Proceedings of the

Shortleaf Pine Conference:

East Meets West

Bridging the Gap with Research and Education Across the Range

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Alabama Cooperative Extension System
(Alabama A&M University and Auburn University)
Auburn University School of Forestry and Wildlife Sciences
Longleaf Pine Standing Dynamics Laboratory
National Bobwhite Conservation Initiative
USDA Forest Service

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PROCEEDINGS OF THE

SHORTLEAF PINE CONFERENCE: EAST MEETS WEST

BRIDGING THE GAP WITH RESEARCH AND EDUCATION ACROSS THE RANGE

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Alabama Cooperative Extension System
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Preface

When considering important southern pine ecosystems, shortleaf pine (*Pinus echinata*) is one that cannot be ignored. Found in 22 of the U.S. states, this species has the widest range of any southern pine and may be found in pure stands west of the Mississippi river or in mixed pine-hardwood forests over the rest of its range. These forests are sources of high-quality forest products and habitat for wildlife species such as Northern bobwhite quail (*Colinus virginianus*) and red-cockaded woodpecker (*Picoides borealis*). Today, shortleaf pine forests in Alabama, and across the region, are decreasing rapidly. This is due in part to landowners and land managers dismissing shortleaf pine due to the prevalence of littleleaf disease and rapid early growth of loblolly pine (*Pinus taeda*).

This symposium provided valuable information for scientists and land managers from 12 states in the shortleaf range. Topics included how forest inventories of shortleaf pine have decreased dramatically over time, restoration methods to reverse this trend, and the use of fire as a management tool. Additionally, a little understood threat to the restoration of this species – hybridization with loblolly pine –was brought to the forefront in this meeting. By understanding the challenges of shortleaf pine restoration and management, we can begin to address these issues through research, policy, and outreach.

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Contents

Speaker Abstracts and Presentations

Poster Abstracts

Appendixes

Speaker Abstracts and Presentations

Wildlife and Restoring the Shortleaf Pine-Grassland Ecosystem

Ronald E. Masters
Tall Timbers Research Station and Land Conservancy

Abstract: Shortleaf pine has the broadest geographical distribution of any of the eastern pine species and occurs in association with a number of other tree species across many forest types in eastern North America. Shortleaf occurrence is related to a range of environmental conditions and especially the natural disturbance regime. Its occurrence and relative dominance is often defined by the natural disturbance regime, particularly fire frequency. Fire frequency is a major factor that defines the understory plant community response and determines shortleaf pine's potential for regeneration and successful establishment in the canopy as well as the relative mix of other associated tree species within a stand. Historically shortleaf pine-grasslands occurred across the range of the species to some extent. They were maintained by frequent, low-intensity surface fire. Historical land use documents such as General Land Office survey notes have successfully been used to describe presettlement and settlement landscapes and to provide structural guidelines for restoration of the type. Fire chronologies developed from fire scars and even historical accounts provide insight for developing a suitable fire regime for restoration. Implementing a restoration plan may require thinning to restructure the system in a manner that is conducive to perpetuating it with fire, particularly where time is critical for conserving fire-dependent wildlife and plant species. Within the range of shortleaf pine, wildlife species are variously associated with shortleaf, based on stand density, the proportion of hardwoods within a structural stage of development, and the availability of habitat structure within the specific niche that each wildlife species occupies. The midstory and understory plant community response to fire or lack of fire defines much of the midstory and ground-dwelling or ground-foraging wildlife species populations. This paper discusses wildlife species associated with different structural characteristics and fire regime in mixed oak-shortleaf and shortleaf dominated forests and woodlands.

The History of Shortleaf Pine on the Cumberland Plateau

Clarence Coffey
Tennessee Wildlife, retired

Abstract: During the late 1990s pine beetle infestations spread westward across Tennessee and to the Cumberland Plateau. On the Catoosa Wildlife Management Area, foresters became aware of pine beetle damage in 1998. In response to the eventual loss of timber due to pine beetle damage, the Tennessee Wildlife Resources Agency initiated a salvage operation in 1999. The salvage operation continued for the next 2.5 years into 2001. During that time, approximately 1,555 acres of pines were cut across the wildlife management area. Much of the timber harvested was shortleaf pine in the 70 to 100 year old range. As the Catoosa timber salvage operation progressed, the response by the plant community was immediate and dramatic. Grassland plants such as big bluestem, little bluestem, Indian grass, and numerous forbs began to quickly respond to the opening of the forest canopy. The increased growth of native warm season grasses was not unexpected. Reviewing the history of Catoosa prior to its acquisition by the state, one discovers much of the area was used as free range by livestock owners. One of the practices used to improve grazing was periodic fires set in the area. Much of the shortleaf harvested was in the area with a fire history and the last site where red-cockaded woodpeckers successfully nested.

Presentation: In discussing the history of shortleaf pine on the Cumberland Plateau, I would like to begin by giving you some background information on the Catoosa savanna. Catoosa is an 80,000 acre wildlife management area (WMA) located on the Cumberland Plateau that is owned by the Tennessee Wildlife Resources Agency (TWRA). The land was purchased with Pittman-Robertson funds during the late 1940s and 1950s.

Often times in the wildlife management profession we can catch ourselves dreaming about what we would like to do if it were possible. There are some strategies we would like to use, but it may seem too risky with too many stumbling blocks to move ahead. Then there are times when some unforeseen circumstances create opportunities even when there are skeptics and doubters.

During the late 1990s pine beetle infestations spread westward across Tennessee and to the Cumberland Plateau on the Catoosa WMA. Foresters became aware of pine beetle damage in 1998. In response to the expected loss of timber due to pine beetle damage, the TWRA initiated a salvage operation in 1999 on The Catoosa WMA. The timber salvage continued for the next 2.5 years into 2001. During that time approximately 1,555 acres of pines were cut across the WMA. Much of the timber harvested was shortleaf pine ranging in age from 70 to 90 years and 20 inches in diameter.

As the Catoosa timber salvage operation progressed, the response by the plant community was immediate and dramatic. Grassland plants such as little bluestem, split beard, big bluestem, Indian grass, and numerous forbs began to quickly respond to the opening of the forest canopy. The increased growth of native grasses was not unexpected. Down through the years several TWRA employees had noted that native grasses grew along roadsides and came in after various fires set in the WMA.

After reviewing the history of the Catoosa area prior to being purchased by the state, one discovers that much of the area was cutover forest land and occupied by small subsistence farms. One common practice of the farmers was to allow their livestock to run free under the free-range law. Another practice used in concert with open range was to use periodic fire to improve grazing and suppress woody growth. I have discussed this practice with former residents of the Catoosa area. It seems that it was a common practice and little thought was given to any potential danger or harm done by fire. Their purpose was to improve grazing and keep down insect pests.

In Cumberland County there was open or "free" range until 1947 when the law was changed. Early settlers on the Plateau found a grassy understory in the woodlands and numerous openings referred to as barrens, glades, or meadows. Two areas in the county were noted by early settlers as being open grasslands: Grassy Cove and Crab Orchard. One settler described Grassy Cove as 3,000 acres of grass that would reach a horse's bridle. From Calvin Dickinson's book on Tennessee counties, he quotes early traveler Francis Bailey in 1797: "It is a fine large plain or natural meadow, containing many hundred acres and covered throughout its whole extent with a tall, rich grass, surrounded on every side by the neighboring mountains." That reference was to Crab Orchard. In Ramsey's *Annals of Tennessee* the author reports that in 1783 on the Cumberland Plateau surveyors on a new road passing through meadow lands reported numerous herds of deer, elk, and buffalo. By discovering the early history of the Plateau, we can see there were grasslands and a fire history dating back to its use by Native Americans. We might even be able to say the settlers continued some of the practices employed by the Indians.

In the Catoosa savanna, one site, known by TWRA as the "Halloween" site because of a hot prescribed fire in late October that took out a lot of woody vegetation, was in the center of a very nice stand of shortleaf pine. Ironically, that same area was the location of one of the last active nests of red-cockaded woodpeckers observed in Catoosa. By 1984 the red-cockaded woodpeckers were gone from the area and soon afterward in Tennessee. Within the Halloween burn one late 1980s forest inventory showed a very open grassy area with scattered post oak with most everything else being shortleaf pine. With a long history of both wild and prescribed fire, it's only natural that native grasses would quickly respond to canopy removal and the introduction of more fire. A fire-tolerant tree species such as shortleaf pine should thrive in an area with thin soils and periodic fires to reduce the competition.

In 1980 the TWRA launched an aggressive forest management system across Tennessee on lands under their control. At that time Catoosa at 80,000 acres was the largest tract owned by the state. It was only natural that Catoosa be the

focus of improved forest management and other innovative practices. As TWRA foresters launched into the new strategy it was met with mixed emotions. There was some opposition even from some inside the agency. One forestry technique that was viewed with skepticism was even-aged management or clear cutting. Most of the cuts on Catoosa were 30 acres or smaller. It was during this time in the mid-eighties when I began to take notice of forest management strategies out of necessity. A short time prior to the implementation of the agencies' new forest strategies, I became a member of the regional staff in the information and education position. I soon found myself in the center of controversy regarding clear cutting on Catoosa WMA. It was a time of real learning and some experiences that would serve me well for years to come. The TWRA personnel fought those battles and came out of it continuing to do the best forest management we could do.

So now back to the pine beetle salvage operation. We knew the timber would die as a result of the pine beetle, so the TWRA made the decision to salvage as much as possible and sell it before it was lost. There was concern of public perception in the salvage operation due to the large size of the cuts being made. The Agency took precautions by getting approval of the wildlife commission and placing signs informing visitors regarding the operation. Press releases were distributed and media contacts were made to inform the public regarding the beetle kill. It was during this time that the idea of allowing nature, with a little help, to take its course and recreate a landscape that was more open with abundant grasses, forbs (including native legumes), and wide spacing between trees. What we wanted was a savanna habitat missing for too long on the Plateau. After some meetings and discussions, Director Gary Myers agreed to the strategy of seizing the opportunity made possible by the unfortunate pine beetle kill.

Soon after the pine salvage operation was underway, prescribed fire was reintroduced to appropriate sites. The savanna began to take shape as the plant community responded. The TWRA again launched into another media campaign to explain the new strategy of recreating savanna. Several universities, other governmental agencies, and NGOs were asked for their support by including their organization's name on signage placed throughout the savanna area. Of course, there is always concern of misperception by the public during the early stages of savanna development. A young savanna is not as beautiful as an older mature site. Again, preparations were made to answer criticism and take the aggressor role by seeking out favorable publicity.

By the time the savanna was started on Catoosa, I was in an administrative position with enough years to retire. I did not wish to retire nor did I want to leave a controversy I had a hand in creating for others to clean up. It was at that time when I began to read everything I could find about the historic barrens on the Plateau and ask anyone who might have information on the historic Cumberland's. The more I found the more intriguing the subject became. Fortunately, negative reaction to the savanna has been minimal with the positives far out weighing any doubts about the project.

