their study showed that by leaving fruit producing trees, openings can be managed to provide a significant source of soft mast throughout the year. Acorns or hard mast are an essential food for numerous species, especially during the winter. Greenberg worked with North Carolina Wildlife Resources Commission scientist Gordon S. Warburton to develop a faster and simpler method to estimate acorn crops. Using 21 years of data, they found the proportion of trees bearing acorns is a successful predictor of hard mast index (HMI). Their method produced similar index values to those using the traditional Whitehead HMI method.

20 Nelson, C. Dana; Johnsen, Kurt H. 2008. **Genomic and physiological approaches to advancing forest tree improvement.** *Tree Physiology*. 28: 1135-1143.

Genomics, the study of an organism's complete DNA complement, is opening new opportunities in understanding how a tree grows and how this information can be used in silviculture through physiology, genetics, and tree improvement. In this paper, Nelson and Johnsen explore opportunities afforded by genome science discoveries and technology advancements in forest trees. They apply the ideotype concept (i.e., an idealized tree) to loblolly pine (*Pinus taeda*) and discuss how this approach can aid the integration of physiologic and genomic information for improving selection methods in tree improvement and process models in physiology and silviculture research.

21 Perry, Roger W.; Thill, Ronald E.; Leslie, David M., Jr. 2008. **Scale-dependent effects of landscape structure and composition on diurnal roost selection by forest bats.** *Journal of Wildlife Management*. 72(4): 913-925.

Forest management affects quality and availability of roost sites for forest-dwelling bats, but information on roost selection beyond the scale of individual forest stands is limited. We evaluated effects of topography (elevation, slope, and proximity of roads and streams), forest habitats, and arrangement of forest patches on selection of summer roosts for six species of forest-dwelling bats in the Ouachita Mountains of Arkansas. We modeled roost selection at two spatial scales (a 250- and 1,000-m radius around each roost). Small-scale models were generally more powerful than large-scale models. Abundance of certain forest habitats was included more often than arrangement of forest patches or topography in differentiating roosts from random locations. Roost locations of one species were influenced by elevation, and roosts of three species were affected by slope. Two species roosted close to water, two species roosted close to roads, and one species roosted away from roads. Results suggest that in a completely forested landscape, a variety of stand types, seral stages, and management conditions varying in size and topographic location throughout the landscape would likely provide the components for roosting required to maintain a diverse community of forest bats in the Ouachita Mountains.

22 Samuelson, Lisa J.; Butnor, John; Maier, Chris [and others]. 2008. **Growth and physiology of loblolly pine in response to long-term resource management: defining growth potential in the Southern United States.** Canadian Journal of Forest Research. 38: 721-732. [Editor's note: Southern Research Station scientist Kurt Johnsen coauthored this publication.]

Eleven years of intensive resource management of loblolly pine resulted in d.b.h., basal area, and volume similar to or greater than values reported for loblolly pine of the same age and planting density in Hawaii. These results indicate that loblolly pine grown in the Southern United States can produce the high yields observed on favorable, exotic locations when stands are below maximum carrying capacity. Short-rotation plantations, perhaps used to produce biofuels, would better exploit the genetic potential of loblolly pine, because stands would be harvested before reaching carrying capacity. High basal area and volume production in older loblolly pine stands in Hawaii are likely a result of low mortality and exceptionally high leaf area index. Interactions between site and climatic factors and physiological processes that control mortality require further study.

23 Waldrop, Thomas A.; Yaussy, Daniel A.; Phillips, Ross J. [and others]. 2008. **Fuel reduction treatments affect stand structure of hardwood forests in western North Carolina and southern Ohio, USA.** Forest Ecology and Management. 255: 3117-3129.

Prescribed fire and mechanical treatments were tested at the two hardwood sites of the National Fire and Fire Surrogate Study (Southern and Central Appalachian regions). The primary management objective was to reduce severity of potential wildfires by reducing live and dead fuels. Secondary objectives were to increase oak regeneration by reducing competition from red maple (*Acer rubrum* L.) and yellow-poplar (*Liriodendron tulipifera* L.); and to improve wildlife habitat by creating early successional habitat, increasing cover of grasses and forbs, and improving oak regeneration. Fire and mechanical treatments used at both sites were designed to restore stand structure to an open woodland condition.

Results will provide managers with a better understanding of several options for reaching this restoration goal.

24 Xu, Shiqin; Tauer, C.G.; Nelson, C. Dana. 2008. **Genetic diversity within and among populations of shortleaf pine (*Pinus echinata* Mill.) and loblolly pine (*Pinus taeda* L.).** Tree Genetics & Genomes. 4(4): 859-868.

Geneticists Shiqin Xu and Chuck Tauer, Oklahoma State University, and Dana Nelson, Southern Research Station, teamed up to complete a genome-wide examination evaluating > 600 amplification fragment length polymorphisms of genetic diversity within two related pine species, loblolly pine and shortleaf pine. They studied seed sources as they existed prior to widespread pine planting in the South and now plan to extend this work to present day populations. The early populations showed high genetic diversity, with most (~ 85 percent) of the diversity being within populations, suggesting a high level of gene exchange between populations even across the Mississippi River Valley.

25 Xu, Shiqin; Tauer, C.G.; Nelson, C. Dana. **Natural hybridization within seed sources of shortleaf pine (*Pinus echinata* Mill.) and loblolly pine (*Pinus taeda* L.).** Tree Genetics & Genomes. 4(4): 849-858.

Geneticists Shiqin Xu and Chuck Tauer, Oklahoma State University, and Dana Nelson, Southern Research Station, teamed up to examine natural hybridization between shortleaf pine and loblolly pine (evaluating 96 shared amplification fragment length polymorphisms genetic markers). Hybridization frequency varied geographically, from 0 percent to 30 percent among seed sources. For both species, the hybridization level was higher in populations west of the Mississippi River than east of the river. The results clearly show that forest management plans need to consider the possibility of interspecies hybridization when planting recommendations are developed, especially in areas where the species' native ranges overlap.

Forest Values

26 Barbour, R. James; Zhou, Xiaoping; Prestemon, Jeffrey P. 2008. **Timber product output implications of a program of mechanical fuel treatments applied on public timberland in the Western United States.** Forest Policy and Economics. 10(6): 373-385.

