COMPASS

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

issue 9

THE MIGHTY OAK

In Upland Hardwood Forests in the South

inside... the science

departments

Cover photo: Spring oak leaves create a mosaic of greens. (Photo by Zoë Hoyle, U.S. Forest Service)

COMPASS
Science You Can Use!

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perspectives and tools to benefit southern forest resources

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

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"Today's mighty oak is just yesterday's nut that held its ground."—*Anonymous*

Oak regeneration plot on the Bent Creek Experimental Forest near Asheville, NC.
(Photo by Rod Kindlund, U.S. Forest Service)

Upland Hardwood Forests in Transition

If only it were that easy.

If you live in the mountain and highland areas of the South, you see oaks all around you every day. You may wonder why we would devote an entire issue of *Compass* to upland hardwood forests, and oak regeneration in particular. Surely the mighty oak is not in danger of dying out?

You might be surprised to find out that upland oak-hickory forests in the Southern highlands have declined by an estimated 70 percent since European settlement. The forests you see today are less than a century old, having grown up after widespread logging and other practices that radically changed forest structure and species composition. Until the early 20th century, the American chestnut was very prominent in upland hardwood forests; by the 1950s, American chestnuts were gone, and oaks had taken the dominant position. Now in their 70s and 80s, this cohort of oaks is aging, becoming more susceptible to death from insects, diseases, and oak decline.

Meanwhile, there's also been a decline in oak regeneration, due to the inability of seedlings that sprout from acorns to grow large enough to be competitive with other species when the overstory on high-quality (moisture, good soil) upland hardwood sites is removed. The problem is that faster growing trees such as maples from stump sprouts and yellow-poplars outgrow the slower growing small oak seedlings. As time goes on, the overstory of the forest becomes dominated by maples or yellow-poplars, and the oaks—which provide food and shelter to a wide range of animals and birds as well as producing high-quality timber—become fewer and fewer.

Oak Regeneration Redux

David Loftis, project leader of the **SRS Upland Hardwood Ecology and Management unit** (upland hardwoods unit), first came to work at the **Bent Creek Experimental Forest** in the 1970s. By then, researchers already knew that even though you might have thousands of new oak seedlings from a good acorn crop, less then 5 percent would survive under a dense canopy of overstory trees. They also knew that if you wanted more oaks you had to increase the light reaching the forest floor enough to promote the growth of oak seedlings, but not enough to stimulate sprouting of yellow-poplars from the seed bank. What they didn't know was just how to do this.

Loftis started designing and setting out studies to look at this question in the mid-1970s and early 1980s, and over time has become the acknowledged expert in oak regeneration in the Southern Appalachians. In the past few years, his unit has expanded across the range of upland hardwood forests into the Cumberland Plateau, and even further west into the highlands of Arkansas. The unit has also expanded into wildlife research as managing forests to provide habitat for different creatures has become a major objective for natural resource managers across private, State, and Federal ownerships.

In this issue of *Compass*, we will explore research studies across the range of upland hardwood forests in the South, looking at silvicultural and wildlife research, as well as combinations of the two. We'll look at a project in Kentucky designed to reduce the damage of an insect pest before it ever arrives, and catch up on the latest news and research about sudden oak death. We'll also offer tips about what you as a resource manager or private landowner can do to promote oaks on your own property.

The Mighty Oak

Oaks are members of the larger beech family of trees (Fagaceae), with its three genera: Fagus *(beech trees proper),* Castanea *(chestnuts and chinkapins), and* Quercus *(oaks). There are almost 600 species of* Quercus, *both deciduous (leaf-shedding) and evergreen trees (such as live oaks) and shrubs.*

In the Eastern United States, upland hardwood stands include scarlet, black, chestnut, red, and white oaks. Scarlet oaks are the fastest growing, and dominate many 100-year-old stands, with white oaks as intermediaries. When scarlet oaks drop out after a century or so, red and chestnut oak dominate for the next century. White oak dominates after 300 years.

The longest lived of oak species in the upland hardwood forests of the Southeast, white oak can live in some settings for 500 or 600 years. In Germany, white oak is managed for veneer on a 600-year rotation.

In the South, white oak grows in association with many other trees: other upland oaks, hickories, yellow-poplar, American basswood, white ash, sweetgum, blackgum, American beech, sugar maple, shortleaf pine, loblolly pine, eastern white pine, and eastern hemlock. The most frequent associates are other oaks and the hickories.

An Oak Regeneration Glossary

advance regeneration: strategy that relies on the presence of an advance regeneration source in the forest understory that persists through a disturbance.

advance regeneration source: large seedlings that must be present in a stand before disturbance and persist through it if regeneration is to take place.

artificial regeneration: process where oak seedlings are outplanted; for situations where there are not enough seedlings from acorns and no advance regeneration source present.

midstory removal: the first phase of a shelterwood cut, when midstory trees and shrubs are killed to allow enough light to promote the growth of oak seedlings—but not enough to promote their competition.

natural regeneration: process that relies on the presence of sufficient oak seedlings from acorns.

release: in shelterwood treatments, the second cut of overstory trees allows young oak trees to grow towards the canopy. Sometimes forest managers use an additional **crown-touching release**, where they remove the competition around the crown of an advancing oak.

shelterwood cut: a regeneration method that removes the overstory of the stand in two or more operations, spaced in time, to allow for the advance regeneration of oaks.

(right) Research forester David Loftis develops silvicultural methods to promote the regeneration of oak on sites where they must compete with faster growing trees such as yellow-poplar. (Photo by Rod Kindlund, U.S. Forest Service)

ALTERED LIGHT:

Regenerating Oak In Upland Hardwood Forests

by Kim MacQueen

SRS project leader **David Loftis** has been intrigued by one of the most important questions in hardwood research—how to regenerate oak—since 1972, when he started working as a graduate student at the **Bent Creek Experimental Forest**. Now his research—along with that of many others—is informing those interested in the same question, whether in the Southeast or beyond.

"We began to recognize a problem with oak regeneration in the Southern Appalachians almost 50 years ago," says Loftis. "Stands being harvested that contained an oak component (usually northern red oak on moist sites), and even stands dominated by oaks on many sites, were regenerating to other species, notably yellow-poplar. Oak was either poorly represented in the new stand or not represented at all."

From an Acorn

Now, thanks to studies by Loftis, earlier researchers at the Bent Creek Experimental Forest, and many other researchers in the East, we have a much better understanding of the oak regeneration process. The first and most important point is that upland oaks, as a group, will only be present in a new stand if competitive oak regeneration sources were present in the previous stand and persist through the disturbance—in this case, harvest. In its simplest form, the process involves three elements:

1. Establishment of new oak seedlings in an existing stand following a good acorn crop
2. Development of those seedlings in the existing stand into regeneration sources that can compete successfully when released
3. Timely and sufficient release from overstory competition

For oaks to regenerate, all three elements must occur in sequence and within a certain time frame. On many sites in the Southern Appalachians and beyond, the lack of oak regeneration appears to result from the failure of the second element—the development of seedlings into competitive regeneration sources—to occur.

"My colleague, retired research forester **Paul Johnson** with the **North Central Research Station** (NRS), literally wrote the book on oak ecology and silviculture," says Loftis. "He suggested that on some very dry sites, development of competitive oak regeneration sources can occur without disturbance, because stand conditions are typically sparse enough to provide enough light for seedling development. Paul coined the term accumulator systems to describe this."

But on most other sites, oak seedlings will not develop sufficiently to be able to compete with yellow-poplar and other species after release without some sort of stand disturbance that alters the light regime in just the right way and for a sufficient amount of time prior to release.

In the Southern Appalachians, very shady conditions under mature stands lead to substantial oak seedling mortality and little growth of the surviving oak seedlings. Treatments that provide too much light, while encouraging the growth of oak seedlings, also promote the establishment and development of competitors such as yellow-poplar.

Part of Loftis' research has involved finding a stand treatment that provides the light necessary for oaks to grow, but retards the establishment and development of yellow-poplar. The treatment resulting from this research, sometimes called an oak shelterwood, leaves the main canopy intact but removes much of the vegetation between the main canopy and the ground. After 10 years or so, the small seedlings that had become established as a result of a good acorn crop have developed into much larger seedlings—the regeneration source—now capable of competing after release.

Cross-Region Ambitions

Attendants at a recent SRS All Scientists meeting talked about the possibility of a future cross-regional oak regeneration study. "The objective of the study we are planning is to test oak regeneration prescriptions across upland hardwood forests in the South, and to determine which prescriptions work and where, with a specific focus on the moisture gradient," says Loftis. "Managers need this information to plan appropriate treatments where the regeneration and maintenance of oak ecosystems helps meet their management objectives."

Loftis commented that some suggested prescriptions for regenerating oak include the use of prescribed fire. "Some people suggest that merely 'returning fire to the ecosystem' will ultimately restore and maintain oak ecosystems, or ecosystems where oak is an important component. **Pat Brose** (NRS) and **Dave Van Lear** (Clemson University) developed a much more specific prescription for the use of fire in oak regeneration. I developed a method

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Forest Openings Grow More Fruit

Fleshy fruit, or soft mast, is a key food resource for wildlife. Unlike many other wildlife foods, fruits are available throughout the year, in seasons when other food sources may be scarce. Both fall migratory and resident winter birds depend on soft mast because it is easily obtained and high in energy. Fruit consumption has also been linked to the survival and reproductive success of several mammals.

Studies have shown a short-term increase in fruit production after natural disturbances such as storms and silvicultural practices such as regeneration cutting. Both reduce plant competition and open gaps in the forest canopy, allowing more sunlight to reach the forest floor. To effectively manage forest land to enhance fruit production, and thus wildlife habitat, we need to understand both the short- and long-term changes in production after a disturbance.

Since 1999, SRS scientists have quantified fruit abundance for 30 genera of plants in both young and mature stands of two common forest types in the Southern Appalachians—drier upland hardwoods and moister cove hardwoods. They found that much more fruit was produced in young stands than in mature forests. In the first 2 years production was similar, but during years 3 to 5 of the study, the younger stands produced 5.0 to 19.6 times more fruit. Due to the fairly stable conditions in mature stands, fruit production remained relatively low and constant.

In contrast, the dynamic process of colonization and recovery in the young, recently harvested stands caused significant changes in fruit production. Adapted to colonize disturbed sites, pioneer species such as pokeweed and blackberry became major fruit producers. Fruit production also increased in huckleberry and stump sprouts of fruit-producing trees. Flowering dogwood, American holly, Fraser magnolia, black cherry, sassafras, and blackgum all produced fruit from stump sprouts within 1 to 3 years. Overall, researchers found that young regenerated stands produce abundant fruit and are an important food source for wildlife.

Wildlife habitat can be significantly enhanced by creating or maintaining openings of young stands within forests. By selecting and leaving a few fruit-producing trees with different seasonal availability, these openings could provide an ideal food source.—*LM*

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Fleshy fruits such as blackberries are a key food resource for wildlife. *(Photo by Chris Evans, River to River CWMA, www.bugwood.org)*

Altered Light

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that does not include the use of fire and seems to be applicable to higher quality sites."

REGENerating More Than Oak

Another component of Loftis' research involves the development of regeneration prediction models. His early work focused on predicting the amount of oak that might be expected, if, at a given point in time, an existing stand were regenerated, based on the oak regeneration sources that already existed in that stand.

"The first step in oak regeneration is to assess the adequacy of oak regeneration sources that are present in the existing mature stand where regeneration is contemplated," says Loftis. "Only then will we be able to compare the amount of oak desired in the new stand with what we would expect based on the prediction."

In his more recent work, Loftis has attempted to develop a more general regeneration model.

"I began to think about a general regeneration prediction model in the early to mid-1980s. It is, in some ways, an extension of my work in oak regeneration and the model I developed to assess oak regeneration potential in the Southern Appalachians."

"The earlier model predicts the amount of oak to be expected in a new stand given the oak regeneration sources that are present in the existing mature stand. But on moist sites that support many species, we need a model that predicts species composition—not just the amount of a single species group."

The newer model, a hybrid that includes both an expert systems component and inputs from empirical models, was designed with regeneration harvests in mind,

but could be applied to other stand replacing disturbances such as wildfires and major weather events. Known as REGEN, the program that implements the model predicts species composition of a new stand created by substantial overstory removal.

While REGEN was developed for the Southern Appalachian region, it can be adapted for use across most ecosystems and tree species.

"The REGEN program is designed to be modified or calibrated for other areas or ecosystems—wherever the underlying concepts seem to provide a reasonable model of the process, and where scientists and managers feel they have enough information to drive the model," Loftis says. "Currently, a version for western Virginia has been calibrated by **Tom Fox** at Virginia Tech and for the northern Cumberland Plateau by **Jeff Stringer** at the University of Kentucky. Within our own unit, **Callie Schweitzer** has been collecting research data for several years that will provide very important information for calibrating and refining the version for the Cumberland Plateau."

In early June, Loftis announced plans to step down from the project leader position to return his focus to regeneration research, effective this fall.

"I will be attempting to do a synthesis of our older regeneration studies, then use that synthesis to explain the working hypothesis for my regeneration model implemented by the REGEN program. And I will be using some newer data from plots I installed in the 1990s to test and refine REGEN," he wrote in a letter to colleagues.

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New Summer Research at Bent Creek

Minigrants Awarded to Local College Students

In spring 2007, the SRS upland hardwoods unit sent out a request for proposals from students and faculty at western North Carolina colleges and universities for summer research projects in the **Bent Creek Experimental Forest**. "Most of the research we do at Bent Creek is long term and involves manipulations at the stand level," says **Henry McNab**, research forester who helped set up the proposal process. "We were looking for small short-term studies that do not require disturbance to answer ecological questions."

Besides expanding the use of the experimental forest for research related to upland hardwood-dominated ecosystems, the grants increase collaborations with local academic institutions and help support the education of future scientists or research by university faculty. Five proposals were selected for this year's season:

Jill Bourdon, Western Carolina University, Cullowhee, NC. Advisor: Dr. Beverly Collins

Location and simulated harvesting effects on the medicinal herb Chamaelirium luteum *(fairywand)*

Brantlee Eisenman, Western Carolina University, Cullowhee, NC. Advisor: Dr. James Costa

Ethology of leaf clipping by caterpillars in Southern Appalachian hardwood forest communities

Christopher Fusting, Warren Wilson College, Asheville, NC. Advisor: Dr. Mark Brenner

Prediction of Cantharellus lateritius *(an edible mushroom) and oriental bittersweet habitat using Global Information Systems (GIS)*

Dr. Mark Yates, adjunct faculty, Warren Wilson College, Asheville, NC.

Habitat occupancy of bat species in Southern Appalachian forests on the Bent Creek Experimental Forest

Conor McGeehan, Warren Wilson College, Asheville, NC. Advisor: Dr. Mark Yates

Effect of distance from roads on the consumption rate and preference for oriental bittersweet and American holly by small mammals

(Photo by Rod Kindlund, U.S. Forest Service)

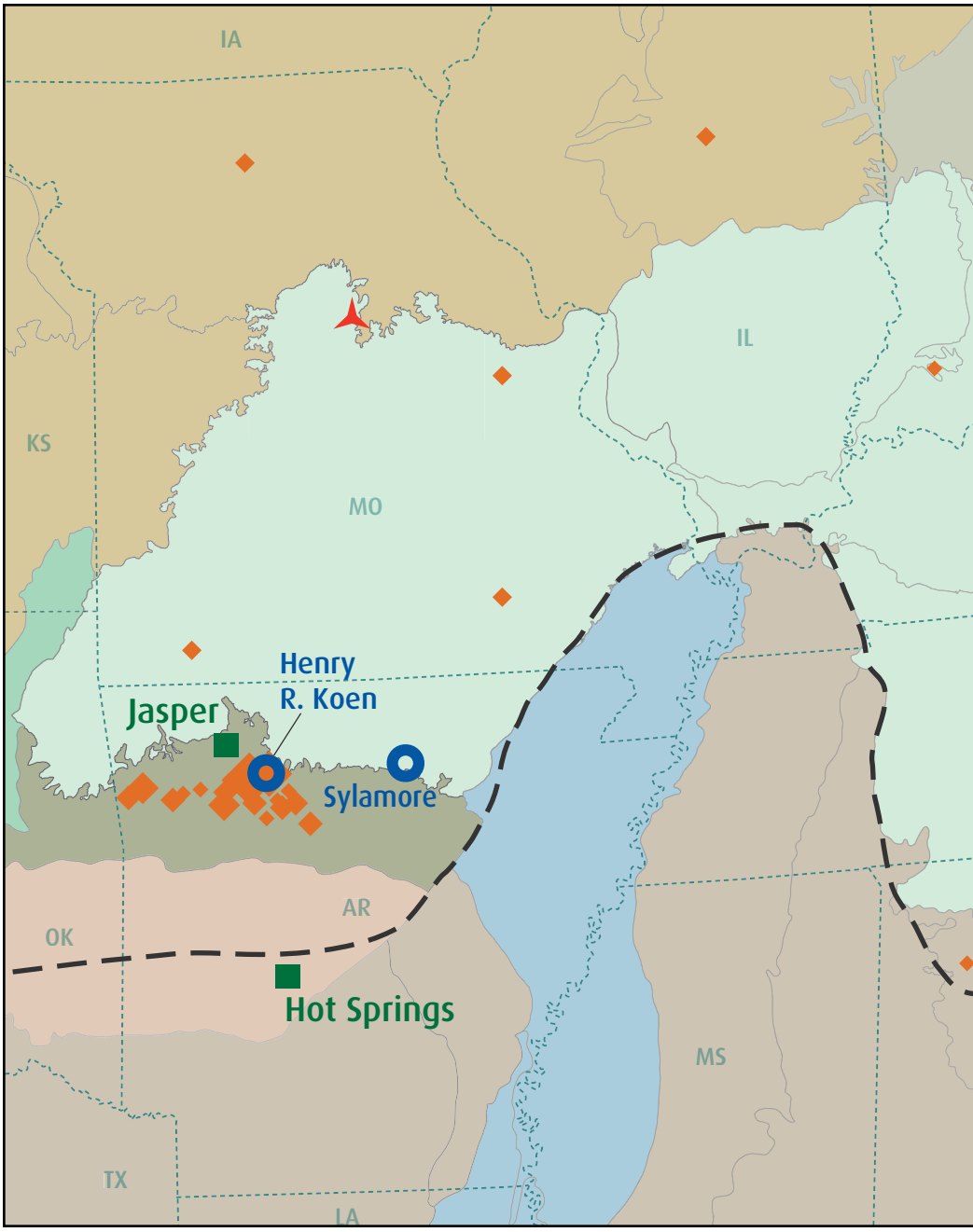
DISTRIBUTION OF UPLAND HARDWOOD FORESTS

Upland Hardwoods Ecology and Management Research Work Unit, SRS

Upland hardwoods unit researchers cooperate with land management agencies across North America to continue to build a comprehensive ecoregion approach to site classification. Ecoregions are defined based on similarities in plant and animal species, climate, soils, and the general topography of the landscape. This method starts with the very broad geographic ecoregions, then focuses on progressively smaller areas—subregions, landscapes, and finally land units. A definitive national ecoregion map was published in 1994. In 2005, a revised national map was produced of ecological subregions that includes digital databases for physical (temperature, precipitation, soils) and vegetation data for each subregion.

Upland Hardwoods Research Work Unit cooperators include:

- University of Kentucky
- Virginia Polytechnic Institute and State University
- Clemson University
- University of Tennessee
- University of Missouri at Columbia
- Alabama A&M University
- North Carolina State University
- University of the South (Sewanee)
- Mississippi State University
- North Carolina Wildlife Resources Commission
- Alabama Wildlife Resources Commission
- The American Chestnut Foundation
- The Nature Conservancy
- Missouri Ozark Forest Ecosystem Project
- Stevenson Land Company
- MeadWestvaco
- Daniel Boone National Forest
- Bankhead National Forest
- Pisgah National Forest
- Ozark-Ouachita National Forest



Eastern Broadleaf Forest

Continental climate of cold winters and warm summers. Annual precipitation is greater during summer, water deficits infrequent. Topography is variable, ranging from plains to low hills along the Atlantic coast. Interior areas are high hills to semi-mountainous, parts of which were glaciated. Vegetation is characterized by tall, cold-deciduous broadleaf forests.