The Catoosa savanna has been visited by universities, state and federal agencies, NGOs, and many individuals interested in its diverse native plant communities. Hunters soon learned to scout the area in pursuit of their favorite game. Professional foresters have often visited the savanna with a keen eye toward the various tree species. On some savanna sites we are now seeing shortleaf pines come back into area where they once dominated. Shortleaf was planted on only one site in the savanna and shows much promise as a new pine savanna.

In looking at the history of pine on the Cumberland Plateau the term "yellow pine" is used rather than shortleaf. The historic range of shortleaf covered the entire plateau up into Kentucky. Fentress County just north of Cumberland County has a long history of producing pine lumber and pine products. According to A.H. Hogue's book, *One Hundred Years in The Cumberland Mountains*, the making of tar and turpentine was Fentress County's first industry. Its huge pine forests were ideally suited to this industry. Many areas of the county were sites of tar camps and kilns. The industry existed for 75 years or more slowing in 1910.

By using census records one can gain information on various occupations the citizens of an era had. In Fentress County during the 1800s, there are such jobs listed as tar burner, distiller, turpentine maker, pine worker, and stiller.

The same book by Albert Hogue reveals that John Young manufactured spirits of turpentine at a spring under a rock on the mountain between Crooked Creek and Mill Creek in 1827. Another record shows that Wesley Owens had a still camp and pine orchard on the mountain in 1830. The term "pine orchard" is intriguing. There are numerous place names that include the word pine or piney. There is a Pine Orchard Community in Morgan County. I'm not sure if pines were cultivated for tar and turpentine purposes.

There are descriptions of tar kiln found in Albert Hogue's book. Joe Schooler, an early settler in Fentress County, built a tar kiln more than 60 feet in diameter, 5 to 6 feet high and capable of yielding 2,000 gallons of tar. The community of Boatland was named because of the flatboats built at the deep hole on the East Fork of the Obey River. The boats from Boatland carried tar and turpentine down the Obey and Cumberland rivers to Nashville and points beyond.

In the community of Allardt, yellow pine is listed as the most abundant for commercial value in the community's history. In 1930 Fentress County yielded more forest products than any Tennessee county. Much of that was from pine.

In Allardt there are records of tar being sold or "cooked out" and in 1871 an entry was made as follows: "Loaded up with 825 pounds venison and twelve kegs of tar." The venison was sold in Frankfort, Kentucky, on January 27, part for .16 2/3 and part for .15. The same records describe Allardt: "surrounded by typical plateau country, with miles of wild grasses, offering fine grazing for livestock of all kinds." Could that area have been a pine savanna?

In Mark Twain's autobiography, he left this statement: "There is no end to the tar, pitch, and turpentine which these vast pineries will yield in the pineries and the knobs of The Cumberland Mountains of Fentress County."

The Fentress County historical society's newsletter gives the following description: "The tar was a 'pine tar' and this was made by digging a ditch in a circle, 20-30 feet in diameter, rich pine was then piled or stacked in the circle, higher in the center, sloped towards the outside and covered with dirt. It was then set on fire and as the fire burned, or more specifically "smoldered," the tar "cooked out" and ran into the ditch. It was then dipped up and put in barrels, the barrels being made by hand, usually of oak, and having a capacity of about fifty gallons. Tar was a very important item in the early days and was used mostly as a lubricant, principally for wagons, which at that time had wooden wheels and wood axles. The last tar made in this section was in the early 1900s and was handled by local merchants in very small quantities as late as 1925.

Another account in the Fentress Historical Quarterly gives this account of lumber production:

> In the period of about 1910-1915 as many as two hundred wagons, loaded with lumber, could be seen on the road between the mills and Glenmary. Most of these were two-mule teams, a few four-mule teams, very few horses and occasionally a team of oxen. Due to the slower rate of travel, oxen, when used at all, were used when the distance was ten miles or less. An average load of lumber for a two-mule team was approximately 1,000 board feet of dry Yellow Pine.

The 1910 census of Cumberland County reveals these occupations by citizens: tie maker, lumber, sawmill, teamster, mule driver, logger, bark peeler, tan bark, and tanner. I find no account of tar and turpentine making in Cumberland County. I do know the making of tar and turpentine was done in White County and in other places on the Plateau. According to research by Wayne Clatterbuck, forestry professor at the University of Tennessee, railroads built across the Plateau in the early 1890s facilitated the shipping of pine lumber. Following the intensive logging operations later in the mid-1900s, fire suppression took on a new role in the history of the Plateau. If one puts the pieces of the puzzle together, it is only natural that some conclusions are reached regarding the status of shortleaf pine. For example, in

1947 the open range law was changed in Cumberland County. Before 1947 and earlier in the century, there were accounts of cattle drives in the fall after a summer of grazing on the wild grasses in the open woods. One source I found related to the agriculture of Cumberland County contends that it was one of the best areas of the state to raise cattle due to the abundant native grass. With all the free ranging cattle on the Plateau during open range law, it was common practice to use fire for improving the growth of the wild grasses. The frequent fire would have suppressed some vegetation and favored others. My conclusion is that it favored shortleaf pine, oaks, and native grasses. Another piece of the puzzle on the Plateau that could be offered is some place names with pine, such as Pine Knob, Pine Knot, Pine Haven, Piney Creek, Piney Falls, Piney Grove, Pine Orchard, and Pine Springs. Other location names which lend evidence of geographic features or fauna, which was present, are names like Buffalo Cove, Barren Springs, and Clark's Range. Clark's Range was the original name of the area around present day Clarkrange at the intersection of Highway 62 and US 127. Cyrus Clark came from New York and brought purebred cattle to graze on the open range of Fentress County. In that area there was abundant wild grass that grew in the trees that were free of underbrush. This area was also within the same county that produced so much tar and turpentine (pine trees).

To summarize this presentation, I point to the many changes the Plateau has undergone in its history that were man-made. If we go back to the late 1700s when the French botanist Andre Michaux traveled over the Plateau on the Avery Trace, he noticed grassy openings, evidence of fire and mega fauna including elk and bison. The bison and elk were extricated, but soon livestock were brought in to run at large. The settlers improved grazing for their cattle by setting fire to the range. The timber was harvested for lumber and other wood products. Open range was stopped and with that, fire suppression ruled the day. One big paper company moved to the Plateau and purchased close to 300,000 acres that was all planted in loblolly. Some of the paper company land is on sites previously occupied by shortleaf pine.

The forests of the Plateau changed and we listened to the stories of how it used to be. Now we know much of what it was so it can be again.

Factors Affecting the Re-Sprouting of Shortleaf Pine Following Prescribed Fire

Rod Will
Oklahoma State University

Abstract: We examined the relationship between the re-sprouting of top-killed shortleaf pine (*Pinus echinata*) following prescribed fire and seedling size, basal crook depth, and maximum basal crook temperature in the Ozark-St. Francis National Forest of northwestern Arkansas. We hypothesized that the basal crook is an adaptation to fire that will insulate buds on larger seedlings with deeper buried crooks, allowing them to survive after top-kill from fire better than those of smaller size with more shallowly buried crooks. A total of 195 seedlings were measured across three locations for a variety of site, size, and fire damage characteristics. Simulated crooks were constructed and calibrated to estimate basal crook temperature and were buried adjacent to each seedling. Prescribed fires were implemented during the early growing season, resulting in a wide range of seedling damage from slightly charred stems to complete immolation of aboveground biomass. All but 14 of the 195 seedlings were top-killed. Of the 181 seedlings that suffered top-kill, 72 did not re-sprout and died. Over the course of the growing season 40 percent of the re-sprouted seedlings died. Re-sprouted seedlings that survived the entire growing season had similar size and crook soil depths as seedlings that initially died, both of which were smaller (ground line diameter of 1.5 cm vs. 3.1 cm) and shallower (crook soil depths of 0.2 cm vs. 0.7 cm) than seedlings that re-sprouted and later died. Crook temperature and crown scorch values were lower for seedlings that sprouted and survived than those that did not survive. To achieve at least 50 percent survival of top-killed seedlings, seedlings should be smaller (0.6 to 1.6 cm ground-line diameter and 0.3 to 0.8 m tall), sustain 50 percent or less of crown scorch, and be exposed to lower intensity fires with associated crook temperatures below 83ºC.

Historic Fire Intervals in Shortleaf Pine Ecosystems

Mike Stambaugh
University of Missouri

Abstract: Prior to Euro American settlement the success and structure of shortleaf pine communities were largely a reflection of fire disturbances. Today, fire regimes are often highly departed from historic conditions making it difficult to envision fire's past role and the influences of long-term repeated burning on shortleaf pine development. Historic fire intervals based on fire scars are commonly used to describe the frequency of a fire regime. Fire intervals vary through time and directly and indirectly influence the success of shortleaf pine. In this presentation historic fire interval data and the relevance to shortleaf pine success will be summarized from study sites located in northwestern portion of the shortleaf range.

Nursery Production of Shortleaf Pine at the East Tennessee Nursery

John Conn
Tennessee State Nursery

Abstract: The East Tennessee Nursery, located in Delano, Tennessee, is owned and operated by the Tennessee Division of Forestry. The nursery produces about 315,000 shortleaf pine seedlings annually. At the East Tennessee Nursery, shortleaf pine seedlings are produced following practices similar to those used to produce seedlings of other southern pine species. Seed is placed into cold, moist stratification approximately 30 to 45 days prior to sowing. In late April, after the stratification period has been completed, the seed is treated with a fungicide and a bird repellent and sown in eight drills on raised seedbeds. The sowing rate is calculated for a target seedbed density of 25 seedlings per square foot. After sowing, soil stabilizer and a pre-emergence herbicide are applied to the beds. The soil stabilizer is allowed to "cure" for about a day and then the beds are irrigated frequently to keep them moist and promote germination. Once germination is complete, irrigation, fertilizer, pesticides and other cultural practices are applied as needed to produce target seedlings averaging 10 to 12 inches in height with root collar diameters of approximately 3/16 inch. Prior to lifting and packaging, the seedlings are undercut at a depth of approximately 5.5 inches and then lateral-pruned between the drills. Seedlings are lifted from the seedbeds with a fobro seedling lifter, counted and culled by hand, and placed into plastic tubs to be transported to the packaging building. A moisture-absorbent gel is applied to the roots of the harvested seedlings and they are packaged in triple-wall craft bags. Packaged seedlings are stored at approximately 36° F until they are shipped.

Shortleaf Pine Restoration at the Land Between The Lakes National Recreation Area

Jaime A. Hernandez
Land Between the Lakes National Recreation Area

Abstract: The Devil's Backbone State Natural Area is one of the two Tennessee state natural areas located on the Land Between the Lakes National Recreation Area (LBL). The largest concentration of naturally occurring shortleaf pine found at LBL is within the Devil's Backbone State Natural Area. The shortleaf pine forest type is found on only 1 percent of the entire 170,000 acres. Recent management efforts include increasing the size of the state natural area and the use of prescribed fire. Future management activities to establish shortleaf pine regeneration and improve woodland conditions are proposed. These activities include the use of several thinning techniques, prescribed fire, and herbicide applications.