This study reports the results from a 5-year simulation of forest thinning intended to reduce fire hazard on publicly managed lands in the Western United States. A simulation model of interrelated timber markets was used to evaluate timber product outputs. Approximately 84 million acres, or 66 percent of total timberland in the West, is publicly managed; 78 million acres are managed by Federal agencies. We considered three budget scenarios using a least-expensive, highest hazard area first policy. Our intention is not to definitively answer questions about where or how to conduct treatments to reduce fire hazard on public lands, but to begin to develop tools that can be used to inform such a policy debate. Initial simulations provide insight into what might happen if available funds were allocated to the least-expensive, highest hazard areas across the West. Using assumptions of (1) an annual "subsidy" (payments for treatments), (2) the treatment costs, (3) the priority ranking by forest type, (4) fire hazard level, and (5) the wildland-urban interface (WUI) status, the simulation suggests that lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*), spruce (*Picea* spp.)-fir (*Abies* spp.), and Douglas-fir (*Pseudotsuga menziesii*) are projected to be major forest types treated in the West. A combination of treatment-ranking assumptions and low total treatable WUI acres on public timberland caused the model to concentrate almost exclusively on all WUI stands and non-WUI ponderosa pine forest type at the budget of \$150 million and \$300 million. With further budget increases, a large proportion of treated acres are lodgepole pine and spruce-fir forest types using the thin-from-below approach.

27 Bowker, J.M.; Lim, Siew Hoon; Cordell, H. Ken [and others]. 2008. **Wildland**

fire, risk, and recovery: results of a national survey with regional and racial perspectives. *Journal of Forestry*. 106(5): 268-276. [Editor's note: Southern Research Station scientist Cassandra Y. Johnson co-authored this publication.]

We used a national household survey to examine knowledge, attitudes, and preferences pertaining to wildland fire. First we present nationwide results and trends. Then we examine opinions across region and race. Despite some regional variation, respondents are fairly consistent in their beliefs about assuming personal responsibility for living in fire-prone areas and believing that residents of such areas should follow government guidelines for managing fire risk. However, we find divergence of opinion on "trusting forest professionals" between African-American and Caucasian people. Across all survey questions related to fire management and public confidence, African-Americans appear to be relatively more concerned than Caucasian or Hispanic people.

28 Cho, Seong Hoon; Yen, Steven T.; Bowker, J.M.; Newman, David H. 2008. **Modeling willingness to pay for land conservation easements: treatment of zero and protest bids and application and policy implications.** *Journal of Agricultural and Applied Economics*. 40(1): 267-285.

This study compares an ordered probit model and a Tobit model with selection to take into account both true zero and protest zero bids while estimating the willingness to pay (WTP) for conservation easements in Macon County, NC. By comparing the two models, the ordered/unordered selection issue of the protest responses is analyzed to demonstrate how the treatment of protest responses can significantly influence WTP models. Both models consistently show that income and knowledge are positive and significant factors, while distance to poorer quality streams and duration of residency are negative and significant factors on WTP.

29 Huggett, Robert J., Jr.; Abt, Karen L.; Shepperd, Wayne. 2008. **Efficacy of mechanical fuel treatments for reducing wildfire hazard.** *Forest Policy and Economics*. 10(6): 408-414.

The efficacy of mechanical fuel treatments for reducing wildfire hazard at a landscape

scale is difficult to quantify. A set of treatments designed to reduce fire hazard were simulated on 0.8 million ha of timberland in Colorado. Hazard ratings based on torching and crowning indices were assessed on each stand pre- and post treatment. The even-aged treatments cost more and place more area within our hazard thresholds, while the uneven-aged treatments yield higher potential revenues. Both higher costs and higher revenues accrue to the treatments on higher risk stands. Treatments also have differing risk reductions depending on the initial risk category.

30 Lowell, Eini C.; Becker, Dennis R.; Rummer, Robert [and others]. 2008. **An integrated approach to evaluating the economic costs of wildfire hazard reduction through wood utilization opportunities in the Southwestern United States.** *Forest Science*. 54(3): 273-283.

This research provides an important step in the conceptualization and development of an integrated wildfire fuels reduction system from silvicultural prescription, through stem selection, harvesting, in-woods processing, transport, and market selection. Decisions made at each functional step are informed by knowledge about subsequent functions. Data on the resource characteristics of small-diameter ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), harvest equipment productivity, lumber recovery, and net profit (loss) by level of fuels reduction achieved were collected from four 8.1-ha (20 acres) sites in northern Arizona. These data were used to develop a Windows-based financial and engineering software program, the harvest cost-revenue estimator, to identify the economic costs of wildfire fuel reduction treatments that may be used to evaluate cost per acre thresholds for logging contractors, appraise contract bid rates, or assess stumpage values for ponderosa pine stands in the Southwestern United States. Application of the model illustrates variability in fuels reduction costs owing to the level of fuels reduction achieved, the volume of merchantable wood removed from different forest stands, and the availability of markets for removed material. Machine productivity helps predict differences in harvest costs but is

secondary to market constraints and the volume of wood harvested.

31 Mitchell, D.; Klepac, J. 2008. **Processing woody biomass with a modified horizontal grinder.** In: Baker, S.A.; Bolding, M.C.; Greene, W.D., eds. *Addressing forest engineering challenges for the future: Proceedings of the 31st annual meeting of the Council on Forest Engineering*. Athens, GA: Warnell School of Forestry and Natural Resources, University of Georgia: 167-172.

This study documents the production rate and cost of producing woody biomass chips for use in a power plant. The power plant has specific raw material handling requirements. Output from a 3-knife chipper, a tub grinder, and a horizontal grinder was considered. None of the samples from these machines met the specifications needed. A horizontal grinder was modified to replace the teeth on the drum with chipping blades in order to process whole trees into biomass chips that met the power plant's size specification. The study was installed on the Shoal Creek Ranger District, National Forests in Alabama, near Heflin, AL. This biomass removal project was the first step in a wildlife habitat improvement treatment to convert a 37-acre stand of off-site planted loblolly pine (*Pinus taeda* L.) to longleaf pine (*Pinus palustris* M.). The trees were 15 years old with an average dbh of 4.0 inches and average total height of 30.5 feet. The time and motion study gathered data on whole-tree processing for short fiber chips up to ½-inch long, short fiber chips from trees that had been partially delimbed to remove needles, and long fiber chips up to ¾-inch long. The average production rate ranged from 24.9-38.2 green tons/productive machine hour (gt/pmh). A machine rate of \$161.20/pmh was calculated, resulting in a cost of \$4.22/gt for producing the long fiber biomass chips.

32 Mitchell, D.L.; Gallagher, T.V.; Thomas, R.E. 2008. **The human factors of implementing shift work in logging operations.** *Journal of Agricultural Safety and Health*. 14(4): 1-14.

