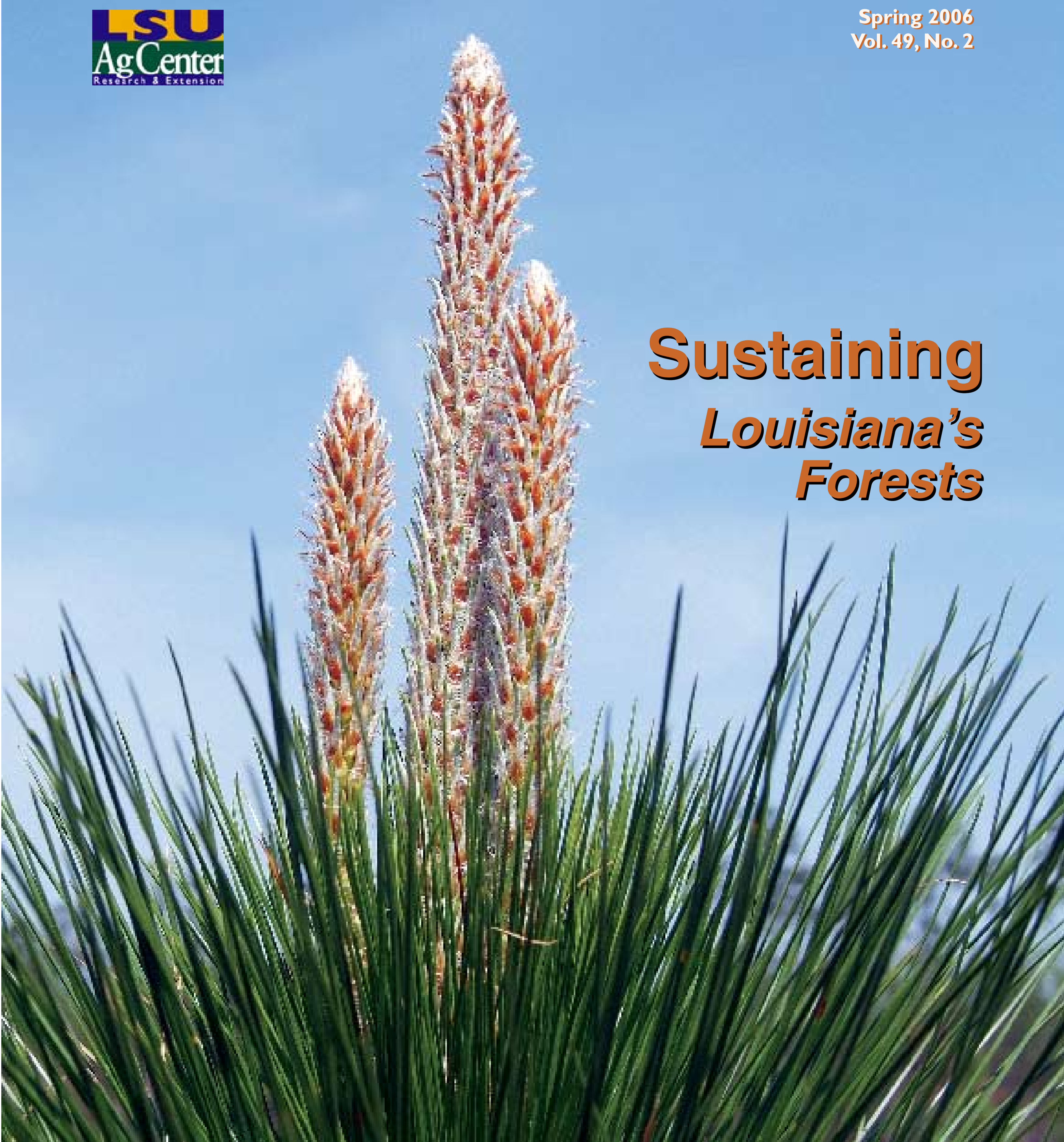
LOUISIANA AGRICULTURE
Assuring Our Future Through Scientific Research and Education

LSU AgCenter Research & Extension

Spring 2006
Vol. 49, No. 2



Sustaining *Louisiana's Forests*

What's New?

What's New?

More Research Needed on Bio-based Fuels

Louisiana farmers and foresters could find a silver lining in the cloud of rising fuel prices with the development of new fuels from crops they already grow or could grow.

"The biofuels industry is poised for explosive growth," Kelsey Short, director of the Agriculture, Forest and Food Technology Division of Louisiana Economic Development, told LSU AgCenter researchers and extension specialists gathered to discuss biofuel possibilities on April 20-21.

"People are looking for ways to improve the value-added components of their farming and forestry operations," said David Boethel, LSU AgCenter vice chancellor for research. "Interest is growing in alternative fuels and how agriculture can play a role."

Short pointed to the availability of agricultural production as a leading reason for supporting a biofuels industry in Louisiana. He also cited the state's proximity to Houston, the fourth largest U.S. market, and the state's broad-based transportation system, as well as federal economic development incentives through the Gulf Opportunity Zone and tax-exempt bond financing as grounds for pursuing research and development in bio-based fuels.

During the meeting, the researchers and extension specialists reached consensus that ethanol and biodiesel offer the primary opportunities for Louisiana agriculture to take advantage of new energy technologies.

While ethanol generally is made primarily from corn grown in the Midwest, other Louisiana crops – primarily sugarcane and grain sorghum – could provide affordable feedstocks for an ethanol plant. The major component of biodiesel currently is soybean oil, although other oilseeds can provide equally good or better sources for the product.

Corn ethanol requires 26 percent less fossil energy to produce than it contains, while cellulosic ethanol – made from whole sugarcane plants and similar plant materials such as grasses and wood – requires as much as 90 percent less energy to produce. Soy diesel requires 69 percent less energy than it contains. Other oilseeds, such as sunflowers, can produce as much as four times the amount of biodiesel per acre as soybeans.

"The future of ethanol production in Louisiana can be divided into two segments – that which can be produced immediately from molasses, milo or corn and that which requires longer-term development, such as ethanol from cellulose or new energy crops," said Don Day of the LSU AgCenter's Audubon Sugar Institute in St. Gabriel. "Biodiesel seems to hold the promise of freeing the Louisiana farmer from the rising fuel cost of producing crops."

Short said six biofuel projects are in the pipeline in Louisiana – three ethanol plants and three bio-diesel plants. ■ **Rick Bogren**

ON THE COVER: For a few years, longleaf pines look like clumps of grass. This young tree has left that stage and has begun to grow skyward. Read more on wildlife in longleaf pine forests on page 16. Photo by John Wozniak.

Editors Receive Award

Linda Foster Benedict, associate director of LSU AgCenter Communications, and Rick Bogren, associate professor, received a gold award for their editing of *Louisiana Agriculture* from the Association for Communication Excellence, an international professional development organization. They were cited for making science understandable. They will receive their award at ACE's annual meeting in June in Quebec City, Quebec, Canada. ■

Barry Moser, 1955-2005

Barry Moser, 50, head of the Department of Experimental Statistics, died unexpectedly April 19, 2006, of a heart attack. Moser had been department head since 1997, having joined the LSU AgCenter faculty in 1985. Moser's area of expertise was applied statistics, and he worked collaboratively with countless researchers in analyzing and interpreting their research. He has been a contributor to *Louisiana Agriculture*. A native of Greensboro, N.C., Barry graduated from North Carolina State University and received his Ph.D. from the University of Georgia. He is survived by his wife, Beverly, and two daughters. ■

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Published quarterly by the Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge, Louisiana.

Subscriptions are free. Send requests to:
Linda Foster Benedict, Editor
Louisiana Agriculture
P.O. Box 25100
Baton Rouge, LA 70894-5100
phone (225) 578-2263
fax (225) 578-4524
lbenedict@agcenter.lsu.edu

www.lsuagcenter.com

LSU AgCenter

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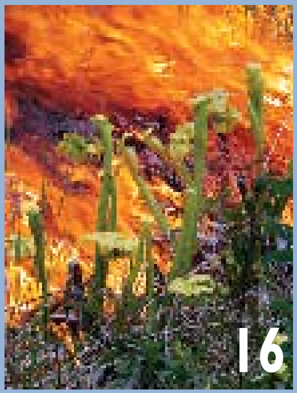

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Volume 49, Number 2, Spring 2006

Photo by Jim L. Chambers

Coppice or sprout reproduction from stumps of harvested trees in Louisiana's coastal wetland forests.

Protecting Coastal Wetland Forests

What Can You Do to Help?

Jim L. Chambers

Louisiana's coastal wetland forests are of tremendous economic, ecological, cultural and recreational value. But many acres of these forests have disappeared over the past century, and many more are being degraded or lost each year. Although coastal land loss has long been recognized, the extent and critical nature of coastal wetland forest loss has largely remained unrecognized or ignored.

In 2004, a 12-member Science Working Group on Coastal Wetland Forest Conservation and Use was commissioned through the Louisiana governor's office. (See sidebar, "Governor's Science Working Group on Coastal Wetland Forest Conservation and Use.") The charge for this group was to:

- Assemble the available information on the status of the forested wetlands.
- Examine the current laws, policies and regulations affecting them.
- Evaluate the regeneration situation of these forests.
- Determine the need for action.
- Make recommendations for the long-term utilization, conservation and protection of Louisiana's coastal wetland forest ecosystem.

Louisiana has about 2 million acres of forested wetlands with more than half in the southeastern and south central parishes. Smaller areas are found along cheniers and river bottoms in the southwestern parishes. The Science Working Group recognized that both large-scale and localized alterations of processes affecting coastal wetlands have caused the complete loss of some coastal wetland forests and reduced the productivity and vigor of others. This loss and degradation threaten ecosystem functions and the many services these forests provide, including wildlife habitat, migratory bird stopover and feeding areas, storm protection, water quality enhancement, soil stabilization, aesthetics and timber production. The value of these functions and services is estimated to be nearly $8,000 per acre per year.

These forests, where present in coastal areas, may also provide important protection from storm surge during hur-

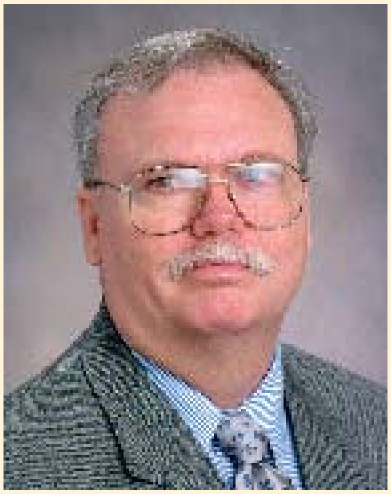


Photo by John Wozniak

Jim L. Chambers

Jim L. Chambers, Weaver Brothers Professor of Forestry, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

Photos by Jim L. Chambers

Baldcypress stump in a partially harvested stand showing no evidence of sprouting.

Baldcypress stump with multiple live sprouts still surviving 20 years after a partial harvest.

Baldcypress stump with live sprouts 20 years after harvest showing considerable decay.

Photos by Jim L. Chambers

Oaks blown down at Tickfaw State Park as a result of Hurricane Katrina.

Large oak downed by Hurricane Katrina. The large, broad, thin root mass demonstrates the shalllow rooting of oak trees on wet sites.

Example of a wind-firm baldcypress and tupelo stand following Hurricane Katrina.

ricanes. Although many tree species are susceptible to high winds during storms, baldcypress and tupelo, the two most common swamp forest species, are inherently more wind firm and less subject to wind-throw (being blown down) and breakage than many other species. Swamps may, therefore, also offer wind protection to nearby low-lying communities.

The Science Working Group found that losses in ecosystem functions and services have been caused by subsidence and levee construction across large areas. Losses have also been caused by local factors such as increased depth and duration of flooding, saltwater intrusion, nutrient and sediment deprivation, herbivory, invasive species and direct loss because of conversion to marsh or open water.

At the local scale, these negative impacts have often resulted from the building of highways, railroads, stream channelization, navigation canals, oil and gas exploration canals, flood control structures, the conversion of forests to urban and agricultural land, and nonsustainable forest practices. While many of these factors have likely had some negative impact on all of Louisiana's wetland forests, the cumulative impacts of multiple factors are greater in coastal areas.

The Science Working Group found that regeneration is a critical process of specific concern in maintaining coastal wetland forest resources. There is currently a lack of regeneration in coastal cypress-tupelo swamp forests in Louisiana. This is a direct result of the cumulative impacts identified above and their interactions with the regeneration process. Baldcypress trees have consistent seed production after age 30. But baldcypress seeds cannot germinate in standing water, and seedlings must grow tall enough during short drawdown periods for their crowns to extend above the water surface to survive multiple flood periods during the growing season. Changes in hydrological regimes (increased flooding) have reduced regeneration in many stands. Harvesting, disturbance and tree mortality – without regeneration – eliminate forest cover and promote site conversion to marsh or open water. When favorable conditions for germination and seedling growth do not immediately precede or follow a regeneration harvest, reliable stand regeneration can only occur through artificial regeneration (planting). Even planting is not possible where flooding is sufficiently persistent and deep. Without hydrological restoration (proper flood regimes), such sites cannot support sustainable forestry activities. Without restoration, these forests will eventually be replaced by marsh or open water.

The Science Working Group made recommendations to the governor's office regarding actions that the state could take to conserve and protect these forests. The recommendations can be found at www.coastalwetlandforestswg.lsu.edu. In general terms, the scientists recommended the following:

- Place priority on conserving, restoring and managing these coastal wetland forests.
- Recognize the set of condition classes that the Science Working Group outlined relative to the regeneration ability of specific sites.
- Place priority on maintaining the hydrological regime of the most productive sites and avoid loss of the more sensitive sites, including placement of a delay on harvesting those sites not likely to regenerate until conditions are changed.
- Ensure proper management and regeneration through recommendations on written forest management plans with specifics on regeneration.
- Develop spatially explicit database and long-term moni-

toring efforts with regular updating to guide management.

- Recognize an expanded area of coastal forests.
- Ensure that all agencies and organizations share and coordinate information, develop practices to prevent coastal forest loss, and actively pursue restoration of degraded forests.
- Enhance forest ecosystem functions through hydrological management decisions related to construction and other activities in wetland areas.

A team from the LSU AgCenter's School of Renewable Natural Resources also conducted a field survey of 18 cypress-tupelo dominated sites harvested 10 to 40 years ago to evaluate the potential of cypress-tupelo forests to regenerate and become established from the sprouts (new shoots arising from the stumps of recently cut trees) common after timber harvesting. The team concluded that stump sprouting was an unreliable means of regenerating baldcypress. Long-term survival of stump sprouts was very low on most sites, and stumps with living sprouts were not well distributed across harvested sites. While growth of surviving sprouts was sometimes good, large amounts of decay were often found within the sprout where the sprout connected to the stump. Further analysis and additional research are planned for stump sprouting as a means of baldcypress regeneration.

What's in a name?

You will see several names given to trees and forest stands that grow in the coastal wetlands in this issue of *Louisiana Agriculture*. Forest stands are often named for their most common tree species. Sometimes areas of wetland forest in Louisiana are referred to as cypress-tupelo stands. This name refers to forest areas where the most common trees may include some combination of bald or pond cypress and water or swamp tupelo. The names baldcypress and pondcypress as single words are used to indicate that they are actually not true cypresses. They are instead relatives of the familiar redwood with similar foliage and cones. You may also see their names spelled as two words, bald cypress and pond cypress. ■

Photo by Jim L. Chambers

Wind-firm tupelo at Tickfaw State Park survived Hurricane Katrina with little damage.