Introduction

LBL established a cooperative agreement with the State of Tennessee recognizing the 1,380-acre Devil's Backbone State Natural Area in June 2008. This is a substantial increase over the original 160-acre state natural area that was originally recognized in the Devil's Backbone area. The agreement recognizes the area as important because of the rare shortleaf pine-oak forest that occurs there, and stipulates that in order to rejuvenate and maintain this unique forest system, mechanical treatment of the forest canopy and prescribed fire would be necessary.

The shortleaf pine ecosystem is declining throughout its range (1). These ecosystems are important for wildlife such as the endangered red-cockaded woodpecker and other birds that require pine-grassland ecosystems; many of these birds are declining (2). The lack of disturbance within the current LBL stands of shortleaf pine has led to the gradual succession of shortleaf-dominated stands to more upland oak forest types. Fire is a primary disturbance regime that would have allowed early successional species like shortleaf pine to dominate the area. Fire suppression policies of the last century have not allowed fire to perform its natural ecological role; therefore, mid- to late-successional hardwoods have become established in the understory and grown into the forest canopy over time. A landscape in which fire is allowed to burn in this natural pattern would eventually discourage advanced hardwood regeneration and would reduce the litter and duff layer, allowing shortleaf pine seeds to contact the mineral soil and germinate. This, coupled with disturbance that provides adequate light to the forest floor, would allow for shortleaf pine to regenerate naturally from seed.

Shortleaf pine is even more shade-intolerant than oak species. In order to successfully regenerate shortleaf pine naturally, canopy gaps are needed between the remaining large shortleaf pines that are kept as the necessary seed source. In addition, small, non-merchantable hardwood trees would need to be controlled until the shortleaf regeneration can become well established. This can be achieved through several combinations of burning, herbicide applications, and mechanical treatments.

During the summer of 2007, stand examination were conducted on 1,591 acres of the Panther Creek Watershed. This encompassed the previous 160-acre Devil's Backbone State Natural Area, along with the surrounding forest. Initial analysis of these data points to several trends supporting the succession of the sub-climax community shortleaf pine (*Pinus echinata*) to the climax community of this region, which is oak-hickory forest. The decline in acreage of young shortleaf pine habitat (0- to 10-year range) was evident by the lack of any shortleaf pine regeneration data collected in the nested plots. In addition to regeneration data collected, the decrease in actual acres covered by shortleaf pine could be verified when stand-level data collected was compared to stand maps derived from past aerial photography. The average age of measured site trees was 90 years old. This places stands in the mature forest classification. Unless a major disturbance regime develops allowing for more sunlight to reach the forest floor, exposure of mineral soil for

seed bed preparation, and a reduction in hardwood competition, shortleaf pine will be reduced to a relic species in the Panther Creek Watershed.

Methods

To support and encourage shortleaf pine regeneration in the Devil's Backbone area, the Forest Service proposes the following actions:

- Combine dormant and growing season prescribed fires over 3,377 acres within the project area multiple times over the next 20 years, as dictated by ground conditions and until project goals are met. Existing trails and roads would be used as fire lines.
- Create shortleaf-oak regenerating forests through regeneration harvests on approximately 250 acres of currently closed canopy shortleaf-oak mixed forest types. Spot planting of shortleaf pines would occur in these areas if sufficient natural regeneration doesn't take place.
- Create mature shortleaf pine and shortleaf pine-oak woodland and open forest conditions through intermediate thinning on approximately 450 acres, removing less than 50 percent of the current forest tree density.
- Thin shortleaf pine-oak forests through cut-and-leave release treatment on approximately 500 acres. Hardwood tree species would be cut to allow shortleaf pines to regenerate under the remaining forest canopy. Some of these acres could overlap with the regeneration and intermediate harvest areas if those harvests do not sufficiently encourage shortleaf pine regeneration in the understory.
- Reduce existing non-native invasive plant species numbers (NNIS) within the project boundary and along the roads and trails enclosed by the project area, using integrated methods (for example, prescribed fire, mechanical removal such as mowing, and herbicide applications).
- Apply herbicides (imazapyr, glyphosate, triclopyr, metsulfuron methyl, and imazapic) for shortleaf pine site preparation and NNIS control on up to 500 acres per year. The goal in the site preparation application would be to reduce numbers of (and therefore competition from) other species, including NNIS, so that shortleaf pines would have a chance to regenerate. Herbicide use would be concentrated on areas where timber treatments are done, along roads and trails, and around the edges of open lands, where NNIS are most likely to occur.
- Maintain a partnership with a local high school to enhance learning opportunities in a science class by providing field trips. Students would study and compare forest management actions and results by establishing study plots located in the project area. Examples of possible data collection include counting and measuring seedlings, documenting tree growth, collecting shortleaf pinecones, or identifying invasive species. The forest service would use a partnership agreement with the school district in order to formulate a natural resource curriculum and would cooperate to resolve any funding issues as they relate to the environmental education actions.
- Create three trail re-routes within the project area—two associated with Artillery Trail (0.7 mile) and one on Telegraph Trail (0.1 mile)—in order to improve trail sustainability and decrease resource degradation.
- Decommission the Shortleaf Trail (1.75 miles) in order to reduce maintenance costs and eliminate a parallel trail to both Devil's Backbone and Artillery Trail systems. A loop within the Fort Henry trail system would still exist.
- Create a trailhead at the intersection of Telegraph Trail and Forest Service Road 400 in order to provide users with a safe and designated parking area with better trail accessibility. This would enable environmental education opportunities about shortleaf pine ecosystems and non-native invasive species concerns.
- Maintain and recondition 0.25 mile of Forest Service (FS) Road 400 according to the Maintenance Prescription Guidelines stated in the Transportation System Maintenance Handbook (FSH 7709.58). Maintenance would include grading and spot surfacing.

Study Area

The Devil's Backbone Project area is located in Stewart County, Tennessee, within compartment 72, also known as the Panther Creek Watershed. Practically all of this 3,402-acre project area is forested, except for 153 acres classified as open lands (Table 1). Forest communities in this project area are a mixture of shortleaf pine (*Pinus echinata*) and upland mixed oak-hickory communities. The project area contains one yellow poplar-sweetgum stand and two even-

age loblolly pine (*P. taeda*) plantations (Table 1). A portion of the project area (1,380 acres) is registered with the State of Tennessee as the Devil's Backbone State Natural Area and is slated for management to encourage shortleaf pine regeneration in cooperation with the state. Of the project's forested acres, 3,046 acres are classified as Core Area and 203 acres are classified as General Forest under the 2004 Area Plan. The area involved in this project represents about 7 percent of the Core Area acreage within LBL.

Table 1. Devil's Backbone project area management prescriptions summary

2004 Area Plan Management Prescriptions	Project Acres	Percent of Project Land Area
Core Area	3,046	89.5
General Forest	203	6.0
Total Forest	**3,249**	**95.5**
Open land / non-forest	153	4.5
Total	**3,402**	**100.0**

There is a history of vegetation management in the project area. The project area was previously organized as Work Areas 62 and 63 under Tennessee Valley Authority (TVA) management. Currently, the area is part of Forest Service Compartment 72, Panther Creek. The proposed actions would be the fifth cycle of vegetative management activities for this project area since LBL was established in 1963. TVA's last management of the area was in Work Area 63 in 1988, and the Forest Service's last management was a prescribed fire in 2010.

The Panther Creek Watershed Assessment was completed in 2007; it evaluated the condition of soils, streams, roads, trails, forest conditions, and wildlife habitat in the area. The watershed assessment recommended future management actions to improve the ecological conditions of the watershed. Restoration of shortleaf pine was a key management recommendation because the area harbors the only shortleaf pine ecosystem on LBL and shortleaf pine ecosystems are declining throughout their range.

The occurrence of shortleaf pine has steadily decreased over time. A Forest Service Common Stand Exam inventoried a portion of the project area in 2007 as part of the Panther Creek Watershed Assessment. The inventory found 95 acres of shortleaf pine forest and 400 acres of shortleaf-oak mixed forest (Table 2). No shortleaf pine regeneration was noted in inventory data; only hardwoods were regenerating in the understory under shortleaf pine and shortleaf pine-oak stands. The remaining forest types in the project area consist mainly of mixed oak stands. The forest inventory is representative of the entire project area, with the exception that there is even less shortleaf pine in the portion of the project area not surveyed.

Table 2. Forest types documented in the 2007 Common Stand Exam

Forest Type	Acres	% of surveyed area	Succession stage	Structure
white oak / red oak/ hickory	545	34.3	Advanced hardwood regeneration in understory	Two-aged
shortleaf pine/oak	400	25.1	Advanced hardwood regeneration in understory	Two-aged
white oak	339	21.3	Advanced hardwood regeneration in understory	Two-aged
chestnut oak	151	9.5	Advanced hardwood regeneration in understory	Two-aged
shortleaf pine	95	6.0	Advanced hardwood regeneration in understory	Two-aged
post/blackjack oak	41	2.6	Advanced hardwood regeneration in understory	Two-aged
loblolly pine	13	0.8	Stem exclusion	Even aged
sweetgum / yellow poplar	7	0.4	Stem exclusion	Two-aged
Total surveyed	**1,591**	**100**		

Most forest stands are two-aged, with an older cohort composed of a shortleaf pine-oak mix that is 80 to 120 years old. Some stands are dominated by a canopy of mixed oak with scattered remnant shortleaf in the overstory (Figure 1). In all of these stands, species such as chestnut (*Quercus prinus*), white (*Q. alba*), post (*Q. stellata*), scarlet (*Q. coccinea*), and black (*Q. velutina*) oak dominate the under and midstory and compose the younger cohort that has grown in under the canopy. Associated understory hardwood species include sourwood (*Oxydendrum arboreum*), blackgum (*Nyssa sylvatica*), flowering dogwood (*Cornus florida*), and sassafras (*Sassafras albidum*). Advance regeneration of the above oak species is prevalent in most stands. There are some *Vaccinium* species present in the shrub layer. The herbaceous layer is underdeveloped due to the closed canopy with many areas where the forest floor is dominated more by fine fuels (leaves and duff) or bare soil (Figure 2). This means that there is opportunity to encourage growth of native grasses and forbs that are currently being excluded due to shade and excess competition for space, water, and nutrients. Many herbaceous plants grow along trails and roads in the project area, and along the South Fork of Panther Creek; as discussed below, these areas are seeing an increase of non-native invasive plants that will compete with native grasses and forbs.

Figure 1: Existing condition example of a mixed species stand proposed for regeneration harvest in the Devil's Backbone Project Area

In spring 2010, a prescribed fire was accomplished in the project area. During the following summer, a large number of shortleaf pine seedlings were seen to germinate under the existing pine stands, in both the areas surveyed and adjacent areas. This led, in part, to the expansion of the project area to include areas to the east of what was originally surveyed in order to encourage shortleaf pine regeneration in those areas as well.