Midwest Broadleaf Forest

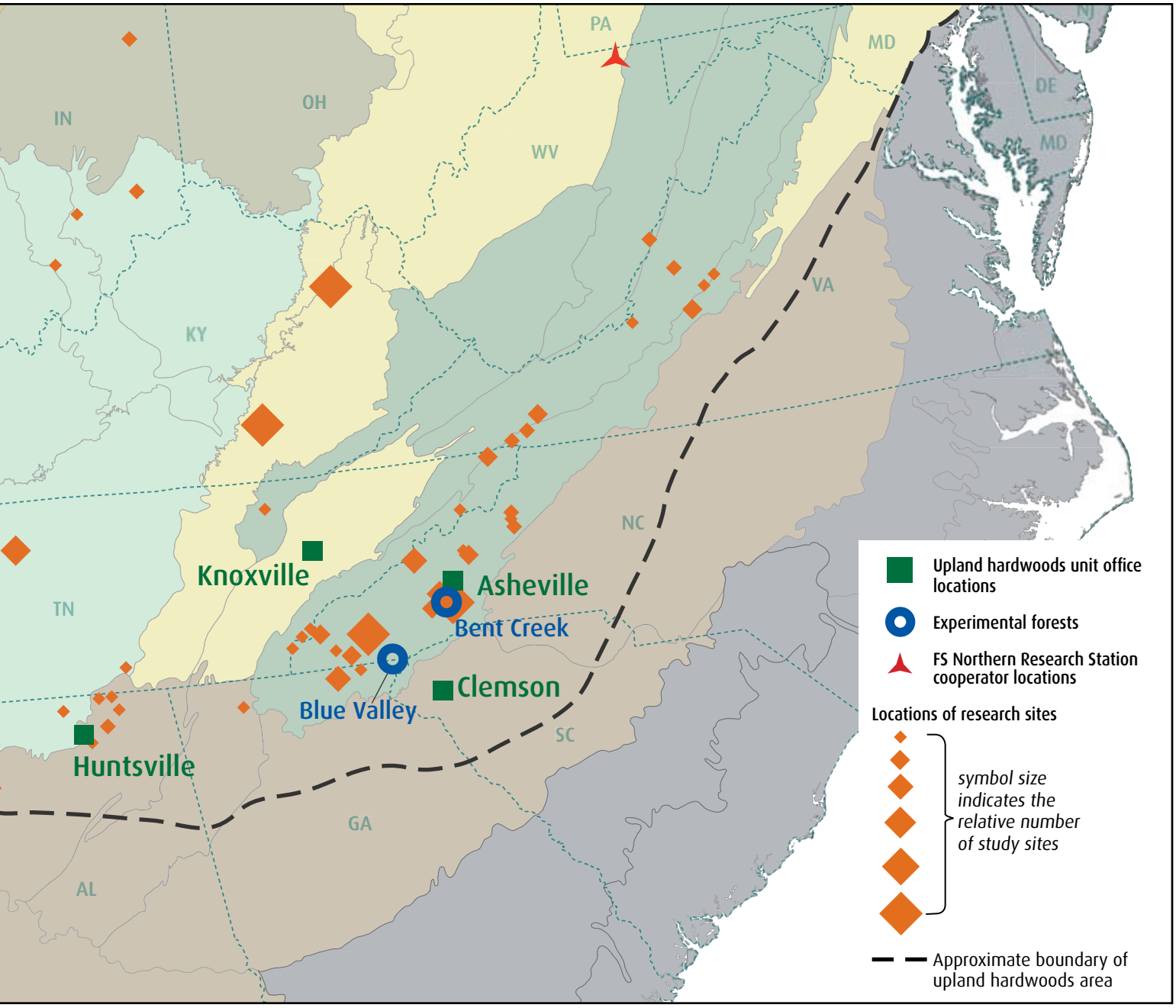
Continental climate with warm to hot summers. Frequent growing season water deficits. Flat to hilly terrain with features associated with former glaciation. Vegetation consists of cold-deciduous, hardwood-dominated forests with a high proportion of species able to tolerate mild, brief, periodic drought during the late summer.

Interior Broadleaf Forest

Continental climate with hot summers. Summer soil moisture deficits are common. Vegetation is broadleaf deciduous forests with a somewhat open canopy and greater density of species tolerant of drought.

Appalachian Broadleaf Forest

Temperate climate with cool summers and short, mild winters. Annual precipitation is plentiful and evenly distributed with short periods of water deficit. Landscapes are predominantly mountainous. Forest vegetation is characterized by a closed canopy of mainly oaks; broadleaf forests change to coniferous or shrub lands at higher elevations. Ice storms are an important broad scale disturbance. High-intensity rain storms are associated with remnants of occasional hurricanes; lightning-caused fires are uncommon.



Boston Mountains

Continental climate with cold winters and hot summers. Landscape is low mountains formed by dissection of sedimentary formations. Forest vegetation is predominately broadleaf deciduous species that can tolerate brief periods of drought.

Southeastern Mixed Forest

Generally uniform maritime climate with mild winters and hot, humid summers. Annual precipitation is evenly distributed, but a brief period of mid to late summer drought occurs in most years. Landscape is hilly with increasing relief farther inland. Forest vegetation is a mixture of deciduous hardwoods and conifers.

Ouachita Mixed Forest

Continental climate, with short, cool winters and long, hot summers. Precipitation occurs throughout year, but summers are dry. Vegetation consists of mixed needle leaf and cold-deciduous broadleaf forests.

Outer Coastal Plain Mixed Forest

Humid, maritime climate; winters are mild and summers are warm. Precipitation is abundant with rare periods of summer drought. Upland forest vegetation is dominated by conifers, with deciduous hardwoods along major floodplains.

Lower Mississippi Riverine Forest

Climate with warm winters and hot summers. Precipitation occurs throughout the year with minimum in fall. Much of this subregion is influenced by periodic flooding of the Mississippi River.

Prairie Parkland (Temperate)

Continental climate with cold winters and hot summers. Moderate amounts of precipitation that occurs mainly during growing season. Landform is mainly plains with areas of low hills. Vegetation was once herbaceous with woodland of scattered deciduous broadleaf trees along floodplains of major rivers; almost all has now been cleared for agriculture.

Prairie Parkland (Subtropical)

Modified maritime subtropical, humid climate of relatively warm winters and hot summers. Moderate amounts of precipitation occurring during summer. Landforms are plains with low hills. Vegetation is mainly herbaceous with areas of deciduous broadleaf woodland, particularly along floodplains.

Research forester Henry McNab.
(Photo by Rod Kindlund, U.S. Forest Service)

Site Quality: What Will Grow Best?

Being able to determine the tree species that grow best on a particular site is a powerful tool for land managers. Conventional methods for determining site quality use tree age and height relationships that are difficult and time consuming to compute—and often result in inaccurate estimates when applied to upland hardwood forests.

Research forester **Henry McNab**, project leader **David Loftis**, and others have developed an alternative method that defines site quality based on the tree species in a stand. "Site quality is defined by where you are on certain gradients, for example, the gradient of dry to moist," says McNab. "There are characteristic sets of species that grow on different parts of the moisture gradient."

McNab and fellow researchers collect data on more than 500 permanent and temporary plots, correlating tree growth to climatic, geological, topographical, soil, and vegetational factors. For a study in North Carolina, the researchers ranked all tree species in relation to their relative moisture requirements and assigned an index value to each species, developing a system that can effectively classify site quality as high, medium, or low.

"Forest managers and private landowners can easily apply the system," says McNab, "If they can identify the tree species present in a stand, they can calculate a moisture index based on the relative moisture values we've determined for each species. From that, they can decide which tree species are best suited to the stand and estimate their growth rate."

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What is Silviculture?

Silviculture is the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis. **Silvicultural prescriptions** or **treatments** are specific, science-based steps designed to achieve specific forest management objectives. For example, if the management objective is to maintain an oak component in a mixed stand, the silvicultural prescription may include reducing the midstory to encourage the development of oak seedlings. Removing the overstory to regenerate a new age class of trees is also a silvicultural prescription, as is thinning in an established stand. The combination of all planned silvicultural treatments is called a **silvicultural system**.

(Photo by Rod Kindlund, U.S. Forest Service)

A Burning Question

Can an Old Tool Help Reshape Upland Hardwood Forests?

by Carol Whitlock

There is a commonly held view about forests in the South. It goes something like this: Before European settlement, a squirrel could travel from the Chesapeake Bay to the Mississippi River without having to touch the ground even once. What often flows from this view is the less supportable belief that natural processes, not human intervention, were responsible for the dense canopy cover that allowed that squirrel to remain airborne.

In fact, findings from recent studies suggest that humans have used fire to manage southern forests for the last 5,000 years, producing a large and healthy oak presence in the uplands, relatively sparse and parklike understory conditions, and abundant game animals. When Europeans arrived bringing the diseases that killed 90 percent of the native populations, they found thriving villages surrounded by fire-adapted landscapes that supported thousands of acres of agricultural lands—all maintained by regular burning.

In the scramble to rebuild southern forests after the abusive logging, grazing, and mining of the late 19th century, forest owners and managers lost sight of the lessons learned from their native predecessors. The last century has seen a rebirth of a very different forest than the Europeans inherited. The once dominant chestnut trees have been eliminated by blight. In some places, fire suppression has left large quantities of highly flammable material on forest floors. Dense thickets of rhododendron and mountain laurel block seedling growth of species, like oak, that are preferred by many types of wildlife. In mixed oak-shortleaf pine forests, white pine is replacing the shortleaf component and shading out the oak component. And reduction of available nitrogen—released when nitrogen compounds are exposed to heat—has resulted both in a decline of overstory trees and in fewer and less diverse understory plants.

Rhododendron "hells" have become common in southern upland forests, invading stands and blocking oak seedling growth. Prescribed burning can reduce the density of rhododendron and help alter forest composition in uplands. (Photo by Carol Whitlock, U.S. Forest Service)

Solutions Needed

These changes in upland hardwood ecosystems have also opened the way for a host of insects and nonnative invasive plants—and have led to renewed interest in prescribed burning among forestry professionals. Prescribed burning has been used even less in the mountains than in other areas of the South because fire behavior is less predictable and smoke management is more difficult in highly variable topographies. However, the situation has reached a point where the ecological and wildfire-prevention benefits from prescribed burning, combined with advances in burning techniques and smoke management, may cause a shift towards acceptance among upland residents—many more of whom are moving into wildfire-prone areas.

Two recent efforts to shift upland forests toward a state that is less stressed and better functioning involve a return to the use of prescribed burning. Both involve research in the mountains of western North Carolina, one at the **Coweeta Hydrologic Laboratory** near Franklin and the other further east at the Green River Game Land near the South Carolina border. Together they paint a comprehensive picture showing the effectiveness of prescribed burning in reducing wildfire risk and the ecological aftereffects of burning on water quality, availability of nitrogen in soils, competing vegetation, and insects, birds, and small mammals.

Coweeta Study

Since the 1990s, Coweeta scientists have taken a multiple landscape approach to applying prescribed fire of varying sources, intensities, and severity—monitoring the effects on carbon cycling, water quality, and vegetation. Treatments include stand-replacement fire (cutting followed

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A Burning Question

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by a prescribed burn that simulates wildfire), low-to-moderate intensity understory burning, and wildfire in old-growth hardwoods.

They found that burning successfully reduces invasive white pines and evergreen shrubs such as mountain laurel with little or no movement of sediments into streams, provided the forest floor is kept intact and vegetation recovery is rapid. Based on these findings, the scientists recommend that fire managers should limit fire severity and size if the goal is to minimize the effects of prescribed burning on water quality, soil nutrient loss, vegetation recovery, and other ecosystem properties.

The restoration work at Coweeta is continuing. In ecosystems that have fallen into decline, scientists are evaluating combinations of treatments such as thinning overstory trees and midstory shrubs followed by prescribed fire and the planting of desirable species.

Green River Study

Ten years after the Coweeta studies began, scientists began new research at the Green River Game Land as a part of the National Fire and Fire Surrogate Study, a network of 13 long-term experiments in different settings across the United States. The purpose of the Green River study was to determine the ecological and economic responses of forests to low-intensity prescribed burning with and without thinning and other mechanical treatments that often serve as surrogates for fire.

The Green River study is ongoing, but **Tom Waldrop**, the SRS research forester who is leading the effort, says that the early results are encouraging. They show that burning and mechanical treatments reduced litter and other forest fuels, which reduce flammability if a wildfire should occur. In addition, organic material in soils increased after prescribed burning. Although mechanical treatments were more effective at removing mountain laurel and rhododendron than fire, oak seedlings from sprouts and acorns increased after prescribed burning.

Jim Hanula, SRS research entomologist based in Athens, GA, reports that an increase in herbaceous plants in the study resulted in increases in a range of insect pollinators including ground nesting bees, wasps and other flies, and even the rare Diana fritillary butterfly, which has been eradicated from parts of its native habitat in North Carolina.

For the same study, **Katie Greenberg**, research ecologist with the SRS upland hardwoods unit, monitored the effects of treatments on breeding birds, frogs, salamanders, lizards, snakes, white-footed mice, and shrews. She found that low-intensity fires increased populations of white-footed mice but had no effect on frogs, salamanders, snakes, and shrews. Among the breeding birds, the only species that decreased in numbers were hooded warblers, which make their nests in shrubs, and worm-eating warblers, which forage and make their nests on the ground and in shrubs.

These studies, while not conclusive, suggest that prescribed burning can have a beneficial effect in upland hardwood forests and the creatures that inhabit them.

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Katie Greenberg at 828–667–5261 (x118) or kgreenberg@fs.fed.us

(left): If the forest floor is kept intact during a prescribed burn and vegetation recovers rapidly afterward, the movement of sediments into nearby streams is minimal. *(Photo by Bill Lea, U.S. Forest Service, retired)*

(left): White-footed mice play important roles in Southeastern forest ecosystems, both as seed dispensers and as prey and predator. Research shows that low-intensity fires lead to increases in their populations in upland hardwoods. (Photo by David Cappaert, Michigan State University, www.bugwood.org)

(right): Research forester Tom Waldrop demonstrates a prescribed burning technique designed to produce predictable and accurate results in the highly variable landscape where upland hardwoods grow. Ping-pong balls filled with combustible chemicals are dropped by a helicopter over the burn site after they've been injected with another chemical timed to ignite after the ball reaches the ground. (Photo by Dr. Vic Shelburne, Clemson University)

Can Fire Help Regenerate Oaks?

It seems as if almost everyone is ready to jump on the prescribed burning bandwagon, with fire as the answer for both reducing fuel loads and restoring ecosystems on forested land. However, a research collaboration between SRS upland hardwoods unit project leader **David Loftis**, University of Kentucky forest ecology professor **Mary Arthur**, and managers on the **Daniel Boone National Forest** (DBNF) suggests that fire management will not provide a simple solution for promoting oak regeneration.

There is ample evidence that fire was a prominent force in the upland hardwood-American chestnut forests of the Southern Appalachian region before Euro-American settlement, as well as during the settlement period. The eradication of the American chestnut shifted hardwood forests towards oak domination; logging combined with fire suppression allowed the rise of shade-tolerant species such as maple and yellow-poplar. Though managers are increasingly looking to fire as a tool to manage oak-dominated forests, data from prescribed burning studies show mixed and sometimes contradictory results.

In 2003, Loftis and Arthur, with the help of Daniel Boone staff officer **Rex Mann**, started a large-scale study to support DBNF fire management objectives of reducing white pines and red maples in the midstories of stands where oak dominates the overstory—and to test the effect of different prescribed burning frequencies on oak regeneration. Supported by two grants from the Joint Fire Science Program (JFSP), the research was designed to look at how single and repeated fires affect stand structure, the light environment, and the response of seedlings to changes in light environment.

Large-scale study areas of 1,000 to 1,200 acres on sites ranging from ridgetops to coves were burned both frequently and infrequently. The project also included small-scale ridgetop sites of 70 to 140 acres where researchers charted the long-term survival of individual chestnut oak, scarlet oak, and red maple seedlings to see if repeated burning on these dry sites would promote oak regeneration. After single and repeated fires, they found a large reduction in stem density and basal area leading to increased light, but this change in light environment was quickly offset by increased sprouting by red maples. After 5 years, the researchers found that the red maple seedlings had higher mortality rates, but showed a larger growth response when compared to oaks.

It is likely that using fire as a management tool in the oak-dominated forests in this region will require long-term burning coupled with burning during periods in the late spring (or possibly in the fall), when shade-tolerant species such as red maple are more easily killed by fire.

The research is in its final year of support from JFSP. Because managing oak-dominated forests with fire will probably require multiple burns over years, if not decades, long-term research in this area is needed. Loftis and Arthur hope to continue to follow the sites into the future in collaboration with managers on the DBNF. *—ZH*

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What Do Foresters Mean By...?

Basal Area Retention

Basal area is the cross-sectional area (in square feet) of the base of the tree measured at breast height (4.5 feet above the ground). For example, the basal area of a tree that measures 14 inches in diameter at breast height (d.b.h.) is about 1 square foot.

Basal area can also refer to the sum of the basal areas of the individual trees within an acre of forest. For example, a well-stocked hardwood stand might have a basal area of 100 to 120 square feet per acre.

When foresters talk about 50 percent **basal area retention**, they mean that half the basal area represented by the standing trees will be cut, the other half retained. In the case above, this would mean cutting out 50 to 60 square feet per acre. This rarely means just going in and cutting half the trees in an area. Depending on the goal of the treatment, this could mean cutting out small diameter trees, large diameter trees, or a combination.

For the intermediate stand treatment on the **Bankhead National Forest** covered in the following article, basal area retention was calculated in terms of **residual square feet** (square feet per acre retained) rather than by percent. For the regeneration studies in Jackson County, AL the researchers reduced basal area by a gradient of percentages, leaving a residual basal area of 0, 25, 50, 75, or 100 percent.

THE FOREST FOR THE TREES

Connecting Silviculture And Wildlife

by Zoë Hoyle

Northern Alabama in early summer is hot and buggy. This summer it's also very dry, the steep banks of the Cumberland Plateau giving off a subtle shimmer of dust. Banks, I said, not mountains.

I'm out in the woods with **Callie Schweitzer**. One of the first lessons she teaches in the field is the difference between the Appalachian Mountains and the Plateau. She raises her hands to demonstrate how the Appalachians were pushed up and together, the Plateau pushed on out. That's why you see the tectonic rocks, layered like overgrown Aztec temples, along the roads.

Schweitzer and **Stacy Clark**, both research foresters with the SRS upland hardwoods unit, are taking us out to three very different sites where they work with a wide range of cooperators to make the scientific connection between silviculture treatments and forest inhabitants—whether they're birds, bats, snakes, frogs, salamanders, or ants. We're starting at a site on the **Bankhead National Forest**, where a total of 180 plots have undergone 9 different treatments—3 levels of thinning, 3 burning frequencies, and combinations of the two.

The purpose here is to remove the loblolly pines planted in the 1970s and move the forest towards an oak-hickory upland hardwood forest. Schweitzer and Clark are also calibrating the REGEN model—developed by **David Loftis** to help managers regenerate hardwood forests in the Southern Appalachians—for the Cumberland Plateau. These same plots host studies on a range of different animals and birds carried out by students from nearby Alabama A&M University (AAMU) under funding from SRS and the National Science Foundation, and under supervision of AAMU associate wildlife professor **Yong Wang**.

A Mantra of Disturbance

Clark is also growing hybrid chestnut seedlings on some of the treatment plots in the Bankhead. One of the things she and Schweitzer want to make clear from the start is what they mean when they talk about restoration and disturbance.

> ***"These are disturbance-dependent systems—whether it's the disturbance of early 20th century logging, storms, or insect invasion; the animals that have taken up residence here are also disturbance dependent."***—*Callie Schweitzer*

"Trying to reestablish chestnut is an example of true restoration," says Schweitzer. "We are literally trying to restore a tree species that has been extirpated to areas where it once grew. Here, we're trying to restore this forest to a certain structure, but not to what it may have been at some particular point in time, say, before European occupation. We have no way of knowing what that was, but we're pretty sure it wasn't static."

Schweitzer has a mantra of disturbance about the forests of the Cumberland Plateau that's applicable to upland hardwood forests across the South.

"These are disturbance-dependent systems—whether it's the disturbance

of early 20th century logging, storms, or insect invasion," she says. "The animals that have taken up residence here are also disturbance dependent. We'll never be able to remove the disturbance from these ecosystems, but we can learn to use silviculture to manipulate disturbance to achieve specific habitat goals. One of the missing pieces is detailed research about animal habitat. That's where the studies by the AAMU students come in."

"But it's silviculture that drives the studies on these sites," she stresses. "We create a disturbance and then look at the effects on specific animals."

One of the plots we visit includes a long aluminum drift fence, really a horizontal funnel that herds snakes and salamanders towards soft traps or white plastic buckets buried in the ground. Graduate student **Bill Sutton** attaches radio telemetry devices to the snakes he traps here, monitoring their movements during thinning operations and fire. This spring, his bucket traps were filled to the brim with salamanders, hard to believe on this hot, dry day. "There's so much we don't know," says Schweitzer. "From preliminary data, we're seeing that salamanders bury down into the forest floor during prescribed burning, which we've found only affects a thin layer of the duff."

Studies on amphibians and reptiles are particularly important; numbers of these animals have been declining worldwide due to habitat alteration and degradation. Forest management alters habitat, but unlike many other land uses, it allows habitat regrowth. Finding out more about these almost invisible animals can help managers learn to manage for their future.

"The more we know about actual habitat and how different animals respond to management activities, the better we can use management to provide habitat for multiple species," says Schweitzer.

Oaks and Animals

The next day we're on the road again, driving up towards the Tennessee border, to research plots in Jackson County, AL. We're on the top of the Plateau near the Walls of

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(below): Research foresters Stacy Clark (left) and Callie Schweitzer (right) on an upland hardwoods regeneration site in the Bankhead National Forest.
(Photo by Rod Kindlund, U.S. Forest Service)

Forest for the Trees

(continued from page 13)

Jericho, a unique formation recently bought by a joint venture between the Nature Conservancy and the Alabama Department of Conservation and Natural Resources. The land the plots are on has been passed back and forth between industry owners, and now belongs to the State of Alabama. We drive down into the forest on a gravel road the locals call "Callie's highway," since it was built to get Schweitzer back into her research sites. On the way down, she points out roadside demonstration sites set up to show different levels of retention cuts. The demonstrations, designed for tours by private landowners and forest managers, are very effective. Looking up from a car, you can easily see the difference between 50 percent retention and a clearcut. That clearcut, by the way, is in its sixth season and already grown up. "The trees were 10 feet tall after the first year," says Schweitzer. "A lot of people wouldn't believe that."

These research sites are Schweitzer's pride and joy, and formed the basis for the studies later installed on the Bankhead National Forest. The road ends, and we walk into a 75-percent retention plot, a pleasant, relatively open forest with a diversity of hardwood species—oak, ash, basswood, sassafras. One of the purposes here is find out how to regenerate oak on good quality sites, where the competition from other tree species such as maple and yellow-poplar is fierce.

The site has some oak seedlings in the understory. The question is how to use forest management to get them to grow up into the overstory, to get the proportion of oak desired for different or multiple purposes. "Here we left the overstory and took out the midstory, except for oak, ash, or persimmon," says Schweitzer. "We followed Loftis' protocol for the midstory treatment, and then installed five different overstory treatments to create five different light levels on the forest floor."

With oak seedlings in the understory, the treatment should have promoted natural oak regeneration—and would have if it weren't for sugar maple. "When they did this experiment at Bent Creek, they didn't have to deal with sugar maple," says Schweitzer.

"Our objective here was to reduce the midstory and allow the small oaks to grow up into a more competitive position. What we did was allow the sugar maples to take the place of the oaks. This brought up the question: What do you do if you don't have the oak seedlings you need for natural regeneration?"