A fairly recent development in the forest industry is the use of shift work in logging in the Southeastern U.S. Logging company owners are implementing shift work as an opportunity to increase production and

potentially reduce the cost of producing each unit of wood, without consideration of the potential impacts on the logging crew. There are many documented physiological and psychological impacts on workers from shift work in a variety of industries, although few address forestry workers in the U.S. Semi-structured interviews were performed to gather information about how logging company owners were implementing shift work in seven Southeastern States. Data collected during the interviews included employee turnover, shift hours, shift scheduling, safety considerations, and production impacts. Various work schedules were employed. The majority of the schedules encompassed less than 24 hours per day. Permanent and rotating shift schedules were found. None of the logging company owners used more than two crews in a 24-hour period. Additional safety precautions were implemented as a result of working after dark. No in-woods worker accidents or injuries were reported by any of those interviewed. Results indicate that a variety of work schedules can be successfully implemented in the Southeastern U.S. logging industry.

33 Mitchell, Dana; Seixas, Fernando; Klepac, John. 2008. **Felling small trees with a drive-to-tree feller-buncher.** Tech. Release 08-R-16. Rockville, MD: Forest Resources Association, Inc. 2 p.

Conventional forestry equipment is often used to harvest small diameter trees. The typical ground-based logging operation is highly mechanized, with the most common using feller-bunchers, grapple skidders, and a chipper or grinder. But these machines may not be economical when used in precommercial or unmerchantable thinning operations in which the number of trees to be removed per acre is high but volume per tree is low. Published studies commonly find that feller-buncher productivity (tons/productive machine hour) is directly proportional to tree diameter. As tree diameters increase, the tons produced per hour increase, resulting in a lower cost per unit of wood produced. Existing literature often reports low feller-buncher production rates in stands with smaller trees (3-inch d.b.h. or less). The feller-buncher productivity observed in this study was higher than expected. Gentle topography, uniform plantation, and operator experience created an

environment conducive to high feller-buncher productivity. This study focused on using conventional, readily available equipment in a unique application that was not related to short-rotation woody crops. The machine tested does not represent a special alternative or technique for felling smaller trees.

34 Poudyal, Neelam; Cho, Seong Hoon; Bowker, J.M. 2008. **Demand for resident hunting in the Southeastern United States.** Human Dimensions of Wildlife. 13: 158-174.

We modeled hunting demand among resident hunters in the Southeastern United States. Our model revealed that future hunting demand will likely decline in this region. Population growth in the region will increase demand but structural change in the region's demography (e.g., "browning" and "aging"), along with declining forest land access will decrease hunting demand. The results suggested that programs encouraging younger and nonwhite populations to participate in hunting could mitigate a forecast hunting decline in the region. Increasing license fees, while politically risky, should increase agency revenues due to price-inelastic demand. The model developed here can be applied to understand and project hunting demand in the Southeast and adapted to other regions.

35 Prestemon, Jeffrey P.; Abt, Karen; Gebert, Krista. 2008. **Suppression cost forecasts in advance of wildfire seasons.** Forest Science. 54(4): 381-396.

Forecasts of wildfire suppression costs are demonstrated for two lead times in advance of a wildfire season: spring and fall of the current fiscal year. Forecast equations relate costs by geographical region to climate variables and time trends. Forecasts are evaluated for their goodness of fit using cross-validation techniques. Results show that the spring forecast of suppression costs is statistically no better than the fall forecast for predicting the coming season's costs. However, both the spring and fall models reduce forecast errors by approximately 60 percent compared to a 10-year moving average of observed historical costs, which is currently used as a budget request formula by the U.S. Forest Service.

36 Prestemon, Jeffrey P.; Abt, Karen L.; Huggett, Robert J., Jr. 2008. **Market impacts of a multiyear mechanical fuel treatment program in the U.S.** Forest Policy and Economics. 10: 386-399.

We describe a two-stage model of global log and chip markets that evaluates the spatial and temporal economic effects of government-subsidized fire-related mechanical fuel treatment programs in the U.S. West and South. The first stage is a goal program that allocates subsidies according to fire risk and location priorities, given a budget and a feasible, market-clearing market solution. The second stage is a quadratic welfare maximization spatial equilibrium model of individual State and global product markets, subject to the fuel treatment allocation. Results show that the program enhances timber market welfare in regions where treatments occur and globally but has an overall negative economic impact, once fuel treatment program costs are included. The overall cost of a mechanical fuel treatment program, when considering timber market welfare, transport costs, treatment costs, and timber receipts, exceeds \$1,000 per acre, implying that the long-run fire effects and ecosystem net benefits of a treatment program would need to exceed this figure in order to justify widespread implementation.

37 Rummer, Bob. 2008. **Assessing the cost of fuel reduction treatments: a critical review.** Forest Policy and Economics. 10: 355-362.

The basic costs of the operations for implementing fuel reduction treatments are used to evaluate treatment effectiveness, select among alternatives, estimate total project costs, and build national program strategies. However, a review of the literature indicates that there is questionable basis for many of the general estimates used to date. Different approaches to estimating cost have been used. Four methods are reviewed with discussion of the appropriate applications to fuel reduction cost analysis. Critical gaps identified in the understanding of operations costs include business overhead, repair and maintenance reserves, and estimates of the cost of risk. Future analyses of fuel treatments should be cautious in extrapolating cost numbers from the existing literature.

38 Shupe, Todd F.; Groom, Leslie H.; Eberhardt, Thomas L. [and others]. 2008. **Selected mechanical and physical properties of Chinese tallow tree juvenile wood.** *Forest Products Journal*. 58(4): 90-93.

Chinese tallow tree is a noxious, invasive plant in the Southeastern United States. It is generally considered a nuisance and has no current commercial use. The objective of this research was to determine the moduli of rupture (MOR) and elasticity (MOE) of the stem wood of this species at different vertical sampling locations. Three Chinese tallow trees were felled and cut into bolts before sampling along the east and west radial directions. It was found that Chinese tallow tree has sufficient bending strength for low to medium structural uses. Tree, bolt, and sampling direction were all found to be significant sources of variation for the MOR and MOE data.

Threats to Forest Health

39 Achtemeier, Gary L. 2008. **Effects of moisture released during forest burning on fog formation and implications for visibility.** *Journal of Applied Meteorology and Climatology*. 47(5): 1287-1296.