LBL has documented 26 wildfires within approximately two air miles of the project area since 1965. Most causes of ignition are listed as human caused (e.g., escaping campfires, lit cigarettes); these fires were generally suppressed before they reached 20 acres in size. The most recent wildfire in the vicinity was the Buckingham Hollow fire in 2005, which was stopped at five acres.

Figure 2: Existing condition example of a shortleaf pine stand proposed for intermediate thinning in the project area.

Using dendrochronology techniques, Rich Guyette conducted field research on two sites on LBL in 2007 to estimate the historic fire interval through fire scars (3). Dendrochronology is the name given to the archaeological dating technique which uses the growth rings of long-lived trees as a calendar. One of the sites he visited, Pine Camp Pine (PCP), was within the Devil's Backbone Project Area where he sampled 28 shortleaf pine trees for historic fire scars. The sites at LBL showed considerable change through time. Since the 1950s, the length of the fire intervals has increased more than 10 times (Table 3). With more spatial data, the present interval is probably much longer than that. The PCP site clearly shows fire interval length increased from the late historic Euro American settlement period (1860 -1954) to the last 50 or more years (Figure 3).

Fuels data for the project area were collected on plots in the summer of 2008 using a modification of Brown's Protocol (4). The findings from the 2008 fuel plots are summarized below (Tables 4 and 5). Since 2008, the prescribed fire of 2010 has reduced the duff layer and fuel depth; the amount of woody debris >3" diameter has been reduced only slightly.

Vegetative surveys were conducted in September and October, 2008. Multiple non-native invasive species were found during these surveys, including both woody and herbaceous species (Table 6). Surveys were concentrated along roads, trails, and stream corridors. Many of these species were also identified in open lands in the project area during earlier surveys, indicating that they are widespread and prevalent, and likely to invade new areas if given the opportunity. In addition, more than a dozen species were identified to have the potential to invade the project area, based on the available habitat types and these species' proximity to the area.

Table 3. Mean fire intervals for shortleaf pine (PCP) sites at Land Between the Lakes during three historic periods, as reported by Guyette et al. (3)[1]

Land use	Period	Mean fire interval	Interval range
Recreation	1953-2006	> 53 years	NA
Euro-American, agriculture & logging	1860-1953	3.5 years	1 to 9 years
Native American, subsistence	1797-1822	~ 12 years	poor record

[1] Since the Forest Service has managed LBL, one fire of the whole project area has been conducted, in 2010.

Table 4. 2008 Fuels survey data in the project area

Avg. duff depth	Avg. fuel depth	Avg. woody debris >3" diameter, sound	Avg. woody debris >3" diameter, rotten
0.9	0.7	5.6	5.4

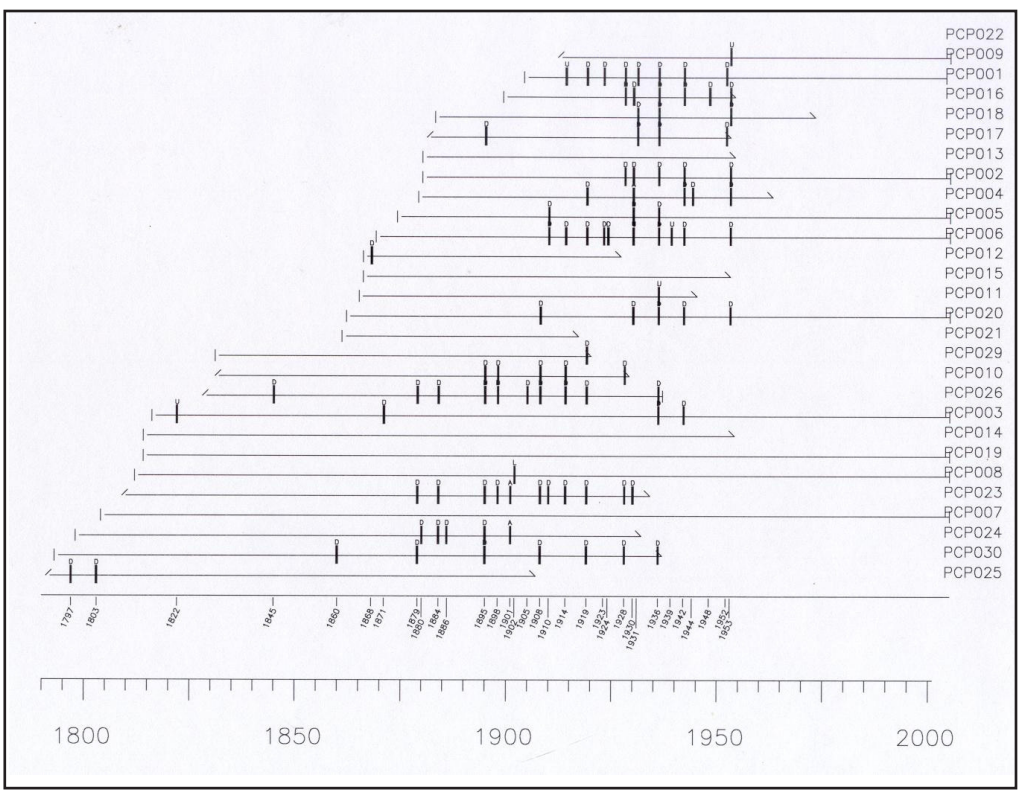

Figure 3: Fire history diagram for a shortleaf pine site (PCP) at Land Between the Lakes. Dark vertical lines represent fire scars while horizontal lines represent the rings of a tree. The bottom line is the composite of all the fire scars and best represents the presence of fire at the site (3).

Discussion

The LBL estimates that the completion of the environmental asssessment for this project will occur by the end of 2012. Implementation of the above proposed activities would then occur by 2014. The prescribe burn conducted in 2010 resulted in shortleaf pine seedlings germinating in many portions of the project area. This single disturbance alone is not enough to perpetuate the long-term survival of a new generation of shortleaf pine in the Devil's Backbone SNA. The combination of thinning treatments, herbicide use, and prescribe burning are planned to have an integrated effect on both species and structural composition across all canopy levels on all sites proposed for treatment. Monitoring efforts to meet the goals of this project will be tiered to each specific treatment. In addition to this monitoring approach, the LBL staff has also established several vegetation monitoring plots throughout the project area based on the different treatments proposed for each individual site. This project is the first

Table 5 Amount of fuels in each fuels class in the project area in 2008						
	0-0.024" class	0.25-0.99" class	1-2.99" class	Sound >3" class	Rotten >3"class	Total of all classes
Tons/acre	0.32	0.97	2.06	0.4	6.5	10.2
Cubic ft./acre	21.5	64.9	164.8	28.7	692.9	927.7

attempt at restoring shortleaf pine in LBL. The activities proposed for the Devil's Backbone State Natural Area will help facilitate the development of any future plans to restore shortleaf pine to the appropriate sites that may exist across the LBL.

Table 6. Non-native invasive species found in the project area during vegetative surveys in 2008	
Common name	**Scientific name**
Mimosa	Albizia julibrissin
Queen Anne's lace	Daucus carota
Shrub lespedeza	Lespedeza bicolor
Sericea lespedeza	Lespedeza cuneata
Korean clover	Kummerowia stipulacea
Chinese privet	Ligustrum sinense
Japanese honeysuckle	Lonicera japonica
Japanese stiltgrass	Microstegium vimineum
Chinese silvergrass	Miscanthus sinensis
Loblolly pine	Pinus taeda
Multiflora rose	Rosa multiflora
Tall fescue	Festuca arundinacea
Yellow foxtail	Setaria pumila
Green bristlegrass	Setaria viridis
Johnson grass	Sorghum halepense

References

1. Stambaugh, M.C.; Guyette, R.P. Long-term Growth and Climate Response of Shortleaf Pine at the Missouri Ozark Forest Ecosystem Project. Gen. Tech Rep NE-316. 14th Central Hardwood Forest Conference; 2004 March 16-19; Wooster, OH: U.S. Department of Agriculture, Forest Service, Northeastern Research Station: Newtown Square, PA 2004.
2. Wilson, C.W.; Masters, R.E.; Bukenhofer, G.A. Breeding bird response to pine-grassland community restoration for red-cockaded woodpeckers. Journal of Wildlife Management1995;59(1):56-67.
3. Guyette, R.P.; Stambaugh, M.C.; Dey, D.C. Developing and Using Fire Scar Histories in the Southern and Eastern United States, Final Report. Project # 06-3-1-16: University of Missouri-Columbia, US Forest Service 2010.
4. Brown, J.K. Handbook for Inventorying Downed Woody Material. General Technical Report INT-16. In: Intermountain Forest & Range Experiment Station, editor. Ogden, UT: USDA Forest Service; 1974.

Building an Initiative for Shortleaf Pine Restoration in the Interior Highlands

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Abstract: The Interior Highlands region of Arkansas, Missouri, and Oklahoma once supported vast expanses of shortleaf pine-bluestem woodlands as well as mixed stands of pine-oak and oak-pine with the variation dependent upon geologic and topography patterns. While there have been efforts focused on the restoration of shortleaf pine and pine-oak ecosystems throughout the region, especially in the Ouachita Mountains as a result of habitat management for the federally endangered red-cockaded woodpecker, it wasn't until January 2011 that a regional partnership emerged with a goal of sharing knowledge about management techniques and quantifying the desired structural attributes of shortleaf or pine-oak ecosystems across the Ozark, Boston, and Ouachita Mountains. I will report on the current composition of the partnership and the results of its efforts to date.

Shortleaf Pine Planting for Diversity and Production

Tim Albritton
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Abstract: The main objective of Natural Resources Conservation Service is to increase planting diversity within Alabama with native species suitable to provide multiple benefits to landowners and society. The NRCS assists landowners with reforesting thousands of acres each year. The majority of the areas have traditionally been reestablished to loblolly or longleaf pine, with a small amount being planting to hardwoods. Recently the decision was made to add shortleaf pine to the species list within the farm bill programs in Alabama. Shortleaf pine grows naturally in the mountains, Piedmont, and upper Coastal Plain. It reaches an average height of 80 to 100 feet and 2 to 3 feet in diameter. It has a clear, well-formed bole and a small, narrowly pyramidal crown. It is generally found on dry upland soils, which are neither highly acidic nor strongly alkaline. The species may be less shade tolerant than loblolly pine, but young trees will endure suppression for many years and yet respond quickly to release. Shortleaf pine is considered slower growing than the other southern pines and is generally disfavored where other pines are well adapted. It is the most common species regenerated in the northern and western parts of its range and is a valuable timber and pulp species. Shortleaf pine seeds are eaten by squirrels and birds and very mature trees with red heart disease are favored nesting sites for the red-cockaded woodpecker. Because of littleleaf disease problems in central and south Alabama, shortleaf pine planting is only eligible in the following counties: Blount, Cherokee, Cullman, DeKalb, Etowah, Jackson, Lawrence, Limestone, Madison, Marshall, Morgan, Walker, Winston, and those eastern portions of Colbert, Lauderdale, Fayette, Franklin, and Marion that are outside of the coastal plain soils. Tree spacing will be 8 foot by 10 foot (545 trees per acre) or wider. Fewer trees may be planted per acre, depending on landowner objectives. Prior approval will be needed if the landowner wants to plant fewer than 300 trees per acre. The Environmental Quality Incentives Program (EQIP) is available to help participants address a wide range of resource concerns on forest land including establishment of shortleaf pine.