Photos by Jim L. Chambers

Rainfall is a source of shallow flooding on some sites.

Permanent deep water flooding prevents regeneration of baldcypress and tupelo.

Flooding and salinity cause some coastal wetland forests to convert from wetland forests to marsh or open water.

What can the people of Louisiana do to see that Louisiana's coastal wetland forests are conserved and protected or used in a sustainable manner?

Professional Foresters

It is the inherent responsibility of all professional foresters to ensure forest sustainability and strive to meet the landowner's objectives. Professional foresters can do much to conserve and protect Louisiana's coastal wetland forests and act in the long-term best interest of landowners, including the following:

- Recommend harvesting of healthy forest areas only when the site can readily be regenerated and establish stands that will maintain sustainable productivity during the next generation of forests.
- Create written forest management plans that are explicit about how management will be sustainable and how regeneration and long-term wetland forest establishment will be guaranteed.
- Indicate what necessary and feasible alterations to site hydrological regime may help ensure future productivity.
- Explore alternative revenues or management options for sites not likely to regenerate and become established.
- Work with scientists to develop more reliable regeneration for a range of difficult site conditions.
- Apply the Sustainable Forestry Initiative to help to protect and conserve these unique and threatened forests for landowners, citizens and future generations.

Coastal Forest Landowners

Perhaps the most important and crucial key to protecting, conserving and continuing to use Louisiana's coastal wetland forests lies with the landowners and their families. They have a great personal connection to these lands, and they hold the public's many values of these lands in their hands. Coastal forest landowners can do a lot to see that these lands are protected and conserved through the following actions:

- Recognize the serious nature of the problems with coastal forest sustainability.
- Work to ensure that proper forest management techniques are used on lands that can be regenerated on a sustainable basis and that regeneration occurs.
- Demand to know the correct state of their lands and the condition they are in relative to regeneration.
- Work with the state and others to further restoration efforts and regain productivity on lands that remain flooded for long periods during the growing season.
- Be willing, if necessary, to temporarily forgo timber harvesting on those portions of their land that will not regenerate and become established under current conditions.
- Insist that professional foresters provide a written management plan that details how their lands will be regenerated after harvest and how a new forest of equal or better productivity will be established. Get a second, independent opinion when their lands are frequently flooded for long periods, especially during the growing season.
- Look for alternative income sources (instead of timber harvests in coastal forests).
- Consider placing lands in a "forest reserve" system or some other category of compensation developed by the state. The group recommended that the governor establish a Coastal Wetland Forest Reserve System.

Photo by Jim L. Chambers

Seasonal flooding along small waterway formed by scarring from pull-boat logging during peak cypress and tupelo harvesting from the 1890s to the 1930s.

- Consider donating their land to a conservation organization that will provide protection and allow them to reap tax benefits.

What Everyone Can Do

- Recognize the serious nature of the problem with Louisiana's coastal wetland forests.
- Contact federal and state senators and representatives, as well as local officials about helping to save existing wetland forests and restore degraded coastal wetland forests in Louisiana.
- Recognize that we can continue to conserve and protect these resources only for those coastal forests that are sustainable.
- Voice support for efforts to conserve and protect these forests in surveys of opinion and to the news media, friends and those at work. ■

Governor's Science Working Group on Coastal Wetland Forest Conservation and Use

In late 2004, the Governor of Louisiana commissioned a 12-member Science Working Group on Coastal Wetland Forest Conservation and Use. The group completed its work in a year and submitted a report with recommendations.

Jim L. Chambers, Professor in the LSU AgCenter's School of Renewable Natural Resources, was appointed chair of this group. Members included four other faculty from the school: Richard F. Keim, Assistant Professor; Melinda S. Hughes, Senior Research Associate; and Craig A. Miller and J. Andrew Nyman, both Assistant Professors. Other members were William H. Conner, Professor, Department of Forestry and Natural Resources, Baruch Institute of Coastal Ecology and Forest Science, Clemson University, Georgetown, S.C.; John W. Day Jr., Professor, Department of Oceanography and Coastal Sciences, LSU, Baton Rouge, La.; Stephen P. Faulkner, Ecologist, USGS National Wetlands Research Center, Lafayette, La.; Emile S. Gardiner, Research Forester, Center for Bottomland Hardwoods Research, USDA Forest Service, Stoneville, Miss.; Sammy L. King, Unit Leader, USGS Louisiana Cooperative Fish and Wildlife Research Unit, Baton Rouge, La.; Kenneth W. McLeod, Associate Professor, Savannah River Ecology Laboratory, University of Georgia, Aiken, S.C.; and Gary P. Shaffer, Professor, Department of Biological Sciences, Southeastern Louisiana University, Hammond, La. ■

Baldcypress Site Relationships AND SILVICULTURE

Richard F. Keim, Jim L. Chambers and Thomas J. Dean

Regional increases in flooding are likely to reduce the productivity of baldcypress-water tupelo swamps in coastal Louisiana. Although these trees are merchantable for lumber production, it will be important to design appropriate management plans for these sites. Given the demand for the wood but reduced site productivity in many natural stands, establishing baldcypress plantations may be a more appropriate long-term strategy for commercial timber production. More baldcypress silviculture research is needed to support intensive management.

More than 800,000 acres of second-growth stands of baldcypress-water tupelo grow in the swamp forests of coastal Louisiana. Most of these stands regenerated naturally after the timber extraction period in the early 20th century and received little subsequent attention. These trees are now large enough to be once again attractive for harvest. People are particularly interested in baldcypress because of the perception that it is naturally rot-resistant. Markets for baldcypress dimensional lumber and garden mulch are developing despite the fact that the second-growth trees are not yet old enough to contain substantial rot-resistant heartwood.

Even as interest in these wood products increases, the swamp forests of coastal Louisiana face difficult times. Large-scale changes in hydrological conditions in the region caused by hydrological management and land subsidence have reduced vigor of many stands and impeded regeneration. Therefore, it is increasingly important to understand how swamp forest productivity interacts with flooding, and tools to facilitate management and restoration are needed.

LSU AgCenter scientists in the School of Renewable Natural Resources are addressing these issues with long-term research of how natural stands grow and respond to management in contrasting hydrological conditions. Also, management of many swamp forests in Louisiana for forest products may not be feasible because of reduced productivity and lack of natural regeneration caused by increased flooding. Plantations of baldcypress trees may, therefore, become more important as management of natural stands becomes more focused on wetland values unrelated to timber production, such as wildlife habitat and water quality protection. Few baldcypress plantations have been established, and fewer still have been measured to guide silvicultural prescriptions. The lack of data for baldcypress growth and yield in plantation environments hinders development of effective management plans. To meet these needs, AgCenter researchers are continuing long-term measurements of baldcypress growth in an experimental plantation.

Photo by Richard Keim

Figure 1. Researchers core a baldcypress tree in the Verret swamp to obtain tree rings for analyzing long-term growth trends.

Richard F. Keim, Assistant Professor; Jim L. Chambers, Weaver Brothers Professor of Forestry; and Thomas J. Dean, Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

Wetland Forest Productivity and Flooding

To better understand how hydrological changes affect the coastal forest ecosystem, researchers are measuring the width of tree rings in baldcypress at several sites to compare the historical relationship of hydrology and productivity of overstory trees. Sites are in swamps near lakes with long-term records of water levels. One of these research sites (Figure 1) is near Lake Verret. Here flood control levees have eliminated seasonal riverine flooding, but inundation has increased because of subsidence, impeded drainage, and backwater flooding from the outlet of the Atchafalaya Basin.

Growth rates of trees at the Lake Verret site have decreased over the past 30 years, coinciding with increased water levels. Short-term water level changes have different effects on growth than long-term water level changes. For example, trees can grow well when water levels were high for a single year, but the worst growth occurs when water levels are consistently high for several years.

Climate variables such as temperature and precipitation further complicate the picture because they affect growth. These variables often occur in predictable patterns with respect to short-term fluctuations in water levels. Researchers expect to learn enough about the relationships between growth and flooding to predict whether recent declines in baldcypress growth are likely to continue.

Researchers in the School of Renewable Natural Resources also are monitoring long-term research plots in baldcypress-water tupelo forests of the Atchafalaya Basin to understand how differences in flooding affect growth and stand dynamics in a more detailed way than is possible with retrospective analyses of tree rings. In 1980, LSU AgCenter researchers established two sets of plots to compare growth of a stand that experiences flooding early in the growing season to a stand that experiences flooding for nearly all of the growing season. These sites initially had the same volume of tree cover (8,040 cubic feet per acre) (Figure 2). After 25 years, the site with less flooding had grown 27 cubic feet per acre per year to 8,730 cubic feet per acre (Figure 3). The site with more flooding had lost 47 cubic feet per acre per year to 6,863 cubic feet per acre (Figure 4). The volume losses at the more-flooded site occurred because 14 percent of the trees died, and the remaining trees grew very little. In contrast, the less-flooded site experienced 37 percent mortality, but the remaining trees grew enough to more than compensate for the volume loss.

Together, the tree ring and Atchafalaya Basin studies tell a common story: with greater long-term flooding comes less vigorous tree growth. When flooding is not severe, normal forest stand development occurs in which growing space formerly occupied by trees that die is reoccupied through increased growth of the remaining live trees, and forest coverage remains complete. Stands that flood enough to reduce tree growth are on a trajectory to lose contiguous forest cover and eventually convert to treeless marsh or open water.

Baldcypress Management: Experimental Plantation

A study is being conducted on an experimental baldcypress plantation of varying spacing treatments established in the early 1980s. Measurements of the plantation have been made at ages 17 and 22 years (Figures 5 and 6) to better understand how baldcypress responds to competition in a plantation setting. Trees were planted at spacings of 12 feet by 12 feet (289 trees per acre), 16 feet by 16 feet (200 trees per acre), 10 feet by 20 feet (168 trees per acre) and 20 feet by 20 feet (100 trees per acre). There were two 1-acre plots planted at each

Photo by John Toliver

Figure 2. A swamp monitoring site in the Atchafalaya Basin established by LSU AgCenter researchers in 1980.

Photo by Jim L. Chambers

Figure 3. After 25 years, the site in the Atchafalaya Basin with less flooding had grown 27 cubic feet per acre per year to 8,730 cubic feet per acre.

Photo by Jason Zoller

Figure 4. After 25 years, the site in the Atchafalaya Basin with more flooding had lost 47 cubic feet per acre per year to 6,863 cubic feet per acre.

Photo by John Toliver

Figure 5. The research baldcypress plantation two years after planting.

Photo by Justin Marvin

Figure 6. The research baldcypress plantation at age 22 years. The plot was planted at 12 feet by12 feet spacing.

spacing. The plantation is on a Sharkey clay soil that is poorly drained and marginally productive for many desirable bottomland hardwood species, but suitable for baldcypress.

Results of this project indicate that baldcypress grows just as well at the higher densities as at lower densities for at least the first 22 years. Tree size was about the same regardless of spacing (Figure 7), and mortality averaged 6 percent to 11 percent for all treatments, so high density stands are yielding the greatest timber volumes on a per-area basis (Figure 8).

The main difference among trees grown at different spacings is that trees in denser stands had fewer live branches low on the tree because there was less light. Although this self-pruning is evidence of the beginning of competition among trees in the plantation, that competition has not been sufficient to reduce tree growth. Instead, the higher densities are producing more desirable trees for lumber production because they will have fewer knots in the butt log. Many trees grown in the least dense plots still retain large live branches below 6 feet.

Based on the first 22 years after planting, the management recommendation from this research is to plant baldcypress at densities at least as high as included in this study. Baldcypress is known for its ability to persist at high densities but is also thought to stagnate (decrease in stand-level growth at very high densities). Therefore, more research is needed to learn an appropriate upper limit for baldcypress plantation densities.

Baldcypress Management: Thinning Natural Stands

In conjunction with the Atchafalaya Basin study monitoring the effects of flooding on productivity, LSU AgCenter researchers implemented a study in 1980 to evaluate the response of naturally regenerated baldcypress-water tupelo stands to thinning. At the less-flooded site, stands were thinned to 10 percent to 50 percent of their original density by removing the smaller and poorly-formed trees. Scientists measured these test plots again in 2005 to determine the effects of the thinning on growth of the remaining trees and on the total wood volume produced per area of forest.

As expected, the remaining trees in the thinned plots grew faster than trees in the unthinned plots: 1980-2005 volume growth was 227 cubic feet per acre in the unthinned plots, but 711 cubic feet per acre in the most heavily thinned plots. The largest trees grew in diameter more rapidly after the heavy thin (2.9 inches) than did the trees in the unthinned plots (2.0 inches). However, net stand production from establishment to 2005 was about the same: 2,907 cubic feet per acre in the unthinned plots, and 3,280 cubic feet per acre in the most heavily thinned plots (no statistically significant difference between these values).

This experiment suggests that thinning productive natural stands is an option if the goal includes growing large trees, but thinning is not warranted if simple volume production is desired. The experiment did not include low-vigor stands, and more research is needed to understand how best to manage forests that are subject to prolonged growing-season flooding. ■

Figure 7. Tree size was about the same regardless of spacing.

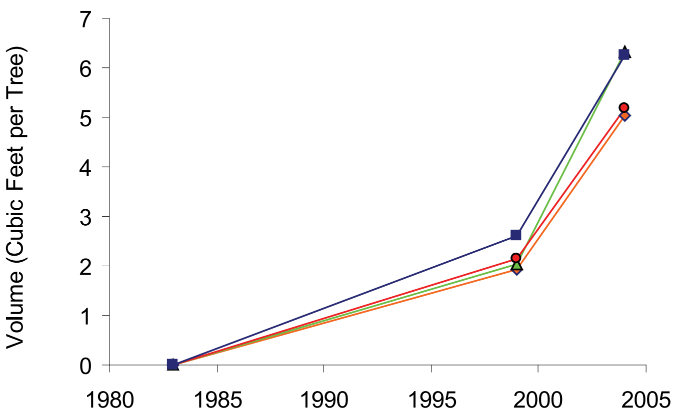
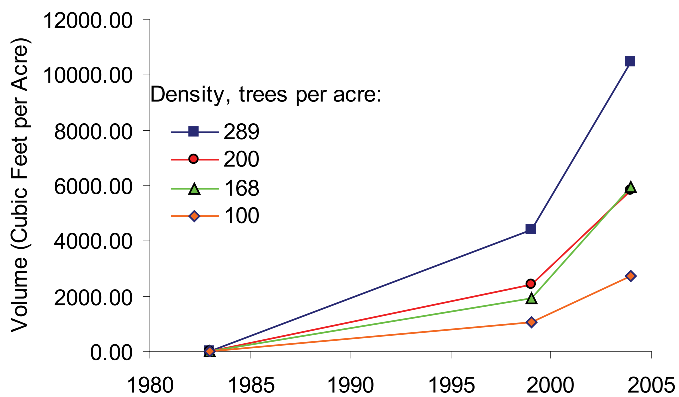


Figure 8. High density stands are yielding the greatest tree volumes on a per-area basis.