Smoke from wildland burning in association with fog has been implicated as a visibility hazard over roadways in the United States. Visibilities at accident sites have been estimated in the range from 1 to 3 m (extinction coefficients between 1000 and 4000). Temperature and relative humidity measurements were taken from 29 "smokes" during 2002 and 2003. These data were converted to a measure of the mass of water vapor present to the mass of dry air containing the vapor (smoke mixing ratio). Smoke temperatures were processed through a simple radiation model before smokes were mixed with ambient air with temperature and moisture observed during the early morning on the days following the burns. Calculations show supersaturations implying liquid water contents (LWC) up to 17 times as large as LWC found in natural fog. Simple models combining fog droplet number density, droplet size, and LWC show that the supersaturation LWC of smokes is capable of reducing visibility to the ranges observed.

40 Campbell, Joshua W.; Hanula, J.L. 2007. **Efficiency of Malaise traps and colored pan traps for collecting flower visiting insects from three forested ecosystems.** *Journal of Insect Conservation*. 11(4): 399-408.

Pollinators provide critical ecosystem services, but sampling them in forests is difficult for a variety of reasons. We tested pan traps constructed from blue, yellow, and white Solo7 bowls and compared them to Malaise traps at three different forest locations (Piedmont, Coastal Plain, and Blue Ridge). Blue pan traps were the most effective overall, although some pollinator groups preferred certain pan trap colors. Pan traps generally caught more pollinators than Malaise traps and, because of their low cost and simplicity, using several colors of pan traps is an effective way to sample relative abundance and species richness of flower-visiting insects in forests.

41 Campbell, Joshua W.; Hanula, J.L.; Outcalt, Kenneth W. 2008. **Effects of prescribed fire and other plant community restoration treatments on tree mortality, bark beetles, and other saproxylic Coleoptera of longleaf pine, *Pinus palustris* Mill., on the Coastal Plain of Alabama.** *Forest Ecology and Management*. 254: 134-144.

Treatments (prescribed burns, thinning of understory, herbicides) to restore understory plant communities of mature (50-80 years old) longleaf pine and reduce risks of wildfire were applied to plots in the Coastal Plain of Alabama that had a substantial shrub layer due to lack of fire. Some saproxylic beetles (which feed on dead and dying wood) are considered pests because they can kill trees and degrade wood, but the majority are beneficial because they aid in decomposition of wood and serve as food for other invertebrate and vertebrate animals. From 2002 to 2004, we captured saproxylic beetles on various treated plots. Our results show that the restoration treatments tested did not cause increased bark beetle-related tree mortality, and they did not negatively affect populations of early successional saproxylic beetle fauna.

42 Campbell, Joshua W.; Hanula, J.L.; Waldrop, Thomas A. 2008. **Effects of prescribed fire and fire surrogates on saproxylic Coleoptera in the Southern Appalachians of North Carolina.** *Journal of Entomological Science*. 43(1): 57-75.

We examined the effects of forest management practices (prescribed burning, shrub removal, and prescribed burn plus shrub removal) on beetles that eat or live in dead or dying trees in the Southern Appalachian Mountains of North Carolina. Although a few beetles are pests, they are greatly outnumbered by lesser known beetles that are valuable parts of forest ecosystems. Saproxylic beetles are important because they contribute to wood decomposition, nutrient cycling, and they are food for other organisms, so we want to know how these unique Coleoptera respond to various forest management practices so they can be conserved. In our study, saproxylic beetle numbers increased greatly from the first year (2003) to the second year (2004) in response to all treatments. Numbers of many species, including various species of Scolytidae, were significantly affected by the treatments. We saw no evidence that the treatments negatively impacted saproxylic species, and in most cases they benefited from the disturbances.

43 Guo, Qinfeng; Symstad, Amy. 2008. **A two-part measure of degree of invasion for cross-community comparisons.** *Conservation Biology*. 22(3): 666-672.

Invasibility is a critical feature of ecological communities, especially for management decisions. However, measuring invasibility has been a major challenge, and different measures such as the richness, survival, density, or biomass of exotic species have so far been used, producing inconsistent results and making comparisons among communities difficult. We propose a measure with the proportions of both exotic species richness and exotic species abundance. By including both of these components, the new practical measure illustrates the importance of dominance of exotic species relative to natives, which is a primary management concern associated with exotic species.

44 Hanula, James L.; Mayfield, Albert E., III; Fraedrich, Stephen W.; Rabaglia, Robert J. 2008. **Biology and host associations of redbay ambrosia beetle, *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae), exotic vector of laurel wilt killing redbay (*Persea borbonia*) trees in the Southeastern United States.** Journal of Economic Entomology. 101[Number unknown]: 1276-1286.

The redbay ambrosia beetle carries a fungus that is killing mature redbay trees in South Carolina, Georgia, and Florida. The beetle was recently introduced to the Savannah, GA, area from somewhere in Asia. In 2006 and 2007 we investigated the seasonal flight activity of redbay ambrosia beetle, what trees it attacks, and population levels of the beetle at eight locations in South Carolina and Georgia, where infestations ranged from very recent to at least several years old. These studies are important first steps in understanding the biology of this beetle and offer some promise for future control strategies.

45 Khaustov, Alexandr A.; Moser, John C. 2008. **Two new species of mites of the genera *Petalomium* Cross and *Caesarodispus* Mahunka (Acari: Heterostigmata: Neopygmephoridae, Microdispidae) associated with *Solenopsis invicta* Buren (Hymenoptera: Formicidae) from the USA.** International Journal of Acarology. 34(2): 115-122.

Two new species of myrmecophilous pygmephoroid mites, *Petalomium hofstetteri* n. sp. (Neopygmephoridae) and *Caesarodispus klepzigii* n. sp. (Microdispidae), associated with the red imported fire ant (*Solenopsis invicta* Buren) Hymenoptera: Formicidae, are described from Louisiana, U.S.A.

46 Koch, F.H.; Smith, W.D. 2008. **Spatio-temporal analysis of *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae) invasion in Eastern U.S. forests.** Environmental Entomology. 37(2): 442-452.

A symbiotic fungus of the beetle has recently caused mortality of redbay and, occasionally, sassafras trees in the Southeast. No one had done a broad-scale analysis of the threat to the Eastern U.S., so we mapped redbay and sassafras densities, delineated potential climatic limits for the beetle, and modeled spread

through time. Our results suggest that key areas with high redbay levels have not been invaded, but some are immediately threatened; climatic conditions may constrain the beetle to the Southeastern U.S. coast; if unchecked, the beetle may spread throughout the range of redbay in less than 40 years. Disruption of human-aided, long-distance dispersal could reduce this possibility.