Forest Management at Lake Guntersville State Park

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Alabama State Parks Forester

Abstract: The Alabama Department of Conservation has recently started manipulating natural resources at Lake Guntersville State Park to enhance the health and biological diversity of ecosystems for outdoor recreation. In 2003 planning began for a proactive, hands-on approach to natural resource management. Since then, tasks implemented on the park include commercial timber and fuel wood harvesting, forestry mulching, herbicide application, prescribed fire, installation of new multipurpose fire lanes and establishment of new permanent openings. The outbreak of tornados that ravished Alabama in April 2011 included two that hit this park on the same day. While a tragic setback for the park and its thousands of annual visitors, new opportunities may arise out of the disaster. New vistas of the Tennessee Valley have been created along the mountain roads and chalets. Salvaging to remove wind thrown and damaged trees has put more sunlight on the ground, improving carrying capacity for the park's famous deer. Substantial destruction of many stands of trees will require replacement by either mixed hardwoods or shortleaf pine. Shortleaf pine offers several advantages for park objectives: it is a long-lived species with moderate fire tolerance that lends itself to open pine forests, which are attractive to people and highly productive for wildlife. Proactive hands-on management contributes more diversity than simple nature preservation ever could over the same period of time. Enhancing and maintaining diverse, healthy ecosystems help to present nature at its best, and healthy ecosystems serve as one of the many settings for outdoor recreation.

Shortleaf Management in the National Forests in Alabama

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Abstract: The extent of the shortleaf pine management and recording of stands data is based on field inventory and records housed in the Forest Service Activity Tracking System (FACTS). The primary distribution of shortleaf pine forests is found west of the Mississippi River in the Ouachita Highlands of Arkansas and Oklahoma. This distribution also extends southward across northwestern Louisiana and well into Texas. Shortleaf pines (*Pinus echinata* Mill.) also flourish across Mississippi and the southern coastal plain. They are known for their ability to tolerate drier upland sites, making it important in species management in the highlands for the Piedmont Province, which includes Alabama, Georgia, South Carolina, North Carolina, and Virginia. Shortleaf pines are considered the second most important southern pine species managed from within its range in the state of Alabama. The planting and establishment of shortleaf pine plantations has been declining in recent decades along with growing stock. Volume decreases are expected to continue downward in the near future in the national forests in Alabama primarily because of management preferences.

Redstone Arsenal's Current Management Regime

Joey Skinner
Redstone Arsenal

Abstract: Redstone Arsenal (RSA) is located in Madison County, Alabama, and encompasses approximately 38,100 acres. RSA has an active forest management program, agriculture leases (including grazing and hay), and a wildlife management program, all of which are focused on innovative ways to optimally manage these resources. Its timberlands are somewhat diverse, with pine (both loblolly and shortleaf) covering 4,318 acres, hardwoods covering approximately 6,601 acres, and mixed stands of cedar, hardwood, and pine covering 4,978 acres. Current budget constraints necessitate a new focus being placed on the implementation of management techniques that have the potential to generate new revenue streams that will hopefully allow these programs to become less dependent on the department of the army's funding. RSA has partnered with local universities for research/technical support in order to more closely analyze alternative management strategies such as an agro forestry management system and the long-term benefits that might be derived. RSA fully understands the benefits of these relationships and plans to continually strive to seek out new and better ways to manage our resources.

Increase in Bidirectional Introgression between Loblolly Pine (*Pinus taeda* L.) and Shortleaf Pine (*P. echinata* Mill.)

John Stewart
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Abstract: Hybridization between loblolly pine and shortleaf pine has been shown in sympatric and allopatric portions of the species native ranges. In this study we used 25 microsatellite markers to determine the hybrid status of 165 and 151 loblolly pine and shortleaf pine trees sampled across their ranges, respectively, and to estimate population differentiation within these species. Estimated differentiation (φpt) for these current day samples was significantly higher in both species—0.115 in loblolly pine and 0.146 in shortleaf pine—than for trees planted from seed collected from the same locations in the 1950s. These increases are likely due to anthropogenic causes such as habitat fragmentation. In addition, the proportion of hybrids rose dramatically in both species: 27.3 percent hybrids in loblolly pine populations and 46.7 percent hybrids in shortleaf pine populations compared to rates of 4.5 percent and 3.3 percent, respectively, in the 1950s populations. Our results suggest that shortleaf pine and remnant naturally regenerated loblolly pine are at risk to anthropomorphic introgression.

Is There a Morphological or Physiological Explanation for the Dramatic Increase in Hybridization Between Loblolly and Shortleaf Pine?

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Abstract: Recent evidence indicates that hybrids between shortleaf pine (*Pinus echinata*) and loblolly pine (*P. taeda*) have been increasing at an alarming rate since the 1950s throughout the southeastern U.S. The goal of this study was to compare the physiology and morphology of artificial hybrids to parent population to determine whether hybrids might inherit useful traits from their parent species that have allowed them to increase in abundance. We examined six half-sib families each of loblolly pine and shortleaf pine as well as 12 artificial crosses of those parent trees over 3 years.

We found that loblolly pine and hybrid pine had greater first-year seedling establishment than shortleaf pine. Hybrids (15.3 sprouts ± 0.6 SE) were intermediate for resprouting following top-kill, with shortleaf pine having the highest resprouting capacity (17.9 sprouts ± 0.8 SE) and loblolly pine having the lowest (7.8 sprouts ± 0.8 SE). Shortleaf pine had the highest frequency of strong basal crooking (42.6 percent ± 3.9 percent SE) whereas the hybrid pine (6.4 percent ± 3.3 percent SE) and loblolly pine had much lower frequencies (1.8 percent ± 3.8 percent). Hybrid pines had similar growth rates as loblolly pine, both of which were greater than shortleaf pine. Instantaneous water use efficiency (WUE) (based on internal CO_2 concentration) indicated hybrid pine had WUE similar to shortleaf pine that was higher than for loblolly pine. In the absence of fire, these characteristics probably give the hybrid pine seedlings a competitive advantage over shortleaf pine seedlings. Displacement of shortleaf pine with hybrids may reduce the resiliency of southeastern forests to future climate change.

Using Herbicides to Restore Shortleaf Pine Systems

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Abstract: When considering herbicide use, society is concerned about human, wildlife, and environmental safety. Therefore, to achieve socially responsible and effective weed control, managers preparing an herbicide prescription should have a comprehensive plan of action based on variables influencing control and reducing risk as well as past application experience and results. Shortleaf pine is more tolerant of commonly used forest herbicides than loblolly pine; therefore, many herbicide prescriptions for loblolly pine will also work for shortleaf pine. Herbicides may be applied using area or individual stem methods of application. Descriptions of application methods and their advantages and disadvantages are presented.

Introduction

When preparing sites for planting, an effective land manager should consider the merits of prescribed fire, mechanical, and herbicidal treatments. For example, mechanical methods are dependable for clearing a site for planting. However, their use can be restricted by weather, poor and excessive drainage, or extremes in topography. Other problems include negative impacts on erodible or fragile soils and the potential for abundant hardwood sprouting. Herbicide treatments alone or in conjunction with controlled burning have limited impact on most soils and are seldom restricted by terrain. When used correctly, herbicides will control hardwood sprouting and are generally less expensive than mechanical treatments. Herbicide use is sometimes restricted by environmental concerns and requires technical training by the user. When integrated, herbicides, fire, and mechanical treatments can be very socially, environmentally, and efficaciously responsible. Making a decision about whether the use of herbicides is appropriate requires an understanding of their effects and limitations. The remainder of this paper will focus on using herbicides.

For responsible herbicide applications, users should establish a routine practice of detailed planning and record keeping helping insure successes are repeated and failures are not. An herbicide prescription contains a list of variables influencing control and reducing risk. When considered carefully and understood, these variables can lead to increased likelihood of effective and safe herbicidal weed control and reduced risk of failure and harm to the environment. A logical outcome of prescription development is a plan of action based on management goals, social and biological conditions and limitations, herbicide options, and expected results. Consider the following.

The Herbicide Prescription

Clearly Define Project Objectives

Always know the crop trees or crop plants that are on the site or that are planned for restoration to the site. It is unlawful to use herbicides on sites for which the product is not labeled or on crop species other than those included on the label.

Prescription Type

Prescriptions are of two types: site preparation and release. Site preparation is accomplished with various mechanical and chemical treatments rendering favorable establishment conditions for seedlings. Prior to crop establishment, management has more herbicide products, rates, application methods, timings, and options available than any other time in the rotation. Failure to act appropriately at this time could mean dealing with an undesired species for many years and perhaps loss of the site to invasive exotic or native species.

A release treatment, in contrast to site preparation, is performed after the crop is established and actions are limited to what the crop can tolerate. That is, management may prescribe a woody release for control of unwanted woody species or a herbaceous release for control of unwanted herbaceous plants. Use rates will vary with the type of release performed and the targeted competitors to be controlled.

Site Specific Considerations

Location

The location of the application may influence product options. Some herbicides have properties determined by the EPA to require special training. The designation "RESTRICTED USE" is on the label and follows the product throughout the United States. The EPA allows states to add additional restrictions and these products are classified as "Limited Use." Some states vary restrictions by the county or precinct within a county. Thus, a legal application may vary not only from state to state but also within a county.

A restricted use herbicide is available for purchase and use only by certified pesticide applicators or persons under their direct supervision. This designation is assigned to an herbicide because of its relatively high degree of potential human and/or environmental hazard even when used according to labeled directions. Thus, avoiding restricted and limited use herbicides can reduce risk to the environment, people, and wildlife. Visit the homepage of the respective state regulatory agency website for specific details.

Soils, Slope, and Topography

Soil texture, percent organic matter, and internal drainage may significantly impact the performance of soil-active herbicides. The capacity of a soil to bind herbicides is determined by soil texture and organic matter. Fine textured and organic soils have a large surface area relative to volume, which tends to absorb more herbicide in proportion to their content and make less herbicide available for uptake by root systems of target vegetation. For this reason, higher rates of herbicide are required on soils high in clay or organic content. Conversely, care must be exercised so that injury to the crop trees does not result from over-application on sandy or coarse-textured soils, particularly for woody and herbaceous release of young pine stands. Generally, product labels provide a range of application rates for various soil types. Users should always read the label carefully, know the soil type, and make sure that applications are conducted according to specifications.

Water moves downhill; thus, slope is a determinate in which way water will run. Always allow for water movement. Care must be used to insure soil-active herbicides do not move into the root zone of non-target plants.

Topography and landform features can impact and potentially limit herbicide application methods. Rough terrain could preclude the use of ground applications leaving only aerial as a practical application method. Applicators must always be aware of ditches, streams, lakes, etc. that might be contaminated by runoff.