Mapping Swamp Forest Conditions

The productivity and composition of wetland forests depend strongly on hydrological conditions. Minor changes in the frequency, duration and seasonality of flooding can favor establishment and growth of entirely separate groups of species. Swamp forests, dominated by baldcypress and water tupelo, are particularly sensitive to changes because they occupy a narrow range of hydrological conditions. Water management and flood control structures have affected most coastal wetlands in Louisiana, and coastal wetland forests have been experiencing large-scale and pervasive changes in hydrological conditions. There have been reductions in vigor and ecosystem conversions in many places.

Effective management and restoration planning of coastal swamps require understanding where effects of changing hydrology are greatest. However, there is no comprehensive information available, nor do methods exist for assembling the required data.

Two new research projects by the LSU AgCenter will enable the use of satellite data to map swamp forest conditions. First, researchers are assessing how satellite imagery correspond to vigor and canopy structure of swamp forests. Second, researchers are beginning work to use a separate set of satellite data to map flooding. The new tools developed by this research will enable resource managers to make informed decisions about how best to manage these important ecosystems. ■

Richard F. Keim, Assistant Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

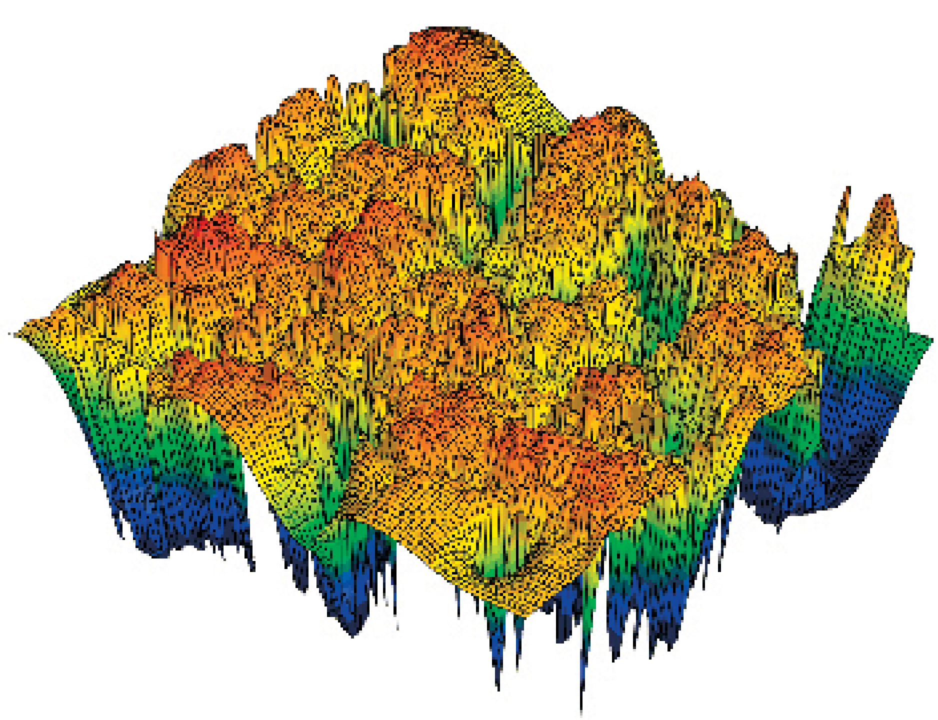
LIDAR promises improved inventory-taking

LSU AgCenter scientists have been researching remote sensing work with airborne lasers to develop three-dimensional pictures to measure the stand and take inventory of a forest.

Called LIDAR, an acronym for Light Detection and Ranging, the process uses a scanning laser in an airplane and global positioning system (GPS) technology to measure the vegetation in a forest. The results are a three-dimensional depiction of the surface below.

"A laser scan 'paints the surface' in three dimensions," said Thomas Dean, a researcher in the School of Renewable Natural Resources. "It creates a picture of the canopy of the forest – the number of trees and their heights."

Like a flashlight beam, the rays of the laser are reflected back to the sending unit, and the increments of time it takes for the beams to return indicate distance. The information is used with a GPS to create what looks like a relief map. But instead of depicting the contours of the ground, the map represents the forest canopy.



This three-dimensional plot of LIDAR data depicts the canopy of a section of forest. Color gradations from blue to red show the differences in height from ground level.

Dean likens the LIDAR map to draping a virtual sheet over the forest to look at the top surface to count trees and measure their heights.

The first application of LIDAR in forestry was in the early 1990s, and the technology has been gaining interest since then.

Dean and Quang Cao, another researcher in the School of Renewable Natural Resources, have been using LIDAR to measure specific properties of the forest canopy, such as length of the green crown.

Dean said their and others' research indicates LIDAR is feasible and accurate for both measuring trees and conducting a forest inventory. The scientists hope to refine the technology to improve the accuracy and speed of taking an inventory of a standing forest.

"It's still too expensive for regular use," Dean said. "People on the ground are cheaper, but technology always becomes less expensive with time." ■ **Rick Bogren**

Restoration and Management of Bottomland Hardwoods

Sammy L. King

Bottomland hardwood forests are distributed along rivers and streams throughout the central and southern United States. These wetland forests contain numerous oxbow lakes, sloughs and other wetlands embedded in a mixture of oaks, sweetgum, hickories, ash, cottonwood, sycamore and other species. These forests are economically valuable for timber production, and they also support diverse wildlife populations including waterfowl, songbirds, black bear, and a variety of reptiles and amphibians. The types and abundance of tree species at a given site depend upon the frequency of flooding, soil types and other site characteristics.

The largest concentration of bottomland hardwoods in the United States occurs in the Lower Mississippi River Alluvial Valley (LMAV). The LMAV consists of the floodplain of the Mississippi River and extends from Cairo, Ill., through parts of seven states to the Gulf of Mexico. Historically, there were about 25 million acres of bottomland hardwood forests in the region. However, extensive harvesting along with the building of levees altered the processes that structure these forests.

In the 1980s, the Louisiana Department of Wildlife and Fisheries and other state and federal agencies became concerned about the effect of widespread forest clearing on wildlife dependent on these forested wetlands. They began experimenting with replanting the forest on sites that had been cleared. These initial trial-and-error experiments have now developed into one of the largest reforestation and wetland restoration efforts in the world. Broad-scale conservation goals have been developed for migrant songbirds, waterfowl, shorebirds, other waterbirds and the threatened Louisiana black bear.

These restoration efforts include management of existing forests to improve forest conditions for wildlife as well as reforestation of former agricultural fields. Reforestation on public lands, and particularly on private lands through the U.S. Department of Agriculture's Wetland Reserve Program, has begun to restore many wildlife and forest-related functions to the region. In Louisiana, the Wetlands Reserve Program has resulted in the restoration of more than 157,000 acres. In 2006, about $9 million will be spent through the Wetlands Reserve Program in Louisiana.

Recent research through the LSU AgCenter and the U.S. Geological Survey's Louisiana Cooperative Fish and Wildlife Research Unit has focused on management and restoration of bottomland hardwood forests to benefit wildlife species in the LMAV. Researchers and land managers are working cooperatively

Bottomland hardwood forests are economically valuable for timber production, and they also support diverse wildlife populations including waterfowl, songbirds, black bear, and a variety of reptiles and amphibians.

Sammy L. King, U.S. Geological Survey's Louisiana Cooperative Fish and Wildlife Research Unit and Adjunct Associate Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

The largest concentration of bottomland hardwoods in the United States occurs in the Lower Mississippi River Alluvial Valley.

to develop forest management guidelines for public lands that will enhance wildlife habitat, particularly for migratory birds and the black bear.

Most bottomland hardwood forests are relatively young because of extensive harvesting at the turn of the 20th century, and they lack characteristics of older stands. For example, ongoing research indicates that younger stands generally have less downed and standing dead wood, and other studies indicate that younger stands may also have fewer tree cavities. Although downed and standing dead wood may seem like an economic loss, it is highly valuable for many species of wildlife, including many species of songbirds, reptiles and amphibians.

There is also concern about the current stress levels of trees and the ability for some forest stands to regenerate. Large-scale flood control and navigation measures have altered surface and subsurface hydrologic patterns, resulting in widespread changes in forest composition. In some cases, sites have become much wetter, whereas in others, sites are much drier. Thus, overstory trees became established under very different conditions than presently exist, and the ability to regenerate a valuable stand is often compromised. For example, recent studies indicate sites along channelized streams had significantly higher sediment deposition than those along unchannelized streams with as much as 32 inches of sediment deposited in one year. Channelized streams also supported less economically valuable species, such as maple and box elder, whereas unchannelized streams supported a greater number of oaks and hickories.

Photo by Yi Jun Xu

Restoring bottomland hardwood wetlands is also challenging because of the long time frame necessary for these forests to mature and because of altered flooding patterns. Initial research results, however, are encouraging. Research was conducted to evaluate the effectiveness of restored wetlands in providing habitat to amphibians, particularly frogs. Amphibian populations have experienced dramatic declines worldwide as a result of habitat loss, diseases and other factors. This is of concern not only because of their overall contribution to biodiversity and ecosystem function, but also because they are an important food resource for many other species of wildlife. Studies indicate that restored wetlands are rapidly colonized by most species of frogs. In Avoyelles Parish, 11 frog species of 12 that occur in the area were observed in wetlands restored through the Wetlands Reserve Program. Studies indicate that dense shoreline vegetation, abundant vegetation in the pond, and mature forest cover in upland areas near the wetland are important to amphibian habitat in restored wetlands. Similarly, other researchers have found substantial use of restored areas by songbirds and waterbirds. It is expected that the types of animals using these sites will change as the forests mature.

As the forests mature, new challenges are expected. How do we manage these stands to get a desirable mix of high quality species beneficial to wildlife and economically valuable? Because open grown oaks are generally of poorer quality than oaks grown in partial shade, can we expect the first rotation to be a high quality stand? Researchers have found that cottonwood interplanted with oak results in accelerated development of forest structure, rapid colonization by songbirds, and increased economic returns on some sites. However, is this method suitable on all sites? Are there alternatives? There are many questions to answer now and in the future. ■

Longleaf Pine Forests

Wildlife of Louisiana's Threatened Grasslands

Philip C. Stouffer

Photo by Erik I. Johnson

What do red-cockaded woodpeckers and gopher tortoises have in common? They are endangered species, and both require a habitat becoming rare in Louisiana and throughout the southern United States. To thrive, they need open pine forests, known as longleaf pine savannahs. In addition to the woodpecker and tortoise, these forests are home to a spectacular array of plants and animals.

As longleaf pine forests have disappeared over the past century to less than 10 percent of their original extent in Louisiana, many of these species have made their way onto the state's list of Species of Conservation Concern. Active management, especially prescribed burning, will be required to maintain these elements of Louisiana's natural heritage.

Longleaf pine forests once covered vast areas of central, southwestern and southeastern Louisiana north of Lake Pontchartrain. About 4 million acres were once longleaf pine forest in Louisiana. Botanists and geologists often subdivide the longleaf forests into flatwoods and savannahs, depending on the topography and soils, but the basic structure remains the same. Longleaf pine trees form a sparse overstory, the midstory is open, and the ground vegetation includes lush growth of grasses and other herbaceous vegetation.

Persistence of longleaf pine forests requires one regular disturbance – fire. Fire stimulates flowering by many of the herbaceous plants, reduces invasion by woody species common in hardwood forests, and allows dominance by longleaf pine. Indeed, the entire system has evolved over millennia in response to lightning-induced fires during the growing season. Most areas historically burned every one to four years. In the absence of fire, the midstory becomes crowded, ground vegetation thins, and the canopy eventually closes with a mixture of hardwoods and pines. These conditions eliminate many of the specialized plants and animals of the open forest.

Although these forests get their name from the magnificent tree that dominates the park-like landscape, the heart of the biological diversity resides in the sublime vegetation underfoot. Some

Philip C. Stouffer, Associate Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

Photo by Erik I. Johnson

Photo by Erik I. Johnson

Many species of concern, including the orchids carolina redroot (*Lachnanthes caroliniana*), above, and manyflower grass-pink (*Callopogon multiflorus*), at right, are found only in longleaf pine habitats. Many other unique wetland species are dependent on the longleaf pine savannah, including the small spreading pogonia (*Cleistes bifaria*), upper right, and yellow pitcher plant (*Sarracenia alata*), below, which is a carnivorous plant.

Photo by Philip C. Stouffer

Photo by Erik I. Johnson

Photo by John Wozniak

The thick shrub layer indicates that prescribed fire is long overdue at this site. Herbicide and physical removal of woody plants may also be needed to restore savannah after many years of fire suppression.

300 plant species grow in Louisiana's savannahs, with as many as 30 species in an area the size of a hula hoop. At this scale, not even rainforests have a diversity of species comparable to our native grasslands. Characteristic plants include dozens of species of grasses, sedges and rushes, as well as showier plants like orchids, asters and pitcher plants. Many of these species are said to be endemic to fire-maintained habitats, which means that they do not occur in other habitats. Indeed, according to the Louisiana Natural Heritage database, the savannahs of southeastern Louisiana host more of the state's rare plants than any other habitat.

Animals of the longleaf pine forests show a similar pattern. Several species, including the red-cockaded woodpecker, require longleaf pine trees. Most species, however, are more closely associated with the ground vegetation. The Louisiana Department of Wildlife and Fisheries' list of Species of Conservation Concern includes more than 25 vertebrate species from longleaf pine forests. More than half of the amphibians, terrestrial reptiles and terrestrial mammals on the list occur in these habitats. Among birds, these grasslands are home for some of the most habitat-specific species in the state, including Bachman's and Henslow's sparrows, as well as game species like turkey and bobwhite quail.

LSU AgCenter researchers have been studying Henslow's sparrows in longleaf savannahs for six years. Results demonstrate how fire helps to maintain habitat quality for savannah species. Henslow's sparrows breed in grasslands of the Midwest and Northeast, where their numbers have declined precipitously in tandem with the conversion of native prairie to agriculture. They arrive in Louisiana in October and November and remain here until March or April. By tracking bird abundance in the same savannahs over multiple years, we have shown how birds respond to growing-season fire. Henslow's sparrow abundance peaks in the first winter after burning, then declines with each successive year without burning. After three years without fire, the birds are gone. Data suggest that the important change in vegetation during this period is the gradual closing of herbaceous vegetation right at ground level. These birds are extremely secretive, moving like rodents at ground level beneath the leaves of herbaceous plants. They probably use the small openings between bunches of grass as they forage for a diverse variety of seeds available on the ground.

The research with Henslow's Sparrows reinforces historical data in showing that longleaf forests require regular burning. In 21st Century Louisiana, this means prescribed burning by managers. Central to this management is public recognition of the critical importance of fire. Fortunately, the extensive areas of longleaf forest in Kistachie National Forest and Fort Polk are being actively

Photo by Philip C. Stouffer

Toothache grass (*Ctenium aromaticum*) and other characteristic savannah species flower only after growing-season fire.

managed with fire, as are smaller areas such as Sandy Hollow and Lake Ramsay Wildlife Management Areas and the Nature Conservancy's Abita Flatwoods Preserve. Some of these areas have required removal of undesirable plants to recover from years of fire suppression.