47 Lu, Min; Miller, Daniel R.; Sun, Jiang-Hua. 2007. **Cross-attraction between an exotic and a native pine bark beetle: a novel invasion mechanism?** Public Library of Science (PLoS) ONE. 12: e1302. 9 p.

We report, for the first time, facilitation between an exotic and a native bark beetle that seems to involve overlap in the use of host attractants and pheromones, resulting in cross-attraction. In China we found that 35-40 percent of *Pinus tabulaeformis* attacked by an exotic bark beetle, *Dendroctonus valens* (native to the USA and Canada), were also attacked by a native pine bark beetle, *Hylastes parallelus*. Antennal and walking responses of *H. parallelus* to host- and beetle-produced compounds were similar to those of *D. valens* in China. The phenomenon of semiochemical-mediated interspecific facilitation should be considered as an invasion mechanism for other species of exotic bark and ambrosia beetles.

48 Miller, Daniel R.; Duerr, Donald A. 2008. **Comparison of arboreal beetle catches in wet and dry collection cups with Lindgren multiple funnel traps.** Journal of Economic Entomology. 101[Number unknown]: 107-113.

We compared the effectiveness of a dry collection cup to a wet collection cup for use with baited Lindgren multiple-funnel traps in catching bark and wood boring beetles in southern pine forests. In general, catches of Cerambycidae, Curculionidae, and Buprestidae in dry cups were 40 to 97 percent lower than those in wet cups. In contrast, catches of some Scolytidae (*Ips avulsus* and *Ips grandicollis*) were largely unaffected by cup selection. Our results support the use of wet cups with baited multiple-funnel traps in areas where maximum trap efficiency is required, such as in the detection of exotic insects at ports-of-entry and within quarantine and containment zones.

49 Nowak, John; Asaro, Christopher; Klepzig, Kier; Billings, Ronald. 2008. **The southern pine beetle prevention initiative: working for healthier forests.** Journal of Forestry. 106(5): 261-267.

The southern pine beetle (SPB) is the most destructive forest pest in the South. After a recent SPB outbreak, the U.S. Forest Service [Forest Health Protection and Southern Research Station (SRS)] received SPB Initiative (SPBI) funding to focus more resources on proactive SPB prevention work. This funding is being used for on-the-ground accomplishments, landowner education, and research and development. Since 2003, on-the-ground accomplishments have totaled over 500,000 acres of thinning and restoration work on State, private, and national forest land. The SRS Insects, Diseases, and Invasive Plants Research Work Unit, based in Pineville, LA, has worked, internally and externally, on projects addressing (1) the risks and costs of SPB, (2) preventing and controlling SPB outbreaks, and (3) recovery from SPB outbreaks. Much work has been accomplished through the SPBI and will hopefully have a long-lasting impact. This article describes the history, current practices, and accomplishments for the first 6 years of the SPBI.

50 Pernek, Milan; Hrasovec, Boris; Matosevic, Dinka [and others]. 2008. **Phoretic mites of three bark beetles (*Pityokteines* spp.) on silver fir.** Journal of Pest Science. 81: 35-42. [Editor's note: Southern Research Station scientist John C. Moser coauthored this publication.]

The species composition and abundance of phoretic mites of the bark beetles *Pityokteines curvidens*, *P. spinidens*, and *P. vorontzowi* on silver fir (*Abies alba*) were investigated in 2003 at two locations (Trakoscan and Litoric) in Croatia. Stem sections and branches from *A. alba* trees infested by *Pityokteines* ssp. were collected and incubated in rearing cages. Bark beetles emerging from the stem sections and branches were examined for phoretic mites. A total of 10 mite species were documented for the first time as associates of *Pityokteines* spp. on *A. alba*. The paper discusses the frequency, spectrum, and relative abundance of the species. None of the phoretic mites found in the survey in Croatia appear to have the potential to be

(continued)

used for biological control of *Pityokteines* spp., although the feeding habits are unknown for many species recorded.

51 Shepherd, William P.; Huber, Dezene P.W.; Seybold, Steven J.; Fettig, Christopher J. 2007. **Antennal responses of the western pine beetle, *Dendroctonus brevicomis* (Coleoptera: Curculionidae), to stem volatiles of its primary host, *Pinus ponderosa*, and nine sympatric nonhost angiosperms and conifers.** *Chemoecology*. 17: 209-221.

The western pine beetle (*Dendroctonus brevicomis*), an aggressive killer of ponderosa pine in Western North America, may use volatile chemical odors to differentiate between host and nonhost trees (both angiosperms and conifers) when foraging. Bark extracts from 10 tree species were separated into individual chemical components, using a gas chromatograph, and simultaneously introduced to beetle antennae attached to electrodes and a signal amplifier. Compounds that elicited measurable antennal responses, indicating a beetle's ability to detect a particular odor, may disrupt host attraction and lead to tree protection. The beetles were able to detect over 40 volatile chemicals, underscoring the complex olfactory environment in which they must locate suitable hosts.

52 Zaccarelli, N.; Riitters, K.H.; Petrosillo, I.; Zurlini, G. 2008. **Indicating disturbance content and context for preserved areas.** *Ecological Indicators*. 8: 841-853.

An accepted goal of conservation is to build a conservation network that is resilient to environmental change. The conceptual patch-corridor-matrix model views individual conservation areas as connected components of a regional network capable of sustaining metapopulations and biodiversity, and assessment of contextual conditions in the matrix surrounding conservation areas is necessary for planning. Context is often assessed in terms of fixed-width buffers surrounding conservation areas; but in practice, different locations within the same conservation area experience different contexts. We present an alternate approach for describing the landscape context of conservation areas, and we illustrate the approach by assessing

vegetation disturbance measured by Landsat NDVI changes over a 4-year period for 51 conservation areas in the Apulia region of south Italy. Insights gained from a multiscale assessment of disturbance, coupled with information about land use and habitat mosaics, are necessary to understand the distinctive features of different preserved areas and, thus, to formulate appropriate plans for a regional conservation network to maintain or enhance biodiversity in the region.

Forest Watershed Science

53 Buehler, David A.; Giocomo, James J.; Jones, Jason [and others]. 2008. **Cerulean warbler reproduction, survival, and models of population decline.** *Journal of Wildlife Management*. 72(3): 646-653. [Editor's note: Southern Research Station scientist Paul B. Hamel coauthored this publication.]