Unwanted Competitors

Before prescribing any herbicide, a survey must be conducted to identify dominant weed species on the site. Usually three or four unwanted herbaceous or woody species will dominate. Know the weeds to control and select the appropriate product, rate, and application method.

Treatment and Application Procedures

Herbicides vary in use and toxicity properties. Effective control means using the appropriate herbicide(s), rate, timing of application, and application method while minimizing risk and toxicity to people, wildlife, and the environment.

Specific Herbicide

Herbicide properties are product specific. Technical use properties are located on the label. When selecting a product, consider the target and non-target species, activity (soil, foliage, stem), maximum use rates, timing of application, method of application, recommended adjuvants (surfactants—materials improving the emulsifying, dispersing, spreading, wetting, or surface-modifying properties of liquids; rain fastness—the length of time a material can withstand rain), product mobility and volatility, environmental toxicity, and regulated use restrictions. See the label for more details.

Product
All forest herbicides have a control spectrum composed of highly susceptible (likely to be controlled), moderately susceptible, or resistant (relatively unaffected) species. An herbicide may be considered acceptable as long as resistant species are only a minor component of the plant community. Because no one herbicide controls everything, tank mixtures of two or more partners are commonly used. For broad-spectrum plant control, tank partners should be selected with complementary spectrums of control. That is, one tank partner should control what the other does not. Do not use herbicides to control resistant species; it will not work! Species susceptibility to an herbicide is addressed in herbicide labels and research literature and will not be covered here.

Rate
Apply only the amount of herbicide(s) needed. More may not be better. Never exceed the maximum labeled rate.

Timing
Timing of the application should match herbicide(s) properties with plant phenology (the appearance of seasonal events in the life cycle). For example, soil-active herbicides are generally applied in the spring to early summer when rainfall required for activation and movement to roots is likely to occur. Similarly, foliar sprays are applied after full foliage development in the spring. Herbaceous plants are commonly controlled with a spring application while woody plant control is generally improved by late summer to early fall applications.

Method of Application
Several application methods are available to deliver the appropriate rate of herbicide in a safe and effective manner to the foliage, stem, soil for root uptake, or cut stump of unwanted trees and shrubs. The advantages and disadvantages of common methods of application are covered later in this paper. Always consult the product label for recommended methods of application. Additional methods may be legal as long as the label does not prohibit their use. Users considering application methods not included on the label should consult a representative of the product manufacturer before applying the product.

Herbicide applications readily complement and integrate with prescribed burning and mechanical treatments to control target plants efficiently. The best herbicide treatment is always the lowest rate of the least toxic herbicide required to meet management objectives. The best timing and application method introduces minimum risk to non-target plants and animals. Always follow the instructions on the herbicide label.

Toxicity
Acute toxicity is estimated from tests of laboratory animals. Results are expressed in milligrams (mg) of pesticide per kilogram (kg) of body weight or LD50. An LD50 represents the individual dose required to kill 50 percent of the test population. Because LD50 values are standard measurements, it is possible to compare relative toxicities among pesticides. The lower the LD50, the more toxic the pesticide.

Signal Word
The signal word on the label refers to the most serious method or route of exposure. For example, if an herbicide has an acute oral LD50 of 368 (which triggers the signal word “Warning”) and an acute dermal LD50 of >2,000 (which triggers “Caution”) and is severely and irreversibly corrosive to the eyes (which warrants “Danger”), then the label signal word is “Danger”. Thus, risk to the environment, people, and wildlife can be reduced by selecting herbicides with the “Warning” rather than “Danger” signal word.

To better understand the scope of the signal word, a brief explanation of EPA testing is presented: The EPA evaluates carcinogenicity, neurotoxicity, reproductive teratology (birth defects), and mutagenicity (genetic mutation) study results based on animal tests conducted during the herbicide registration and re-registration processes. The study data

is used to make inferences relative to human health. Consider the example risk to cancer (carcinogenicity) from an herbicide. The EPA considers how strongly carcinogenic the herbicide is (its potency) and the likelihood of human exposure. The herbicide is evaluated not only to determine if it causes cancer in laboratory animals, but also as to the potential to cause human cancer. For any herbicide classified as a potential carcinogen, the risk depends on the extent (frequency, duration, quantity) to which a person is exposed. Results from many tests are reviewed: short-term studies, long-term cancer studies, mutagenicity studies, and structure activity concerns. The "weight-of-the-evidence" is the term used to refer to a review of an herbicide. This means the EPA's recommendation is based on the results of all studies that are available. Clearly, the signal word captures the essence of the risk associated with an herbicide and should be a reference when selecting an herbicide. Detailed toxicity information is found on the material safety data sheet (MSDS) for each herbicide and in the Herbicide Handbook published by the Weed Science Society of America.

Other Variables Influencing Control

Weather. Weather extremes can influence applications and control. For example, cloud cover on the horizon may suggest the need for an adjuvant increasing rain fastness. Drought may dictate the shifting of rates for tank partners, changing of herbicides, or delayed applications.

Plant Vigor. All systemic herbicides require physiological activity for movement of the herbicide within the plant. Injured stems and broken branches reduce plant vigor and leaf surfaces for herbicide droplet deposition. Plants injured during harvesting may be controlled more readily when allowed to recover before treatment.

Site Debris. Debris on the site may intercept herbicide spray and prevent products from reaching the desired target. Heavy debris loads can be reduced with prescribed fire or chopping to facilitate product contact with the soil or foliage for plant uptake.

Stand Structure. Aerial applications are affected by stand structure. Uneven-aged stands, stratified canopies, and lower components within multistoried canopies can be difficult to cover with foliar treatments due to shielding from taller trees. To compensate, managers should seek solutions that decrease interception by non-target species and maximize herbicide delivered to target species. Partial solutions to this problem include using larger droplet size, more total gallons of spray per acre, solid formulations, or products with both foliar and soil activity.

Probable Response. What is the expected response to treatment? Managers should ask themselves if the expense and risk justify the expenditure for the response.

Impact on Other Resources. Herbicide applications are not isolated events. Managers should examine how well the proposed application meshes with all objectives, both short- and long-term, and consider people, other land uses, and wildlife when making herbicide-related decisions.

Sensitive Areas

The location of crops, endangered species, water sources, wetlands, grazing lands, dwellings, vistas, and public areas can have a direct effect on application method as well as herbicide selection. Movement of herbicide from the target area to any of these is a label violation subject to litigation. This can occur through drift of fine spray particles during aerial application, movement of volatilized product during or after application, and movement of products in surface water. Potential problems can be avoided by using proper equipment and selecting products that do not volatilize or move with surface water.

Aerial applications should be used cautiously and avoided completely in high-risk areas. Applications should be conducted under ideal weather conditions (wind speed less than 5 mph and temperatures lower than 85 degrees Fahrenheit). Nozzles that deliver herbicides in large droplet sizes should be used in combination with drift control agents. Also, the presence of a helicopter or fixed wing aircraft near any sensitive area is likely to draw considerable attention to a spray operation regardless of risks. Advance notification of the operation to the local population can be used to determine any objections. In such cases alternative application methods or mechanical treatments may be advisable. Foliar ground applications are generally less prone to drift than aerial. However, similar precautions should be used. At times it may be advisable to treat buffer areas surrounding a tract by hand or other ground methods and broadcast treat only the interior portion of the site.

Soil-active products in liquid or granular form can be applied from the ground with little risk of drift. Products will move with surface water and should not be used on sloped sites draining into water supplies or any other sensitive area.

Wildlife Considerations

Land managers should be aware of possible impacts of herbicides on wildlife. Wildlife species are often featured in management objectives and certain plant and animal species are protected under the Endangered Species Act.

Normally, impacts on wildlife due to direct exposure to forestry herbicides are negligible. Forestry herbicides are not highly toxic to animals, are applied at relatively low rates, and do not persist for long periods in the environment.

Herbicides impact wildlife primarily by affecting habitat. This impact may be positive or negative. The degree of habitat modification depends upon the component of the vegetation community at which the treatment is directed and the type of application. Some herbicides primarily control woody species, some control herbaceous grasses and forbs, while others can temporarily eliminate nearly all vegetation on a site when broadcast at highest labeled rates. Even in the most extreme case the effects are temporary. Sites treated with broadcast applications generally re-vegetate within a year after treatment. Herbicide applications can be designed to favor wildlife.

Keeping Records

Guidelines for record keeping are provided by state regulatory agencies. Records should include all the information needed for a stranger to complete the project if need be. Good records include the following:

1. Recipe. Contains a list of the target species, the crop species, all the ingredients, and their respective amounts, to be mixed.
2. EPA Registration Numbers. Ingredients in the recipe are labeled by common name, EPA number, rate per acre, and rate in each tank.
3. License. List the applicator's license number.
4. Environmental Data. Record the starting and ending time. At initiation record ambient temperature, wind speed and direction, and soil temperature. Collect a soil sample for analysis.
5. Equipment. Record the equipment, boom, nozzles, metronome setting, MPH, and GPA.
6. Location. GPS the coordinates of the site. Draw a map of the treatment area and write directions to the site.
7. Contacts. List project cooperators and their contact information.
8. Observations. Record at completion of the project any special observations or unexpected events.
9. Results. Collect any needed data and summarize the success or failure of the project or treatments.

A Comparison of Individual Stem and Area Methods of Application

Unwanted woody plants may be controlled using methods of application that focus on the individual woody stem or the area wherein weeds grow. Each approach has advantages and disadvantages and should be studied carefully before making a selection.

Individual stem methods of woody plant control

Unwanted woody rootstocks may be controlled on an individual basis using sprays to the base of the stem (basal bark treatment), to the stump (cut stump treatment), in an incision (injection method), to the soil (spotgun treatment), and on the foliage (foliar spray). Individual stem methods of application have the advantage of (1) being very selective with only the specific tree receiving herbicide, (2) offering minimum environmental impact with only the unwanted trees receiving the appropriate rate of herbicide directly to the stem or roots, and (3) low to high visibility.

Visibility varies with the method used (Table 1). For example, all application methods may be used during the growing season. Unfortunately, this timing produces controlled trees with a brown skeleton silhouetted against a background of green (untreated) plants that brings attention to the controlled tree. In contrast, the low volume basal bark method may be used on dry bark any season of the year. During winter months, deciduous trees lack leaves and when treated there is no brown phase and the skeleton is hardly noticed until spring, when other plants green-up and treated trees do not. Still less conspicuous is the cut stump method. Here, trees are cut and allowed to fall to the ground where they are concealed by surrounding vegetation. There is no standing skeleton to attract attention.

Individual stem methods of application are ideal for weed conditions involving (1) low maintenance, (2) short (<8 feet tall) or sparse (<300 rootstocks/acre) stems, (3) small acreage, and (4) sensitive areas. Unfortunately, these methods are often labor intensive and, therefore, more expensive than area methods.

Area methods of woody plant control

Area methods of application focus on the area to be treated, not the individual stem (Table 2). Herbicide is applied to the area knowing roots or leaves are in the treated area for uptake of the product. Liquid or granular herbicides may be applied from the air using a helicopter or airplane (aerial application) or from the ground (ground application) using a skidder, tractor, four wheeler, backpack, or spotgun (liquid only). Area methods of application may be either broadcast to cover the entire area without skips or gaps or banded to cover continuous strips spaced between deliberately untreated strips, all within the total area.