Given the limited extent of longleaf forests in Louisiana, even small areas could support native biodiversity, especially for plants. Although using fire makes management more difficult for owners of small parcels of land, some landowners are attempting to restore or maintain longleaf forests. Longleaf pine doesn't produce the return of short-rotation loblolly pine, but it is valuable timber when harvested.

What does the future hold for Louisiana's longleaf savannahs and their wildlife? Savannahs on public land should persist, if managed properly. These large blocks of forest hold the most promise for wildlife, as some species have already disappeared from smaller remnants. Unfortunately, some species have declined to such small populations that their survival remains in the balance. Gopher tortoises, red-cockaded woodpeckers, and dozens of less charismatic plants and animals need every bit of longleaf savannah that remains. ■

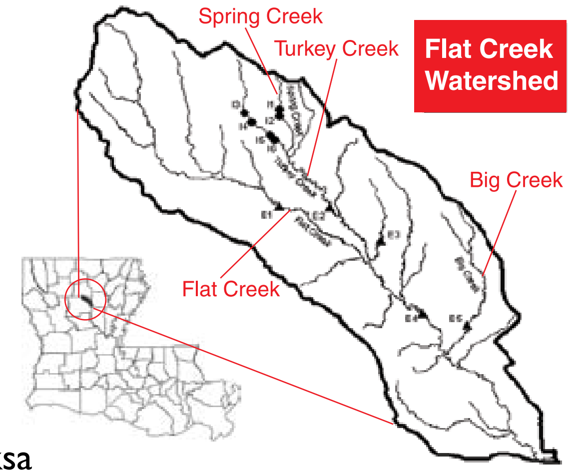
Henslow's sparrows breed in prairies of the Midwest and Northeast and winter in savannahs along the Gulf Coast. Because of habitat loss, the species has declined considerably in numbers.

Many savannah plants bloom in the fall. This photo was taken in September.

Photos by Philip C. Stouffer

A small longleaf pine provides cover for this wild turkey nest. Other game species including white-tailed deer, Eastern cottontail rabbit, Northern bobwhite and Wilson's snipe also use open grasslands.

Forestry BMPs Protect Water Quality in Louisiana's Streams, Bayous and Lakes



Yi Jun Xu, Adrienne Viosca, April Mason and Philip Saksa

Louisiana is blessed with an abundance of forests and waterways. Miles of rivers, bayous and lakes provide Louisiana's citizens with fishing, hunting, boating and recreational opportunities, which contribute to the state's wealth and economic growth. Many of these water bodies are located in or adjacent to forested areas, which occupy nearly half of the state's land base. Louisiana's forests, water and economic and environmental well-being are inextricably intertwined.

Water quality of streams and bayous is not only dependent upon conditions within the channel, but can be significantly affected by the surrounding landscape. A riparian buffer comprised of trees and vegetation can help mitigate the impact of land uses, such as roads or agricultural fields that can affect a stream. Forested areas play an important role in maintaining healthy water quality by reducing surface runoff. They have the ability to slow down storm water runoff, allowing for increased infiltration and soil water storage. Excess nutrients are then absorbed into the soil, where they can be used by plants instead of reaching waterways and potentially causing eutrophication. Additionally, forests help reduce erosion, contributing directly to stream channel stability and habitat quality.

Maintaining forests near waterways helps protect water quality. Lower order streams hold small volumes of water and are especially prone to changing air temperature and the influence of sunlight. Trees help maintain the temperature of the stream by providing valuable shade, blocking direct sunlight with canopy cover. Stream temperature often affects other critical water quality parameters. For example, increased temperature tends to cause decreased dissolved oxygen, which is especially critical in many of Louisiana's streams and bayous.

While protecting the environment, Louisiana's forests produce a large variety of commercial products. Forests of Louisiana managed for timber production constitute the state's top agricultural crop, contributing an estimated $4.55 billion to Louisiana's economy in 2005. Because of the large land base of forests, management practices in forested areas directly or indirectly affect physical, chemical and biological properties of many waterbodies.

To minimize the effects from forestry operations, a best management practices (BMPs) manual was developed in 1988 for forest landowners, logging contractors and the forest industry to serve as a practical field guide. In 2000, the manual was revised with more detailed guidelines and technical procedures to be followed for each forestry operation. The revised manual, available on the Louisiana Department of Agriculture and Forestry Web site at www.ldaf.state.la.us, includes descriptions of federally mandated BMPs for forestry operations in wetlands and consists of an array of various forestland management guidelines and techniques to prevent sediment, nutrient and organic material runoff. Although it is a voluntary program, implementation of the BMPs is currently high across various land ownerships and regions in Louisiana (Figure 1).

The effectiveness of these forestry BMPs may vary widely from the southern coastal lowland to the northern upland of the state. Land managers need to understand the inherent variability of topography, soils and hydrology of the forested area for BMPs to be properly implemented and therefore effective.

Yi Jun Xu, Associate Professor, and Adrienne Viosca, April Mason and Philip Saksa, all graduate students, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

Photo by Yi Jun Xu

April Mason, left, and Philip Saksa, both graduate students working with Yi Jun Xu, measure dissolved oxygen, pH, temperature and conductivity in the Flat Creek watershed.

Photos by Yi Jun Xu

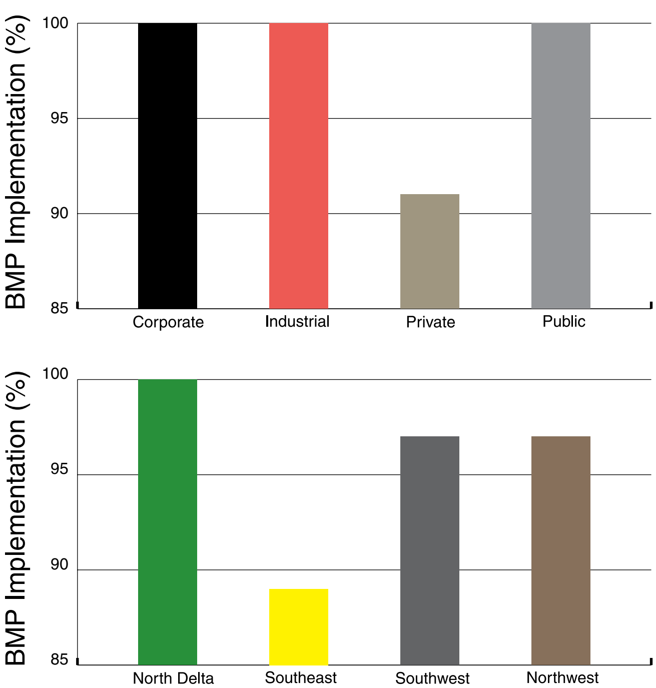
Graduate student April Mason checks a sampler that analyzes the chemical content of the water.

It is also important to determine how local forestry operations might affect stream conditions in the larger watershed.

LSU AgCenter scientists are conducting research to evaluate the effectiveness of current Louisiana Forestry BMPs. A study located in a predominately forested watershed, Flat Creek Watershed, in central Louisiana monitors water quality changes across the entire basin (See top of page 20). Storm runoff and nutrient discharge are being measured at various locations using automatic stream sampling systems. Physical, chemical and biological indicators are being analyzed to evaluate water quality changes with forestry operations that implement BMPs.

Geographic Information Systems (GIS) will also be used to identify spatial and temporal water quality patterns in the watershed. This spatial analysis will help the researchers quantify the effects of forest operations on water quality and evaluate the BMP effectiveness in water quality protection across the landscape. Such information will be essential in refining forestry BMP guidelines to optimize protection of stream health. ■

Figure 1. Implementation of forestry best management practices (BMPs) in 2003/2004 by land ownerships and regions in Louisiana.



Graduate student Adrienne Viosca conducts a stream channel cross-sectional profiling in a stream in the Flat Creek watershed.

Photo by Y. Jun Xu

The Role of Louisiana's Forest Ecosystems in Carbon Sequestration

Yi Jun Xu and Fugui Wang

Carbon Dioxide and Global Climate Change

Since the late 19th century, the global average temperature of the Earth has increased by 0.7 to 1.4 degrees F. The significant global warming has been attributed to human activities such as fossil fuel combustion and land use change, which lead to the increase of the concentrations of greenhouse gases, especially carbon dioxide (CO_2).

Total annual carbon emission from the Earth's surface and from fossil fuel use is estimated to be about 7 billion metric tons, of which 2 billion metric tons are taken by the oceans and 1.8 billion metric tons are sequestered by vegetation growth, resulting in an annual increase of 3.2 billion metric tons in the atmosphere. Over the past 150 years, humans have put nearly 300 billion metric tons of carbon into the air. The atmospheric CO_2 level is continuously rising and has recently surpassed 380 parts per million by volume (ppmv).

The Intergovernmental Panel on Climate Change (IPCC), established by the United Nations World Meteorological Organization (WMO) and Environment Programme (UNEP), has predicted that if anthropogenic emissions of carbon dioxide continue at present-day levels, the atmospheric concentration of carbon dioxide would increase to 460-560 ppmv by 2100. The global surface temperature would then be at least 0.7 degree F warmer than the levels in 1990.

Role of Forests in Global Carbon Budget

Trees are referred to as carbon sequesters because they take CO_2 from the atmosphere and store it in biomass – live and dead tree trunks, branches, foliage and roots – and soils. About half of a tree is made up of carbon. The world's forest cover is estimated to be about 9.4 billion acres. The amount of carbon stored in forest biomass alone is about 283 billion metric tons. Together with deadwood, litter and soil, the world's forests store about 50 percent more carbon than the amount of carbon in the atmosphere, making a significant influence on the global carbon cycle.

Forest ecosystems in the United States contain about 53 billion metric tons of carbon, of which 41 percent is stored in biomass and 59 percent in forest soils. Spatial and temporal changes in this large carbon storage are complex and can be a result of: (a) local site conditions such as climate, geomorphology and soil, which determine long-term carbon sequestration potential; (b) disturbances such as changes in land use, previous and current forest management practices, and natural disasters, which alter carbon pools; (c) vegetation types as con-

Yi Jun Xu, Associate Professor, and Fugui Wang, graduate student, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

sequences of (a) and (b); and (d) forest growth phases, which determine temporal biomass accumulation rates.

In the context of global climate change, two substantial challenges exist:

1) How to maintain and increase the forest carbon storage.
2) How to predict its future change, given the large uncertainties of the inherent variability in forest ecosystems.

Forest Carbon Storage and Distribution in Louisiana

To answer those questions, scientists at the LSU AgCenter have been assessing space-time variation of the forest biomass carbon in Louisiana and the predictability of potential future change of the carbon stock. As watersheds are increasingly becoming primary planning units for natural resource management, the research takes full advantage of advanced GIS technology and rich sources of spatially referenced databases to analyze forest ecosystem carbon stock and dynamics at the watershed scale.

The study shows that forest carbon density in Louisiana increases from the southeast Mississippi delta, to the lower coastal plain, and to the northwest upland region (Figure 1). The spatial distribution reflects the land use and management practices in the state. As of 2003, Louisiana's forests store 268 million metric tons of carbon in all biomass components. Pine forests and oak-gum-cypress bottomland forests are two communities that present the largest stock of biomass carbon in Louisiana.

Louisiana Forest Carbon Change in the Past and Future

During the period from 1991 to 2003, carbon stock of Louisiana's forests underwent considerable change (Figure 2). Biomass carbon stocks in all forestry types, except for the longleaf-slash pines, have decreased by 2.7 percent to 18.4 percent. In total, the state lost 9.3 percent (or 27 million tons) of the carbon stored in the forests in 1991. The largest percentage loss was observed in the elm-ash-cottonwood (18.4 percent) and oak-hickory forest types (13.8 percent). The largest mass change in biomass carbon, however, occurred in the oak-gum-cypress forests (9.4 million tons), whereby a 5 percent decrease of the land area by this forest type was also evidenced. This is a further alarming sign for the rapid loss of Louisiana's bottomland hardwoods. Biomass carbon stock in the loblolly-shortleaf pine forests – the state's major commercial timber source – also decreased by 9.6 percent from 1991 to 2003. However, the land area of this forest type increased by 17.5 percent. For the entire state, the forested land area increased by 1.7 percent from 1991 to 2003 (Figure 3).

According to the Louisiana Department of Agriculture & Forestry, the state's landowners (industrial and non-industrial) reforested the land with more than 128 million seedlings in 2004. This includes about 55,000 acres of land (usually marginal farm land) converted to forestry. Another 10,345 acres were regenerated naturally. This increase of forested land areas with seedling trees indicates that the growth of the Louisiana's forests will sequester a large amount of carbon in the coming 20-30 years, if managed properly.

LSU AgCenter researchers continue to develop and analyze a geographically referenced database of terrestrial ecosystem carbon to fully understand the spatiotemporal dynamics of the forest biomass carbon under a changing environment, especially land use change and climate change. ■

Figure 1. Forest carbon density increases from the southeast delta to the northwest upland region.

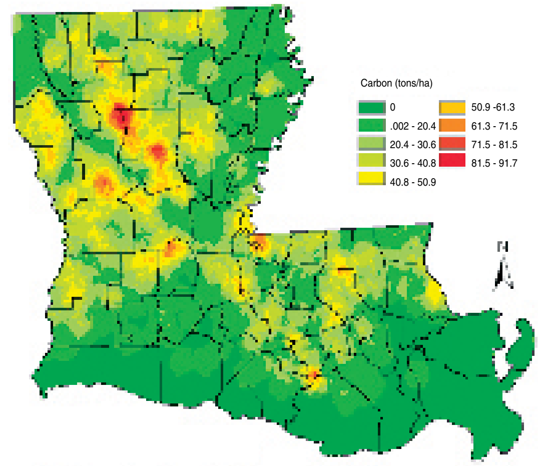


Figure 2. From 1991 to 2003, carbon stock has undergone considerable change.

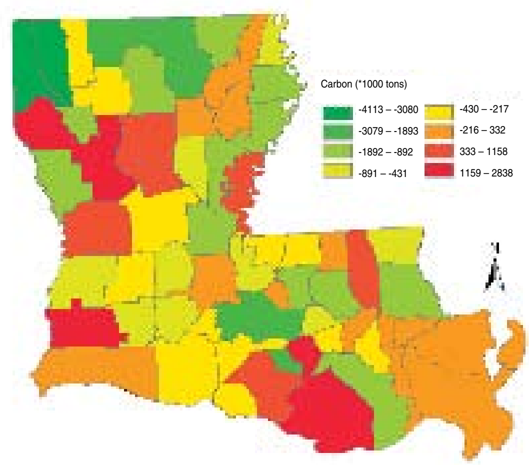
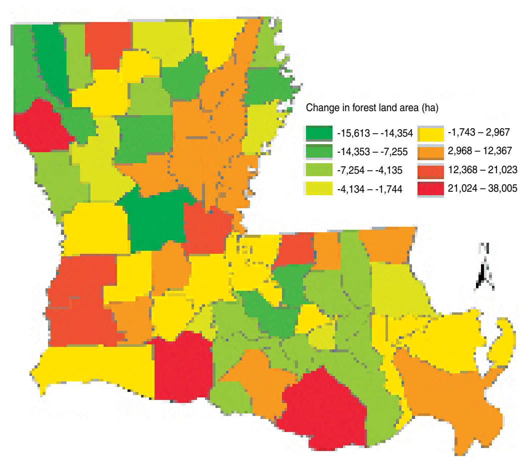


Figure 3. Louisiana's forested land area increased by 1.7 percent from 1991 to 2003.