Thirteen collaborators combined data on cerulean warbler breeding into this first comprehensive analysis of reproduction and survival in this species of intense conservation concern. Results from Arkansas, Tennessee, Indiana, Michigan, and Ontario suggest potential continuing difficulty for cerulean warblers. Populations in agriculture-dominated landscapes are likely not maintaining themselves absent immigration, while those in forest-dominated landscapes are closer to maintaining themselves. Modeled population growth indicates that much better survival estimates are needed for the species, and that efforts to improve survival during the nonbreeding season would have the greatest positive effect on population growth.

54 Coyle, David R.; Coleman, Mark D.; Aubrey, Doug P. 2008. **Above- and below-ground biomass accumulation, production, and distribution of sweetgum and loblolly pine grown with irrigation and fertilization.** *Canadian Journal of Forest Research*. 38(6): 1335-1348.

Forest plantations grown with various levels of nutrient and water availability aid our understanding of optimal resource requirements. Much of our understanding of resource demand is based on aboveground parts of the tree sampled or on measurements collected

on only one occasion. This study was conducted to evaluate how nutrient and water availability influence above and belowground growth in loblolly pine and sweetgum. It was predicted that more belowground growth would be observed when resources were limited. Such a response was observed for individual sampling occasions; however, this compares developmentally different trees. When developmentally similar trees were evaluated, there was very little difference in the proportion of above and belowground growth. In fact, for loblolly pine an extremely consistent ratio of above to belowground growth was observed, and this consistency was observed among a wide variety of loblolly pine studies. These results aid our understanding growth processes and carbon cycling in forest plantations.

55 De Steven, Diane; Sharitz, Rebecca R. 2007. **Transplanting native dominant plants to facilitate community development in restored Coastal Plain wetlands.** *Wetlands*. 27(4): 972-978.

Methods to restore depressional wetlands in the Southern U.S. usually involve plugging drainage ditches to raise water levels and allowing wetland plants to colonize naturally from soil seed banks. However, the typical dominant grasses may not recolonize because they are absent in the seed banks and cannot disperse easily. We experimentally transplanted rooted sprigs of two vegetative-spreading wetland grasses (maidencane, southern cutgrass) into restored depressions that were left unplanted after hydrology restoration. The simple transplanting methods were successful, as both species attained 15-85 percent cover in 2 years. Planted plots developed greater vegetative cover during early drought conditions and greater cover of wetland plant species after 4 years. Selectively planting dominant species can assist restoration by accelerating plant cover development and creating a vegetation structure similar to natural wetlands.

56 Elliott, Katherine J.; Vose, James M.; Knoepp, Jennifer D. [and others]. 2008. **Simulated effects of sulfur deposition on nutrient cycling in class I wilderness areas.** *Journal of Environmental Quality*. 37: 1419-1431. [Editor's note: Wayne T. Swank, Southern Research Station scientist emeritus, and William Jackson, U.S. Forest

Service, coauthored this publication.]

As a consequence of human land use, population growth, and industrialization, wilderness and other natural areas are threatened by air pollution, climate change, and exotic diseases or pests. Air pollution in the form of acidic deposition is comprised of sulfuric and nitric acids and ammonium derived from emissions of sulfur dioxide, nitrogen oxides, and ammonia. We predicted the effects of altered sulfate (SO₄) deposition on Joyce Kilmer/Slickrock, Shining Rock, and Linville Gorge Wildernesses in western North Carolina using a nutrient cycling model. Although the areas range in soil acidity, nutrient availability, and soil solution and stream chemistry, all three areas have low soil calcium/aluminum (Ca/Al) ratios, low SO₄ retention, and soils are acidic and low in weatherable minerals. Even with large reductions in SO₄ and associated acid deposition, it may take decades before these systems recover from depletion of exchangeable Ca, magnesium, and potassium. These forests are significantly stressed under current conditions.

57 Ford, Chelcy R.; Hubbard, Robert M.; Kloeppel, Brian D.; Vose, James M. 2007. **A comparison of sap flux-based evapotranspiration estimates with catchment-scale water balance.** *Agricultural and Forest Meteorology*. 145: 176-185.

Studies evaluating comparability of sap flux-based estimates of transpiration with alternative methods for estimating transpiration at the landscape scale are rare. Determining and accounting for sources of variation are critical for making landscape inferences about transpiration. We monitored sap flux in 40 trees in a 50-year old eastern white pine plantation for 2 years. We scaled estimates of transpiration and interception to the catchment and compared these with water balance estimates of evapotranspiration. For both years, the two independent estimates were similar, differing by an average of 10 percent. Results indicate that sap flux-based estimates of transpiration may also be useful in mixed-species stands and could provide a tool to evaluate impacts of

species losses on catchment water balance.

58 Jelks, Howard L.; Walsh, Stephen J.; Burkhead, Noel M. [and others]. 2008. **Conservation status of imperiled North American freshwater and diadromous fishes.** *Fisheries*. 33(8): 372-407. [Editor's note: Southern Research Station scientist Melvin L. Warren, Jr. coauthored this publication.]

An expert panel of ichthyologists compiled a list of imperiled (i.e., endangered, threatened, vulnerable) freshwater fishes of North America under the auspices of the American Fisheries Society's Endangered Species Committee. The panel included 700 imperiled fish taxa representing 133 genera and 36 families. The panel regarded about 39 percent of native fish species on the continent as imperiled, including 230 vulnerable taxa, 190 threatened taxa, 280 endangered taxa, and 61 taxa presumed extinct or extirpated from nature. Of fishes listed by the committee as imperiled in 1989, most (89 percent) are the same or worse in conservation status; only 6 percent have improved in status, and 5 percent were delisted for various reasons. Habitat degradation and nonindigenous species are the main threats to at-risk fishes, many of which are restricted to small ranges.

59 Knoepp, Jennifer D.; Vose, James M.; Swank, Wayne T. 2008. **Nitrogen deposition and cycling across an elevation and vegetation gradient in Southern Appalachian forests.** *International Journal of Environmental Studies*. 66(3): 389-408.

We studied nitrogen (N) cycling patterns in several vegetation types and elevations in the Southern Appalachian Mountains to understand the potential effects of climate change and atmospheric deposition on some of the most diverse forests in the US. N inputs from rainfall increased with elevation. In all sites tree canopies retained inorganic N and lost organic N; net canopy effects varied among forest types. High elevation sites had the greatest litterfall N, soil N, soil solution N, and stream N exports. Low stream N exports from low elevation sites suggest they are N limited. Our study suggests that high elevation watersheds are more sensitive to increased N deposition and climate change.

60 Lemly, A. Dennis. 2007. **A procedure for NEPA assessment of selenium hazards associated with mining.** *Environmental Monitoring and Assessment*. 125: 361-375.