Oaks are advance-regeneration dependent, which means seedlings have to be present on the site before treatment to have a chance of growing into trees. This is in contrast to yellow-poplars and maples, species with a robust seed bank strategy and lightweight seeds easily spread by wind. Schweitzer ended up using artificial regeneration on the site, planting oak seedlings and controlling the midstory competition until, years in the future, the seedlings are competitive enough to be released when the overstory is cut.

There are also chestnut seedlings planted in the understory. Schweitzer and Clark are taking physiological readings on oak and chestnut seedlings under different levels of light on the forest floor, trying to find out where the seedlings use light most efficiently.

Nuthatches and Salamanders

Wang and his students from AAMU have been actively involved on this site studying birds and herpetofauna. They've identified 60 different bird species, and over 40 herpetofauna species, including 11 frogs and toads, 10 salamanders, 5 lizards, 12 snakes, and 2 turtles. One study by graduate student **Lisa Barillas** involves using radioisotope studies to track the origins of birds that stop over in the area during fall migration. Student **Adrian Lesak** analyzes songbird community variation among the five levels of overstory retention. For

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Aluminum drift fence set up to herd herpetofauna—snakes and salamanders—towards soft traps, part of the wildlife studies set up by AAMU collaborators on the Bankhead National Forest. (Photo by Rod Kindlund, U.S. Forest Service)

Rings and Cores

Research forester **Stacy Clark** uses dendrochronology—the study of tree rings—to continue a 23-year old study in Dick's Cove, in Sewanee, TN. Oaks in the cove regenerated after the Civil War, probably from harvesting used to rebuild the nearby University of the South. The forest, part of the 10,000-acre Domain owned by the university, hasn't been actively managed since. Clark is working closely with University of the South forestry faculty member **Scott Torreano** to rebuild the stand's disturbance history.

Gene McGee, project leader for a research unit once housed on the Sewanee campus, started the study in the early 1980s. "McGee noticed that the northern red oaks and hickories in the cove were dying at a faster than normal rate, so he started surveying all the dead trees, taking cores to get their ages," says Clark. "Then he put in permanent plots to tally regeneration and the overstory trees. He confirmed that the trees were dying, but never figured out exactly why."

Two decades later Clark relocated McGee's original plots, resurveying, coring, and restructuring the data to reevaluate the situation on about 70 acres of the cove. She's found an incredible diversity of trees and shrubs: northern red oak, chinkapin oak, American elm, green and white ash, pawpaw, bladdernuts, redbud, deciduous holly, spicebush, blueberries, huckleberries, and many more.

Clark adds her expertise in dendrochronology to the mix, looking at tree rings to take a fresh look at why oaks and hickories were dying in the 1980s, and how the stands are changing in structure over time. "I'm basically reconstructing the stand history through the tree rings, trying to determine both what established the stand in the 1880s and what caused the decline a century later," says Clark. "The data contributes to our overall knowledge of upland hardwood regeneration in the Cumberland Plateau area."

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Dick's Cove, a part of the 10,000-acre Domain owned by the University of South, is home to some of the largest hardwood trees left on the Cumberland Plateau—and is the site of a 23-year research disturbance history study started by Gene McGee in the 1980s and recently reinstated by Stacy Clark. (Photo by Rod Kindlund, U.S. Forest Service)

Research forester Stacy Clark. *(Photo by Rod Kindlund, U.S. Forest Service)*

Forest for the Trees

(continued from page 14)

another study, Wang monitored bark-foraging and cavity-breeding birds on the five treatment sites, looking at activity in relation to the presence of the dead trees foresters call snags.

"When we took out the midstory, we created a lot of snags out here, which we know are really valuable to wildlife," says Schweitzer. "So we wanted to know if all those snags we created—about 400 an acre, we found out—made any difference to wildlife foraging behaviors. Yong and his students found that bark-foraging birds like nuthatches definitely used these sites more than any other. It'll be interesting to follow up with the salamander work."

Managing forests for wildlife depends on learning enough to predict and model habitat, ideally for whole suites of species—and on the larger landscape, for multiple suites of species.

"No species have gone extinct due to forest management," stresses Schweitzer. "With more research, we can learn how to create or maintain good habitat for multiple species. This means doing different things across a landscape, creating a very subtle mosaic of gaps and variations in over-, mid-, and understory that support a wide diversity of plants and animals."

Additional partners and cooperators include: MeadWestvaco, Coastal Lumber Company, Stevenson Land Company, Alabama Department of Conservation and Natural Resources, USDA Natural Resources Conservation Service, Jacksonville State University, University of Kentucky, Western Kentucky University, University of Tennessee, and University of the South.

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A Case in Point: The Cerulean Warbler

The cerulean warbler, so named for the male's sky-blue plumage, is a neotropical migratory songbird. Migrating to the lower slopes of the Andes in August, cerulean warblers return in April or May to build nests and breed in the upper canopy of forests in the Eastern United States. Since 1966, populations of the species have declined an estimated 70 percent, the decline tied to the fragmentation and destruction of habitat in both breeding and winter ranges.

The northern part of Alabama was once considered the southern limit of the bird's breeding range, but until very recently, there had been very few confirmed sightings since the 1970s. In 2002, the cerulean warbler was designated a species of highest conservation concern in Alabama.

In 2002, Alabama A&M University (AAMU) associate wildlife professor **Yong Wang** was working with graduate student **Adrian Lesak** on breeding bird studies on the overstory retention plots SRS researcher **Callie Schweitzer** had established in Jackson County, AL, (see story on p. 12). Lesak had started his drive home one day when, to his complete surprise, he heard the song of a cerulean warbler.

As a result of his observation, the researchers located the first breeding population of cerulean warblers seen in that area since the 1960s. Since then, another breeding population has been found in the Jackson County area; AAMU student **John Carpenter** now studies these populations, which in 2004 numbered almost 30 birds. Further south, in the **Bankhead National Forest**, bird surveys have counted a total of 32 cerulean warblers between 1999 and 2004, mostly in the Sipsey Wilderness Area.

In addition to detailed maps of where cerulean warblers have been found, researchers are able to provide information on the size of their populations, breeding status, and habitat and landscape relationships.

Wang and his students have also started to develop Geographic Information System and statistical models of habitat and landscape characteristics that predict areas where the birds are most likely to be found—information that will help resource managers develop strategies to provide or ensure habitat specifically for the cerulean warbler. **Paul Hamel**, SRS wildlife biologist and national leader of cerulean warbler research profiled in this issue, helped develop this important research.

The work of Wang and his students on cerulean warbler is part of a large-scale wildlife study associated with SRS upland hardwood regeneration research in Jackson County, AL. A sister study on the Bankhead National Forest looks at the wildlife community response to thinning and burning treatments. In addition to birds, studies look at snakes, salamanders, bats, frogs, even ants. Many of these studies are the first of their kind for the southern Cumberland Plateau, and invaluable for making clear the connection between silviculture and wildlife habitat. These research activities have been supported jointly by SRS, the National Science Foundation, the U.S. Environmental Protection Agency, and the Alabama Department of Conservation and Natural Resources. *—ZH*

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Research findings help resource managers create habitat for wildlife such as the Cerulean warbler (Dendroica cerulea), a neotropical migratory songbird. *(Photo © Mike S. Nichols.)*

Return of the American Chestnut?

On the same plots in the **Bankhead National Forest** where the SRS upland hardwoods unit tests different treatments to promote hardwood regeneration, research forester **Stacy Clark** has set out American chestnut and hybrid seedlings to see how well they will do under the different treatments.

American chestnut dominated the forests of the Southeast until most of the mature trees were wiped out by chestnut blight by the 1950s. Though a few mature trees remain, efforts to reestablish the tree have been stymied by the nature of the blight itself. Chestnut blight attacks the tree stem; because the roots remain, sprouts can come back year after year. But the blight also returns, usually killing the tree around the time it starts to flower and before it produces nuts.

Chestnut breeders have been crossing the American chestnut with Asian and European varieties to produce blight-resistant hybrids that look and act as much like the American chestnut as possible. They've managed to produce hybrids that are 94 percent American. The seedlings planted on the Bankhead plots were grown from a mixture of pure American nuts from The American Chestnut Foundation and hybrid nuts containing DNA from four other chestnut species. The study is part of a cooperative agreement with **Scott Schlarbaum**, professor and director of the University of Tennessee's Tree Improvement Program.

Clark and other Forest Service researchers are planting selections of pure American chestnut and hybrids in plots across the Southeast to test their survival. In addition to seedlings on the Bankhead sites, Clark has planted chestnuts on oak regeneration

American chestnut (Castanea dentata). *(Photo by David J. Moorhead, University of Georgia, www.bugwood.org)*

research plots in Jackson County, AL, and will plant more in the **Daniel Boone National Forest** in Kentucky next year.

On the Bankhead, the chestnut seedlings out in the sun in a 25-percent retention plot are doing well. "We're finding that chestnut seedlings grow well out in the full sunlight, but we don't know whether the tree is advance-growth dependent," says Clark. "Does it need to be established before disturbance, or can it come in after? How does it respond to competition? We control the competition now to keep the seedlings alive, but eventually we want to know how we can use silviculture to help restore this tree to the forests of the Southeast." *—ZH*

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There is, of course, much more to say about American chestnut. Stay tuned to a future issue of Compass devoted entirely to SRS research related to the restoration of the tree once known as the "king of the forest."

it's all good

An Interview with Paul Hamel

by Zoë Hoyle

Wildlife biologist Paul Hamel in Stoneville, MS. (Photo by Nathan Schiff, U.S. Forest Service)

Paul Hamel, wildlife biologist with the **SRS Center for Bottomland Hardwoods**, is an acknowledged expert on the cerulean warbler, a bird once common in the hardwood forests of the Eastern United States—now in steady decline. Hamel is a founding member of the **Cerulean Warbler Technical Group**, and is very active in El Grupo Cerúleo, a subcommittee concerned with the activities of the bird in its wintering range in South America .

How did you get interested in birds?

I had to do a book report in the fourth grade, so I picked out the skinniest book I could find in the library, the *Golden Field Guide to Birds*. Around the same time, our local dentist was giving out little cards featuring different kinds of birds for good behavior. It all came together when I was walking home from school one day in that same year. It was a warm day—in Michigan in late winter, that's hard to come by—and cedar waxwings were feeding in the multiflora rose bushes in the park. I knew what they were, from having done that little bit with the bird book. That was 1959, and I have been watching birds ever since.

You seem to have gone from books to nature, rather than vice versa . . .

I was a city kid. Historically, people who end up in this field were often raised on a farm or from families where there was hunting and fishing. For me, it was kind of the other way around. I was raised in Grand Rapids, MI—not a big city, but certainly an urban area, with mass transit. When I was in high school, I joined the Grand Rapids Audubon Club. That's where the first mentors that I remember were. They were local people who birdwatched, and who took me under their wing.

How did you get started in research?

I went to a residential high school in upstate New York. During my sophomore year, I found a book in the library called *An Introduction to Ornithology* written by **George Wallace**, the ornithologist at Michigan State University. They let me check it out for the summer, and I actually read it all over that summer. My senior year I did a breeding bird census project on the grounds of the school and got those data published. It was really fun.

When I started college at Michigan State, there wasn't much doubt in my mind that I was going to be a biologist, but I didn't exactly know what I was going to do. I latched on to different professors, but my curiosity always went towards birds. When I graduated, I had a choice between working with that same professor, George Wallace, or the herpetologist. Southern Michigan is a better place for somebody who studies birds than for somebody who studies salamanders, so I ended up working on birds.

What led you towards your current work?

In 1984, I got a job as the zoologist for the Tennessee Natural Heritage Program maintaining a database of records of rare animals throughout the State. We looked at where these animals might be, the habitat they might use, the kind of environmental features that might indicate where to find them. We were interested in how we could gather those data quickly, and then translate them into useable information for environmental protection. Part of the job was verifying records. I have a predilection for survey work, and I got involved in cooperative projects with other agencies doing what we called natural area surveys, looking in different parts of the State to identify areas valuable for rare species protection that we didn't already recognize or about which we could improve our knowledge.

How did you get into cerulean warbler research with the Forest Service?

In February 1993, **Winston Smith** hired me to work for the Forest

Service at the same place where I am right now—Stoneville, MS. The cerulean warbler project was already in existence before the job came open, and I had been cooperating on it while I was in Tennessee. I had encountered cerulean warblers, in small numbers, in the surveys we did in both middle and west Tennessee. Two people involved in a conference in 1989 in Massachusetts on migratory birds, **Chan Robbins** and **John Fitzpatrick**, had started writing a paper on cerulean warbler because they recognized that the birds were in trouble, and that we didn't know very much about them. I had some data from our work in Tennessee that I could add, so we wrote a paper that was published in 1992.

What inspires you about the research you do?

I don't know, except that it's really fascinating. What immediately popped into my mind when you asked the question is that it seems like Murphy (of Murphy's law) is in charge. In any extended field project, what we thought we understood at the end of the last iteration of activity in some respect no longer applies in the next one. It's fascinating to keep going, and try to understand what may have been underneath the change in perception that occurred. What was it that led to the assumption I had last time that now needs to be changed in light of what I have just observed? In some situations, it just takes time to amass enough information to be able credibly to address questions that may seem so obvious in the early stages that they don't get evaluated carefully.

Can you give me an example?

When I was in Tennessee, I assumed that cerulean warblers had to be in woods that were pristine and untouched, so old-growth forest would be the best place to look for them. And because I believed that to be the case, I was convinced that any sort of forest management would have a negative effect on their environment. That's just wrong. I didn't have enough experience, and I didn't know enough about silviculture. It's been a rich education to be the wildlife biologist in a silviculture unit, where I'm surrounded by people who understand the biology and economics of trees—and to learn things that as a city boy and as an environmental protection specialist I missed out on in terms of the dynamics of forests. Through working with some very smart people in different areas of expertise, I've realized that it's just not true that forest management is bad for cerulean warblers, and in fact, forest management has an important role to play in maintaining habitat on the landscape.

What is that role and how does it play out?

It's really about the interaction between silviculturists and bird biologists. What silviculturists bring is a knowledge of forest growth patterns and ability to manipulate stands of trees from a current condition in terms of species composition and vegetation structure to a more desirable condition that meets specific management objectives, for example, habitat for cerulean warbler. What the bird and salamander people and those interested in other inhabitants of the forest bring is information about how to specify what that desired condition is. Once it's defined, there's the opportunity to work with the silviculturist to devise ways to groom the forest from the current condition to the desired condition. Now, because those of us who are interested in birds have learned something about silviculture, we can have that interaction. I think it's been beneficial in both directions. The role of forest management with respect to cerulean warbler is to maintain the diverse physical vegetation structure that is preferred by the birds.

What's your favorite project?

Whatever I'm doing today ends up being my favorite project. It really is true: I'm fascinated by the work on small mammals while we're doing that, and I'm fascinated by the work on winter bird populations while we're doing that. I'm equally fascinated by the work on rusty blackbirds, cerulean warbler, and on pondberry. It's all good.

What gives you hope?

Two things: One is the interactions possible among diverse groups of people. The Cerulean Warbler Technical Group is an absolutely wonderful example of people working together, with interaction from forest industry, from nongovernmental organizations, from the coal mining industry, from numerous State and Federal agencies, and from universities in North America and South America. That's really hopeful.

The other is the really intense and high-quality interest of Latin Americans in bird study. I see the quality of the science that's being done by colleagues across South America. There are wonderful scientists, young scientists, in these countries, and that's exciting as we watch human population go up and the proportion of landscape in forest go down. It's not an entirely hopeless situation. There is a future.

*Indiana bat (*Myotis sodalis*).* *(Photo by Jerry A. Payne, USDA Agricultural Research Service, www.bugwood.org)*

Southern Bats Like Hardwoods

by Perdita Spriggs

Bats are one of the most numerous and diverse groups of mammals, existing on every continent except Antarctica. The world's current bat fauna represents over 50 million years of adaptation to a variety of environmental conditions and unique niches. The only true flying mammals, bats are fascinating for a variety of reasons, including the ways their bodies have evolved for flight. Millions of years ago, bat forelimbs evolved into wings and their hips rotated 180 degrees, allowing the animals to hang by their feet. Bats also developed the ability to echolocate, or use sound to locate objects and orient themselves in their environment, which helps them navigate through caves and forests as well as locate prey.

There are over 1,000 species of bats, each playing an essential role in their environment—including consuming vast quantities of insects. As an additional perk, bats redistribute nutrients throughout the forest in their guano. Many bat species also feed on pollen and fruit, serving as pollinators and seed dispersers. Though abundant in the United States before 1900, 13 percent of bat species are now at risk of extinction due to human disturbance. Studying and understanding the lifestyle patterns of these animals is essential to reversing species decline.

How Do You Track a Bat?

Researchers at the SRS upland hardwoods unit located in Clemson, SC, are particularly interested in learning more about the lives of bats in the South, where four species—gray bat, Indiana bat, Virginia big-eared bat, and Ozark big-eared bat—are on the Federal endangered species list. Four additional species—Rafinesque's big-eared bat, southeastern myotis, small-footed bat, and Florida bonneted bat—are considered species of special concern.

"Because bats are small, nocturnal, and fly over large distances, they can be very difficult to study," says **Susan Loeb**, research ecologist who initiated SRS bat research in 2000. "However, technological advances over the past 10 to 15 years have opened a new window on their ecology and habitat relationships."

This technology includes very small radio transmitters and field-hardy bat detectors. The tiny transmitters, which are literally glued onto the body of the bat, give researchers the ability to track foraging and roosting patterns. Because bat echolocation calls are species-distinct, researchers can use detectors to identify which bat species are foraging in a particular area. These tools help researchers look at how the landscape affects habitat use, whether bats prefer certain forest types or age classes over others, or if they are affected by silvicultural treatments such as thinning and prescribed fire.

Picky About Habitat

Loeb and her Clemson research team collaborate with other SRS units, universities, and Federal and State agencies to discover more about bat behavior in hardwood forests. Studies in the upper Piedmont and South Carolina mountains have shown that bats use habitats with an open structure, such as early succession or

mature forests, more than forests with cluttered structures. Collaboration with Clemson University on roosting habits of red bats and eastern pipistrelles on the Clemson Experimental Forest have confirmed that both species roost exclusively in hardwoods, primarily oaks and hickories.

Another cooperative study with Clemson University examines the importance of riparian zones and effects of riparian zone management on bat foraging and roosting ecology in upland hardwoods in the **Nantahala National Forest**. Additional research on the effects of silvicultural practices associated with gypsy moth suppression and oak decline on habitat use are being conducted in conjunction with Eastern Kentucky University, Kentucky Department of Fish and Wildlife Resources, and several other research work units.

Bats can be pretty particular when choosing their habitats, especially when selecting roost sites. However, little is known about how forest management affects bat habitat use or selection, particularly in hardwood forests. Some studies in the Midwest suggest that bats prefer to roost in hardwood areas after a prescribed burn. "Bats usually prefer to roost in trees that get a lot of sunlight," says Loeb. "Burning increases light while decreasing clutter in the forest, resulting in more solar exposure and greater access to potential roost trees." Many more studies are needed to determine how forest management activities affect roost site availability, insect abundance, and foraging.

Researchers are also trying to determine whether the decline in some bat populations is due to factors in their summer or winter habitats. Many bats migrate in the spring and fall; some fly less than 50 miles, others

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Research ecologist Susan Loeb takes measurements on a bat captured as part of a night-time "bat blitz" sponsored by the Southeastern Bat Diversity Network.
(U.S. Forest Service photo)

Southern Bats

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over 500. Migration can be very risky; bats go into unfamiliar territory with unpredictable weather and predators—all factors that could significantly reduce their populations. Very little is really known about the migratory patterns of bats; linking summer and winter habitats could help scientists determine factors in each seasonal environment, and potentially both, responsible for population declines. Loeb and colleagues at several universities are currently testing whether a technique called stable isotope analysis can provide more specific information on migratory patterns.

Bat Blitz

Loeb is always on the lookout for new and interesting opportunities to study bats and to open their nocturnal world to natural resource managers, students, and the public. In 2002, she took part in the first annual bat blitz sponsored by the **Southeastern Bat Diversity Network**. Held in the Great Smoky Mountains National Park, the blitz brought together bat enthusiasts from State and Federal agencies, universities, and private industry to exchange information, ideas, and share techniques for studying bats.

"The blitz is an excellent way to inventory the bat community of a specific area," says Loeb. "During a 3-night intensive survey, biologists from around the country network, receive training, and share current research methods." SRS jointly hosted the 2006 blitz with the **Francis Marion** and **Sumter National Forests**, the **Chattahoochee National Forest**, and the South Carolina and Georgia Departments of Natural Resources. The 2007 blitz was held in late summer on the **Cherokee National Forest** in Tennessee.

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Avian Expertise

*SRS research wildlife biologist **Kay Franzreb** has spent almost her entire professional working career working on endangered and threatened bird species. When recently asked what inspires her in her work, she answered, "the opportunity to do something that could impact how the Nation conserves and protects its endangered and threatened bird species and its neotropical migratory birds."*

(Photo by Rod Kindlund, U.S. Forest Service)

Of Fire Scars and Arkansas Oaks

by Kim MacQueen

Arkansas oaks have been under attack for years, on several fronts. Thanks to a 3-year drought from 1998 to 2000 that incited a widespread oak decline event, a lack of periodic fire that has encouraged lesser quality competitors—as well as myriad other causes such as armillaria root fungi, hypoxylon canker (a killing fungus that enters oaks through injuries to the trunk), and a brief but sizeable increase in the native oak borer population—researchers in the areas surrounding the **Ozark National Forest** have documented years of oak distress.

Answers about why that's happening and how to reverse the trend have begun to come in over the past several years. **Martin Spetich**, SRS upland hardwoods research forester based in Hot Springs, AR, is at work tying together a network of 16 studies centering on upland oak forest dynamics in Arkansas. However, some of the best information comes from two centuries in the past, when Native American populations were prevalent and periodic low-intensity forest fires were a regular occurrence.