Forest Management and Stream Organisms

role of trees in aquatic food webs

William E. Kelso and Douglas A. Rutherford

It is imperative that efforts be made to preserve forested buffer zones along Louisiana's streams. These streamside management zones, or SMZs as they are known, help prevent loss of aquatic biodiversity essential to the well-being of the environment.

Water quality monitoring efforts in Louisiana's streams focus on the concentrations of sediment, nutrients and other compounds in the water. However, activities within the watersheds of these streams actually play the most critical role in determining stream water quality. The development and implementation of best management practices (BMPs) for all major land uses can contribute greatly to the protection of Louisiana's streams, rivers and bayous.

In forested watersheds, forest management activities such as road building, tree removal, site preparation, thinning and prescribed burning can result in increased inputs of water, sediment, nutrients and organic matter in adjacent streams. However, implementation of effective forestry BMPs can minimize these inputs.

One forestry best management practice focuses on the maintenance of a streamside management zone, or SMZ, which is a strip of forest along each bank of a stream, known as the riparian zone. An SMZ is typically 30-200 feet wide within which timber harvesting is minimized or prohibited, providing a buffer between the stream and the disturbed area.

Riparian trees have long been known to provide important habitat for forest-dwelling wildlife, particularly birds. From an aquatic standpoint, the importance of an SMZ has been linked to its role as a filter for water moving to the stream. However, maintenance of trees within the riparian zone actually results in other important benefits to the stream and the organisms that live there.

In smaller streams, the riparian forest provides a closed or near-closed canopy that shades the stream and keeps water temperatures low. In Bratton Branch, a small stream in Kisatchie National Forest, LSU AgCenter researchers found that stream temperatures during summer were often 18 degrees F cooler than air temperatures, which often exceeded 80 degrees F. In addition to temperature amelioration, the forest canopy reduces light levels in small streams, minimizing the development of algal communities. Although this might not seem beneficial, loss of the canopy results in large increases in algal growth, particularly in streams with high nutrient loading. This increase in algal biomass results in high dissolved oxygen conditions during the day, but extremely low levels at night. Because of the continual movement and oxygenation of water in most streams, resident invertebrates and fishes are not well adapted to low dissolved oxygen concentrations. Consequently, loss of the riparian canopy can result in low dissolved oxygen levels at night due to algal respiration, and higher water temperatures (which also result in lower dissolved oxygen levels) during the day. Most stream fishes in smaller systems are adapted to cooler waters and moderate to high dissolved oxygen levels, and loss of the canopy can cause sensitive species to move downstream or die, resulting in large changes in the abundance and species composition of the resident invertebrate and fish communities.

As streams increase in size, the canopy opens. The types of organisms inhabiting the stream change, and the importance of the shading function of the SMZ declines. However, riparian trees also play a critical role in determining the shape and habitat structure of a stream, which is closely linked to the diversity of resident organisms. The root structure of riparian trees helps stabilize the bank by resisting erosion during periods of high stream discharge. This in turn helps stabilize the stream channel and reduce sediment inputs that typically increase stream turbidity during storm events. In addition, continued erosion underneath the root mass will form an undercut bank, which is preferred habitat for many stream fishes.

Through time, the undercut bank will collapse, and the tree, now referred to as large woody debris, will fall into the stream. This promotes the formation of upstream slackwater pools, as well as shallow, higher velocity habitats (riffles) as flow is restricted to a smaller part of the channel. Downstream pools are scoured out as water flows over the trunk during storm events.

It is important to maintain natural densities of trees adjacent to streams, creeks and bayous. The sequence of events leading from a growing tree to submerged woody debris is a key link between riparian forests and aquatic habitat diversity. This habitat diversity, in turn, is positively related to the distribution and abundance of invertebrates and

William E. Kelso, F.O. Bateman Professor of Renewable Natural Resources, School of Renewable Natural Resources, and Douglas A. Rutherford, Bryant Bateman Professor of Renewable Natural Resources, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

fishes in a stream. Some invertebrates, such as larval mayflies and certain fishes like darters and some minnows, are riffle-dwelling species. Snails, crayfishes, sunfishes, bass and topminnows prefer pool conditions. Loss of large woody debris because of the removal of riparian forests often results in long reaches of uniform habitat conditions in adjacent streams, resulting in a concurrent decline in the diversity and abundance of stream organisms.

In addition to large woody debris, riparian trees also provide streams with a continuous supply of organic matter in the form of small sticks and leaves. As stated previously, little sunlight reaches streams that have dense overstory canopies, which results in low levels of algal production in the stream. Consequently, these streams depend on forest-derived organic material to provide the energy that drives the aquatic food web. This material, known as detritus, can fall directly into the stream or move to the stream during riparian flooding associated with storm events and is processed first by bacteria and fungi, which continue the detrital breakdown that began with the leaching of water-soluble compounds.

A group of organisms known as shredders, such as crayfish, amphipods, and the larvae of certain aquatic insects, consume pieces of the detritus and its bacterial and fungal coating, and break it into smaller particles as they feed. These smaller detrital particles are food for other invertebrates and some fishes that collect the particles or filter them from the water column. All of the shredders, collectors and filterers provide food to carnivorous insects, crustaceans, fishes, birds, mammals and reptiles at the top of the stream food web. Thus, contribution of organic detritus to the aquatic food web is another role that riparian forests play in the ecology of adjacent streams. This role again emphasizes the importance of maintaining an adequate diversity and density of trees within the SMZ.

In addition to large woody debris and seasonal leaf fall, riparian forests also provide continual input of small woody debris in the form of sticks and branches. The low-gradient, sand-dominated streams characteristic of Louisiana's coastal plain and upland watersheds have minimal amounts of bedrock or gravel, which are preferred habitats for stream organisms in higher gradient stream systems. As a consequence, small woody debris often provides the only available hard-surface habitats, which are used extensively by a diversity of stream-dwelling invertebrates and fishes as cover, food, feeding sites and reproductive habitat. LSU AgCenter scientists have found that many Louisiana fishes, such as pirate perch and brown madtoms, are closely associated with accumulations of small woody debris, which provide a refuge from the current, a hiding place to escape predators and an abundance of invertebrate prey. Researchers have also found that invertebrate species that inhabit woody debris are often different from those inhabiting the substrate, so the loss of small woody debris inputs would have significant effects on the community abundance and species composition.

In larger streams with open canopies, submerged woody debris provides a surface for development of bacterial and algal communities, called biofilms, which are important food sources for a group of invertebrates known as scrapers, such as snails. Throughout Louisiana, submerged woody debris accumulations are biological hotspots, and these habitats probably support a majority of the invertebrate and fish production in the state's stream systems. ■

Larval stages of aquatic insects, like this damselfly, are often abundant in woody debris.

Photos by John Wozniak

As streams increase in size, the canopy opens. The types of organisms inhabiting the stream change and the importance of the shading function of the SMZ declines.

The Hurricane Impact on Southern Pine Sawtimber Stumpage Prices in Louisiana

Sun Joseph Chang

Within a month, hurricanes Katrina and Rita damaged about 4.4 billion board feet (3.0 billion by Katrina and 1.4 billion by Rita) of sawtimber inventory in Louisiana. Sawtimber inventory is the amount of standing timber that could readily be harvested for solid wood products, such as lumber and plywood. Katrina hit Louisiana on Aug. 29, 2006, and Rita followed on Sept. 24.

In comparison, the total harvest of pine and hardwood sawtimber for Louisiana in 2004 was 1.221 billion board feet. In essence, Katrina and Rita wiped out the equivalent of more than two years' worth of pine sawtimber harvest and more than 11 years' worth of hardwood sawtimber harvest for the entire state.

Beyond Louisiana, Hurricane Katrina damaged 12 billion board feet of sawtimber inventory in Mississippi and 1.3 billion board feet of sawtimber inventory in Alabama. Furthermore, in Texas, Hurricane Rita damaged an additional 4 billion board feet of sawtimber inventory.

The sudden loss of about 22 billion board feet of sawtimber inventory is unprecedented. We surmise that the statewide southern pine sawtimber stumpage prices will probably drop by more than half in the coming months and that the trough of depressed prices will likely last six quarters. After this difficult period is over, we expect stumpage prices to return to pre-Katrina levels of about $350 per thousand board feet (MBF), as reported by the Louisiana Office of Forestry for the second quarter of 2005. We encourage forest landowners whose timberlands lie outside the hurricane damaged areas to keep up with prices and look for the best possible price and thus time to sell.

Historical Review

Over the past 50 years, the southern pine sawtimber stumpage prices have undergone three phases – 1955 to 1969, 1969 to 1989, and 1989 to present (Figure 1).

Between 1955 and 1965 of the first phase, the prices first trended downward because sawtimber inventory was increasing rapidly in response to expanded reforestation efforts after World War II. This lowering price trend triggered the arrival and the subsequent expansion of the southern plywood industry. Between 1965 and 1969, timber harvests doubled, and the stumpage prices rose by about 50 percent.

From 1969 to 1989, there were two episodes of rapid stumpage price rises. The first episode was caused by the expansionary federal spending of the 1960s, chiefly the War on Poverty, the Space Race and the Vietnam War. The second episode was caused by the country's expansionary monetary policy during the late 1970s. The first episode of rapid stump-

Clearing debris after Hurricane Katrina.

Sun Joseph Chang, Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

Figure 1. Yearly real southern pine sawtimber stumpage prices in Louisiana 1956-2004.

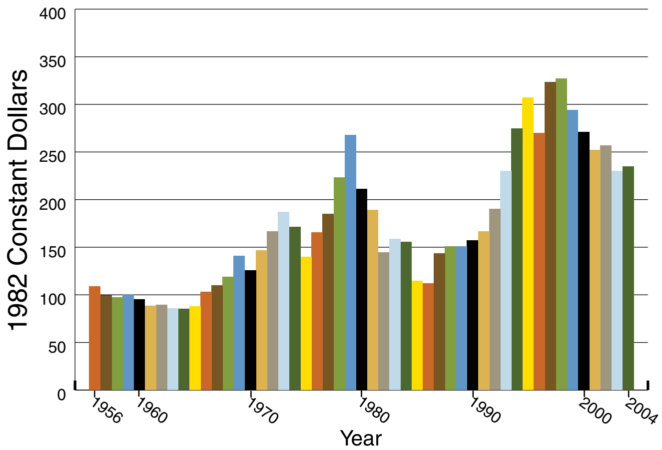
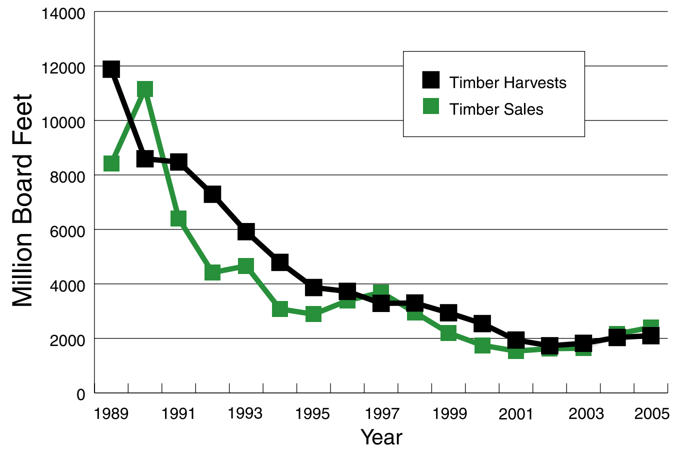


Figure 2. USDA Forest Service timber sales and harvest volume.



age price rise was quashed by the 1973-74 oil embargoes, while the second one was eliminated by efforts to lower inflation in the early 1980s. In addition between 1984 and 1986, stumpage prices dipped by about a third when southern pine beetle outbreaks ravaged the pine forests of Louisiana. The important thing to note here is that if we were to shave off the peaks of the early and late 1970s and fill in the trough of 1985-86 caused by the beetle outbreaks, stumpage prices were essentially flat, averaging around $150 per thousand board feet between 1969 and 1989.

Photo by John Wozniak

Since 1989, after the northern spotted owl was officially listed as a threatened species under the Endangered Species Act, the timber volume sold by the national forests dropped from nearly 10 billion board feet in 1990 to less than 4 billion board feet by 1994 (Figure 2). This drop in federal timber sales benefited forest landowners in Louisiana tremendously. Southern pine sawtimber stumpage prices increased more than 80 percent from $150 per MBF in 1989 to $274 per MBF in 1994. A new era had dawned on the timber market in the Louisiana and the South.

Stumpage prices since 1994 have been marked by wild gyrations. The reduction of 6 billion board feet in timber supply from the national forests between 1990 and 1994 meant significant tightening in the timber supply and demand situation. As a result, when too much rain in the wet winter seasons reduced the area available for timber harvest in Louisiana, stumpage prices soared. For example, the 18.1 inches of rain in the first quarter of 1995 caused stumpage prices to peak at $330 per MBF, exceeding the $300 per MBF mark for the first time. Stumpage prices dropped below $250 per MBF in the second quarter of 1996 when Louisiana experienced a brief drought in the first half of the year.

The high rainfalls of the first half of 1997 sent stumpage prices back up to near $330 per MBF again. In 1998, however, 23.37 inches of rain pushed stumpage prices to an all-time high of $367.57 per MBF. Ever since the second half of 1999, southern pine stumpage prices have been sliding back and settling down around $230 per thousand board feet. Once these peaks are accounted for, sawtimber stumpage prices in Louisiana since 1993 were essentially flat averaging around $220-$240 per MBF.