This paper gives step-by-step instructions for assessing aquatic selenium hazards associated with mining. The procedure was developed to provide the U.S. Forest Service with a proactive capability for determining the risk of selenium pollution when it reviews mine permit applications in accordance with the National Environmental Policy Act (NEPA). The procedural framework is constructed in a decision-tree format in order to guide users through the various steps, provide a logical sequence for completing individual tasks, and identify key decision points. By utilizing the procedure, NEPA workers can be confident in their ability to understand the risk of aquatic selenium pollution and take appropriate action. Although the procedure was developed for the U.S. Forest Service, it should also be useful to other Federal land management agencies that conduct NEPA assessments, as well as regulatory agencies responsible for issuing coal mining permits. Mining companies will also benefit from the application of this procedure because priority selenium sources can be identified in relation to specific mine-operating parameters. The procedure will reveal the point(s) at which there is a need to modify operating conditions to meet environmental quality goals. By recognizing concerns early in the NEPA process, it may be possible for a mining company to match operational parameters with environmental requirements, thereby increasing the likelihood that the permit application will be approved.

61 Lemly, A. Dennis; Skorupa, Joseph P. 2007. **Technical issues affecting the implementation of U.S. Environmental Protection Agency's proposed fish tissue-based aquatic criterion for selenium.** *Integrated Environmental Assessment and Management*. 3(4): 552-558.

The U.S. Environmental Protection Agency is developing a national water quality criterion for selenium based on concentrations of the element in fish tissue. Although this approach offers

advantages over the current water-based regulations, it also presents new challenges with respect to implementation. A comprehensive protocol that answers the “what, where, and when” is essential with the new tissue-based approach in order to ensure proper acquisition of data that apply to the criterion. Dischargers will need to understand selenium transport, cycling, and bioaccumulation to effectively monitor for the criterion and, if necessary, develop site-specific standards. This paper discusses 11 key issues that affect the implementation of a tissue-based criterion, ranging from the selection of fish species to the importance of hydrological units in the sampling design. It also outlines a strategy that incorporates both water column and tissue-based approaches.

62 Lockhart, Brian Roy; Chambers, Jim L. 2007. **Cherrybark oak stump sprout survival and development five years following plantation thinning in the Lower Mississippi Alluvial Valley, USA.** *New Forests*. 33: 183-192.

Cherrybark oak (*Quercus pagoda* Raf.) stump sprouts were studied for 5 years in a 30-year old plantation thinned to 70–75 percent stocking (light thinning) and 45–50 percent stocking (heavy thinning). Sprouting success, survival, number of sprouts per stump, and sprout height differed little between thinning treatments throughout the 5-year study period. Pre-harvest tree d.b.h. also had no influence on sprout survival and development. A 2-year drought reduced survival and may have influenced sprout development. Sprout clump survival dropped from 90 percent one year following thinning to 46 percent 3 years after thinning. Although sprout height averaged 337 cm 5 years after thinning, annual sprout growth decreased from 166 cm the first year after thinning to 33 cm in each of the last two growing seasons. Results indicated that bottomland hardwood regeneration evaluation models may underestimate the potential of oak stump sprouts to contribute to preharvest regeneration assessments. Further study in the role of stump sprouts to regenerate bottomland oak species is needed.

63 Lockhart, Brian Roy; Gardiner, Emile S.; Stautz, Theran P. [and others]. 2007. **Nondestructive estimation of leaf area for pondberry.** Res. Note SRS-14. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 5 p. [Editor’s note: Southern Research Station scientists Theodor D. Leininger, Paul B. Hamel, Kristina F. Connor, Nathan M. Schiff, A. Dan Wilson, and Margaret S. Devall co-authored this publication.]

Pondberry [*Lindera melissifolia* (Walt.) Blume] is a federally listed endangered shrub found as isolated populations in seasonally flooded forests across the Southeastern United States. Because this shrub is rare, it has received little research attention, and basic knowledge of its ecology and physiology is lacking. To facilitate future ecological and physiological studies on pondberry, we developed and tested a model to predict area of individual leaf blades from simple dimensions that are obtained nondestructively. A linear function, using the product of blade length and width as the independent variable, was found to be the most suitable predictor of pondberry leaf blade area based on correlation coefficients ($r^2 = 0.9956$), plots of actual versus predicted values, and predicted versus residual values. We demonstrate that simple dimensions that are obtained nondestructively, such as blade length and width, can be used to reliably predict leaf blade area of pondberry, but model coefficients should be calibrated for local colonies to improve estimates. Development of this model allows for leaf blade area determination at the plant level without the need to destructively harvest foliage.

64 Lockhart, Brian Roy; Kellum, Jamie E. 2006. **A complex stand on the White River National Refuge: implications for bottomland hardwood old growth.** *Journal of the Arkansas Academy of Science*. 60: 181-184.

Tree species composition was sampled in an old, remnant bottomland hardwood forest in Desha County, AR. The stand has 312 trees ha⁻¹ greater than 10 cm d.b.h. and a mean basal area of 30.4 m²ha⁻¹, values within ranges reported for other bottomland hardwood

old-growth forests. Tree species of greatest importance included sugarberry, sweet pecan, overcup oak, Nuttall oak, and green ash. Observations indicate that this stand is undergoing gap-phase regeneration dynamics. Numerous canopy gaps of various sizes, large coarse woody debris, and patches of even-aged trees indicate that this stand may fit criteria of an uneven-aged forest in the old-growth stage of stand development.

65 Meadows, James S.; Skojac, Daniel A., Jr. 2008. **A new tree classification system for southern hardwoods.** *Southern Journal of Applied Forestry*. 32(2): 69-79.

We describe a new tree classification system for southern hardwoods. It replaces the old system originally developed by John Putnam in 1960. Descriptions of individual tree classes within Putnam’s system are too broad, too subjective, and are poorly defined, which leads to inconsistency among users in the field. Our new system consists of five tree classes used only for sawtimber-sized trees: (1) preferred growing stock, (2) desirable growing stock, (3) acceptable growing stock, (4) cutting stock, and (5) cull stock, and two tree classes used only for poletimber-sized trees: (1) superior poletimber stock and (2) inferior poletimber stock. We use well-defined, objective criteria for the descriptions of the individual tree classes. Our new tree classification system can be used as a basis for planning thinnings and for developing marking rules in southern hardwood forests. Tree classes are used to identify those trees that should be cut and those trees that should be retained during a hardwood thinning operation. Other uses and adaptations of our new system are also described.