There are oaks still standing along the Arkansas River that started growing there between 1719 and 1857, during the time the area was inhabited by the Quapaw Indians. Centuries old, the trees sport scars that show they lived through multiple fires, while their competitors burned away. The lack of fire over the last century of fire suppression may help to explain the decline of oaks in the Ozarks and other areas of Arkansas.

Understanding the role of historic fires in these forests is key to understanding how they developed. To learn more, Spetich teamed up with **Richard Guyette** at the University of Missouri to document fire history in the Boston Mountains of Arkansas. Together, they have examined fire history back to the early 1600s, and have been able to identify trends in historic fire frequencies associated with such things as human population fluctuations and long-term climate variability.

An Over-Arching View

Part of the problem with studying Arkansas oak forests is that, like most if not all forests, they're constantly evolving, complex systems. The same can be said, though, of Spetich's method of studying them. When he first began working with the Hot Springs unit in 1998, he inherited a number of forest research studies. Spetich calls these studies his orphans.

"They were excellent research studies, but there was really no way to comprehensively tie them together. Without someone to care for them, they could have gone by the wayside like so many other orphaned studies," Spetich said.

Spetich took the orphans under his wing, then started interviewing land managers and others to see what they needed from existing and future studies. The end result was an overarching keystone study that ties together data from 16 integrated projects that span millions of acres and hundreds of years.

"One of the first things I did, back in 1998, was talk to researchers and resource managers around the State, as well as others involved with management of forests, to find out

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Oaks, People, and Fire

Natural fire regimes vary significantly across the range of upland hardwood forests in the Southeast. In the Southern Appalachians, fire started by lightning is very infrequent. As we move across the map west into Tennessee, natural fire becomes more frequent—and more frequent still as we move into Arkansas and Missouri. In all of these oak systems, fire is often tied to human activity.

Martin Spetich, upland hardwoods unit research forester and vegetation research team leader based in Hot Springs, AR, is working with **Rich Guyette** (University of Missouri), **Mike Stambaugh** (University of Missouri), and **Dan Dey** (**FS Northern Research Station**) to develop fire histories using the scars that show up in the growth rings of trees that have survived fire.

Guyette and other researchers examined fire scar data from more than 40 different sites in Eastern North America to document fire regimes in forests with oak. They found that fire frequency was highly variable across the region and from site to site. Sites that burned as frequently as every 2 or 3 years could be found near others that burned once in 20 years. The fire scar data study showed that the major factors controlling fire frequency were human population density, culture, and drought.

A study Spetich and Guyette conducted on the fire history of the Boston Mountains in Arkansas made the human connection more explicit. In general, the researchers found that fire was more frequent during the period when Native Americans and early settlers were in the area, with large fire years strongly tied to climate conditions, especially drought. Once a certain population density was reached in the 1880s, fire became less frequent, with fire suppression becoming the norm in the following decades. A second study by Spetich, Guyette, and Stambaugh over a larger

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Oaks, People, and Fire

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portion of the Boston Mountains further implicated humans as well as short- and long-term climate variability. This may be the first fire history study to directly link a known Native American population to historic fire.

A third study now underway by Guyette, Stambaugh, Spetich, and Dey examines fire in upland forests throughout the Southeast. In this study, the researchers use fire scars to reconstruct historic fire intervals in deciduous and subtropical forests. They can then use the data to develop models to provide information for areas where fire scar data are not available. This project will help fill both spatial and temporal gaps in the fire scar record and provide information to better estimate mean fire intervals at the national level.—*ZH*

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(Photo by Dave Powell, U.S. Forest Service, www.bugwood.org)

Of Fire Scars And Arkansas Oaks

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what their real needs were in terms of research information," Spetich says. "There were areas where there was a significant amount of research as well as areas where the data didn't really exist. So I used that information to address their needs by filling in research gaps."

The resulting keystone study examines the effect of fire on species dynamics in the Ozark-Ouachita Highlands, analyzing both burned and unburned areas in combination with a number of treatments. When combined with his other, smaller studies, the keystone study will provide both the bug's-eye view (the opportunity to pinpoint specific stand dynamics and understand interactions with other species) and the bird's-eye view (insight into creating sustainability in Arkansas oaks not only now but across time). It encompasses everything from spatial modeling of large forested landscapes hundreds of years into the future to looking at the ability of a single seedling to survive.

"I wanted to look at the whole Ozark-Ouachita Highlands area across both space and time. There are a number of study sites, and we can work on a portion of them each year. The first part is getting initial measurements; the second part is getting the treatments done. And then there are all of the followup measurements. So each year we get to do something new," Spetich says. "I expect to have preliminary information out in the next 4 years, and then about every 5 years for the next 15 years, when all of this will come together in a comprehensive, integrated way."

SRS technicians **Richard Chaney** and **Jim Whiteside** work throughout northern Arkansas forests, with their home base at the **Koen Experimental Forest** established in 1948. "They both grew up here and they really have a thorough understanding of the area. They can describe the oak projects in a way that relates to local culture," Spetich said.

While final results from the keystone study will take, in Spetich's words, "as long as it takes the trees to grow," one thing he's got up and running now is the Oak Understory Success Program, or OAKUS. The interactive, online tool helps foresters better evaluate alternative silvicultural treatments before shelterwood creation and underplanting. *(For more about OAKUS, see page 32.)*

"I kept running into people who were asking for something like this," Spetich said. "It goes back to when I was in school, looking at publications that were coming out, nearly all of them designed for other researchers. There really weren't many publications or tools out there that were written by scientists specifically for land managers."

He said the original idea for all of this goes back much further than 1998 to the early 1960s when he was a kid fishing in Amish country—and to the gratitude he felt for the experiences he had there.

"We would rent a rowboat, and after several hours of fishing out on the lake I would hike through the surrounding forest, finally stopping to sit and just watch the activity of the forest around me. Recognizing the interconnectedness of that activity led to a need to do something with my life that benefited society in an equally meaningful way," he said. "I really wanted to develop this idea of doing research that would benefit both people and the environment in an integrated way. Now I can do that."

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THE GYPSY MOTH INVASION

Can Silviculture Save the Day?

by Zoë Hoyle

There's an enemy making its way into Kentucky. The gypsy moth, originally imported into Boston in 1869 as part of a failed silkmaking experiment, has moved slowly but steadily south and west towards the Southern Appalachians, sapping the strength of its preferred hosts—red and white oaks—leaving them more susceptible to death from oak decline. Gypsy moth infestations currently cover more than 386,000 square miles, with populations found from Maine to North Carolina and west to Wisconsin.

Gypsy moths are expected to arrive in Kentucky in 2010 or later, moving into oak-dominated forests already weakened by oak decline, a "disease complex" that results when tree age, adverse climate, and site conditions combine with stress from disease or insects to push oaks toward untimely death.

In the **Daniel Boone National Forest** near Cold Hill, KY, a team of Forest Service (FS) and university researchers and national forest technicians have started an ambitious experiment to find out whether manipulating the structure of forest stands before the gypsy moth arrives can reduce damage from the pest. Set up as a silvicultural assessment under Title IV of the Healthy Forests Restoration Act (HFRA) of 2003, the project will test the ability of four different silvicultural treatments to improve the health of existing hardwood stands and reduce oak mortality.

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Infestations by the gypsy moth now cover over 386,000 square miles, with populations found from Maine to North Carolina.
(U.S. Forest Service photo, www.bugwood.org)

GYPSY MOTH INVASION

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Callie Schweitzer, research forester with the SRS uplands hardwood unit, coordinates the work among research and national forest personnel setting up the silviculture assessment. This has meant collecting data, selecting stands for the treatments, and keeping the communication going among partners. "Within the next year, the majority of the treatments will be implemented," says Schweitzer. "Then we'll start collecting data on how each treatment affects the structure and species composition of the forest, the ability of oaks to regenerate, and wildlife habitat."

Early Into the Fray

Kurt Gottschalk is all for getting the drop on gypsy moth. Research forester with the FS **Northern Research Station**, Gottschalk has spent over 25 years developing methods to minimize the effects of gypsy moth on oak-dominated forests and to regenerate and rehabilitate them after attacks. He is currently in charge of a Title IV HFRA project on the **Monongahela and Wayne National Forests** in Ohio, an area where the gypsy moth is already resident or expected within the next couple of years. In an ideal world, Gottschalk would like to see treatments in place 4 to 10 years—or even longer—before infestation.

"Preoutbreak treatments focus on reducing the vulnerability of stands by removing the trees most likely to die and regenerating stands that are close to maturity or understocked," says Gottschalk. "The most effective control is active forest management before the gypsy moth arrives. Everything you do after infestation is reactionary."

Gottschalk worked extensively with Schweitzer and others on the Daniel Boone project. "We used some of Kurt's criteria for our initial evaluations of stand health," says Schweitzer. "He also sent his technical staff to the Daniel Boone to help with data collection, and his forester **Dave Feicht** helped develop marking guidelines for several of the treatments."

The situation at the Daniel Boone is complicated by a high level of oak decline, a naturally occurring process that defoliation by gypsy moths speeds up. One round of defoliation will not usually kill a tree, but trees already weakened by age or drought and then stripped of their leaves can be taken down more easily by other organisms such as shoestring root rot or the twolined chestnut borer.

"You can see gypsy moth as a special case, or subset, of oak decline," says Gottschalk. "In some cases, defoliation by the insect collapses mortality that would occur over 10 years into as little as 2 years." Data from the Northeast and Mid-Atlantic show that about 20 to 25 percent of the areas defoliated will have 50 percent or greater mortality.

Treatment Options

Gottschalk and others have outlined three basic options for dealing with impending gypsy moth infestation: do nothing (the most frequently chosen option); alter the susceptibility of the forest by changing species composition; or alter vulnerability by removing dead and dying trees and improving the vigor of remaining trees by altering stand structure.

The Daniel Boone experiment uses four levels of treatments to both improve vigor and promote oak regeneration. The most intensive treatment, shelterwood harvest with reserves, removes all but the largest trees to eventually create two-aged stands. A second option, oak shelterwood, retains more of the overstory. A third option involves thinning to simply reduce stand density with no special attention given to oak regeneration, while the fourth treatment combines thinning to create a grassy, open woodland habitat with prescribed burning to maintain this condition. Control plots with no treatments, the "do nothing" option, will provide data for comparison.

With over 600 acres of experimental plots mapped out, the silvicultural assessment is one of the largest experiments of its kind and includes multidisciplinary studies on wildlife, stand dynamics using tree-ring data, forest harvesting operations, and the potential of using the wood thinned from plots as biofuel.

"We want to come up with specific recommendations for improving oak regeneration under these situations," says Schweitzer. "We also want to be able to specify the harvesting operations needed to reduce impacts to soil, and the prescribed burning prescriptions that will sustain open oak woodland conditions on these sites."

The experimental plots will also be set up as demonstrations areas, where land managers and private landowners can actually see the effects of different silvicultural approaches on oak-dominated forests. **Jeff Stringer**, associate Extension professor at the University of Kentucky, who has already provided funding for data collection and plot preparation, will provide his expertise in technology transfer when the demonstration plots have been installed.

The enemy is still on the way, but the experiments underway will provide new understanding about how managers can help oak-dominated forests weather the storm. "Compared to other invasive insects, gypsy moth is extremely manageable," says Gottschalk. "If we increase the vigor and regeneration capacity of our forests, they can weather the initial attack with relatively little long-term damage."

Other cooperators include: The National Wild Turkey Federation, Rocky Mountain Elk Foundation, Kentucky Forest Industries Association, Eastern Kentucky University, and the University of Tennessee.

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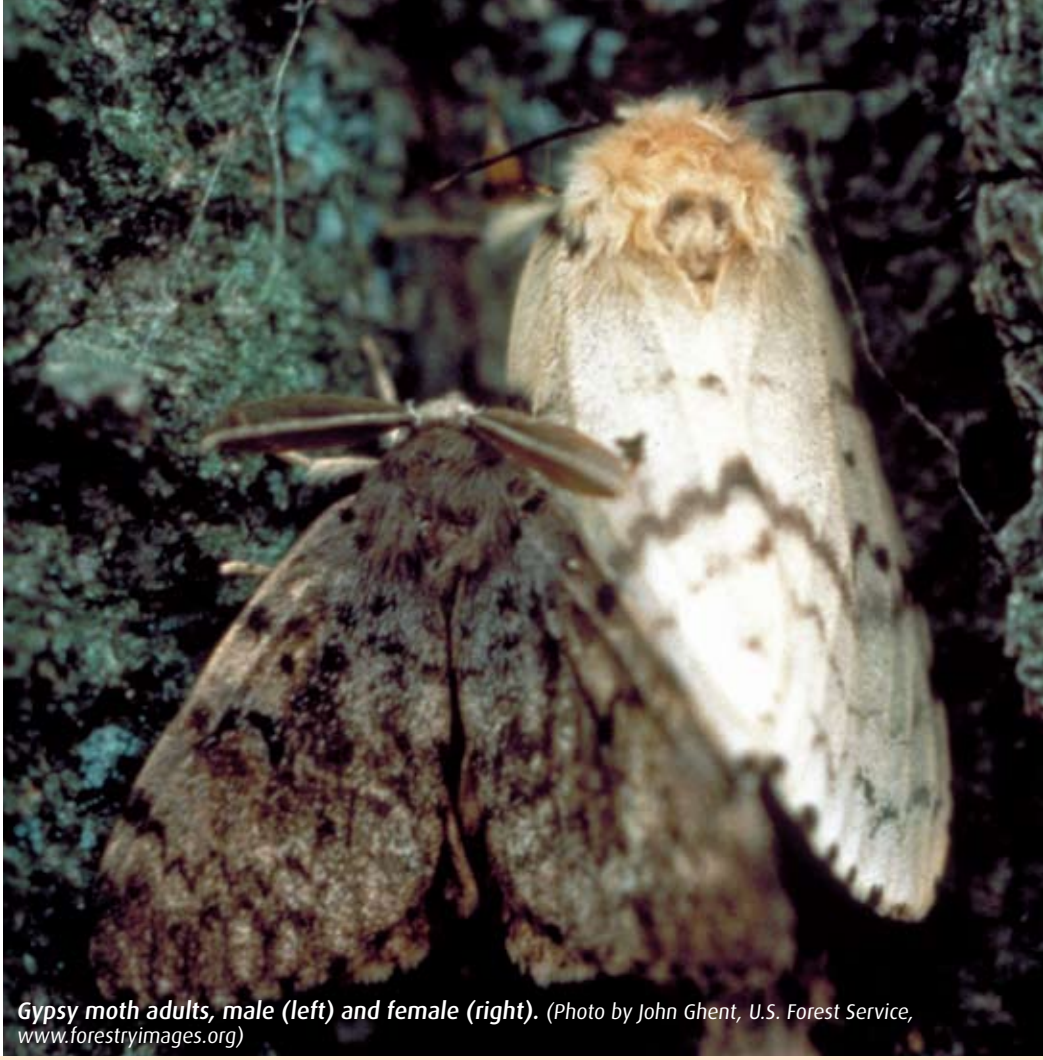

Gypsy moth adults, male (left) and female (right). *(Photo by John Ghent, U.S. Forest Service, www.forestryimages.org)*

Gypsy Moths

Balloonists and Hitchhikers

Gypsy moth (*Lymantria dispar* L.) is a nonnative insect introduced in 1869 into the Boston area, where some of the larvae escaped and spread into New England. The moth has since spread west and south to Ohio, Michigan, and Wisconsin, into the Mid-Atlantic States and south into Virginia and North Carolina.

Female gypsy moths are flightless, so the insects spread slowly. Newly hatched gypsy moth larvae crawl to the tops of trees, where they spin strands of silk they can hang from until the wind "balloons" them to other trees. If this were the only way gypsy moths spread, advancing infestation would be glacial; unfortunately, the insects are also great hitchhikers. Females often lay their eggs on portable objects—vehicles, plant stock, campers, or lawn furniture—which carry them to new locations, sometimes hundreds of miles away.

Gypsy moth caterpillars feed on the leaves of many woody plants; a large buildup of the insects can defoliate whole stands, especially hardwood stands with many of the species the moth prefers. White oaks, followed by other oaks, are generally the species most preferred. Older stands suffer more damage; there is a strong relationship between age, drought, oak decline, and gypsy moth defoliation.

One defoliation will not usually kill a tree, but even healthy trees may become stressed and die if defoliation is repeated for several years. Gypsy moth outbreaks come in cycles which can last 1 to 5 years in oak-dominated stands. After that, gypsy moth populations decline due to buildup of disease, natural enemies, and starvation; populations can remain low for 4 to 12 years before building up again.

The Cumberland Plateau and the Southern Appalachians are considered favorable for supporting large gypsy moth populations; the forests contain many of the species the insect favors. Damage from defoliation could be significant; a majority of the oaks grow on ridgetops and steep south- and west-facing slopes with the infertile soils and low moisture that further stress trees, making them more susceptible to damage from defoliation.—*ZH*

Energy Efficiency

Most experts agree that forest treatments designed to improve tree health in advance of gypsy moth should be done 1 to 3 (ideally 4 to 10) years before the arrival of the pest. Stands not completely recovered from cutting operations may rebound more slowly from gypsy moth infestations. Damage from logging can also attract other insect pests, while dead stumps and root systems attract the organisms that cause root rot.

In May 2007, work started on the treatments for the silvicultural assessment in the **Daniel Boone National Forest** featured on page 25, with a single contractor performing all the prescriptions designed by Forest Service researchers and cooperators. **Callie Schweitzer** and a research team from Huntsville, AL, measured trees and understory vegetation in each area before any harvesting.

As part of the assessment, **Bob Rummer**, project leader of the **SRS forest operations unit** in Auburn, AL, and his team are analyzing traffic patterns of operators in the plots to measure soil disturbance from skid trails. They will also look at residual stand damage such as stem damage from skidders and root damage from operators driving too close to trees. But Rummer is equally interested in finding out if it's cost-effective to truck out the wood harvested from treatments to facilities that can use them for energy production. The basic system the operators are using to collect biomass is different from the conventional, more mechanized systems routinely used for timber management.

Rummer's team has installed Global Positioning System (GPS) monitors to track the movement of machines within plots. The GPS monitors will allow researchers to visually trace the path of every machine so that they can analyze how biomass is collected in relation to traffic on the stand. "We know there will be less traffic in the denser treatments and that it will be concentrated on a few skid trails, but we don't know the cost of getting the wood out to the road," says Rummer. "I suspect that the shelterwood treatment, as the most open, will be the easiest, maybe the most cost-effective, to operate in."

"Operators often chip the wood at road side, which makes it more cost-effective to truck it out as fuel," says Rummer. "In this case, the contractor is taking the wood out to a chipping yard. We're trying to find out what the net energy recovery would be for this type of operation. One of the main obstacles to using wood for energy is transportation costs, generally 50 percent of the total wood cost. That may climb higher this summer." —*ZH*

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For more on the biomass challenge, see Compass, *Winter 2005, available online in PDF format from the Compass archives at http://www.srs.fs.usda.gov/compass/archives.htm.*

Gypsy Moth Host Preferences

Favored: Species preferred or readily eaten by gypsy moth during all larval stages—most oak species, apple, basswood, river and white birch, hawthorn, hazelnut, hornbeam, serviceberry, sweetgum, willows, and witch-hazel

Not favored: Species eaten by some larval stages when favored species not available—American beech, sweet and yellow birch, blackgum, boxelder, buckeyes, butternut, black cherry, chestnut, elms, cottonwood, cucumbertree, hackberry, hemlock, hickories, red and sugar maples, pear, persimmon, most spruces, most pines, redbud, sassafras, sourwood, and black walnut

Avoided: Species rarely eaten by gypsy moth larvae—most ash, most azaleas, baldcypress, catalpa, dogwood, eastern redcedar, American holly, horsechestnut, black and honey locust, mountain laurel, mulberry, rhododendrons, sycamore, and yellow-poplar

Biomass collected as part of the silvicultural assessment project on the Daniel Boone National Forest. (Photo by Jason Thompson, U.S. Forest Service)

sudden oak death

in pursuit of a plant destroyer

By Susan Andrew

Once upon a time in the East, before the arrival of Europeans, an immense forest stood, its leafy canopy dominated by the American chestnut tree. That so-called "climax forest" was changed forever by the introduction of chestnut blight, a fungal pathogen first found in New York City in 1904, having arrived with infected nursery stock from overseas. Once established, the disease wiped out one of the region's most important hardwood species in just a few decades, removing a major food source for countless wildlife species.

The gap created by the disappearance of the American chestnut was soon exploited by oaks. By the middle of the last century, oak species had replaced chestnut as the dominant species in vast areas of the eastern forest, with creatures who had feasted on chestnuts consuming acorns instead.

History has a way of repeating itself. Forest pathologists in the East have reacted with alarm to the threat of a new blight, another nonnative pathogen introduced via nursery stock, this time affecting oaks. The new disease, known as sudden oak death, manifests as bleeding stem cankers, blighted leaves, and twig dieback, and can kill a mature tree in just a few growing seasons. The disease has killed a range of species, including tan oaks and live oaks in California and Oregon. There is no treatment yet available for infected trees; just how the disease unfolds is not completely understood.

PathoProfile

The organism that causes sudden oak death belongs to a class known as the *Oomycetes* or water molds, a group which includes the potato late blight, the disease responsible for the Irish potato famine in the mid-1800s. *Phytophthora ramorum*, or *Pr* for short, gets its genus name from the Greek word for "plant destroyer," and is not to be confused with oak decline, a disease that also affects oak forests in our region. *Pr's* life cycle includes an airborne phase, where spores float aloft until they land on susceptible hosts, particularly where water is available, perhaps where dew has collected in droplets on a leaf surface or shoot. *Pr* apparently survives in soil for long periods, probably an adaptation to survive those times when a host isn't present. After penetrating the leaf surface or bark of its host, *Pr* spreads through host tissue, producing leaf spots, dying twigs, and bleeding cankers on the tree's trunk.