Lessons from the Past

The southern pine beetle outbreak of 1985-86 provides insight into the likely scenario of development for the stumpage prices after hurricanes Katrina and Rita. The 1985-86 outbreaks killed about 1.1 billion board feet of Louisiana's southern pine sawtimber inventory plus another 0.5 billion board feet in Texas. The stumpage prices plummeted by about a third from $150 to $100 per thousand board feet and the trough of depressed stumpage prices lasted for about six quarters. On the other hand, Hurricane Hugo in 1989 damaged about 25 percent or roughly 4.8 billion board feet of the southern pine sawtimber inventory in South Carolina. The sawtimber stumpage prices plummeted about 30 percent and lasted about one year. ■

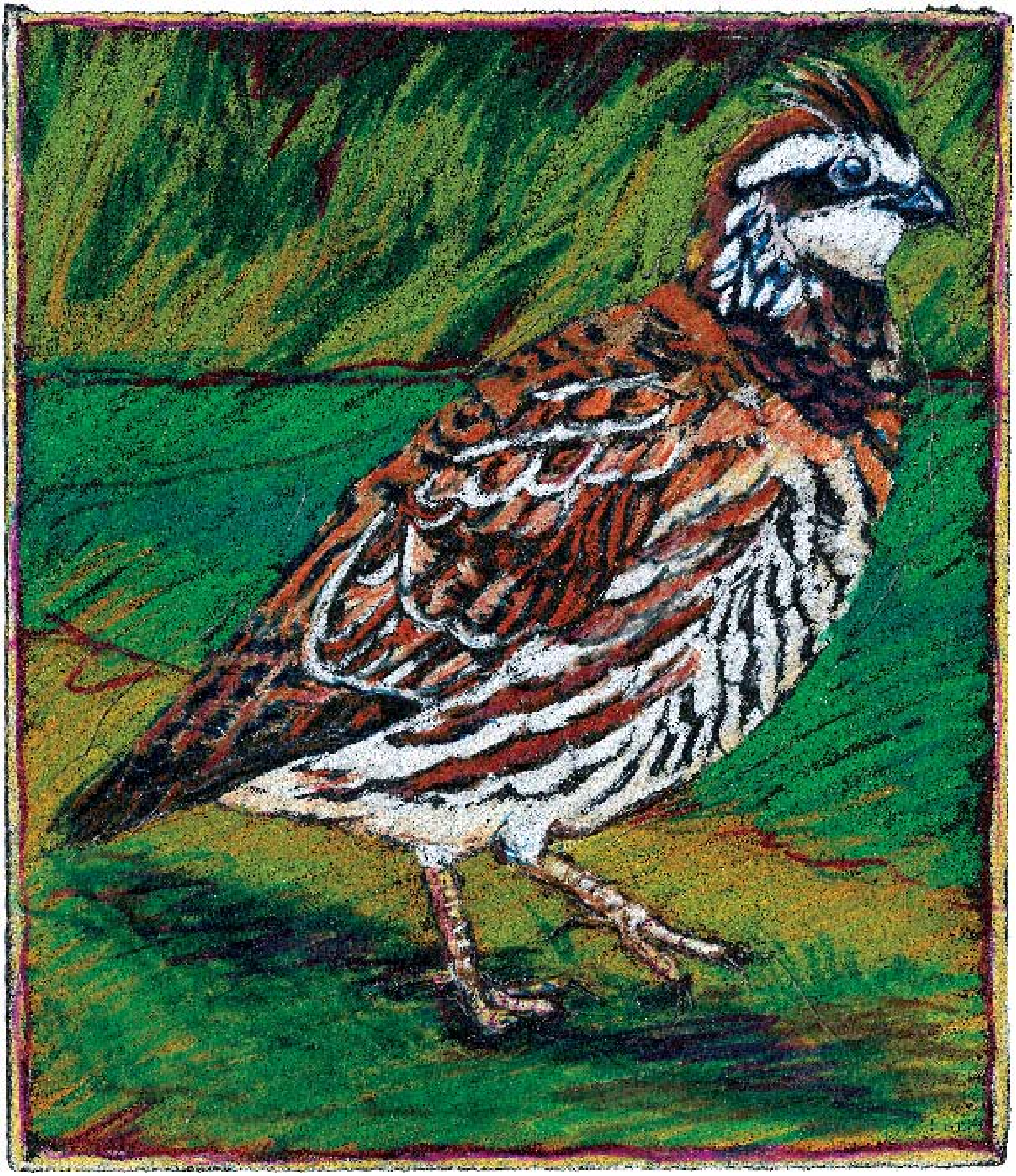


Illustration by Frankie Gould

Using Herbicides and Fire to Manage Pine Forests for Northern Bobwhites

Michael J. Chamberlain and Judy J. Jones

Northern bobwhite populations have declined over the past 30 years throughout their range. This decline is due to habitat loss caused by a combination of factors including changes in landscape use from small farms with brushy fence lines and hedgerows to clean-farming, silvicultural practices creating large monocultural stands, and more recently, reduction of fire as a silvicultural tool.

In Louisiana, bobwhites were historically abundant throughout pine forests maintained with frequent fires. Prescribed burning has been a traditional silvicultural practice.

Today, however, because of funding limitations, lack of qualified professionals and public perception of risk, prescribed burning is little used throughout the Southeast. Currently, wildlife managers can use prescribed fire only when conditions allow, often resulting in extended burning rotations that make it impossible to re-establish the native pine savannah that bobwhites prefer. Although herbicides have been used to improve habitat conditions for various wildlife species, little research has examined habitat quality for bobwhites within pine forests following application of selective herbicides, particularly in conjunction with prescribed fire.

LSU AgCenter researchers examined the effects of two herbicide treatments in conjunction with prescribed fire and prescribed fire alone on vegetative structure within pine stands. This research was conducted at the AgCenter's Idlewild Experiment Station near Clinton during 2000-2002.

The procedure involved an initial dormant season burn to nine 8-acre plots, then application of imazapyr and imazapyr with glyphosate to three plots each in September 2000. The remaining three plots served as controls. In February 2002, researchers conducted a second year post-treatment dormant-season burn in all plots to remove excess debris from experimental plots and for a two-year burn rotation for control plots. Two-year burning rotations are frequently recommended for managing bobwhite habitat in pine forests. Researchers sampled vegetation during the summer of 2000 (pre-treatment) and during 2001 and 2002. The vegetation structure was evaluated for suitability for bobwhite nesting and brood-rearing.

Herbicide treatments in combination with prescribed fire generally were more effective than prescribed fire alone.

Both herbicide treatments in combination with prescribed fire generally were more effective than prescribed fire alone at improving vegetation structure for brood-rearing and nesting bobwhites during the first year post-treatment. Both herbicides reduced vegetation height to levels (about 1 meter) conducive to bobwhite nesting and brood-rearing, reduced the percentage of woody and hardwood midstory vegetation, and increased bobwhite food plants. Plant diversity and abundance of herbaceous vegetation, however, were reduced during the first growing season after treatment. Initially, both herbicide applications allowed for abundant pine seedlings in all herbicide-treated plots.

During the second growing season, both herbicide treatments in conjunction with fire were more effective than prescribed fire alone at improving vegetation structure for brood-rearing and nesting bobwhites. Imazapyr with fire was more effective at controlling woody vegetation while reducing litter depth relative to imazapyr-glyphosate with fire and fire alone. Bobwhite food plants were most abundant on imazapyr plots, and both herbicide applications with fire increased herbaceous vegetation needed for nesting and brood-rearing habitat. Imazapyr application with fire increased vines – honeysuckle, jessamine, blackberry, greenbriar and grape. Blackberry and grape are an important food source for bobwhites in spring, summer and fall. Notably, all treatments produced low percentages of bare ground (less than 10 percent), yet bare ground is an essential component for quality bobwhite habitat because it improves foraging success of adults and chicks. Landowners managing mature pine forests similar to those studied will have difficulty producing abundant bare ground because of needle cast and litter accumulation. Therefore, additional mechanical manipulations such as discing and tilling may be necessary.

Both herbicide treatments greatly reduced sweetgum, but neither negatively affected hard-mast producing species (those greater than 10 centimeters in diameter). Sweetgum are considered undesirable when managing pine forests for bobwhite, primarily because of their propensity to stump sprout following dis-

Michael J. Chamberlain, Associate Professor, School of Renewable Natural Resources, LSU AgCenter, and Judy J. Jones, Biologist, Louisiana Department of Wildlife and Fisheries, Baton Rouge, La.

turbance and their ability to outcompete desirable forbs and legumes. Conversely, mast-producing hardwoods are important for bobwhite, particularly during winter. Applying imazapyr and imazapyr with glyphosate likely will not affect the availability of mature, mast-producing species, although regeneration will be negatively affected through reductions in woody understory species.

Management Recommendations

Both herbicide treatments in combination with prescribed fire greatly improved brood-rearing and nesting habitat for bobwhites. Overall, imazapyr with fire provided a greater benefit than imazapyr-glyphosate with fire and retained a diversity of plant species. Prescribed burning historically has been used to manage and maintain pine and pine-hardwood forest ecosystems, and fire typically increases production of native legumes used by bobwhites. Absence of disturbance in these forest ecosystems eventually will cause early successional pine-grasslands required by bobwhites to revert to thick hardwood midstory, which will become a closed pine-hardwood canopy with little herbaceous vegetation. Using herbicides and thinning the stands can help prevent these closed canopy conditions.

Although imazapyr improved vegetative characteristics for bobwhites more than prescribed burning alone, the greatest net benefit from imazapyr application occurred following the dormant-season fire before the second growing season. Landowners and managers interested in using imazapyr to benefit bobwhites should be cognizant of the continued importance of prescribed fire in managing landscapes for bobwhite.

Bobwhites require diverse, patchy habitat to successfully survive and reproduce; therefore, widespread application of imazapyr in forested stands would not achieve this goal. Bobwhites prefer vegetation higher than 1 meter for escape cover, and only prescribed fire alone created and maintained cover suitable as escape cover. Therefore, the LSU AgCenter recommends that landowners and managers target areas where prescribed burns are not possible or areas where benefits of prescribed fire are low, such as areas where understory vegetation is too rank and dense to be controlled by fire alone, and apply imazapyr in conjunction with fire. Applying imazapyr to these stands will improve vegetative characteristics for bobwhite, and coupled with the continuation of prescribed fire when possible, will help create diverse, patchy habitat typically associated with greater numbers of bobwhites. ■

LSU AgCenter Forestry Agents Serve As Front-line Forces

The LSU AgCenter provides forest landowners with educational opportunities to help them manage their timber resources for profit and sustainability. Louisiana has more than 140,000 non-industrial private landowners owning 67 percent of the forest land in the state.

Four LSU AgCenter area forestry agents offer forestry education through forums, trade shows, educational materials, field tours, personal visits and youth programs. They are Brian Chandler in Clinton, Barry Crain in Alexandria, Steve Hotard in Calhoun and Ricky Kilpatrick in Shreveport.

The area foresters serve as front-line forces for the LSU AgCenter's School of Renewable Natural Resources providing assistance to landowners, homeowners, non-governmental organizations, interest groups and local governmental officials. Also, they bring together expertise from around the state, region and country to educate local stakeholders regarding resource management and care.

Work in urban and shade tree care is perhaps where most requests for assistance and information originate. Issues surrounding wood products, whether originating from homeowners concerned about wood damage or companies seeking assistance regarding wood utilization, continue to grow in importance in the state.

Invasive species that affect Louisiana economically and environmentally are coming more into the forefront of thought among Louisiana's leadership in natural resource management, government agencies and officials.

In addition, area agents develop numerous programs with schools. They cooperate with the Louisiana Department of Agriculture and Forestry, Louisiana Forestry Association, private industry foresters, USDA Forestry Service and others to instill a desire to learn about forestry among youth.

For example, in central Louisiana there is an annual Forest Awareness Week targeting youth in the fifth grade. Professionals provide guided tours through the forest with stops along the way for lessons to be conducted. Because of the success of Forest Awareness Week in central Louisiana, the program has been expanded to include more than 15 parishes in this state.

In northwest Louisiana, the area agent trains teachers and others on how to use the Project Learning Tree educational materials. Students learn to apply scientific and mathematical principles in a fun way. Recently, a fifth grade teacher at Oil City Elementary School, Brenda Smith, received national recognition as an Outstanding Educator who uses the Project Learning Tree material.

In northeast Louisiana, nearly 1,000 fourth grade students attended the 2006 AgAlley exhibit, which was part of the Ag Expo in Monroe. The students learned about the products made from trees, benefits of growing trees and the importance of sustaining forest resources. Also, about 8,500 residents from the area walked through the AgAlley forestry display.

South Louisiana was hit hard by the hurricanes in 2005. The area agents quickly met with other agencies and industry to plan educational programs to inform landowners about assistance programs, tax incentives, fire control, the importance of harvesting downed timber, the need to replant and other practices to get the land back in timber production.

Agents and specialists play a vital role in working with these groups regarding forestry, ecology and environmental issues as well as long-term management of natural resources. ■ **John Chaney**

Photos by John Wozniak

Best management practices at work on an East Feliciana tree farm

Linda Carruth does not allow hunting on her property.

Picture an ideal tree farm with beautiful trees, a stream, some good roads and wildlife. Such a farm exists in the rolling hills of East Feliciana Parish under the watchful ownership of Linda Carruth.

Carruth began planting trees on this farm in 1980, when her father gave her 10 acres of it. Initially, he questioned her plan.

"He thought trees should just be allowed to regenerate," Carruth said. "I talked him into it, and he allowed me to plant those first pine seedlings."

Carruth said her father was able to see those young trees before he died and agreed that she had made a wise decision.

When she started planting timber, Carruth's one concern was the trees, but now she sees the bigger picture.

"It's not just planting trees. It's taking care of all of it – the soil, the water, the air and the wildlife," Carruth said.

Solitude Hill timber farm now spans 370 acres. There are 11 stands on the property, most of it pine with about 10 acres of hardwood.

Carruth is active in forestry associations. She is a member of the Forestry Landowners Association, Louisiana Forestry Association and Feliciana Forestry Association. The American Tree Farmer System certified her farm, and she has participated in two short courses, the Master Tree Farmer and Master Wildlifer programs.

The Master Tree Farmer program, offered through the Louisiana Forestry Association, is now called the Sustainable Forestry Initiative (SFI) program and is administered across the nation. The Master Wildlifer program, also nationwide, was offered last year in Louisiana through the LSU AgCenter.

These programs and organizations emphasize using best management practices and being good stewards of the land. Carruth said that is now her top priority.

She doesn't allow hunting on her property. She plants food plots such as rye grass, puts out corn for deer and has bluebird and duck boxes around her farm. She doesn't burn in certain areas.

"Part of being a tree farmer is being a good neighbor and by having smoke go across the road and in my neighbor's house is not good, so I choose to bush hog under the trees close to the road and around houses."

In a corner of Carruth's property, one can find a thriving population of damsel dragonflies. Carruth said their habitat is protected by a 50-foot stream-side management zone (SMZ).

She uses low-water crossings and has five of them on her property.

"This is less costly than a culvert application."

At these low-water crossings, large rocks are packed with a dozer. This keeps the soil in place while allowing water to flow freely.

When loggers are on her property, she does not allow them to cross water beds except at the crossings and they must keep their equipment away from water sources.

Best management practices recommend 30-foot SMZs, but Carruth doesn't allow logging within 50 feet of streams. She says the 50-foot SMZ reduces erosion, keeps the water cleaner and provides habit for the dragonflies, birds and even deer.

"I've seen the deer nest in the tall grasses."

Twenty-five years later, Carruth is happy with her decision to plant timber.

"I believe God has given me a gift – a gift of being a tree farmer," she said. ■ **Tobie Blanchard**

Louisiana has more than 140,000 nonindustrial private landowners owning 67 percent of the forest land in the state. Carruth owns a 370-acre tree farm in East Feliciana Parish.

Establishment Success and Growth of Southern Pine Plantations on Water- and Nutrient-Poor Soils

Michael A. Blazier and Terry R. Clason

Forests of Louisiana managed for timber production constitute the state's top agricultural crop, contributing an estimated $4.554 billion to Louisiana's economy in 2005. Louisiana's managed forests, which are often loblolly pine plantations, are among the world's most productive forests at producing timber and fiber. Typical rates of return for loblolly pine plantation management are between 8 percent and 15 percent.

The potential for good returns on investment makes loblolly pine plantation management attractive to landowners. However, profitably establishing and managing loblolly pine plantations on the sandy, gravelly soils common in the upland areas of Louisiana can be problematic. These soils are poor at holding water and nutrients, so seedling mortality can be high, particularly in a droughty year, and the long-term growth of the surviving trees is often relatively low. Poor tree survival and slow growth reduce timber yields and economic returns of loblolly pine plantations.