Area methods have the advantage of being well suited for large tracts, tall trees (>8 feet tall), and high stem density (>500 rootstocks per acre). These methods may be highly visible with a high potential for environmental impact. Aerial applications are low in labor and cost as compared to individual stem treatments.

Table 1. A comparison of specific characteristics of individual stem methods of applying herbicide

Individual Stem Method	Timing of Application	Visibility of Application
Spotgun	Spring-early summer	High, leaving skeletons
Low volume basal bark	Any time the bark is dry	Low, leaving skeletons
Cut stump	Active growth; no heavy sap flow	Low, with no skeletons
Injection	Active growth; no heavy sap flow	High, leaving skeletons
Foliar spray	Late summer-early fall	High, leaving skeletons

Table 2. A comparison of specific characteristics of area methods of applying herbicide

Area Stem Method	Timing of Application	Visibility of Application
Spotgun	Spring-early summer	High, leaving skeletons
Foliar spray	Late summer-early fall	High, leaving skeletons
Granule	Spring-early summer	High, leaving skeletons

Descriptions of Application Methods for Weed Control

Selected properties of individual stem and area methods of application are presented (Table 3). Detailed descriptions of each application method follow.

Table 3. A list of application methods approaches to herbicide delivery, target plant group, and probable use in forestry

Application Methods	Individual Stem or Area Approach	Woody or Herbaceous Plants	Probable Uses
Cut stump	Individual stem	Woody	Release; small openings
Injection	Individual stem	Woody	Release; small openings
Low volume basal bark	Individual stem	Woody	Release; small openings
Spotgun	Individual stem	Woody	Release; small openings
Foliar spray	Individual stem	Woody	Release; small openings
Granules	Area	Woody	Release; site preparation
Spotgun	Area	Woody	Release; site preparation
Foliar spray	Area	Woody or herbaceous	Release; site preparation

Cut stump applications for individual woody stem control

The Concept. A cut stump treatment consists of applying an herbicide mixture to the recent cut surface of a tree stump, taking care to treat the cambium area and the top edge of the stump. The herbicide mixture consists of the herbicide and a carrier. When cut, the tree develops a callus layer at the site of injury. The carrier moves the herbicide through the developing callus layer and to vascular tissues for translocation throughout the plant.

Method of Application. Before applying herbicide, remove sawdust from stumps. On a stump 4 inches tall, apply the herbicide mixture to the entire surface of small stumps and to the vascular tissues located inside the bark. Apply sufficient herbicide mixture to soak the entire circumference of the stump surface, running over the top 2 inches of the stump edge. For large trees, exposed roots may be treated also. Because some herbicides are soil active, care must be taken to avoid non-target plant damage through soil movement. Control can be achieved without treating the soil with herbicide. Always follow the labeled instructions.

Age and Size of the Tree. Small trees are more readily controlled than large trees, but the technique works on all trees.

Timing. Best control results from applications immediately after the tree is cut. Control with oil-based sprays will decline over the next two days. Do not treat stumps more than two days old. For water-based sprays, treat stumps immediately as control decreases if treatment is delayed for more than one hour. Cut and treat stumps during periods of active growth, commonly after full leaf expansion, but not during heavy sap flow.

Expected Results. Cut stump treatments are effective any time of the year except during periods of very active growth (heavy sap flow).

Necessary Product and Equipment. A backpack hand-pump sprayer with a wand fitted with an adjustable cone nozzle works well. For small projects, a squirt bottle or paintbrush is adequate.

Some oil-based products labeled for cut stump treatments are Garlon 4 Ultra (Remedy Ultra), Pathfinder II, and Stalker. For Garlon 4 Ultra (Remedy Ultra) prepare a 20 to 30 percent mixture of product and oil. Pathfinder II is

ready-to-use (requires no mixing). For Stalker, prepare a gallon of mixture containing 8 to 16 ounces of product in diesel or penetrating oil. Some penetrating oils appropriate for mixing with the above herbicides are diesel, kerosene, Basal and Brush Oil by Helena, Bark Oil (Blue) by Aquamix, and Bark Oil EC (Blue) by Aquamix.

Garlon 3A (undiluted), Pathway (undiluted), Accord Concentrate (50 to 100 percent solution), Accord XRT (40 to 50 percent solution), Transline (50 percent solution), and Stalker (8 to 16 ounces or 6.25 to 12.5 percent) are water-based herbicides labeled for cut stump treatments.

Injection for individual woody stem control

The Concept. Stem injection, including hack-and-squirt, consists of making horizontal incisions in the tree and placing a measured amount of herbicide in each incision. Incisions are evenly spaced at a uniform height that is comfortable for the applicator. The herbicide is moved in vascular tissues throughout the tree for control.

Method of Application. A hatchet, machete, ax, or tree injector is used to make evenly spaced incisions in a tree. The incision forms a pocket where concentrated or diluted herbicide is applied. The incision temporarily holds herbicide while it soaks into the tree. Always follow the labeled instructions.

Because some herbicides are soil active, avoid applying or spilling herbicide on the tree trunk or onto the soil where rain can wash the herbicide to the roots of non-target surrounding plants.

Age and Size of the Tree. Stems less than 2 inches in diameter are difficult to inject and should generally be considered too small for stem injection. Trees > 2 inches in diameter are more readily controlled than large trees, but the technique works on all sizes. Edge-to-edge (no gaps) incisions may be needed for large or difficult to control species.

Timing. The injection concept works any time of the year. Products vary in the season during which each is most efficacious (Table 4). Read the label for more details.

Table 4. Herbicide name, undiluted or diluted mixture to be injected, herbicide per incision and spacing of incisions, and timing of application for tree injection

Herbicide Active Ingredient	Mixture	Incision Spacing[1] ml per incision	Timing of Application
Velpar L Hexazinone	undiluted	1ml/incision 4-inch intervals	summer
Stalker Imazapyr	8-12oz/gal of mix	1ml/incision <1-inch interval between cut edges	periods of active growth, but not during heavy sap flow
Garlon 3A Triclopyr	50% or undiluted	1 or 0.5ml/incision slightly overlapping and continuous	periods of active growth and after full leaf expansion
Pathway Picloram+2,4-D	undiluted	1ml/incision/ inch of dbh	any season
Transline Clopyralid	50% or undiluted	1 or 0.5ml/incision 3[2]-4 inches between centers	periods of active growth and after full leaf expansion
Accord XRT II Glyphosate	40-100% solution	1ml/incision 2[2]-3 inches of dbh	periods of active growth and after full leaf expansion
Accord Concentrate Glyphosate	25-100% solution	1ml/incision 2[2]-3 inches of dbh	periods of active growth and after full leaf expansion

[1] Horizontal incisions are uniformly and evenly spaced at a height comfortable for the applicator or approximately diameter at breast height (dbh).
[2] Smaller values are for easy to control and larger values are for more difficult to control species. See the herbicide label for details.

Expected Results. Best results can be expected when trees are injected during periods of active growth, commonly after full leaf expansion, but not during heavy sap flow. Avoid injecting trees when rainfall seems imminent or during extreme drought.

Necessary Product and Equipment. A hatchet, machete, or ax may be used to make an incision at a comfortable height for the user. The squirt bottle is used to apply herbicide into the incision. In this example, the squirt bottle can be a thoroughly cleaned reusable plastic bottle or a new plastic bottle. Either bottle should be dedicated and labeled for herbicide use only. In this approach, the user fills the squirt bottle with herbicide, makes an incision in the tree, and squirts the herbicide in the incision. This process is repeated until incisions completely encircle the stem. The hypo-hatchet is another hatchet approach that eliminates the need for a separate squirt bottle. The hypo-hatchet comes with a tube and lid that fits the herbicide jug. Each time the hypo-hatchet strikes the tree; a piston in the head of the hatchet opens and closes dispensing herbicide from the jug into the incision. The Jim-Gem is a basal injector. In this example, herbicide is poured into the tube of the injector and dispensed through the blade at the end of the injector with each pump of the handle. To use, the applicator stabs the base of the tree, making an incision, and pumps the handle, releasing herbicide into the incision. This process is repeated until incisions completely encircle the tree.

Velpar L, Stalker, Garlon 3A, Pathway, Transline, Accord XRT, and Accord Concentrate are all labeled for individual tree injection. Always follow the herbicide label. See Table 4 for suggestions.

Low volume basal bark application for individual woody stem control

The Concept. A basal bark treatment consists of applying an herbicide mixture to the base of the unwanted stem (individual stem) or rootstock (multiple stems). The herbicide mixture consists of the herbicide and a carrier (material transporting the herbicide through the bark and to the vascular tissues). The carrier moves the herbicide through the bark and to the vascular (conductive tissues in plants) tissues for translocation throughout the unwanted plant.

Method of Application. Spray the herbicide mixture to the lowest 12 to 18 inches of the bark around the entire stem. This is best achieved by starting at ground line and moving up with each pass of the wand gradually circling the stem, with any excess spray occurring at the top of the treated area to then soak in as it runs down the stem. Spray until the bark is saturated but without runoff on the ground. Always follow the labeled instructions.

Age and Size of the Tree. Small trees approximately 5 inches in diameter at breast height (dbh) or 6 inches in ground line diameter usually have young, thin, smooth bark requiring less spray than old, thick, coarse bark of larger trees. Small stems are more easily controlled than larger, older stems.

Timing. Do not spray when the bark is wet. To check the bark for excessive moisture, press the bark with your thumb. If moisture is visible, the bark is too wet. Also, spray a test tree and if the oil-herbicide mixture turns white then the bark is too wet. Under either of these two conditions, do not spray.

Expected Results. Applications can be made successfully any time of the year. Treatments are often most effective during late summer, fall, and winter when trees are moving food reserves to the roots. Least effective control can be expected during early spring when energy reserves are moving from the root to shoot tips.

Necessary Product and Equipment. A backpack hand-pump sprayer with a wand fitted with an adjustable cone nozzle is recommended. Adjust the size of the cone spray to accommodate the size of treated stems.

Some commonly used products labeled for low volume basal bark sprays are Garlon 4 Ultra (Remedy Ultra), Pathfinder II, and Stalker herbicides. For Garlon 4 Ultra (also Remedy Ultra), prepare a 20 to 30 percent mixture of product with diesel, kerosene, or basal oil. Pathfinder II is ready-to-use (requires no mixing). Stalker should be mixed 8 to 12 ounces of product with diesel or penetrating oil per gallon of mixture.

Some basal oils appropriate for mixing with the above herbicides are diesel, kerosene, Basal and Brush Oil by Helena, Bark Oil (Blue) by Aquamix, and Bark Oil EC (Blue) by Aquamix.