66 Rosen, David J.; De Steven, Diane; Lange, Michael L. 2008. **Conservation strategies and vegetation characterization in the Columbia Bottomlands, an under-recognized southern floodplain forest formation.** *Natural Areas Journal*. 28(1): 74-82.

The Columbia Bottomlands along the Texas Gulf Coast represent the westernmost extent of southern floodplain forest. The forests today represent only 25 percent of their presettlement extent, and they are threatened by urban and agricultural

development. Their importance as migratory landbird habitat led to the Columbia Bottomlands Conservation Plan, a multipartner effort to establish a regional network of protected forest sites. By 2007, approximately 8,100 ha in 26 tracts had been conserved. We found the forest composition of a typical tract to be a mosaic of different tree species influenced by floodplain topography, flooding pattern, and soil type. Knowledge of forest composition will help to guide future land acquisitions and to develop approaches for management and restoration.

67 Samuelson, Lisa J.; Farris, Marianne G.; Stokes, Tom A.; Coleman, Mark D. 2008. **Fertilization but not irrigation influences hydraulic traits in plantation-grown loblolly pine.** *Forest Ecology and Management*. 255(8-9): 3331-3339.

Evaluating water demand of managed forest tree plantations is critical for assessing production requirements for bioenergy, pulp and paper, and timber products. Information is limited on how processes controlling tree water use is influenced by soil water and nutrient availability. This study reports on measurements of water demand and other hydraulic properties of loblolly pine stands grown with variable irrigation and fertilization. Individual tree water demand was largely determined by the amount of leaf area in the tree canopy, although sap wood area also had some influence. Loblolly pine grown with high fertility maintained more leaf area and therefore had higher water demand, while irrigation had no positive impact on leaf area and thus little impact on water use. Results of this study will aid predictions of water requirements for pine plantations and products produced from them.

68 Schiff, Nathan M.; Valley, Steven A.; LaBonte, James R.; Smith, David R. 2006. **Guide to the siricid woodwasps of North America.** FHTET-2006-15. Morgantown, WV: U.S. Department of Agriculture Forest Service, Forest Health Technology Enterprise Team. 102 p.

The Siricidae are a family of large, colorful, stingless wasps whose larvae bore into wood. While most species of siricids are of only minor importance in their native forests, exotic species can be

quite damaging. *Sirex noctilio*, a species native to Europe, Asia, and North Africa has been very destructive to plantations of introduced North American pines in several Southern Hemisphere countries. It was so destructive to Monterey pines in Australia and New Zealand that the Australians started a research program in the 1960s to control it. A European nematode, *Deladenus siricidicola*, has proven extremely effective as a classical biological control agent for *Sirex noctilio* in both Australia and New Zealand. In 2005, *Sirex noctilio* was discovered in New York and Canada. A program is being developed to control it, but there are unique problems in North America, the most basic of which is identification of this pest. In contrast to the Southern Hemisphere countries, which have no native siricid species, North America has many siricids, including several that are very similar to *Sirex noctilio*. This guide, including keys and photographic figures, was produced as a reference to help foresters, land managers, students, and all those concerned with our native forests identify North American Siricidae, including the introduced *Sirex noctilio*.

69 Stroh, Chrissa L.; De Steven, Diane; Guntenspergen, Glenn R. 2008. **Effect of climate fluctuations on long-term vegetation dynamics in Carolina bay wetlands.** *Wetlands*. 28(1): 17-27.

In southeastern depression wetlands, water levels are influenced mainly by annual rainfall and are sensitive to droughts. Models suggest that the plant communities will respond to annual hydrologic fluctuation in one of two ways: either cyclic change maintaining herbaceous vegetation, or succession to forest. In seven wetlands, we analyzed hydrologic variation and vegetation change over a 15-year period spanning two drought and reflooding cycles. Wetland drying during droughts led to increased cover of grass, upland, and woody species. Conversely, reflooding resulted in expansion of aquatic and emergent species, and reduced the cover of flood-intolerant woody and upland species. These large semi-permanent wetlands generally exhibited cyclic change, whereas succession to forest may be favored in smaller, shallower depressions. Understanding responses to short-time

climate fluctuation provides a basis for predicting the long-term effects of climate change.

70 Wilson, A. Dan; Lester, Donald G.; Luckenbill, Brian K. 2008. **Control of clavicipitaceous anamorphic endophytes with fungicides, aerated steam, and supercritical fluid CO₂-seed extraction.** *Plant Pathology Journal*. 7(1): 65-74.

A group of fungi known as clavicipitaceous anamorphic endophytes (CA-endophytes) are carried within the seeds of numerous temperate grasses worldwide. These fungi are important because some of them confer beneficial effects (resistance) in their grass hosts to a wide range of insect and disease pests, while others produce powerful alkaloids that are toxic to mammalian herbivores. The presence of CA-endophytes in grasses complicates the evaluation of genetic traits. Thus, endophyte-free cultivars are needed to evaluate agronomic characteristics in the absence of modifying endophytes. Three different control methods were evaluated in this study to determine which treatments could provide significant endophyte control without causing appreciable seed or seedling mortality. Several potential applications of these new technologies for controlling seed-borne fungal pathogens are discussed.



Research Work Units

<i>Location and project leader</i>	<i>Name and Web site</i>	<i>Phone</i>
Athens, GA Ken Cordell	Pioneering Forestry Research on Emerging Societal Changes	706-559-4263
Forest Ecosystem Restoration and Management		
Asheville, NC Cathryn 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		
Gainesville, FL Vacant	Integrating Human and Natural Systems www.srs.fs.usda.gov/trends	352-376-3213
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
Research Triangle Park, NC David Wear	Forest Economics and Policy www.srs.fs.usda.gov/econ	919-549-4093
Threats to Forest Health		
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Longleaf pine on the Harrison Experimental Forest, Saucier, MS. (Photo by John Butnor)



“Linking science and human purpose, adaptive management serves as a compass for us to use in searching for a sustainable future.”

—Kai N. Lee, *The Compass and the Gyroscope—Integrating Science and Politics for the Environment*¹



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Next Issue...

The Southern Research Station maintains 19 experimental forests scattered across the Southeastern United States. Experimental forests were established to represent a specific ecosystem or forest type; many were set up to collect data over decades, even centuries. The experimental forests represent the backbone of Forest Service research, their baseline data invaluable for charting the changes now taking place in the forests of the South. In the next issue of Compass, we'll take a closer look at experimental forests, their history, contributions, and future uses.

Margaret Staunton-Abel, the first professional woman forester in the Forest Service. Photo taken at Bent Creek Experimental Forest, Asheville, NC. (U.S. Forest Service Photo)