The conventional management tactic for overcoming survival and growth problems on droughty sites is to plant extra seedlings, sometimes more than twice the number planted on better sites. The hope is that enough leftovers will remain to produce an adequate plantation. However, seedlings rarely die in an evenly distributed pattern. The resulting plantation often has sections of tightly-spaced, low-value trees and other sections with few trees. Thus, the tendency to plant higher numbers of seedlings on droughty sites negatively affects economic success because it increases planting costs and reduces the value of the surviving trees.

The feasibility of managing loblolly pine plantations on droughty, nutrient-poor soils can be improved by planting the same number of trees optimum for better soils – 300 to 600 trees per acre – and using management practices that increase the distribution of water and nutrients to crop trees. Crop trees can be given a head start by using herbicides near planting time to reduce woody and herbaceous vegetation that compete with trees for water and nutrients.

Containerized Seedlings

Another tactic that can improve pine survival and growth on sandy and gravelly soils is the planting of containerized seedlings. This type of seedling, available at most nurseries, is planted with the root systems encased in a soil-filled plug (Figure 1A). Compared to the more conventionally planted bareroot seedlings (Figure 1B), which are planted with exposed root systems, the root systems of containerized seedlings are larger and healthier. A healthier root system may increase survival of seedlings during the sensitive first growing season on soils with poor water- and nutrient-holding capacity.

At the LSU AgCenter's Hill Farm Research Station in northwest Louisiana, a research project was conducted to determine the pine survival and growth rates associated with various herbicides and seedling types on a soil with relatively low water- and nutrient-holding capacity. In 1993, a loblolly pine plantation was planted on a gravelly, fine sandy loam soil (classified as a Darley-Sacul soil). The effects of the herbicides applied near planting time on loblolly pine growth and survival were assessed with the four treatments listed in Table 1.

Seedling type effects were tested by comparing growth and survival of containerized seedlings to that of bareroot seedlings. All containerized and bareroot seedlings were of the same loblolly pine family. The fam-

Figure 1A. Container longleaf pine seedling.

Photo by Mary Anne Sword-Sayer

Figure 1B. Bareroot loblolly pine seedling.

Photo by Eric Taylor

Michael A. Blazier, Assistant Professor, Hill Farm Research Station, LSU AgCenter, Homer, La.; and Terry R. Clason, State Forester, USDA Natural Resources Conservation Service, Alexandria, La.

ily was selected because of its good growth potential on well-drained soils.

Among the herbicides tested, the HEXSULF treatment produced the highest tree survival rates from 1993 through 2003 (Figure 2). The HEXSULF treatment also promoted the greatest tree growth rates in the 10 years after planting among all the herbicide treatments. Overall, the mixtures of herbicides used in the HEXSULF and IMAZMET treatments produced better growth than the single-herbicide LOHEX and HIHEX treatments (Figure 3). Using mixtures of herbicides controls a wider array of underbrush species, which was particularly beneficial on this water- and nutrient-poor site. The herbicide mixtures used in the HEXSULF and IMAZMET treatments are widely available and used.

Table 1. Herbicide treatments applied to a loblolly pine plantation near the time of planting on a droughty soil in northern Louisiana.

Treatment	Herbicides*	Application rate (lb active ingredient per acre)
LOHEX	hexazinone	2.00
HIHEX	hexazinone	4.00
HEXSULF	hexazinone,	2.00
	sulfometuron methyl	0.09
IMAZMET**	imazapyr,	0.75
	metsulfuron methyl	0.04

*hexazinone = Velpar, sulfometuron methyl = Oust, imazapyr = Arsenal, and metsulfuron methyl = Escort
**imazapyr and metsulfuron methyl were tank-mixed

Figure 2. Effects of four herbicide treatments applied near the time of planting on survival of loblolly pine trees on a droughty site in northwest Louisiana.

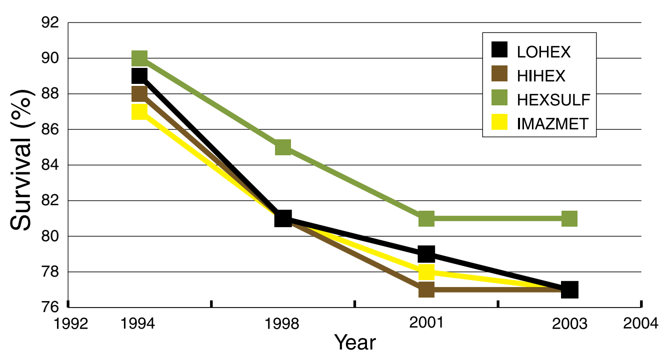


Figure 3. Effects of four herbicide treatments applied near the time of planting on volumes of loblolly pine trees on a droughty site in northwest Louisiana.

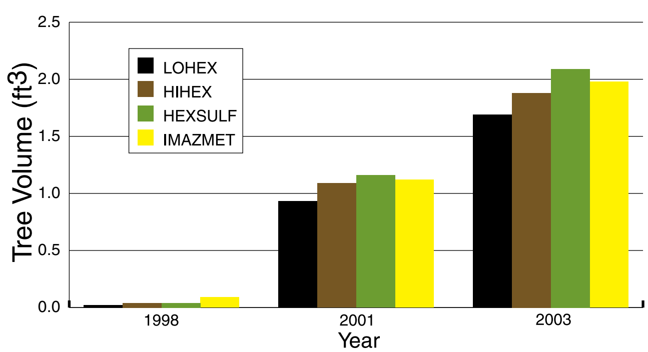
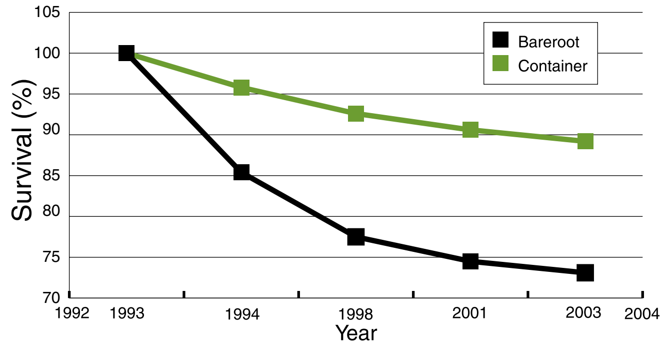


Figure 4. Effect of seedling type on survival of loblolly pine trees on a droughty site in northwest Louisiana.



Survival Rates

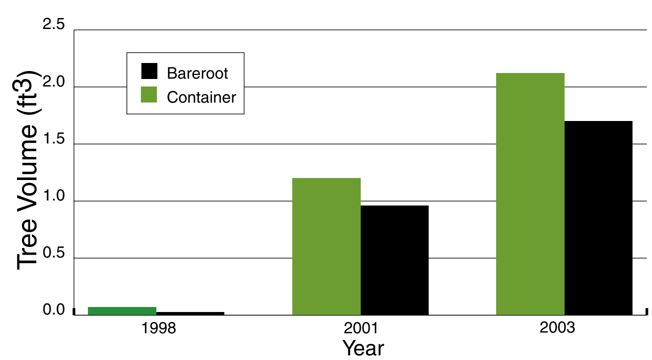
Planting container seedlings had a profound effect on survival on this droughty site (Figure 4). The survival advantage of planting container seedlings was striking in the first year after planting, in which survival of container seedlings was 11 percent higher than that of bareroot seedlings. Survival of the container trees continued to be 10 percent to 15 percent higher than that of bareroot trees up through 2003.

This finding highlights the paramount importance of good root systems on such soils. Containerized seedlings survived well because they had a fully formed root system when planted. Their root systems were able to expand quickly and mine the soil for water and nutrients. By contrast, bareroot systems started with a partial root system. The extra time and energy required to form their root systems can make a difference between life and death on a water- and nutrient-poor soil.

The superior root systems that have likely given a survival advantage to container pines are also apparently helping them grow better than bareroot pines on this soil. The stems of containerized trees have persistently grown at a faster rate than those of bareroot trees (Figure 5). As of age 11, the combination of better tree growth and survival has led to wood volume yields per acre for the containerized trees that are 35 percent greater than those of the bareroot trees.

Although container seedlings cost twice as much as bareroot seedlings, the greater survival and growth of container seedlings can make them more economically advantageous to plant. Based on the estimated yields at this study site, the rate of return for planting the container seedlings may be up to 10 percent higher than for planting bareroot seedlings. ■

Figure 5. Effect of seedling type on volume of loblolly pine trees on a droughty site in northwest Louisiana.



Invasive Species in Louisiana Forests

Hallie Dozier

Over the past 300 years, tens of thousands of animal and plant species have been introduced in the United States. A small number have proved invasive. That is, they cause harm to natural and managed landscapes, and they are difficult to eradicate. Several species make their homes in Louisiana's forests. Three plant species, two animal species and an insect are of particular concern because of the extensive impact they have on the integrity of our forests.

Chinese tallow tree

The Chinese tallow tree is a small, short-lived tree well-known in Louisiana. Also called popcorn tree, chicken tree, Florida aspen and – locally in Washington Parish – soapberry tree, this Asian native was originally brought to North America in the 1700s as an alternate source of oil for lighting and soap making. Its desirability as a home garden plant – brilliant fall color, fast growth and small size – and its attractiveness to migrating birds as a food source have contributed to its spread.

Today, the tallow is distributed across the southeastern states. In Louisiana, it grows in every parish, though it is particularly troublesome in bottomlands, old fields, coastal prairies and riparian areas. Until fairly recently, Chinese tallow was not considered a threat to forested lands because it grows poorly in the shade. Its appearance in the understory of closed canopy forests and undisturbed sites, however, raises concern because of its potential to dominate gaps created by management operations and to prevent regeneration of desirable species. Forest managers say tallow is the most important invasive plant in Louisiana forests.

Photos by Hallie Dozier

Chinese tallow tree has been in our landscapes for over 200 years. Its brilliant fall color makes this a popular landscape species. Its abundant fruit attracts a variety of bird species that consume and spread the seed across the landscape. Tallow trees in the forest understory can quickly dominate forest gaps (created by natural tree falls and management activities such as harvesting) slowing regeneration of other forest species.

Chinese privet

This plant was introduced to North America in the 1800s to replace common privet in landscapes. It is one of the worst forest invaders in the Southeast because of its ability to dominate the understory, midstory and edges of forests and to impede regeneration of desirable plants, including canopy trees. Its extensive use in landscaping creates a seed reservoir for continuous introduction to forests, and it is particularly troublesome along expanding wildland urban interface areas such as the growing communities along the northern shores of Lakes Pontchartrain and Maurepas and in St. Landry Parish.

The characteristics that make Chinese privet and other ornamentals-turned-invaders valuable landscape plants also contribute to their invasiveness. They are easy to grow under a variety of soil and light conditions. They have few pests, and they are hard to kill.

Cogon grass

Chinese privet and tallow tree are practically ubiquitous across Louisiana, but cogon grass is a relative newcomer and possibly the greatest emerging threat to forests, especially in the southern half of Louisiana. A rhizomatous grass native to Southeast Asia, cogon grass first entered the United States in

Chinese privet dominates a streamside bank in West Feliciana Parish. A prolific fruit producer, Chinese privet attracts birds that spread the seed far and wide. In the forest understory and along edges, privet displaces other plants, including canopy tree seedlings.

Hallie Dozier, Assistant Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

Photos by Hallie Dozier

Cogon grass rhizomes "creep" away from parent plant. They break away easily and can stick in mud attached to shoes, equipment and vehicle wheels, making long-distance transportation possible.

the early 1900s as packing material, though it was later reintroduced at several sites in Florida as potential forage. Cogon grass is a cosmopolitan invader, occurring in agricultural areas, coastal lands, mining areas, forests, watersheds and shrub lands on almost every continent in the world. This aggressive invader forms dense colonies that displace other plant species and prevent their re-establishment. It can alter the pyrogenic characteristics of forested grasslands, such as longleaf pine savannas, increasing flame lengths and temperatures to the point of killing even fire-adapted species. It tolerates a wide range of soil types and soil and fertility gradients. Cogon grass reproduces sexually through flower and seed production and asexually through rhizome growth.

Cogon grass has made its appearance in the southeastern parishes of Louisiana, possibly entering our state through rail, road and pipeline rights-of-way. Rhizomes break away from the main plant easily and can stick in dirt and mud on the wheels of vehicles, enabling it to hitchhike from site to site. Recent hurricane clean-up activities have presented a unique opportunity for this species to spread farther into Louisiana. Thus far, infestations are restricted, but cogon grass's history elsewhere almost guarantees it will become a major problem if not contained early.

Cogon grass competes with young loblolly pine trees in Ben's Creek Wildlife Management Area in Washington Parish. Suspected pathways for arrival in Louisiana include movement along rail, road and pipeline rights-of-way.

All of these species require an integrated management approach for control that includes mechanical (cutting, mowing), cultural (burning) and chemical (herbicide applications) manipulation plus revegetation. Use of indiscriminate, broad spectrum herbicides may not produce desirable results because of non-target mortality. Research exploring the use of more selective chemicals shows promise for controlling these invaders, but more research on how populations respond to management is needed.

Nutria, wild hogs

Two exotic mammals, nutria and wild hogs are particularly destructive to plant life in Louisiana's forests. Nutria are voracious herbivores whose populations have an enormous negative impact on wetland vegetation. In Louisiana in less than a century, these semi-aquatic rodents have managed to wreak considerable damage to coastal areas, including marshlands and regenerating coastal forests. Less pressure from trappers and alligators in the past several decades may have exacerbated their population growth.

Wild hogs also damage trees and reduce regeneration. Unfortunately, their populations are greatest in forested areas with dense understories. Wild hogs root for their food, destroying understory plants, including canopy seedlings, and disturbing the soil. They compete with other wildlife for food, and they are a reservoir for several serious diseases, including pseudorabies, which is fatal to some cat species, and swine brucellosis, which can be fatal in people.

Formosan termites

Exotic insects also play a key role in forest health and integrity. A potential concern in Louisiana forests is the Formosan subterranean termite. About 11 percent of urban trees in the greater New Orleans area and in Lake Charles are infested, and informal estimates in some forests are similar. Cypress, oaks and pines all are vulnerable to these termies. The ease with which people move this insect from site to site is alarming, and once populations are established, they are almost impossible to eradicate. Though not able to disperse long distances naturally, the Formosan termite can be transported in contaminated wood products such as building materials and equipment, railroad ties and utility poles.

Controlling invasive species

The LSU AgCenter has been an active member of groups across the state addressing the problem of invasive species. Research and extension faculty develop educational materials to inform the public about these invasive species and continue to study invasive organisms. Projects include exploring the use of more selective chemicals that show promise for controlling privet and many aquatic species and investigating methods for better assessing the impacts of Chinese privet on forest composition and regeneration.

Faculty also have been active on the Louisiana Aquatic Invasive Species Task Force, which includes 29 appointed members representing both public and government entities. In 2005, the task force published the State Management Plan for Aquatic Invasive Species in Louisiana along with the Louisiana Department of Wildlife and Fisheries, the Louisiana Department of Wildlife and Fisheries, the Louisiana Sea Grant, and the Center for Bioenvironmental Research at Tulane and Xavier Universities. The complete plan is available at http://is.cbr.tulane.edu/docs_IS/Louisiana-AIS-Mgt-Plan.pdf. ■

Cooperative Research *in Sustainable Silviculture and Soil Productivity*

Thomas J. Dean

For many years, sustainable forest management was judged by two simple factors: replacement of harvested trees and consistent yields. Because forestry in the United States originated in response to exploitive logging and land clearing, these were sufficient and effective indicators of sustainability. But today forests produce more than just wood and fiber. Sustainability also includes landscape-level properties such as biodiversity, soil and water conservation, global carbon cycles and socio-economic values.