The pathogen was introduced into numerous States in plant nursery shipments, mostly on camellias and rhododendrons, which can serve as sporulators—plants that aren't killed but are sources of reproductive spores. In one of the first known and largest introductions in 2004, 1.5 million potentially infected plants were shipped from a single nursery in California; every State in the United States received potentially infected stock.

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REVEALING THE GENETICS OF A PATHOGEN

If you've ever considered how you'd design a pathogen, consider *Phytophthora ramorum*, the cause of sudden oak death. According to SRS geneticist **Tom Kubisiak**, from the SRS **Southern Institute of Forest Genetics**, DNA markers show that it reproduces clonally (by making identical copies of itself), not sexually. "With a disease organism, that's good news—if there were two mating types, you'd have sexual reproduction and the kind of genetic shuffling that could permit the evolution of increased virulence."

Kubisiak's genetics work includes testing a new detection tool, a rapid diagnostic that can uniquely identify most *Phytophthora* species including *P. ramorum*. From among 10 diagnostic techniques being tested by various labs on a collection of blind samples featuring most of the currently named *Phytophthora* species, the technique was the only one that produced no false negatives and no false positives.

"The technique was able to distinguish *P. ramorum* from every other *Phytophthora* species—and there are many," says Kubisiak. "But there is a caveat. Although it seems to work very well on DNA extracted from cultured *Phytophthorans*, we don't know if it will perform as well on tissue taken from plant hosts showing symptoms of sudden oak death. That's a big difference—a sample full of host DNA and possibly other disease organisms, even other *Phytophthora* species."

Even so, a reliable diagnostic is essential to keep *P. ramorum* from spreading further, and nursery stock from being quarantined. "We don't want nurseries to ship infected material, nor do we want to shut down nurseries on the basis of false test results."—*SA*

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Sudden Oak Death

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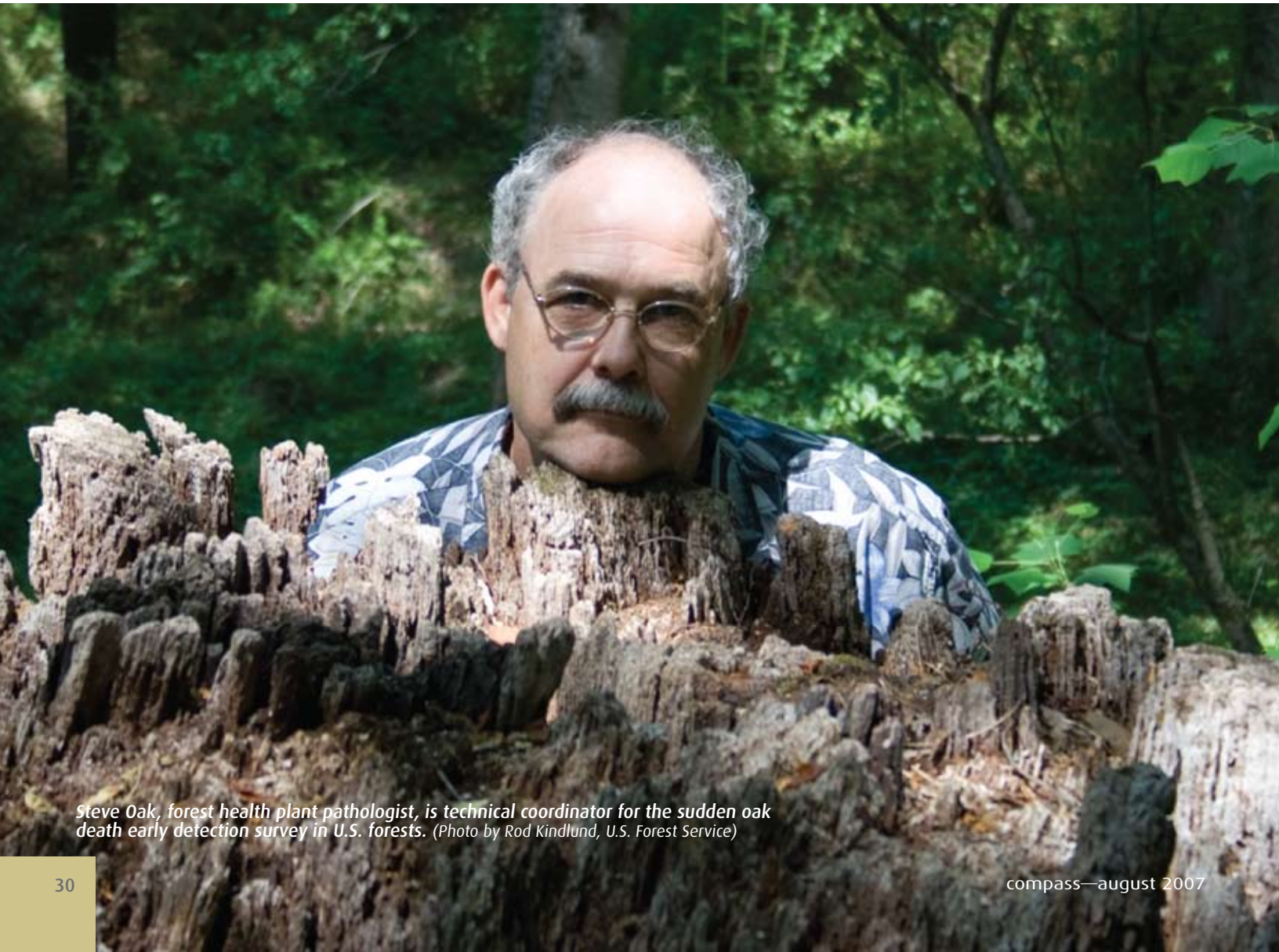
Steve Oak, plant pathologist with the **Forest Service**, **Southern Region Forest Health Protection** unit and technical coordinator for the sudden oak death early detection survey in U.S. forests, cites his informal scratch-pad estimation that perhaps 2,000 to 5,000 infected plants ended up in people's backyards and gardens nationwide. His nightmare scenario: an infected rhododendron planted in a backyard with a stream nearby, a mature oak forest with a rhododendron understory upwind.

"If eastern oaks are susceptible, we'll have a problem," he says, and so he supplied seedlings of nine eastern oak species to be tested with the pathogen at a USDA Agriculture Research Station containment greenhouse at Fort Detrick, MD, by research plant pathologist **Paul Tooley**. The results showed that all nine eastern oak species tested could be infected under optimal conditions—with the caution that those conditions may be hard to find in nature. The pathogen needs a host to support the production of spores; rhododendron (and perhaps other species) will do, while oaks will not.

Location and Opportunity

For the disease to infect and establish, three conditions must be present: (1) hosts, (2) pathways for introduction, and (3) the right environment. Oak, along with **Bill Smith**, coordinator with the **SRS Eastern Forest Threat Assessment Center**, **Frank Koch** from North Carolina State University, and members of the **National Forest Health Monitoring Risk Mapping Team** have produced a map of areas where all three factors are present: potential hosts, favorable environment, and pathways—in this case, nurseries that may have received infected plants. The map provides a set of target areas for field monitoring by a team of State forestry agencies trained by Oak in disease recognition and survey protocols. Smith's data show the Southern Appalachians at high risk for infection, along with a small area on the western part of the Mississippi coast.



Steve Oak, forest health plant pathologist, is technical coordinator for the sudden oak death early detection survey in U.S. forests. *(Photo by Rod Kindlund, U.S. Forest Service)*

In addition, **Pauline Spaine** and **Bill Otrosina** of the **SRS Insects, Diseases, and Invasive Plants unit** in Athens, GA, have come up with a descriptive index of some of the microclimate features believed to be critical to an outbreak—a Sudden Oak Death Infection Index—to estimate when and where natural forests could be susceptible to infection. They collected hourly temperature and humidity values in natural forests, choosing sites where previously published data suggested that temperature and humidity values indicated a level of risk for *Pr* infection. The index can be used to highlight times when the dew point occurs at the optimum temperature for infection for at least 6 hours—times when water would be collecting on leaf surfaces where spores land. Based on their data, Spaine and Otrosina predict that certain areas in western South Carolina and along the Georgia coast, where humidity is high, may be at the greatest risk for *Pr* infection in the future.

Early Detection is Essential

This spring in Mississippi, rhododendron leaves deployed as *Pr* bait downstream from a nursery that received infected nursery stock tested positive for the pathogen. The presence of the pathogen is not the same as a disease outbreak. No such outbreak has yet occurred in wild forests in the Eastern United States. While infected vegetation has not been found in the natural environment, State and Federal forest health professionals continue to intensively monitor this site and other areas in the Southeast that might be vulnerable to sudden oak death.

"The State forestry and agriculture agencies are doing a tremendous job with survey and monitoring," says Oak. "Regulation has been improved and strengthened, but it's still leaky. There are two confirmed cases of *Pr* identified in nurseries in Florida and Mississippi this year so far, but still none found in wild forests anywhere outside of California and Oregon. Still, the take-home message for homeowners and landscapers who want to minimize the risk of introducing *Pr* is to buy locally propagated plants."

If the disease is found through monitoring, current eradication measures call for ringing the affected area with a 100-foot buffer, then cutting and burning all plant material within the ring. "If it shows up simultaneously in 10 States in 100-acre blocks, there's not much that can be done," says Oak. "There are some key questions still to be answered. What is the latent period between introduction and establishment and between establishment and detectable infestation? How much response time do we have between detection and action?"

Though the disease hasn't been detected in eastern oaks, forest pathologists remain vigilant.

"Are we out of the woods yet? No, the resource at risk is too great to let down our guard," says Oak. "Our only hope is early detection, and it would be irresponsible to assume less than the worst-case scenario—another chestnut blight—until we can get more information about the epidemiology in eastern hosts."

For more information:

Steve Oak at 828–257–4322 or soak@fs.fed.us

Bill Otrosina at 706–559–4295 or wostrosina@fs.fed.us

Pauline Spaine at 706–559–4278 or pspaine@fs.fed.us

Susan Andrew is a freelance science writer based in Asheville, NC.

Tanoak showing sudden oak death symptoms. *(Photo by Joseph O'Brien, U.S. Forest Service, www.bugwood.org)*

science science

You Can Use!

If You're Ready to Restore Oaks to Your Forest, Check Out OAKUS

by Livia Marqués

Wouldn't it be great to know how many trees you need to plant to get just one successful tree for your site conditions? Would planting larger diameter seedlings pay off in the end? How much of a difference will controlling competing vegetation really make? If you're ready to underplant oaks but still have questions, the **Oak Understory Success Program (OAKUS)**, can help provide answers.

A collaborative effort of the **Southern** and **Northern Research Stations**, OAKUS allows you to evaluate alternative oak planting and restoration strategies by predicting the future success of various treatment options based on your forest site quality (site index) and other environmental variables. The probability of seedling success is based on the results of an 11-year study conducted by **Martin Spetich**, research forester with the SRS upland hardwoods unit. Spetich found that the probability of success is most impacted by the percent of shelterwood stocking (canopy cover), the control of competing woody vegetation, and the initial diameter of the seedlings.

The likely success of a planted tree, or dominance probability, was determined using a logistic model that integrated the combined effects of the environmental and management variables. Perhaps more significant to resource managers, Spetich found that the reciprocal of this value could be used to determine the number of trees to plant to achieve the desired future stocking level (the number of successful planted oaks per acre).

To take maximum advantage of your investment and meet your management goals, take a look at OAKUS before you underplant. A CD containing the OAKUS program, instructions and examples, as well as a summary of the research is available. To order copies, contact Pearley Simmons at 828-257-4830 or psimmons@fs.fed.us. *—LM*

For more information:

Martin Spetich at 501–623–1180, x105 or mspetich@fs.fed.us.

(Illustration by Rod Kindlund, U.S. Forest Service)

How to Start Regenerating Oak 10 Acres at a Time

Callie Schweitzer encourages private landowners to come out to the demonstrations set up on State land in Jackson County, AL. If you like what you see on the 75-percent retention plot where researchers are experimenting with overstory treatments, here's what you can do:

- Take everything out of the midstory except the oaks.
- Don't create any gaps in the canopy.
- To kill midstory trees, make one hack in the stem for every 3 inches of diameter and spray one small squirt of Roundup™ in the cut.
- Remember, don't kill your midstory oaks!
- Do this little by little all summer long; by the end of the summer, you can have 10 acres treated and give your oak seedlings a chance to make it into the midstory.

New Method to Predict Acorn Crop Sizes

The annual production of acorns in a forest ecosystem directly impacts the regeneration of oak species—as well as the reproduction, survival, and body condition of many wildlife species. Black bears, wild turkeys, ruffed grouse, white-tailed deer, and several small mammals all depend on acorns for food. It's no wonder that State and Federal resource agencies make such a tremendous effort each year to estimate the size of acorn crops, or hard mast production.

Estimates are made using one of several hard mast index methods (HMI) that have been developed by researchers to rate acorn crops on a relative scale. HMIs effectively track patterns of acorn production because they allow for comparisons of crop sizes among years and areas, given the same method is used. Because different agencies use different HMIs, it's difficult to compare acorn crop production among States and regions. HMIs can also be labor intensive and time consuming. There has long been a need to simplify HMI methods and coordinate them regionally, in this case, among the Eastern States.

A Faster, Simpler Method

SRS research ecologist **Cathryn Greenberg** and **Gordon Warburton**, wildlife biologist with the North Carolina Wildlife Resources Commission, have developed a faster, simpler method to estimate acorn crop sizes based on their finding that the proportion of trees bearing acorns alone is a successful predictor of HMIs. Their method, based on 21 years of data from visual acorn surveys, produced similar index values to those generated using the Whitehead HMI method. This similarity allows for continuity between the historic HMI data collected by States and the new Greenberg and Warburton method. If adopted by State and Federal agencies as a standard stand alone index of acorn production, the new method would allow acorn data to be compared and tracked across the Eastern United States. *—LM*

For more information:

Cathryn Greenberg at 828–667–5261, x118 or kgreenberg@fs.fed.us.

(U.S. Forest Service photo)

recommended reading

These publications are available in full-text format from the SRS publications database at http://www.srs.fs.usda.gov/pubs/.

Altered Light

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Loftis, D.L.; McGee, C.E., eds. 1993. **Oak regeneration: serious problems practical recommendations.** Gen. Tech. Rep. SE–84. Asheville, NC: U.S. Department of Agriculture Forest Service, Southeastern Forest Experiment Station. 319 p.

Forest Openings Grow More Fruit

Greenberg, C.H.; Levey, D.J.; Loftis, D.L. 2007. **Fruit production in mature and recently regenerated forests of the Appalachians.** Journal of Wildlife Management. 71(2): 321-335.

A Burning Question

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Hamel, P.B.; Buckner, E.R. 1998. **How far could a squirrel travel in the treetops? A prehistory of the southern forest.** In: Wadsworth, K.G., ed. Transactions of the sixty-third North American wildlife and natural resources conferences. Washington, DC: Wildlife Management Institute: 309-315.

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Schweitzer, C.J.; Loftis, D.L.; Wang, Y.; Janzen, G.C. 2004. **Regeneration potential of selected forested stands on the Cumberland Plateau of north Alabama.** In: Spetich, M.A. Upland oak ecology symposium: history, current conditions, and sustainability. Gen. Tech. Rep. SRS–73. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 269-274.

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Robbins, C.S.; Fitzpatrick, J.W.; Hamel, P.B. 1992. **A warbler in trouble: *Dendroica cerulea*.** In: Hagan, J.M.; Johnston, D.W., eds. Ecology and management of neotropical migrant landbirds. Washington, DC: Smithsonian Institution Press: 549-562.

Southern Bats Like Hardwoods

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(Photo by Rod Kindlund, U.S. Forest Service)

Julia Murphy (right) conducts a teacher's workshop at Bent Creek Experimental Forest.
(Photo by Rod Kindlund, U.S. Forest Service)

EXPERIMENTAL FORESTS
delivering the science, east to west

Since the 1920s, the Forest Service has maintained a system of experimental forests to test hypotheses and collect long-term data about the ecological effects of fire, grazing, insect infestations, air pollution, and other disturbances. In the South, researchers from Federal agencies and universities use 15 active experimental forests for studies ranging from the practices needed to maintain healthy forests, to the water filtration functions of forests, to habitat restoration for endangered species.

Experimental forests are some of the few places in the United States where long-term data are collected about forests and how they change over time. These living laboratories also serve as demonstration sites where cooperators and landowners can see the results of different forest management options.

School in the Woods

Julia Murphy is a busy woman. As forestry technician and certified interpretive guide for the SRS upland hardwoods unit, she works full time on science delivery at the **Bent Creek Experimental Forest** in Asheville, NC, leading tours, setting up workshops and training sessions, and teaching in both the classroom and the field. The experimental forest consists of over 6,300 acres and includes a demonstration forest, where side-by-side silvicultural treatments are set up to show visitors the results of research on upland hardwood ecosystems. Murphy also takes visitors to research sites dedicated to oak regeneration, invasive plants, wildlife habitat, fire, or other natural and human-caused disturbances. As a project for her master's in forestry from Clemson University, Murphy produced a 15-minute film used to welcome visitors to Bent Creek.

Although much of Murphy's work is with forestry professionals and college students, she likes to focus on younger students. She enjoys teaching them forestry techniques like measuring and boring trees, and talking about the importance of forestry management in producing healthy, productive forests to enhance air and water quality.

"So many kids have not stepped foot in a forest. I try to teach them about local native trees so they can identify them in their backyards," Murphy says. "I hope to spark an interest, to make them aware of their natural surroundings. Tree cookies are always a big favorite, and they give me

an opportunity to talk about how big trees grow and the age of forests."

Murphy helps the North Carolina Forestry Association teach a 4-day environmental camp for 250 middle school students at Lake Julian in south Asheville. Working with the North Carolina Forestry Association, she leads a Bent Creek tour for 40 K–12 teachers who visit Federal, State, and private forests.

Summer brings intense use of the experimental forest, including this year's 16th annual upland hardwood silviculture training, geared for State foresters. Course instructors include Forest Service scientists from the **Southern** and **Northern Research Stations** and the **Southern Region's Forest Health Protection** unit. Forest Service professionals from the **National Forests in North Carolina** provide valuable on-the-ground perspective. **Craig Harper**, University of Tennessee, and **Jeff Stringer**, University of Kentucky, bring science into practical focus through their expertise in Cooperative Extension forestry. **Bill Alexander**, landscape and forest historian, leads a tour that combines past and active forest management activities at the nearby Biltmore Estate.

The Cumberland Plateau: Partnerships Are the Way to Connect

As a scientist with the upland hardwoods unit, **Callie Schweitzer** combines her expertise in forest management, her passion for public involvement, and her ability to work with partners who range from academics to forest practitioners. Collaboration is essential in the Cumberland Plateau area, where rapid changes in land ownership are the rule. The ownership of two Jackson County, AL, sites where Schweitzer conducts experiments changed five times in 2 years. To maintain access to her research plots, Schweitzer, who is based in Huntsville, AL, developed a strong partnership with forest industry. **Greg Janzen**, employed by Stevenson Land Company and formerly with MeadWestvaco, has helped facilitate field tours so Schweitzer can educate representatives from the new owners about why research matters. She developed handouts about avian, reptile, and amphibian habitat; artificial regeneration of red oak and American chestnut (which gets everyone's attention); and insect research. She stresses the importance of a mosaic of habitats across landscapes and the use of different forest management strategies—clearcuts, shelterwoods, artificial regeneration—to maintain forest ecosystems.

Schweitzer's collaboration with **Yong Wang**, an avian ecologist and biometrician at Alabama A&M University, has provided additional opportunities to connect with partners who might "fear the timber beast," and to talk about forest management as good for the health of the land and animals as well as for the landowner's pocketbook. "Timber will pay for itself. You can manage for wildlife habitat, medicinal plants, and other forest products, but those things won't pay their way out of the woods," says Schweitzer. "Our message is that you can use timber management to get to other desired results."

Schweitzer's focus on upland hardwoods leads her to work frequently with **Wayne Clatterbuck** at the University of Tennessee and **Jeff Stringer**, University of Kentucky, both professors of Extension Forestry and leaders in the field of hardwood forest regeneration. She and Stringer are researching silvicultural management alternatives on the **Daniel Boone National Forest** in Kentucky, collaborating with **Paul Finke** from the Daniel Boone National Forest.

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What are Tree Cookies?

Tree cookies are not baked goods, not something you want to eat unless you're an insect.

Tree cookies are cross sections of tree trunks that educators use to show how trees grow. Tree cookies are great teaching aids; they show the functions of the different layers of the tree, its age, and health. How the rings have grown can even reveal what the weather was like in a particular year, whether there was drought or a major fire.

(Photo by Rod Kindlund, U.S. Forest Service)

Extending the Reach of Forest Service Science

As an Extension forester for the University of Kentucky, **Jeff Stringer** knows what matters in his State. Using Forest Service research, he develops site-specific programs that Kentucky foresters can use more effectively and efficiently. Stringer takes regional information and factors in local species, stand structure, and markets to deliver science that is more directly applicable to foresters in his area. He organizes professional forestry courses—often distributing publications written by Forest Service scientists—develops training materials, and adds field exercises. He also offers programs targeted for private landowners. As Stringer says, "that's where Extension comes in, addressing local needs."

Stringer also increases the knowledge base available to the Forest Service as an instructor for the upland hardwood silviculture course offered at the **Bent Creek Experimental Forest**. "The expertise of **David Loftis** and **Henry McNab** is working with high-quality stands of timber. That's difficult to apply on low-quality stands, and I have a lot of experience in that area," Stringer says. His involvement with the upland hardwoods course, where he is a perennial favorite among State foresters and other participants, is in response to Loftis' reaching out for a needed expertise. As an offshoot of his work with Bent Creek, Stringer is working with the **Northern Research Station** to develop management materials and workshops for degraded stands. —*CP*

For more information:

Jeff Stringer at 859–257–5994 or stringer@uky.edu.

Cumberland Plateau

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Schweitzer will participate as an instructor for a professional forestry course Stringer is organizing. Schweitzer counts **John Hodges**, emeritus professor of silviculture from Mississippi State University, as another key collaborator.

When Schweitzer moved to Alabama in 2001, she contacted **Gene McGee** and **Glendon Smalley**, scientists with the former **Southeastern Forest Experiment Station**, which operated a laboratory in Sewanee, TN. Since the Sewanee laboratory closed in 1989, Forest Service research hasn't had a formal presence in the area, although Smalley continues his work as an SRS emeritus scientist. Now Schweitzer and research forester **Stacy Clark** teach several classes a year at the University of the South in Sewanee for forestry professor **Karen Kuer**; Sewanee students participate in field tours on SRS research plots, the only access they have to large-scale replicated studies. SRS has two research sites on the 10,000-acre Domain owned by the University of the South—one on old-growth dynamics and another on artificial regeneration of oak.

A Walk in the Woods

Five years ago, Schweitzer started the Cumberland Plateau Walk in the Woods in Jackson County, AL, as a way to foster conversations about natural resources, silviculture, and Forest Service research. "During one tour, I noticed all the birders going nuts about the numbers and varieties of birds," she recalls. "We were in a 3-year-old clearcut with 15-foot vegetation regrowth. So I realized this was a great opportunity to talk about the importance of different habitats for different species. The birds and the bugs really like the open spaces. I wanted them to see that, hey, there might be a role for harvesting. It was a great teachable moment."—*CP*

For more information:

Julia Murphy at 828–667–5261, x104 or juliamurphy@fs.fed.us

Callie Schweitzer at 256–372–4230 or cschweitzer@fs.fed.us

Researcher forester Callie Schweitzer explains how silviculture can be used to create a range of different habitats across a forest stand. (Photo by Rod Kindlund, U.S. Forest Service)

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

Grace Receives International Award

SRS research engineer **Johnny Grace** has received the 2007 Most Distinguished Technical Paper award from the International Erosion Control Association for his research report, *Modeling Erosion from Forest Roads with WEPP*. The paper reports results from an 8-year study which evaluated the ability of the Water Erosion Prediction Project (WEPP), originally developed for agricultural applications, to model erosion and stormwater runoff from forest roads under different management practices. Grace's research compared the amount of erosion estimated by the WEPP to actual erosion rates on 24 roadside slopes in the **Talladega National Forest** in eastcentral Alabama and three road sections in the **Chattahoochee National Forest** in northeastern Georgia. Grace specializes in forest operations research and is located at the **G.W. Andrews Forestry Science Laboratory** in Auburn, AL.

Forest Vegetation Management Article Wins Silvicultural Prize

An article coedited by **Jim Miller**, research ecologist also based in Auburn, AL, has won the Silvicultural Prize awarded by *Forestry: An International Journal of Forest Research* published by Oxford University Press. The Silviculture Prize is awarded annually to the authors of the best silviculture paper published in *Forestry* during the previous 3 years. Coeditor **Phillippe Balandier** from the Team of Applied Ecology of Woodlands based in Clermont-Ferrand, France, accepted the prize in London in April.

The winning paper, "Designing Forest Vegetation Management Strategies Based on the Mechanisms and Dynamics of Crop Tree Competition by Neighboring Vegetation," includes an overview of how forest vegetation management practices influence these components; a synthesis of the literature provides the basis for guidelines for managing forest vegetation to optimize tree crop performance while safeguarding diversity. The article is the result of one of five synthesis projects Miller organized for the forest vegetation management session at the 5th International Weed Science Society Congress held in South Africa in 2004.

International Workshop on Rusty Blackbird

On behalf of the International Rusty Blackbird Technical Group (IRBTG), the **SRS Center for Bottomland Hardwoods** hosted the Rusty Blackbird Workshop

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Rusty Blackbird

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held April 12–13, 2007, at the Delta Research and Extension Center in Stoneville, MS. The 2-day planning session brought together experts to assess research needed to address declines in populations of rusty blackbirds.

The IRBTG, an ad hoc group of biologists from Canada, Germany, and the United States, is interested in understanding the biology and status of the rusty blackbird, whose populations have declined by about 95 percent since the 1960s. The species depends on wetland habitats in Alaska, Canada, and the northeastern lower 48 States for breeding, and winters primarily in bottomland hardwood forests.

Research Forester Tara Keyser is new to the upland hardwoods unit. (Photo by Rod Kindlund, U.S. Forest Service)

Hanula Recognized for Pollinator Research

In May 2007, **Jim Hanula**, research entomologist at the **SRS Insects, Diseases, and Invasive Plants** unit at Athens, GA, received the 2007 Karner Blue Excellence in Pollinator Management award, a national honor for outstanding leadership in the management and conservation of pollinators. Hanula received the award from Forest Service Deputy Chief Joel Holtrop at a ceremony in Washington, DC.

Hanula was recognized for two projects that contributed to greater awareness of and better management for pollinators. As part of a larger national study on the effects of prescribed burning on forest ecosystems, Hanula and collaborators looked at the effects of prescribed burning on pollinators in sites in western North Carolina and the Alabama Coastal Plain. For a second project, Hanula tested two methods of removing the nonnative invasive Chinese privet from riparian forests, showing that both methods resulted in a greater abundance and diversity of pollinators.

Pollinators are essential for reproduction for over 80 percent of flowering plants and include species of birds, bats, butterflies, moths, flies, beetles, ants, and bees.

Research entomologist Jim Hanula's studies on forest pollinators has received national attention. (U.S. Forest Service photo)

New to the Station: Research Forester Tara Keyser

This June, **Tara Keyser**, who recently received her Ph.D. in forestry from Colorado State University, arrived at the **Bent Creek Experimental Forest** in Asheville, NC, to take a position as research forester for the upland hardwoods unit.

As part of her graduate studies, Keyser looked at the changes in forest structure and composition in ponderosa pine forests following a large, mixed-severity wildfire in the Black Hills of South Dakota. Her experience with disturbance dynamics will fit in well with the work at Bent Creek, and she will take the lead in several parts of a new oak regeneration study that will involve sites across the SRS region.

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Tara Keyser

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"I identify myself as an applied ecologist who combines perspectives from disturbance ecology and forest management to answer practical questions about managing resources for multiple goals," she says. "The Southern Appalachian forests, with their complex species composition and history of disturbance, will be a good place for me to continue to look at how different species grow and respond in response to various natural and human-caused disturbances."

Chad Keyser, a forester/biometrician with the **Forest Service Forest Management Service Center** in Fort Collins, CO, and Tara's husband, arrived with her. While his duty station is now in Asheville, NC, he will continue to work with his Colorado-based unit on the Forest Vegetation Simulator (FVS), an individual-tree forest growth model widely used to support forest management decisionmaking. He is part of a specialized staff that focuses on model development and maintenance as well as provides FVS technical support and training throughout the United States.

Station Director's Awards Presented

SRS Director **Pete Roussopoulos** recognized outstanding contributions from SRS groups and individuals during a ceremony in Asheville on May 18, 2007.

Natural Resource Stewardship Award

Ken Cordell, Pioneering Scientist, Athens, GA

For providing and continuing national research on off-highway vehicle recreation that addresses the Chief's unmanaged recreation threat, in support of the Final Rule on Routes and Areas for Motorized National Forest Use

Global Stewardship Award

Carl Trettin, Supervisory Soil Scientist, Charleston, SC

For advancing research and education on the sustainability of managed and restored wetlands

Distinguished Science Award

Kurt Johnsen, Team Leader, Research Triangle Park, NC

For exceptional contributions to the field of forest physiology, with particular attention to carbon accumulations, allocation, and sequestration under ambient and increased levels of carbon dioxide

Early Career Scientist Award

Wendell Haag, Fishery Research Biologist, Oxford, MS

For high productivity of quality research on freshwater mussels as an early-career scientist with the Aquatic and Terrestrial Fauna Team, Center for Bottomland Hardwoods Research

Technology Transfer Award

H. Michael Rauscher, Retired

For innovation, vision, and persistence in the conception, design, and implementation of the Forest Encyclopedia Network

Natural Resource Leadership Award

Craig Roghair, Fishery Biologist, Blacksburg, VA

For leadership in creating and delivering solutions to aquatic management problems through the Center for Aquatic Technology Transfer

Multicultural Organization Award

Bernard Parresol, Mathematical Statistician, Asheville, NC

For leadership in providing support to the Station's diversity goals through outreach activities and bringing cultural awareness to the workplace

Partnership Award

Devendra Amatya, Research Hydrologist, Charleston, SC

For vision, initiative, and effectiveness in establishing the Turkey Creek research partnership, an important foundation of the Station's watershed sciences program

Excellence in Providing Business Operations Support Award

The Administrative Realignment Team

For successfully achieving the team goals of bringing together functions that required collaboration and related skills, clarifying roles and responsibilities, and creating clear accountability and continuity for delivering administrative services

Research Technical and Professional Support Award

Julia Murphy, Forestry Technician, Asheville, NC

For extraordinary efforts in implementing the recreation visitor use study on the Bent Creek Experimental Forest

Customer Service Award

Mark McDonough, Assistant Station Engineer, Asheville, NC

For providing exceptional customer service to the Southern Research Station, technical support to the Management Team, and reengineering efficiencies

Early summer at SRS Headquarters (Photo by Rod Kindlund, U.S. Forest Service)

NEW PRODUCTS

natural resources inventory and monitoring

1 Brown, Mark J.; New, Barry D.; Oswalt, Sonja N. [and others]. 2006. **North Carolina's forests, 2002.** Resour. Bull. SRS-113. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 63 p.

In 2002, forests covered 18.3 million acres in North Carolina, of which 17.7 million were classified as timberland. Hardwood forest types prevailed on 72 percent of timberland; planted pine stands occupied 15 percent. Nonindustrial private forest landowners controlled 78 percent of timberland, forest industry holdings declined to 8 percent, and publicly owned timberland totaled 13 percent. Volume of live trees totaled 33 billion cubic feet, 66 percent of which was hardwood. Planted pines made up 3.1 billion cubic feet. Loblolly pine dominated, with 6.7 billion cubic feet. Net annual growth of live trees averaged 1.2 billion cubic feet, and annual removals averaged 1.2 billion cubic feet. Softwoods made up 51 percent of growth and 59 percent of removals. Softwood removals exceeded growth by 105 million cubic feet, whereas hardwood growth exceeded removals by 104 million cubic feet. There were 249 sawmills, pulpwood mills, and other primary wood-processing plants across the State. The Coastal Plain accumulated more fuels than other regions of the State due to hurricane impacts on coastal forests.

2 Conner, Roger C.; Sheffield, Raymond M. 2005. **Analysis of the timber situation in Florida, 1995 to 2025.** Res. Pap. SRS-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 17 p.

Demand for wood fiber nationwide is expected to increase in the foreseeable future. Harvesting restrictions on forest lands in the West have increased pressure on the South's forest resources to provide more wood. The ability of Florida and other Southern States to respond is uncertain. The authors describe the

current extent, condition, and availability of Florida's timber resource and project levels of growing-stock volume, net annual growth, and annual removals to the year 2025. They base projections on future timber demand, as represented by harvest requests. Overall, projections suggest that Florida is well positioned to meet increased demand for wood, in spite of an expected shortfall of available southern yellow pine volume on forest-industry timberland by 2010. However, crucial factors influencing future timber availability in Florida include retaining the current timber base and working with ever-changing public sentiments about forest-management practices.

3 Johnson, Tony G.; Bentley, James W.; Howell, Michael. 2006. **The South's timber industry—an assessment of timber product output and use, 2003.** Resour. Bull. SRS-114. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 52 p.

In 2003, industrial roundwood output from the South's forests totaled 8.2 billion cubic feet, 6 percent less than in 1999. 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 3.7 billion cubic feet; pulpwood ranked second at 3.3 billion cubic feet; veneer logs were third at 830 million cubic feet. The number of primary processing plants declined from 2,551 in 1999 to 2,281 in 2003. Total receipts declined 5 percent to 8.3 billion cubic feet.

4 Oswalt, Christopher M.; Oswalt, Sonja N.; Clatterbuck, Wayne K. 2007. **Effects of *Mictostegium vimineum* (Trin.) A. Camus on native woody species density and diversity in a productive mixed-hardwood forest in Tennessee.** Forest Ecology and Management. 242: 727-732.

In a recent study conducted by scientists at the U.S. Forest Service, Southern Research Station, Forest Inventory and Analysis unit and the University of Tennessee, researchers noted that the invasive non-native grass, Nepalese browntop *(Microstegium vimineum)* may significantly impact tree regeneration and woody seedling diversity following disturbance. The study, conducted on the Ames Plantation in Tennessee, examined the response of the grass to three levels of canopy disturbance associated with tree harvests. High levels of soil and canopy disturbance resulted in the formation of grass "mats" that negatively impacted the successful establishment of tree seedlings, consequently reducing regeneration success and woody seedling diversity. Additional studies continue to investigate the impacts and mechanisms of Nepalese browntop establishment and spread.

5 Pollard, James E.; Westfall, James A.; Patterson, Paul L. [and others]. 2006. **Forest Inventory and Analysis national data quality assessment report for 2000 to 2003.** Gen. Tech. Rep. RMRS-GTR 181. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 43 p. [Editor's note: David L. Gartner, Southern Research Station scientist, co-authored this publication.]

The Forest Inventory and Analysis's quality assurance program includes measurement quality objectives (MQO) for each measured variable. These MQOs consist of a measurement tolerance and a requirement compliance rate. The efficacy of these MQOs was tested by comparing data from blind check plots where a quality assurance crew measured the plot without knowledge of the first field crew's results. These QA data were collected between 2000 and 2003 and analyzed for measurement precision between FIA crews. This report is a national summary of MQO analyses. Results for each regional analysis are presented in appendix tables.

forest ecosystem restoration and management

6 Bridgwater, F.E.; Nelson, C.D. 2006. **Biotechnology in the Southern Research Station: A problem analysis.** Gen. Tech. Rep. SRS-96. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 35 p.

We provide an analysis of opportunities and challenges for biotechnology in forest research in the Southern United States. Major areas of biotechnology were identified, described, and rated for priority among three groups of researchers—private sector, public sector, and the U.S. Forest Service, Southern Research Station (SRS). We concluded that these groups have different research priorities with respect to biotechnology and that these differences complement each other. In particular, the SRS should continue its work in molecular marker technology development for applications in tree improvement, conservation genetics, forest health, and basic science. Also, the SRS should increase its efforts in genomics/bioinformatics, while decreasing its research on vegetative propagation. Finally, the SRS should work on assessing potential risks and impacts of planting and managing clones and/or genetically modified trees.

7 Buckley, David S.; Clatterbuck, Wayne K. (eds.) 2007. **Proceedings, 15th central hardwood forest conference** [CD-ROM]. e-Gen. Tech. Rep. SRS–101. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 770 p.

This proceedings of the 15th central hardwood forest conference held February 27–March 1, 2006, in Knoxville, TN, includes 86 papers and 30 posters pertaining to forest health and protection, ecology and forest dynamics, natural and artificial regeneration, forest products, wildlife, site classification, management and forest resources, mensuration and models, soil and water, agroforestry, and fire.

8 ECOMAP. 2007. **Delineation, peer review, and refinement of subregions of the conterminous United States** [CD-ROM]. Gen. Tech. Report WO-76A. Washington, DC: U.S. Department of Agriculture, Forest Service. 11 p. [Editor's note: Station scientist W. Henry McNab co-authored this report.]

This work briefly describes the background of the U.S. Forest Service National Hierarchical Framework of Ecological Units and the methods used for delineating map units at the subregion planning and analysis scale. Also presented is the process for scientific review and continuous refinement of ecological units and associated data of subregions.

9 Franzreb, Kathleen E. 2007. **Reproductive success and nest depredation of the Florida scrub-jay.** Wilson Journal of Ornithology. 119(2): 162-169.

The Florida scrub-jay *(Aphelocoma coerulescens)* is listed as a threatened species. I studied nest predation on the Ocala National Forest in 2002 and 2003 and found that snakes were responsible for more losses that were either birds or mammals. I examined reproductive success by monitoring nests. Groups with helpers produced significantly more fledglings (0.5 more per breeding pair) and had higher daily survival rates of nests than groups lacking helpers. Population management on the Ocala National Forest will likely require habitat management to increase the number of breeding territories and reduce the effectiveness of predator communities.

10 Greenberg, Cathryn H.; Levey, Douglas J.; Loftis, David L. 2007. **Fruit production in mature and recently regenerated forests of the Appalachians.** Journal of Wildlife Management. 71(2): 321-335.

Fleshy fruit is a key food resource for both game and nongame wildlife. Land managers need to know how land uses affect fruit production, and how it changes over time. We quantified fleshy fruit abundance for 5 years in both young, recently harvested, and mature forest stands of 2 forest types—drier upland hardwoods and moister cove hardwood forest types. Total dry pulp biomass production was low and relatively constant in both mature forest types. In contrast, fruit production was initially low but increased each year in young stands, and was 5-19.6 times greater in young than mature stands beginning 3-5 years postharvest. In the Southern Appalachians, young, recently regenerated stands provide abundant fruit compared to mature forest stands and represent an important source of food for wildlife for several years after harvest.

11 Greenberg, Cathryn H.; Miller, Stanlee; Waldrop, Thomas A. 2007. **Short-term response of shrews to prescribed fire and mechanical fuel reduction in a Southern Appalachian upland hardwood forest.** Forest Ecology and Management. 243: 231-236.

Shrews are important as both predators and prey, and some species are rare. Because they are secretive, we know little about their habitat requirements. We trapped shrews to determine how prescribed fire and other fuel reduction methods affect them and their arthropod prey in the Southern Appalachians. Treatments were (1) prescribed burning; (2) mechanical felling of shrubs and small trees; (3) mechanical felling + burning; and (4) forested controls. Compared to other treatments, high-intensity fires and high tree mortality increased canopy openness in the mechanical felling + burn treatment. Burning reduced leaf litter depth in both burned treatments. Arthropod dry biomass was similar among all four treatments. Low-intensity fuel reduction treatments, with minimal change to canopy cover or leaf litter depth, had little detectable impact on shrews. High-intensity disturbance, such as prescribed burning that killed trees and dramatically reduced shade and leaf litter depth, reduced abundance of pygmy shrews and all shrews combined, at least in the short term.

12 Islam-Faridi, M. Nurul; Nelson, C. Dana; Kubisiak, Thomas L. 2007. **Reference karotype and cytomolecular map for loblolly pine *(Pinus taeda L.)*.** Genome. 50: 241-251.

The genus *Pinus* includes many commercially and ecologically important species. Detailed information about individual *Pinus* chromosomes has been limited due to their uniform size and shape. Identification of individual chromosomes

(Photo by Rod Kindlund, U.S. Forest Service)

in *Pinus* is a prerequisite for advancing genome research. The hybridization pattern observed for various repetitive DNA probes was used to unambiguously identify all 12 chromosomes of loblolly pine, a model species for pine genomics. A genome map consisting of unique chromosomal regions was developed and will serve as a reference for placing markers and genes on the pine genome for years to come. This map has the potential to significantly increase our understanding of genome evolution, species conservation, and to help improve marker-based selection in pine breeding programs.

13 Kremer, Antoine; Casasoli, Manuela; Barreneche, Teresa [and others]. 2007. ***Fagaceae* trees.** In: Kole, C., ed. Genome mapping and molecular breeding in plants, vol. 7; Forest trees. Berlin, Germany: Springer-Verlag: 161-187. Chapter 5. [Editor's note: SRS scientist Thomas L. Kubisiak co-authored this publication.]

This book chapter provides an overview of the current status of genome analysis on members of the family Fagaceae. The chapter synthesizes information regarding ploidy, karyotypes, genome sizes, genetic maps, comparative maps, and the genetic mapping of economic and ecologic traits of interest within relevant species. This chapter will serve as a comprehensive basis for further studies of genomes within this family, helping to aid improvement and conservation.

14 Kubisiak, T.L.; Dutech, C.; Milgroom, M.G. 2007. **Fifty-three polymorphic microsatellite loci in the chestnut blight fungus, *Cryphonectria parasitica*.** Molecular Ecology Notes. 7: 428-432.

This paper reports on the development and screening of microsatellite marker loci in *Cryphonectria parasitica*. Most of the markers (48 of 53) were developed from an expressed sequence tag library and, hence, offer the opportunity to examine population structure or provide genome location information for specific expressed genes versus anonymous genomic regions. In 40 isolates collected throughout the Northern Hemisphere, the number of alleles per locus ranged from 2 to 14 (mean 5.17), with gene diversity values ranging from 0.049 to 0.859 (mean 0.437). The sample from Asia was found to be more diverse than the sample from Europe and North America. Results are consistent with *C. parasitica* originating in Asia with a recent introduction into Europe and North America.

15 Lang, Ping; Dane, Fenny; Kubisiak, Thomas L.; Huang, Hongwen. 2007. **Molecular evidence for an Asian origin and a unique westward migration of species in the genus *Castanea* via Europe to North America.** Molecular Phylogenetics and Evolution. 43: 49-59.

In this study we used sequence data from different regions of the chloroplast genome to reconstruct phylogenetic relationships and infer the biogeographical history among species within the genus *Castanea*. A unique westward expansion of extant *Castanea* species is hypothesized, with *Castanea* originating in eastern Asia, an initial diversification within Asia during the Eocene, followed by intercontinental dispersion and divergence between the Chinese and the European/North American species during the middle Eocene, and a split between the European and the North American species in the late Eocene. Morphological evolution of one nut per bur in the genus may have occurred independently on two continents.

16 Mehlenbacher, Shawn A.; Brown, Rebecca N.; Nouhra, Eduardo R. [and others]. 2006. **A genetic linkage map for hazelnut *(Corylus avellana L.)* based on RAPD and SSR markers.** Genome 49:122-133. [Editor's note: SRS scientist Thomas L. Kubisiak co-authored this publication.]