Forest sustainability depends not only on large-scale factors but also on stand-specific properties such as soil productivity. Soil scientists and foresters recognize that site productivity can be compromised by harvesting and reestablishing trees. Effects accumulate through the years, and Louisiana is harvesting its third crop and planting the fourth.

Given the increasing reliance on high-quality sites to produce larger amounts of wood and fiber products, long-term productivity of individual forest stands has become a priority issue. Concerns over forest productivity extend beyond the obvious problems of surface erosion, rutting and mass wasting that can be initiated by road construction, harvesting and subsequent establishment practices that directly treat the soil. Prudent foresters are keenly aware that soil quality is key to the revenue potential of a site and its ability to produce other forest values. The concern now is whether organic matter removal and subsequent nutrient loss, combined with heavy machines working on forested sites, reduce the productive capacity of the soil despite proper soil conservation practices.

A greater expectation from timberland in Louisiana is anticipated as timber-related activities move from the Atlantic seaboard to the western Gulf region because of urban sprawl. The nearly exclusive use of rapidly growing, resource-demanding genotypes of loblolly pine on industrial lands may also tax the productive capacity of timberland.

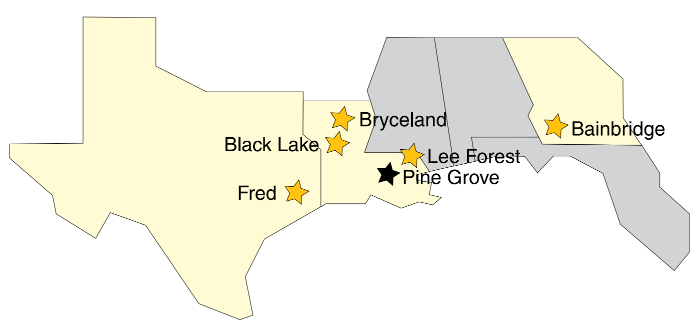
Sustainability Project

In 1993, the LSU AgCenter joined with five other entities to evaluate how whole-tree conventional harvesting and subsequent establishment techniques affect the growth of new generation of loblolly pine trees. The five cooperators were the U.S. Forest Service-Southern Research Station, International Paper Co., Temple-Inland Forest Products Corp., Willamette Industries and Louisiana Tech University.

Since then, the cooperative – now called Cooperative Research in Sustainable Silviculture and Soil Productivity (CRiSSSP) – has grown. Roy O. Martin Timber Company joined the cooperative and Willamette Industries was bought by Weyerhaeuser Co. In addition, two new sites have been added, and one site was lost to fire. Trees in the oldest installations are now approaching canopy closure. The oldest CRiSSSP site is in its 10th growing season, and the youngest site is in its third growing season (Figure 1).

If harvesting and establishment affect tree growth, the effects presumably occur through changes in the soil. Therefore, the primary objective of CRiSSSP is to evaluate the effects of soil compaction and organic matter removal at levels created during normal harvesting operations. Rarely does the forest industry plant seedlings after harvest and not apply some treatment to stimulate early growth. Treatments such as vegetation

Figure 1. Field installations of the Cooperative Research in Sustainable Silviculture and Soil Productivity. Gold Stars represent active sites, and the black star represents a site that was burned in 2000. The Fred and Bainbridge sites are 10 years old; the Bryceland site is 9 years old; the Black Lake and Lee Forest sites are less than 5 years old.



Thomas J. Dean, Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

control and fertilization applied singularly or in various combinations to reduce the time required for trees to reach harvest size.

The second objective of CRiSSSP is to measure the capacity of these various establishment practices to overcome negative harvesting effects and even to enhance the growth of the new stand. With careful monitoring and measurements, foresters can determine how harvesting and establishment practices affect the growth of the new stand. Another objective of CRiSSSP is to develop new methods for detecting management effects on forest productivity before they are manifested in the trees.

Experimental Protocols

The principal comparison conducted by CRiSSSP is the height accumulation of loblolly pine planted on plots where the stand was harvested with and without heavy machinery. Where machines were used, whole trees were removed from the plot, and where machines were not used, trees were cut with chainsaws, and only the commercially valuable portions of the stems were removed. Each harvesting method was combined with a series of various site preparation and follow-up treatments, such as burning to eliminate small logging debris. While harvest treatments were the same at each location, site preparation and other treatments varied by site.

Before harvesting a stand, data were collected to determine the total above-ground biomass, nutrient content and standing volume of pine trees and mature hardwood trees. In addition, a subsample of the best trees on the site was felled to determine height growth patterns. CRiSSSP uses tree height as the primary measure of growth response to the harvesting and establishment treatments because it is relatively unaffected by competition.

Preliminary Results

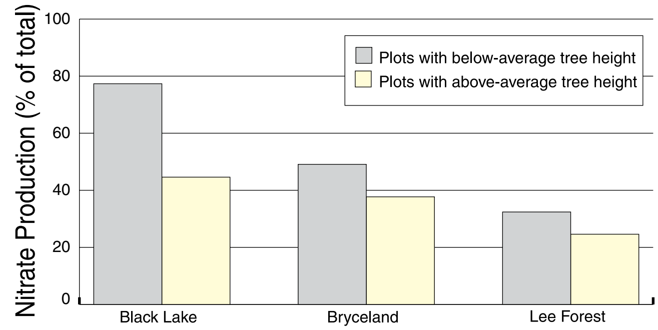
Height growth of the trees in the previous stand was measured by counting the number of rings on disks cut from the stems at regular intervals. The difference in the number of rings between successive disks represents the time required for the tree to grow that distance. Further analyses convert this information to tree height at annual intervals. Height growth of these trees can then be compared with the annual height measurements made of the trees planted on the harvested sites.

At two of the installations, cutting and dragging the whole tree with heavy machinery did not reduce the height growth of new trees planted on these sites when compared with the growth pattern of the best trees in the previous stand, at least during the first decade of growth.

While removing the whole tree from the site with heavy machinery did not seem to reduce height growth of trees in the new stand compared with trees in the previous stand, the heavy disturbance caused by whole-tree machine harvesting sometimes affects the height of the new trees compared to trees planted on other plots where the trees were cut with chain saws and usable portions lifted from the plot. This is seen when the height curve of the trees planted on the plots harvested with minimal disturbance is higher than the height curve of trees planted on plots harvested with maximum disturbance.

Since machines greatly increase harvest efficiency, can the reduced growth that may occur with machine harvesting be offset with additional treatments? According to our results for the first decade of growth since harvesting, the answer appears to be "yes," if the treatments reduce competition from other vegetation such as seen at the Bryceland site. Adding nutrients through fertilization resulted in significant height increases at the Fred site but had no effect at the Black Lake site. Burning the site to clear small logging debris reduced growth at the Bryceland site for six years after planting. At the Lee Memorial Forest site, burning reduced height growth the first two years after planting.

Figure 2. Nitrate produced in the soil as a percentage of the total mineral nitrogen produced (ammonification plus nitrification) measured in plots where the average height is above-average and where the average height is below-average. Although the percent of nitrate production differs with location, the percentage is consistently greater in the plots with the shortest trees.



Finding soil properties affected by harvesting that also affect tree growth has been difficult. While machine harvesting can measurably compact the soil, tree growth may only be affected if the soil was already dense before harvest. Some soil effects that were measurable one year after harvest – such as the total amount of carbon in the soil and the amount of organic nitrogen converted to mineral nitrogen – disappeared one year later. Soil sampling indicates that harvesting at these sites does not cause important nutrients to move below the root zone of the newly planted trees.

Two relationships between soil properties and tree growth, however, show some promise as indicators of site productivity. The Forest Service's Long-term Soil Productivity study indicates that for loblolly pine plantations in central Louisiana, phosphorus availability before harvest seems to predict tree response to soil compaction and organic matter removal. The CRiSSSP study indicates that the rate in which nitrate is produced in the soil may be associated with stand production. In plots where tree height is below average, the nitrification rate as a percent of the total mineral nitrogen produced in the soil is relatively high. In plots were tree height is above average, the relative nitrification rate is relatively low (Figure 2). The relationship is consistent across locations and plantation age. It is also consistent regardless of the treatment that increased tree height above average.

The potential for using nitrification rate relative to the combined rate of nitrate and ammonium production in the soil as an indicator of site productivity needs further study. But differences in relative nitrification and ammonification rates across a range of site quality has been seen in other studies. Such an indicator would be useful in diagnosing whether harvesting and establishment practices have reduced site potential before growth losses and lower revenues have occurred. ■


Photo by John Wozniak

Quang V. Cao in the LSU AgCenter's School of Renewable Natural Resources has developed a new way to predict growth rates in forest stands. His "model" takes into account that young trees grow faster than older trees and that sparse stands grow faster than crowded trees.

LSU AgCenter Scientist Develops New 'Model' To Predict Timber Production

Timberland owners and managers use statistical models to predict growth and yield of their forests. Quang V. Cao in the LSU AgCenter's School of Renewable Natural Resources has developed a new predictive model that promises to improve on current ones.

Current models start with an inventory of trees in a stand and then use three variables – the age of the trees, the density of the stand and the quality of the site – to predict tree growth and yield 5 or 10 years in the future. The shortcoming of this type of model, Cao said, is that it implies constant growth. But that just isn't so.

Annual predictions of individual tree survival and growth have always been difficult because trees are not measured every year but usually once every five or 10 years. The method used by most models assumes constant diameter and height growth rates along with constant survival probability during the growing period.

"We know that young trees grow faster than older trees and that sparse stands grow faster than crowded trees," Cao said. "So over time, growth rates change. Inaccurate models can lead to poor decisions that might result in substantial losses to timber companies."

Cao said his forest growth and yield model should help forest managers select appropriate strategies to enhance economic returns.

"We developed a new, flexible method that allows these growth rates to vary from year to year and therefore should track growth and survival of trees much better than the old method," Cao said.

Cao developed his model from trees measured each year for 21 years. He used two plots, each with 171 loblolly pine trees, in the Lee Memorial Forest in Washington Parish. The results of his observations confirmed the variability.

"The trees don't fit the predictions of average growth but fit every-year growth," he said.

So using statistical methods, Cao developed a mathematical equation – or model – to predict tree growth over time.

Tree diameter and stand density no longer follow straight-line growth, but growth is measured on a curve that starts out steep and flattens out over time.

Photos by John Wozniak

Quang V. Cao is one of the professors in the School of Renewable Natural Resources who teach at Lee Memorial Forest in Washington Parish. An eight-week teaching session is held during the last half of spring semester at Lee forest for students with junior standing. A two-week course for wildlife majors is offered between spring and summer semesters.

"Tree survival is toughest to estimate," Cao said. "It's an either-or situation."

The generally accepted model assigned an annual life-expectancy value that remained constant over time. The result was more trees were expected to die than actually occurred.

Cao fitted the tree growth equations to the annual data, then fitted the same equations to intervals of two, three, four, five and six years. The results were finally plotted on a graph.

"The tremendous improvement over the old method is evident from the graphs, as the new method produced consistent growth and survival curves while growth intervals vary from one to six years," Cao said. He added that the model provides similar growth estimates regardless of length of the intervals.

The individual-tree model takes each tree as a unit. Cao said forest modeling can also be done by using whole-stand models, which treat all the trees together as a unit.

"Whole-stand models are relatively simple, whereas individual-tree models are complicated, simulation models," Cao said. "There are advantages and disadvantages for each type of model."

He said use of individual-tree models to predict stand-level results typically suffers from accumulation of errors and subsequently poor accuracy and precision. On the other hand, outputs from whole-stand models are often better behaved but lack detailed information.

"We investigated approaches to combine the high resolution of the individual-tree model and the reliability of the whole-stand model by adjusting outputs from an individual-tree model to match predictions from a whole-stand model," Cao said. "We expected that these methods were compromises between an individual-tree model and a whole-stand model."

The results exceeded his expectations. The new methods provide superior predictions of stand survival, basal area – the area of the cross section of a tree at a height of 4.5 feet above the ground – and volume.

"The methods under evaluation performed much better in predicting stand attributes while providing comparable predictions of tree diameter, height and survival probability," Cao said. "The results show promise in the on-going effort to link growth models having different resolutions."

For more information on Cao's improved model, people may contact him directly at (225) 578-4131, or qcao@agcenter.lsu.edu. ■ **Rick Bogren**

Lee Memorial Forest serves Louisiana's forestry industry

Lee Memorial Forest with more than 1,200 acres of managed timberland is an important research and teaching resource for the LSU AgCenter.

"It was clobbered pretty hard by the hurricanes, as was the rest of Washington Parish," said Thomas Dean of the School of Renewable Natural Resources. No buildings were damaged, and salvage sale of felled timber was completed by March 2006.

Located between Franklinton and Bogalusa in Washington Parish, the Lee forest began with a 1,000-acre donation from the Great Southern Lumber Company in 1926 and was augmented with a gift of 210 acres from the William A. Knight estate in 1991. The forest provides its own operating budget with income generated from timber sales.

The main lodge was built in 1927 with lumber from the forest and was the home to a summer field studies program through the early 1960s. The summer program was moved to the Baton Rouge campus until 1982, when it moved back to the Lee forest. In 1992, it changed to an eight-week teaching session held during the last half of the spring semester for junior students. A two-week field course for wildlife majors is also offered between spring and summer semesters.

"Students develop their field skills at camp and see actual forestry activities," Dean said.

Along with being a teaching facility, the Lee forest is home to several research projects. For example, a recently established project works with sustainable silviculture and soil productivity to determine if any negative effects come from conventional harvest on new growth compared with trees previously on the site.

Other research projects include fertilizer and spacing studies, progeny testing of crosses between slash pine and longleaf pine, longleaf pine forest restoration and studies of Bachman's and Henslow's sparrows – two species whose ranges are limited to open pine forests. ■ **Rick Bogren**

Hurricane Katrina damage at Lee Memorial Forest in Washington Parish.

Crain Helps Youth Develop Forestry Skills

LSU AgCenter area forestry agent Barry Crain helps youth develop forestry skills during a special 3-hour training event every year before the state 4-H University competition held on the LSU campus in June.

Like other area forestry agents, Crain trains local youth so they can be formally exposed to all areas of the state contest in forestry. Crain's training is at the Grant Walker 4-H Educational Center near Pollock, and 10 to 20 young people participate.

Foresters have worked through the years to develop an outdoor classroom at the center to help prepare contestants for the state forestry competition. They have marked trees and developed a compass course at the site so students can perfect their volume measurements and compass skills. Tree specimens are collected to teach participants skills in tree identification, insect damage and disease problems. ■ **John Chaney**

Photos by John Chaney

Jennifer Martin, 4-H member from Rapides Parish, places her mirror-sighting manual compass on top of a stake and looks through the sights to get her bearings to the next stake in the course during a forestry short course training held at the Grant Walker 4-H Educational Center near Pollock.

LSU AgCenter forestry agent Barry Crain, right, uses a slash pine branch to illustrate how to identify the different pine trees. Specimens of all trees, diseases and insects are available for participants to study at the training.

Inside:

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