Genetic linkage maps are a prerequisite for map-based cloning of individual genes. In this study, linkage maps of European hazelnut were constructed using RAPD and SSR markers. Eleven groups were identified for each parent, corresponding to the haploid chromosome number of hazelnut. The maps are quite dense and markers tightly linked to two different genes of interest. We identified the S-locus, which controls pollen-stigma incompatibility, and a locus for resistance to eastern filbert blight (EFB) caused by *Anisogramma anomala*. These maps will serve as a starting point for future studies of the hazelnut genome, including map-based cloning of the S-locus and the EFB resistance locus.

17 Mitchell, R.J.; Hiers, J.K.; O'Brien, J.J. [and others]. 2007. **Silviculture that sustains: the nexus between silviculture, frequent prescribed fire, and conservation of biodiversity in longleaf pine forests of the Southeastern United States.** Canadian Journal of Forest Research. 36: 2724-2736.

Frequent surface fires are a hallmark of the biologically diverse longleaf pine ecosystem. High fire frequency is correlated to high biodiversity, and these frequent fires are carried by fine fuels, made up in a large part by pine needle litter. Much of the focus on silvicultural management of longleaf forests has focused on maximizing timber production and pine regeneration. In forest lands where there is a focus on conservation of biodiversity, timber exploitation can still be a compatible activity, but the impact of silviculture on fine fuels and subsequent fire behavior becomes paramount. We summarize and synthesize the scientific literature to compare the impacts of various silvicultural treatments on fine fuels and subsequent fire effects in longleaf forests.

18 Plomion, C.; Chagné, D.; Pot, D. [and others]. 2007. **Pines.** In: Kole, C., ed. Genome mapping and molecular breeding in plants, vol. 7; Forest trees. Berlin, Germany: Springer-Verlag: 29-92. Chapter 2. [Editor's note: SRS scientists C. Dana Nelson, Craig Echt, Thomas L. Kubisiak, and M. Nurul Islam-Faridi co-authored this publication.]

This book chapter provides an overview of the current status of genome analysis on members of the family *Pinaceae*. The chapter synthesizes information regarding systematics and phylogeny, hybridization, cytogenetics, DNA content, genome composition, molecular diversity, genetic maps, comparative maps, and the genetic mapping of economic and ecologic traits of interest within relevant species. This chapter will serve as a comprehensive basis for further studies of genomes within this family, helping to aid improvement and conservation.

19 Saenz, Daniel; Fitzgerald, Lee A.; Baum, Kristen A.; Conner, Richard N. 2006. **Abiotic correlates of anuran calling phenology: the importance of rain, temperature, and season.** Herpetological Monographs. 20: 64-82.

We surveyed anuran calls nightly at eight ponds in eastern Texas from January 2001 through December 2002. Air temperatures and daily rainfall also were recorded for each site. Given the level of anuran diversity and the amount of seasonal variation in temperature and rainfall, we expected to find a variety of breeding strategies. Analyses suggested five basic strategies: (1) breeding within a predictable season (summer) independent of local weather patterns; (2) breeding opportunistically within a predictable season (summer) dependent on local rainfall; (3) breeding opportunistically within a predictable season (winter) dependent on local temperature; (4) breeding opportunistically dependent on local flood level rainfall events; (5) breeding opportunistically year round dependent on local temperature in the winter and local rainfall in the summer.

20 Schaefer, Richard R.; Fagan, Jesse F.; 2006. **Commensal foraging by a fan-tailed warbler *(Euthlypis lachrymosa)* with a nine-banded armadillo *(Dasypus novemcinctus)* in southwestern Mexico.** Southwestern Naturalist. 51(4): 560-562.

Occasionally a serendipitous encounter with wildlife makes for a noteworthy publication. This happened during a few days of bird observations in southwestern Mexico during January 2005. While in the Pacific lowlands of the state of Guerrero, we observed a fan-tailed warbler *(Euthlypis lachrymosa)* closely following a foraging nine-banded armadillo *(Dasypus novemcinctus)*. The warbler searched for prey, probably various invertebrates, in the leaf-litter disturbed by the armadillo. This association between these two species had previously been reported from one site in El Salvador. Our observation now shows the described behavior to be more widespread, and contributes to the ecological knowledge of the species involved.

21 Selgrade, James F.; Roberds, James H. 2007. **Global attractors for a discrete selection model with periodic immigration.** Journal of Difference Equations and Applications. 13(4): 275-287.

The one-island selection-migration model provides a useful paradigm for studying the genetic and demographic properties of populations subjected to immigration but for which out-migration is not a factor. This model can be used to approximate the behavior of transgenes that have escaped into a natural population of forest trees from a genetically modified planted population of the same species. We report results pertaining to the long-term fate of transgenes in such a model. We consider cases in which fitnesses associated with the transgenic loci are controlled by two different levels of dominance. In the context of our model, levels of dominance indicate the relationship between homozygous and heterozygous genotypes with reference to trait expression, whereas fitness is a measure of the ability of individuals to transmit genes to the next generation.

22 Stover, Daniel B.; Day, Frank P.; Butnor, John R.; Drake, Bert G. 2007. **Effect of elevated CO_2 on coarse-root biomass in Florida scrub detected by ground-penetrating radar.** Ecology. 88(5): 1328-1334.

A joint effort between Old Dominion University, the Southern Research Station, and the Smithsonian Institute used ground-penetrating radar (GPR) to study roots nondestructively in a shrub-oak ecosystem at the Kennedy Space Center. To simulate the effect of rising atmospheric CO_2, plots were fumigated with CO_2-enriched air using open-top chambers. After 9 years of fumigation, it was discovered that coarse root mass increased 27 percent relative to controls, and 85 percent of the biomass in this system is stored belowground. These findings demonstrate the importance of belowground carbon storage in fire-adapted ecosystems, how they will be affected by rising CO_2, and the feasibility of using GPR.

forest values, uses, and policies

23 Bowker, J.M.; Bergstrom, John C.; Gill, Joshua. 2007. **Estimating the economic value and impacts of recreational trails: a case study of the Virginia Creeper Rail Trail.** Tourism Economics. 13(2): 241-260.

Many communities are interested in developing and maintaining recreational trails to benefit trail users and as tourist attractions to stimulate economic growth. In this paper we describe a study which estimates the net economic value to trail users and the local economic impacts of the Virginia Creeper Rail Trail in southwestern Virginia, USA. The monetary valuation results suggest that the trail is a highly valuable asset to the people who enjoy using it and to local businesses that benefit from trail-related tourist expenditures. The integrated valuation methodology and results can facilitate quantification of recreational trail economic benefits in other locations.

24 Grace, J.M., III; Skaggs, R.W.; Cassel, D.K. 2007. **Influence of thinning loblolly pine *(Pinus taeda L.)* on hydraulic properties of an organic soil.** Transactions of American Society of Agricultural and Biological Engineers. 50(2): 517-522.

The objective of this study was to evaluate the impact of forest thinning operations on soil hydraulic properties of a shallow organic (Belhaven series) soil in the Tidewater region of North Carolina. Soil physical properties were evaluated in a nested design by collecting soil cores from an unthinned control and following a 40-ha fifth-row thinning with selection performed on a 14-year-old loblolly pine plantation in April 2001. Thinning decreased saturated hydraulic conductivity and drained volumes for a given water table depth; however, changes in bulk density were not detected. Thinning resulted in a 3-fold decrease (from 100 to 32 cm hr^{-1}) in saturated hydraulic conductivity.

25 Klepac, John; Rummer, Robert B.; Hanula, James L.; Horn, Scott. 2007. **Mechanical removal of Chinese privet.** Res. Pap. SRS-43. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 5 p.

Chinese privet *(Ligustrum sinense Lour.)*, a highly invasive nonnative plant, is prevalent in the Southern United States. Chinese privet infestations can hinder regeneration of desirable species, reduce stand productivity, and have other undesirable consequences. A combined mechanical (mulching) and chemical (triclopyr) treatment was applied to Chinese privet in forest stands in Georgia on an experimental basis. The cost of removing Chinese privet was estimated to be $737 per acre when a tracked 110-horsepower mulching machine and a two-person herbicide application crew are employed.

26 Leduc, Daniel J. 2006. **PINEVOL: A user's guide to a volume calculator for southern pines.** Gen. Tech. Rep. SRS-95. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 12 p.

Taper functions describe a model of the actual geometric shape of a tree. When this shape is assumed to be known, volume by any log rule and to any merchantability standard can be calculated. PINEVOL is a computer program for calculating the volume of the major southern pines using species-specific bole taper functions. It can use the Doyle, Scribner, or International _-inch log rules or calculate solid wood volume inside or outside of bark. This document describes the methods used in volume calculation in PINEVOL and is a program user's guide.

27 Mason, A.; Xu, Y.J; Grace, J.M., III. 2007. **Comparison of stream nutrient conditions in a subtropical lowland watershed to EPA suggested criteria.** In: ASABE 2007 TMDL conference. St. Joseph, MI: American Society of Agricultural and Biological Engineers: 271-276.

A paired watershed study was initiated in a subtropical forested watershed within the Ouachita River Basin in Louisiana to identify stream nutrient conditions with respect to the U.S. Environmental Protection Agency (EPA) suggested criteria, and to examine changes in nutrient levels following timber harvesting operations with and without BMP implementation. The preliminary results show that the low-order streams in these watersheds frequently exceeded the suggested criteria before any harvesting activities were initiated. Average nitrite/nitrate was significantly higher than EPA's recommended level, especially during rainstorm events and warmer months. Total phosphorus varied from 0.028 to 0.104 mg L^{-1}, which were within the EPA recommendation levels.

28 Mason, A.; Xu, Y.J.; Saksa, P. [and others]. 2007. **Stream flow and nutrient dependence of temperature effects on dissolved oxygen in low-order forest streams.** In: ASABE 2007 TMDL conference. St. Joseph, MI: American Society of Agricultural and Biological Engineers: 374-380. [Editor's note: Station scientist J.M. Grace III co-authored this publication.]

In Louisiana, natural stream conditions such as low flow, high temperature, and high organic content often result in dissolved oxygen (DO) levels already below current water quality criteria, making it difficult to develop standards for BMPs. Along three low-order streams within a West Gulf Coastal Plain watershed in central Louisiana, stream flow conditions, temperature, organic carbon, and DO were measured for one year. The results show overall oxygen depletion in most of the sampled streams. There was a wide range of monthly DO levels, with the lowest levels generally occurring from May to July. There was a close relationship between organic carbon and DO, which appeared to be further affected by stream hydrologic conditions.

29 Wear, David N.; Carter, Douglas R.; Prestemon, Jeffrey. 2007. **The U.S. South's timber sector in 2005: a prospective analysis of recent change.** Gen.Tech. Rep. SRS-99. Asheville, N.C.: U.S. Department of Agriculture, Forest Service, Southern Research Station. 29 p.

Our findings suggest demand for domestically produced timber products has declined somewhat in the United States, as domestic demands as well as exports have fallen. Supply of domestically produced timber products has continued to expand since the late 1990s. The net result may be (a) a decline in timber product output and (b) a disproportionately strong decline in associated prices. Evaluation of investment of wood products firms in manufacturing capacity within the Southern U.S. provides insights into future production potential. Indications are that demand for pulpwood to produce paper may not rebound

(Photo by Rod Kindlund, U.S. Forest Service)

to late 1990s levels in the foreseeable future. However, persistent low prices for softwood pulpwood could indicate long-term opportunities for manufacture of other products from this product class. Long-term demand for solid wood products appears strong, signaling that a relatively favorable investment climate should exist in this part of the forest sector.

30 Winn, Matthew F.; Araman, Philip A.; Wynne, Randolph H. 2005. **ALOG user's manual: A guide to using the spreadsheet-based Artificial Log Generator.** Gen. Tech. Rep. SRS-79. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 13 p.

Computer programs that simulate log sawing can be valuable training tools for sawyers, as well as a means of testing different sawing patterns. Most available simulation programs rely on diagrammed-log databases, which can be very costly and time consuming to develop. Artificial Log Generator (ALOG) is a user friendly Microsoft® Excel®-based program that accurately generates random, artificial-log data. The program's design is based on information from an analysis of real red oak *(Quercus rubra L.)* logs, which ensures the validity of the data. The program provides information about generated-log features, and external and internal defects. An incorporated algorithm checks the grade of the generated log. This user's guide provides all the information necessary to install and run ALOG, and to interpret program output.

threats to forest health

31 Campbell, Josh W.; Hanula, James L.; Waldrop, Thomas A. 2007. **Observations of *Speyeria diana* (Diana fritillary) utilizing forested areas in North Carolina that have been mechanically thinned and burned.** Southeastern Naturalist. 6(1): 179-182.

The Diana fritillary *(Speyeria diana)* is a forest dwelling butterfly considered very rare throughout much of its native habitat in North Carolina. In 2003 and 2004, we conducted butterfly surveys on forested, 10 ha plots in the Southern Appalachians of North Carolina to which various forest management practices had been applied. During one survey (June 2004) we observed male Diana fritillary butterflies feeding on flowering sourwood *(Oxydendrum arboretum)* within plots that had been mechanically thinned and burned. These plots also had the greatest herbaceous plant cover. Our observations suggest that some forest management related disturbances may improve habitat for this species.

32 Eberhardt, Thomas L. 2007. **A reassessment of the compressive strength properties of southern yellow pine bark.** Forest Products Journal. 57(4): 95-97.

Few studies have focused on the mechanical properties of bark. Although the stiffness of bark is significantly lower than that for wood, bark contributes significantly to the resistance of stem segments to bending forces. The mechanical properties of bark are also important for practical reasons since bark can be found in wood-based composites. Samples of southern yellow pine outer bark and wood were tested in compression to determine the mechanical properties of interest. Results resolved inconsistencies in data previously reported by others. Testing of solvent-treated bark blocks suggests that although extractives are present in significant amounts, their contribution to the mechanical properties is minimal.

33 Eberhardt, Thomas L.; Elder, Thomas; Labbé. 2007. **Analysis of ethanol-soluble extractives in southern pine wood by low-field proton NMR.** Journal of Wood Chemistry and Technology. 27(1): 35-47.

Wood extractives can have a significant influence over wood processing parameters, as well as the performance of wood-based products. Extractives' contents are typically determined by solvent extractions that are both time consuming and involve the handling/disposal of organic solvents. Low-field proton nuclear magnetic resonance (NMR) was evaluated as a nondestructive and rapid technique for measuring the extractives' contents of southern pine wood specimens. Data from the analysis were positively correlated with the extractives' contents of the matchstick-sized wood specimens when in the oven-dry state. A novel pretreatment with dichloromethane-d2 allowed the determination of the extractives' contents without prior drying.

(Photo by Rod Kindflund, U.S. Forest Service)

34 Gao, Heng; Shupe, Todd F.; Hse, Chung Y.; Eberhardt, Thomas L. 2006. **Antioxidant activity of extracts from the bark of *Chamaecyparis lawsoniana* (A. Murray) Parl.** Holzforschung. 60: 459-462.

Chemicals present in Port-Orford cedar (*Chamaecyparis lawsoniana* (A. Murray) Parl.) bark are of interest for their antioxidant activities. One mechanism of activity exhibited by antioxidants involves the scavenging of free radicals which have known damaging effects. Free radical-scavenging assays were used to determine the antioxidant activities for fractions obtained from a crude bark extract after solvent partitioning. This provided extraction and partitioning processes for the isolation of antioxidants of interest. Results showed that the antioxidant activity of each fraction could be correlated with the presence of phenolic compounds. Applications for these phenolic antioxidants range from direct consumption as nutraceuticals to the incorporation into packaging materials for the protection of products from oxidation.

35 Horn, Scott; Hanula, James L. 2006. **Burlap bands as a sampling technique for green anoles *(Anolis carolinensis)* and other reptiles commonly found on tree boles.** Herpetological Review. 37(4): 427-428.

A variety of methods have been used to study lizard populations, including rubber bands, active searching and noosing, pitfall traps, glue boards, and hook extraction. In some cases, these techniques result in lizard mortality or stress. We were interested in developing a technique that successfully monitored arboreal lizards while limiting stress. We compared burlap bands wrapped around tree boles to three methods commonly used to sample lizards. We found that burlap bands provided the largest number of green anole observations in the shortest amount of time. Our results suggest that burlap bands are a simple, inexpensive, and effective way to catch or monitor bole-active lizards, and this method causes no harm to the animal or environment.

36 Miller, D.R.; Asaro, C. 2005. **Ipsenol and ipsdienol attract *Monochamus titillator* (Coleoptera: Cerambycidae) and associated large pine woodborers in Southeastern United States.** Journal of Economic Entomology. 98(6): 2033-2040.

We found that the bark beetle pheromones (±)-ipsenol and (±)-ipsdienol were attractive to the southern sawyer beetle, *Monochamus titillator*, in Florida, Louisiana, Georgia, and North Carolina. These two compounds had varying effects on three other common species of wood-boring beetles in the South: *Acanthocinus obsoletus*, *Pachylobius picivorus*, and *Chalcophora virginiensis*.

37 Miller, D.R.; Asaro, C.; Berisford, C.W. 2005. **Attraction of southern pine engravers and associated bark beetles (Coleoptera: Scolytidae) to ipsenol, ipsdienol, and lanierone in Southeastern United States.** Journal of Economic Entomology 98(6): 2058-2066.

We found that the smaller southern pine engraver, *Ips avulsus*, and the eastern fivespined ips, *I. grandicollis*, were significantly attracted to traps baited with (±)-ipsenol and (±)-ipsdienol in Florida, Georgia, Louisiana, and North Carolina. (±)-Ipsdienol was the only consistent attractant for the pine engraver, *I. pini*, and the sixspined ips, *I. calligraphus*. The interruptive effect of (±)-ipsenol on attraction of *I. pini* to (±)-ipsdienol was negated by lanierone, which synergized attraction of *I. pini* to (±)-ipsdienol.

38 Miller, Daniel R. 2007. **Limonene: Attractant kairomone for white pine cone beetles (Coleoptera: Scolytidae) in an eastern white pine seed orchard in western North Carolina.** Journal of Economic Entomology. 100(3): 815-822.

We found that traps baited with the pine monoterpene limonene were attractive to the white pine cone beetle, a destructive insect pest of eastern white pine cones. Further, we found that limonene increased catches of beetles to traps baited with the cone beetle pheromone pityol. Our results and those of others suggest promise in developing a semiochemical-based control program for white pine cone beetles in eastern white pine seed orchards.

39 Miller, Daniel R.; Borden, John H.; Lindgren, B. Staffan. 2005. **Dose-dependent pheromone responses of *Ips pini*, *Orthotomicus latidens* (Coleoptera: Scolytidae), and associates in stands of lodgepole pine.** Environmental Entomology. 34(3): 591-597.

We found that the pine engraver, *Ips pini*, exhibited dose-dependent increases in trap catches to its pheromones, ipsdienol and lanierone, whereas a sympatric species of bark beetle, *Orthotomicus latidens*, did not exhibit a dose-dependent response to its pheromone, ipsenol. The predator, *Thanasimus undatulus*, exhibited dose-dependent increase in attraction to traps baited with ipsenol, whereas another species, *Enoclerus sphegeus*, exhibited dose-dependent increases to traps baited with lanierone.

40 Miller, Daniel R.; Lindgren, B. Staffan; Borden, John H. 2005. **Dose-dependent pheromone responses of mountain pine beetle in stands of lodgepole pine.** Environmental Entomology. 34(5): 1019-1027.

We examined the effect of pheromone release rates on attraction of the mountain pine beetle (*Dendroctonus ponderosae*), a major pest of lodgepole pine in Western North America. We found that beetles exhibited a multi-functional dose response to funnel traps baited with a mixture of cis- and trans-verbenol in areas with low population levels, whereas response was directly proportional to release rate in areas with high population levels. The multi-functional response is consistent with an optimal attack density hypothesis.

41 Mulrooney, J.E.; Wagner, T.L.; Shelton, T.G. [and others]. 2007. **Historical review of termite activity at Forest Service termiticide test sites from 1971 to 2004.** Journal of Economic Entomology. 100(2): 488-494.

The U.S. Forest Service has a long history of providing termiticide efficacy data used for product registration and labeling. Four primary test sites (Arizona, Florida, Mississippi, and South Carolina) have been used for this purpose. Various parameters of termite attack at water-only control plots in termiticide studies installed between 1971 and 2001 were examined in

this study to assess the relative pressures of termites at each site. Termite pressure was greater in the Southeast. Plots were attacked sooner and at a higher percentage than those in Arizona. In addition, damage to wooden blocks was greater in the Southeast.

42 Peterson, Chris J.; Wagner, Terence L.; Shelton, Thomas G.; Mulrooney, Joe E. 2007. **New termiticides necessitate changes in efficacy testing: A case study of fipronil.** In: Lyga, John W.; Theodoridis, George, eds. Synthesis and Chemistry of Agrochemicals VII. ACS symposium series 948. Washington, DC: American Chemical Society: 179-193.

Without accurate product testing methods, inferior products can enter the marketplace and put the consumer at risk. In efficacy tests conducted with the termiticide Termidor®, termites were absent from untreated plots near the treated plots. Two reasons for this were proposed: one, the high levels of insecticide used in the study area suppressed the local population or two, the active ingredient was transferred between termites and the local population was suppressed that way. Either reason removes our ability to determine if the termites were killed because of the insecticide, or if the termites were not there in the first place. A new testing method was developed that provided satisfactory results.

43 Sullivan, Brian T. 2005. **Electrophysiological and behavioral responses of *Dendroctonus frontalis* (Coleoptera: Curculionidae) to volatiles isolated from conspecifics.** Journal of Economic Entomology. 98(6): 2067-2078.

Olfactory sensitivity of the southern pine beetle, *Dendroctonus frontalis* Zimmermann, to compounds isolated from the mid/hindguts of newly emerged conspecific adults was assayed with coupled gas chromatography-electoantennographic detection. All previously reported pheromones for *D. frontalis*, plus eight additional compounds, consistently elicited antennal responses from at least one sex. The eight additional compounds were bioassayed individually at three release rates for the ability to alter *D. frontalis* responses to traps baited with *D. frontalis* aggregation pheromone. Seven of the eight compounds reduced beetle aggregation responses, while one increased beetle attraction. Analyses of volatiles from individual *D. frontalis* indicated that the majority of the eight compounds were produced in greater quantities by newly-emerged beetles than ones initiating attacks on pine bolts. Five of the compounds were associated predominantly with one sex. Possible ecological roles of these compounds in the biology of *D. frontalis* are discussed. The seven newly-discovered aggregation inhibitors for *D. frontalis* may prove effective in protecting individual trees from beetle attack or suppressing beetle infestations.

44 Sullivan, Brian T.; Dalusky, Mark J.; Wakarchuk, David; Berisford, C. Wayne. 2007. **Field evaluations of potential aggregation inhibitors for the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Curculionidae).** Journal of Entomological Science. 42(2): 139-149.

Semiochemicals that inhibit response of southern pine beetle, *Dendroctonus frontalis* Zimmermann, to its aggregation pheromone have been used with varying degrees of success to protect individual trees from attack and to stop infestation growth. However, semiochemical disruptants have not experienced wide use in management of *D. frontalis*, due in part to the normally prohibitive expense associated with treatments using verbenone and 4-allylanisole, the two EPA-registered semiochemicals for this species. We conducted initial trap-based screenings of candidate compounds with the aim of discovering alternatives. Baits containing either 2-phenylethanol or myrtenol significantly reduced attraction of one or both sexes of *D. frontalis* to traps baited with a standard attractant. In combination, the two compounds caused a 92 percent decrease in total beetle response, although reduction was not significantly greater than that produced by 2-phenylethanol alone. At specific doses, we failed to observe reduction in *D. frontalis* attraction by the following compounds presented singly: benzaldehyde, guaiacol, 3-methylcyclohex-2-en-1-one (3,2-MCH), myrtenal, and verbenone.

45 Ulyshen, Michael D.; Hanula, James L.; Horn, Scott. 2007. **Burying beetles (Coleoptera: Silphidae) in the forest canopy: The unusual case of *Nicrophorus pustulatus* Herschel.** Coleopterists Bulletin. 61(1): 121-123.

Although the importance of canopy research is now widely recognized, almost nothing is known about the vertical distribution patterns of insects in Southeastern forests. During a recent comparison of beetles captured in the canopy and near the ground in a bottomland hardwood forest, we found evidence of stratification of the burying beetle community. *Nicrophorus pustulatus*, a rarely collected and poorly understood burying beetle, was significantly more abundant in the canopy than near the ground. Ongoing research suggests that the canopy is more important for many insect groups than previously believed. A better understanding of canopy processes is essential for protecting biodiversity.

46 Wickham, J.D.; Riitters, K.H.; Wade, T.G.; Coulston, J.W. 2007. **Temporal change in forest fragmentation at multiple scales.** Landscape Ecology. 22:481-489.

Studies of temporal changes in fragmentation focus on patch and edge statistics, which might not detect changes in the spatial scale at which forest dominates the landscape. In the Chesapeake Bay region, forest patch statistics changed very little between 1991 and 2001, while at the same time, the loss rate of dominant forest was two to 10 times larger than the loss rate of forest area. The trend probably indicates a regional transition from a forest-dominated landscape to a landscape dominated by developed land uses, which could trigger other changes in the ecological function of forest land in the region.

47 Zurlini, Giovanni; Riitters, Kurt H.; Zaccarelli, Nicola; Petrosillo, Irene. 2007. **Patterns of disturbance at multiple scales in real and simulated landscapes.** Landscape Ecology. 22:705-721.

Previous national assessments of forest fragmentation identified the need for better indicators of fragmentation and more efficient computational approaches. This paper develops a framework to characterize and interpret the spatial patterns of disturbances at multiple scales. Domains of scale are defined in pattern metric space and mapped in geographic space, which identifies the scale of fragmentation in different places.

The conceptual model is illustrated with simulated maps and real disturbance maps from satellite imagery in south Italy. The new technique will be used in the future US national assessments of forest disturbance and fragmentation.

forest watershed science

48 Adams, Susan B. 2006. **Dainties of the first order.** Wings: Essays on Invertebrate Conservation. 29(2): 4-7.

Scientists have learned a great deal about crayfish in the past 100 years, including that hundreds of crayfish species are native to the U.S. Over 75 percent of the world's crayfish species are native to North America. Cambaridae is the largest family, and 80 percent of those species are native to the Southeastern U.S. Crayfish are surprisingly variable in size, color, behavior, and habitats occupied, and serve complex and important roles in aquatic and terrestrial ecology. As with many aquatic organisms, conservation threats come in many forms, one of which is invasion by nonnative crayfish introduced via live food, fish bait, and pet trades.

49 Barker, S.; Benítez, S.; Baldy, J. [and others]. 2006. **Modeling the South American range of the cerulean warbler.** Paper UC-1656. In: Proceedings of 26th ESRI International User Conference. http://gis2.esri.com/library/userconf/proc06/papers/papers/pap_1656.pdf. [Date accessed: May 3, 2007]. [Editor's note: Southern Station scientist Paul B. Hamel co-authored this publication.]

Successful conservation of rare species requires detailed knowledge of distribution. Modeling spatial distribution is an efficient means of locating potential habitats. Cerulean Warbler (*Dendroica cerulea*, Parulidae) was listed as a Vulnerable Species by the International Union for the Conservation of Nature and Natural Resources in 2004. These Neotropical migratory birds breed in Eastern North America. The entire population migrates to the northern Andes in South America to spend the nonbreeding period. We developed spatial hypotheses of the bird's occurrence in South America. We summarized physical, climatic, and recent land-cover data for the northern Andes using ESRI software, ArcGIS. We developed five hypothetical distributions. Combining results of the different models on the same map allowed us to design a rigorous strategy to ground-truth the map and thus identify sites for protection of the species in South America.

50 Bowen, Liessa T.; Moorman, Christopher E.; Kilgo, John C. 2007. **Seasonal bird use of canopy gaps in a bottomland forest.** Wilson Journal of Ornithology. 119(1): 77-88.

We studied the relative use of mature forest versus small gaps in the forest canopy (0.33-1.25-ac harvest openings) by birds from spring through fall in a bottomland hardwood forest in South Carolina. We documented more birds, including species typically associated with the forest interior, in canopy gaps than in surrounding mature forest during all seasons. Birds used mature forest more during the breeding season than other periods, but most species selectively chose gap habitat over surrounding mature forest during the non-breeding periods. The creation of small canopy gaps within a mature forest may increase local bird species richness.

51 Coyle, D.R.; Coleman, M.D.; Durant, J.A.; Newman, L.A. 2006. **Survival and growth of 31 *Populus* clones in South Carolina.** Biomass & Bioenergy. 30(8-9): 750-758.

Populus species and hybrids have many practical applications, but clonal performance is relatively undocumented in the Southeastern United States outside of the Mississippi River alluvial floodplain. In spring 2001, 31 *Populus* clones were planted on two sites in South Carolina, USA. The sandy, upland site received irrigation and fertilization throughout the growing season, while the bottomland site received granular fertilizer yearly and irrigation in the first two years only. Over three growing seasons, tree survival and growth differed significantly among clones at both sites. We emphasize that information presented is preliminary, and that clones should be followed through an entire rotation before large-scale deployment.

52 Ford, Chelcy R.; Vose, James M. 2007. ***Tsuga canadensis* (L.) Carr. mortality will impact hydrologic processes in Southern Appalachian forest ecosystems.** Ecological Applications. 17(4): 1156-1167.

Eastern hemlock, an important streamside and cove species in Southern Appalachian forests, is facing widespread mortality from hemlock woolly adelgid (HWA), an exotic invasive insect. To estimate the impact that the loss of hemlock will have on forest water balance, we measured hemlock water use (transpiration) over a range of tree sizes for 2 years. Daily tree transpiration was substantial; large trees transpired as much as 186 kg (or 49 gal) water tree-1 day-1. With increasing HWA infestation and progressive loss of leaf area, we expect further declines in transpiration rates. For Southern Appalachian forests specifically, we estimate that eastern hemlock mortality could reduce annual and winter and spring forest transpiration by 10 and 30 percent, respectively. We also expect that the loss of eastern hemlock from streamside areas and coves will alter stream flow quantity and timing.

53 Ford, Chelcy R.; Wurzburger, Nina; Hendrick, Ronald L.; Teskey, Robert O. 2007. **Soil DIC uptake and fixation in *Pinus taeda* seedlings and its C contribution to plant tissue and ectomycorrhizal fungi.** Tree Physiology. 27(3): 375-384.

Plants can acquire carbon (C) from sources other than atmospheric carbon dioxide (CO_2), including soil-dissolved inorganic carbon (DIC). Soil DIC can be taken up by the roots, transported within the plant, and fixed through both light and dark reactions. We exposed loblolly pine seedlings to a ^{13}C-enriched soil DIC solution with two levels of ammonium ($NH4^+$) and measured the amount of C acquired from soil DIC in plant tissues. Our results indicate the potential for uptake and fixation of exogenous soil CO_2 and the re-incorporation of root-respired CO_2 in forest trees. While soil DIC only contributes a small amount to C gain in forest trees, it may be important in C fixation processes of specific tissues, such as newly formed stems and fine roots, and ectomycorrhizal roots assimilating $NH4^+$.

54 Haag, Wendell R.; Warren, Melvin L. 2007. **Freshwater mussel assemblage structure in a regulated river in the Lower Mississippi River Alluvial Basin, USA.** Aquatic Conservation: Marine and Freshwater Ecosystems. 17(1): 25-36.

We document a diverse freshwater mussel community (20 species) in Lower Lake, an impounded, regulated portion of the Little Tallahatchie River below Sardis Dam in Panola County, MS. Lower Lake represents one of the few areas of stable large stream habitat in the region. The diverse mussel community present in this highly modified habitat suggests that a large component of the regional mussel fauna is relatively resilient and adaptable and is limited primarily by the absence of stable river reaches. Management actions that increase stream stability are likely to result in expansion of the mussel fauna and restoration of a valuable component of ecosystem function.

55 Haag, Wendell R.; Warren, Melvin L., Jr. 2006. **Seasonal feeding specialization on snails by river darters (*Percina shumardi*) with a review of snail feeding by other darter species.** Copeia. 4: 604-612.

We report food habits of river darters (*Percina shumardi*) in Brushy Creek and the Sipsey Fork, Black Warrior River, AL. River darters preyed heavily on pleurocerid snails in both streams. Snail feeding was highest in October when snails represented nearly 100 percent of darter food items. Snail feeding declined through the spring, but increased to high levels in July when hatchling snails composed about 80 percent of darter food items. Non-snail food items were dominated by insect larvae, most commonly eaten during periods of low snail feeding or feeding on hatchling snails. Few other fish species prey heavily on riverine snails. *Percina shumardi* and *P. tanasi* represent two of the few native fishes that exploit the abundant and diverse pleurocerid snail fauna of Eastern North America.

56 Hawkins, Tracy S. 2006. **A forest transect of Pine Mountain, Kentucky: Changes since E. Lucy Braun and chestnut blight.** Journal of Kentucky Academy of Sciences. 67(2): 73-80.

Forest composition and structure were determined for Hi Lewis Pine Barrens State Nature Preserve, a 68-ha tract on the south slope of Pine Mountain, Harlan County, Kentucky. Four forest types were identified: *Liriodendron-Acer*, *Quercus-Tsuga*, mixed *Quercus*, and *Pinus-Quercus*. Percent canopy compositions were compared with those reported by Dr. E. Lucy Braun prior to the peak of chestnut blight. Chestnut remains an important component in the subcanopy and is present in the groundcover in three types. Except for its absence, species composition of Braun's forest types has remained relatively unchanged during the past 70 years; however, loss of chestnut initiated changes in the relative importance of these species, resulting in varying degrees of transition to post-blight forest types.

57 Lockhart, Brian Roy; Weih, Robert C., Jr.; Smith, Keith M. 2005. **Crown radius and diameter at breast height relationships for six bottomland hardwood species.** Journal of Arkansas Academy of Sciences. 59: 110-115.

The relationship between a tree's crown radius and diameter at breast height (d.b.h.) has a variety of uses, including stocking relationships and tree volume estimations. Estimating d.b.h. from mean crown radius (MCR) is of interest to managers because MCR can be estimated from digital imagery using remote sensing techniques. D.B.H. is a common tree dimensional characteristic that is used to quantify tree and stand structure. This research presents MCR/d.b.h. and d.b.h./MCR relationships for boxelder, sweet pecan, sugarberry, green ash, Nuttall oak, and American elm. The linear model, $y = a + b * x$, provided the best model fit with adjusted r^2 values of 0.567 to 0.855.

58 Moorman, Christopher E.; Bowen, Liessa T.; Kilgo, John C. [and others]. 2007. **Seasonal diets of insectivorous birds using canopy gaps in a bottomland forest.** Journal of Field Ornithology. 78(1): 11-20.

Little is known about how insectivorous bird diets are influenced by arthropod availability in timber harvest openings, and less about how diets vary seasonally. We assessed bird diet composition from spring through fall in relation to arthropod availability in mature forest and in small timber harvest openings. Birds primarily consumed arthropods of eight orders, with no apparent seasonal shifts among orders. The more heavily used orders were slightly more abundant in mature forest than in harvest openings, yet birds were more abundant in openings. Thus, birds did not simply use areas with the greatest food abundance. They were likely attracted to the openings by the protective cover provided by dense understory vegetation.

59 National Agroforestry Center. 2007. **Buffer$—An economic analysis tool** [CD-ROM]. Gen. Tech. Rep. SRS-e100. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Buffer$ is an economic spreadsheet tool for analyzing the cost-benefits of conservation buffers by resource professionals. Conservation buffers are linear strips of vegetation managed for multiple landowner and societal objectives. The Microsoft® Excel™-based product can calculate potential income derived from a buffer, including income from cost-share/incentive programs, agroforestry specialty products, leases, and other enterprise sources. The program can compare a proposed buffer income stream to that of various cropping alternatives. The tool can also be used to evaluate the economic impacts of removing an existing buffer.

60 Predny, Mary L.; DeAngelis, Patricia; Chamberlain, James L. 2006. **Black cohosh (*Actaea racemosa*): an annotated bibliography.** Gen. Tech. Rep. SRS-97. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 99 p.

Black cohosh (*Actaea racemosa*, Syn.: *Cimicifuga racemosa*), a member of the buttercup family (Ranunculaceae), is an erect perennial found in rich cove forests of Eastern North America. Native Americans used black cohosh to treat rheumatism, malaria, sore throats, and complications associated with childbirth. Europeans have used this important medicinal plant to treat menopausal symptoms for over 40 years. Clinical evidence supports the efficacy and safety of black cohosh for these symptoms. Decisions by the U.S. Food and Drug Administration on hormone replacement therapy have resulted in increased demand. Nearly 100 percent of black cohosh raw materials are wild harvested. Conservation groups list the species as "at risk" in the United States and "endangered" in Illinois and Massachusetts. Research is underway to determine sustainable harvest levels and to establish suitable cultivation methods.

(Photo by Zoë Hoyle, U.S. Forest Service)

61 Samuelson, Lisa J.; Stokes, Thomas A.; Coleman, Mark D. 2007. **Influence of irrigation and fertilization on transpiration and hydraulic properties of *Populus deltoides*.** Tree Physiology. 27(5): 765-774.

Water used by forest trees is known as transpiration, necessary for vigorous and healthy forests. Transpiration is measured to understand growth requirements and to estimate how much water will drain from forest landscapes. Ability to predict water yield will become increasingly important as we study impacts of environmental change. There is only limited information on how different rates of growth may control water use. This study monitored water use in fast growing trees that had been fertilized and irrigated, and compared results to water use in slower growing trees that had not been fertilized and irrigated. Greater transpiration in fast growing trees was partially due to the fact that they had more leaves. However, leaves did not explain all the increase. They also had a larger amount of wood for each square meter of leaf surface. The balance between leaf and sap wood area was important in understanding differences in water use of forest trees.

62 Smith, David R.; Schiff, Nathan M. 2005. **A new western Nearctic species of *Calameuta* Konow (Hymenoptera: Cephidae).** Proceedings of Entomological Society of Washington. 107(4): 864-868.

We describe *Calameuta middlekauffi*, a new species, from southern Oregon and California. It is the second species of *Calameuta* in North America and is differentiated from *C. clavata* (Norton) by head shape and coloration. Illustrations, descriptions, and a key are given to separate the two species. The food plant is unknown, but Palearctic species of *Calameuta* are known to feed in grass stems.

63 Taylor, Christopher M.; Holder, Thomas L.; Fiorillo, Riccardo A. [and others]. 2006. **Distribution, abundance, and diversity of stream fishes under variable environmental conditions.** Canadian Journal of Fisheries and Aquatic Sciences. 63: 43-54. [Editor's note: Station scientist Melvin L. Warren, Jr. co-authored this publication.]

Effects of stream size and flow regime on spatial and temporal variability of stream fish distribution, abundance, and diversity patterns were investigated in streams in forested watersheds in the Ouachita Mountains, AR. Assemblage variability and species richness were significantly associated with a complex environmental gradient contrasting smaller, hydrologically variable stream localities with larger localities characterized by more stable flow regimes. Assemblages showing least variability were the most species rich and occurred in relatively large, stable environments. We suggest that spatial and temporal heterogeneity in the environment largely determines both assemblage richness and variability. Changes in species richness of local assemblages across time were coordinated across the landscape. These results suggest an important link between local community dynamics and community-wide occurrence. At the species level, mean local persistence was significantly associated with regional occurrence. Thus, the more widespread a species was, the greater its local persistence. Results illustrate how integrity of local stream fish assemblages is dependent on local environmental conditions, regional patterns of species distribution, and landscape continuity.

64 Wilson, A. Dan. 2007. **Clavicipitaceous anamorphic endophytes in *Hordeum* germplasm.** Plant Pathology Journal. 6(1): 1-13.

This article provides final results of a study initiated over 10 years ago to investigate occurrence of a specialized group of fungi in wild grasses stored within a seed bank of the U.S. National Plant Germplasm System. These important and unique fungi known as clavicipitaceous endophytes form perpetual symbiotic (mutually beneficial) relationships with their grass hosts. Incidence of these fungi was determined in 17 species of wild barley (*Hordeum* species) from many countries and regions throughout the world. This discovery has great potential significance because these fungi are known to be very effective biological agents useful for control of numerous major insect and disease pests in cultivated barley and other cereal grasses.

(Photo by Rod Kindlund, U.S. Forest Service)

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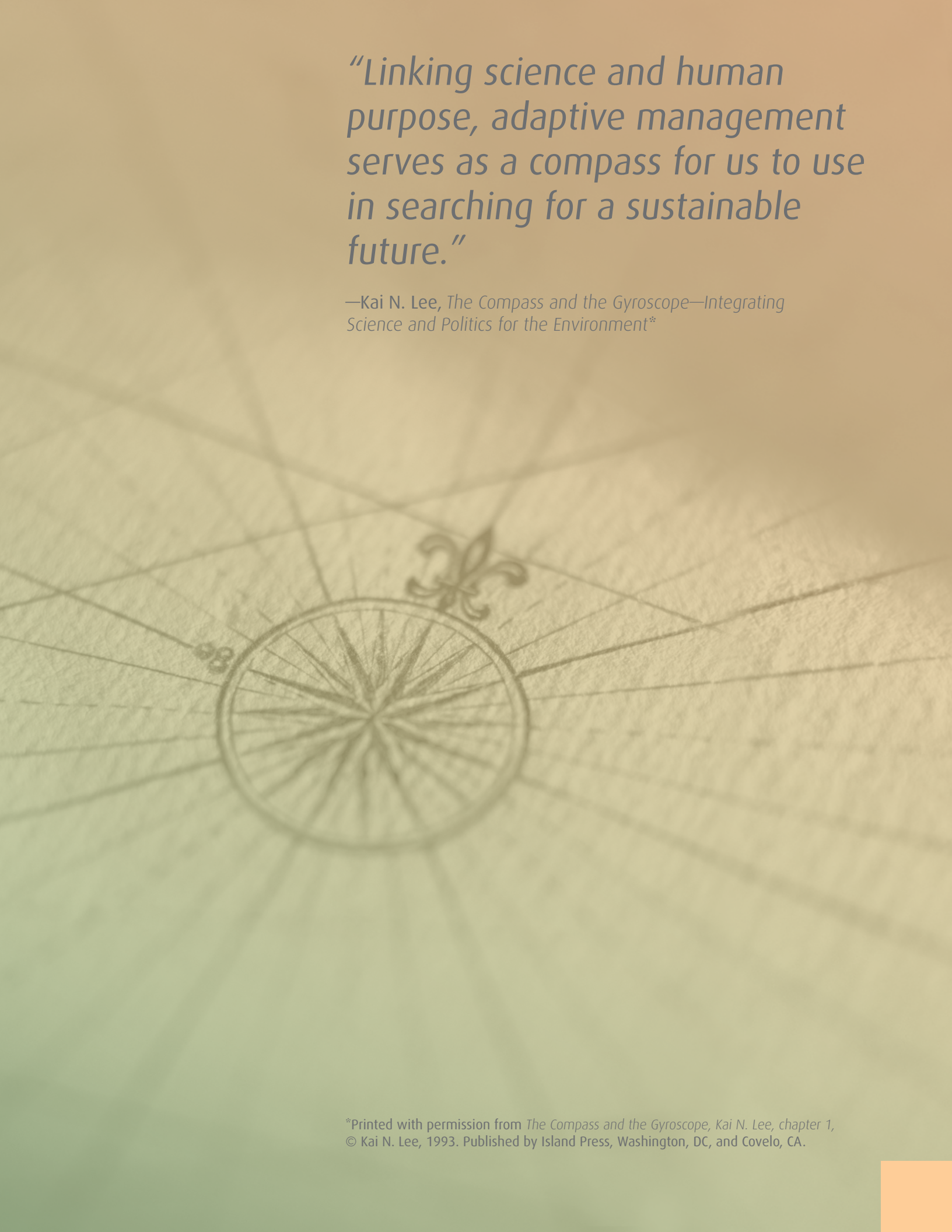

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