Spotgun application for individual woody stem control

The Concept. Using a spotgun, apply a spot of herbicide to the soil, beneath the canopy, and within the root zone of an unwanted tree for root uptake and control. Velpar L is the only herbicide labeled for spot applications to the soil for control of forest trees and shrubs. Be aware that the roots of non-target species in the treatment area are at risk to herbicide uptake and plant death.

Method of Application. Using a handgun applicator, apply Velpar L to the soil. Adjust the amount of herbicide delivered to the soil based on size and dimension of the tree to be controlled. (Table 5). Because Velpar L is soil active, spot the soil on the uphill side of stems on slopes allowing plenty of room between the spot and the roots of non-target surrounding plants. All small stems of susceptible species that have roots in the treated area will be killed also. Always follow the labeled instructions. If treating brush on sloped sites, apply most of the Velpar L on the uphill side of the stem. If treating resprouts from brush disturbed by cutting or shredding, the rate of application must be proportional to the original tree's size, not just the small regrowth of sprouts.

Age and Size of the Tree. The amount of herbicide needed varies with tree size or dimension. For example, apply Velpar L at the rate of 2 to 4ml for each inch of dbh. Direct the treatment to the soil within 3 feet of the root collar of the plant to be controlled. When a large stem requires more than one delivery of Velpar L, make applications evenly spaced around the stem. For multi-stemmed brush, apply Velpar L at the rate of 2 to 4ml per 3 feet of canopy width. For tall, slender brush types, apply 4 to 8ml per 3 feet of height. Base the rate on whichever canopy dimension is greater (width or height). Difficult to control species or stems on clay soils should receive the higher dose of herbicide.

Table 5. Examples of Velpar L soil-applied with a spotgun for individual stem control of arborescent and shrub species[1]

Single Stem dbh	Shrub Height	Shrub Crown Diameter
2-4ml	4-8ml	2-4ml

[1] The high rate is for fine-medium textured soils (clay or loam) and hard to control species. The low rate is for coarse soils (sandy) and easy to control species. For single stemmed arborescent species, rate is for each inch of stem dbh. For shrubs, the rate is for 3 feet of canopy width or 3 feet of height, whichever dimension is greater.

Timing. Apply Velpar L from early spring to early summer after trees have broken bud and before full leaf expansion.

Expected Results. Best results can be expected when trees are actively growing. Rainfall is needed to move the herbicide into the soil and down to the roots for uptake. On herbaceous plants, symptoms usually appear within 3 to 4 week and woody plants 4 to 8 weeks after activation by moisture. Defoliation and refoliation may occur with susceptible plants killed. Avoid applications when excessive rainfall seems imminent or during extreme drought. Do not apply Velpar L when crop trees are stressed. Do not apply Velpar L in areas where roots of desired trees are present.

Necessary Product and Equipment. Different models of spotguns are available. A handgun, consisting of an adjustable graduated cylinder or syringe that is operated by squeezing the handle, is highly desirable. The graduations on the spotgun are not accurate, thus calibration of the spotgun should be checked. One pull of the handle will deliver the same amount of water or Velpar L, so use water to calibrate. To calibrate, pull the handle 10 times. If 20ml are captured, the spotgun is set for 2ml/spot. If 30ml are captured, the spotgun is set for 3ml/spot. Adjust the setscrew to fix the piston of the syringe to deliver the desired amount.

Foliar spray for individual woody stem control

The Concept. Spray water-herbicide-adjuvant mixture directly onto foliage of unwanted individual plants while avoiding desired plants.

Method of Application. Spray the herbicide mixture in a total volume of 5 to 30 gallons per acre, with 5 to 10 gallons per acre being common. The spray is directed to cover the foliage, growing tips, and terminal leader of all sides of the tree. Leaves are sprayed to wet without drip or runoff. Nozzles, adjuvants, spray pressure, and techniques that minimize drift should be used. Non-soil-active herbicides and spray shields may be used to reduce exposure to desired plants. Always follow the label instructions.

Age and Size of the Tree. Appropriate trees are short, usually < 8 feet tall, and readily accessible. The applicator should be able to spray the entire crown from top to bottom and all sides.

Timing. This method may be used anytime mature leaves are present and trees are actively growing but before autumn coloration. Late summer and early fall is common.

Expected Results

Best results can be expected when trees are actively growing. Do not apply herbicides under adverse environmental conditions such as temperature extremes or when weeds are stressed due to low rainfall.

Necessary Product and Equipment. A backpack hand-pump sprayer with a wand fitted with a flat or adjustable cone nozzle or a Model 30 GunJet with rollover nozzle is recommended.

Some examples of herbicides labeled for unwanted woody plant control with directed low-volume foliar sprays are Arsenal AC, Chopper GEN2, Milestone VM Plus, Transline, Garlon 3A, Accord XRT II, Accord XRT, Accord Concentrate, and Garlon 4 Ultra. See product labels for specific details on rates, timing of application, instructions for application, as well as limitations and precautions. Examples of individual stem control of unwanted hardwoods while releasing pines are presented in Table 6.

Table 6. Examples of common foliar-applied herbicides for woody release of pines

Herbicide Mixture	Product/Acre	Target Competitor
Arsenal AC+Li-700	14 oz + .25 %v/v	Broadleaf and grass species
Arsenal AC+Escort XP+Li-700	14 oz + 1 oz + .25%v/v	Broadleaf, grass and Rubus species

Area control of unwanted woody stems with a spotgun application

The Concept. Apply the soil-active herbicide Velpar L directly to the soil in a grid. Roots of unwanted trees extending into the grid take up the herbicide and are controlled. Velpar L is the only forest herbicide labeled for spot applications to the soil for control of species of forest trees and shrubs.

Method of Application. Using a handgun applicator, apply a spot of Velpar L to the soil. Adjust the amount of herbicide delivered to the soil based on soil texture and grid pattern (Table 7). Always follow the labeled instructions.

Age and Size of the Tree. The amount of herbicide needed does not vary by tree size or dimension. Rate is determined by soil texture and species susceptibility. That is, use lower rates on coarse-textured soils and where the

Table 7. Soil texture, ml/spot, grid pattern and rates for undiluted Velpar L herbicide applications to the soil with a spotgun

Soil Texture	ml/Spot	Grid (ft)	Quarts/Acre
Coarse	0.6	3 x 3	3
	2.0	4 x 4	6
	3.1	4 x 6	8
Medium/Fine	1.6	3 x 3	8
	2.8	4 x 4	8
	3.5	4 x 4	10
	5.2	4 X 6	10

major hardwood components are susceptible species. Use high rates on fine-textured soils and where species that are partially controlled or suppressed dominate the stand.

Timing. Apply Velpar L from early spring to early summer after trees have broken bud and before full leaf expansion. Rainfall is needed to move the herbicide into the soil and down to the roots for uptake. Avoid soil treatments when heavy rainfall seems imminent.

Expected Results. Best results can be expected when trees are actively growing. Rainfall is needed to move the herbicide into the soil and down to the roots for uptake. On herbaceous plants, symptoms usually appear within 3 to 4 weeks and on woody plants, 4 to 8 weeks after activation by moisture. Defoliation and refoliation may occur with susceptible plants killed. Avoid applications when excessive rainfall seems imminent or during extreme drought. Do not apply Velpar L when crop trees are stressed. Do not apply Velpar L in areas where roots of desired trees are present.

Necessary Product and Equipment. Different models of spotguns are available. A spotgun, consisting of an adjustable graduated cylinder or syringe that is operated by squeezing the handle, is highly desirable. The graduations on the spotgun are not accurate; thus, calibration of the spotgun should be checked. One pull of the handle will deliver the same amount of water or Velpar L, so use water to calibrate. To calibrate, pull the handle 10 times. If 20ml are captured, the spotgun is set for 2ml/spot. If 30ml are captured, the spotgun is set for 3ml/spot. Adjust the setscrew to fix the piston of the syringe to deliver the desired amount.

Area control of unwanted woody stems with a foliar spray

The Concept. Apply an herbicide directly in an area occupied by unwanted trees and shrubs. Roots or leaves of unwanted trees resident or extending into the area absorb the herbicide and are controlled.

Method of Application. Using a helicopter, skidder, tractor, or other suitable device, apply the herbicide mixture to the area. Always follow the label instructions.

Age and Size of the Tree. This approach is well suited for trees of various size, dimension, and age.

Timing. This method may be used anytime mature leaves are present and trees are actively growing but before autumn coloration. Late summer and early fall is commonly the best.

Expected Results. Best results can be expected when trees are actively growing. Do not apply herbicides under adverse environmental conditions such as temperature extremes or when weeds and crop species are stressed.

Necessary Product and Equipment. A helicopter or skidder outfitted with dedicated and appropriate nozzles, etc. for forestry site applications is recommended.

Some herbicides labeled for unwanted woody plant control using foliar sprays are Arsenal AC, Chopper Gen II, Milestone VM, Transline, Garlon 3A, Garlon XRT, Accord XRT II, Accord XRT, Accord Concentrate, and Escort XP. See product labels for specific details on rates, timing of application, instructions for application, as well as limitations and precautions. Some examples follow in Table 8. Notice that each treatment is an herbicide mixture targeting specific competitors and containing more than one herbicide. Because no one product controls all unwanted species, mixtures are used to achieve efficient broad-spectrum control with the least amount of herbicide. Users commonly achieve broad-spectrum control by selecting tank partners with strengths that complement the weaknesses of the other tank products, thereby reducing the holes in the spectrum of control.

Table 8. Some examples of common herbicide mixtures for aerial applications during forestry site preparation		
Herbicide Mixture	**Product/ Acre**	**Target Competitor**
Milestone VM + Accord XRT II + LI-700 (nonionic surfactant)	7 oz + 6 qts + .5%v/v	Noncrop pine
Arsenal AC + Accord XRT II + Escort XP + LI-700	24 oz + 64 oz + 1 oz + .5%v/v	Miscellaneous Broadleaf Control
Broadleaf Control Arsenal AC + Garlon XRT + LI-700	24 oz + 16 oz + .5%v/v	Miscellaneous Broadleaf Control
Broadleaf Control Chopper Gen II + Garlon XRT + Methylated seed oil	48 oz + 32 oz + 1-2 qt	Miscellaneous Broadleaf and Waxy Control
Accord XRT II + Garlon XRT + LI-700	1 gal + 32 oz + .5%v/v	Miscellaneous Broadleaf Control
Milestone VM + Accord XRT II + Chopper Gen II + LI-700	7 oz + 6 qts + 12 oz + .5%v/v	Noncrop pine + Broadleaf Control

Table 9. Soil texture requirements for granules of Velpar ULW applications to the soil	
Soil Texture	**Velpar ULW Pounds per Acre**
Sand, Loamy Sand, Sandy Loam	1 to 2
Loam, Sandy Clay Loam, Silt Loam	2 to 3
Clay Loam, Sandy Clay, Silty Clay Loam, Silty Clay, Clay	3 to 4

Area control of unwanted woody stems with herbicide granules to the soil

The Concept. Broadcast or band-apply Velpar ULW, a soil-active herbicide, directly to the soil. Roots of unwanted trees extending into the treated area absorb herbicide and are controlled. Velpar ULW is the only forest herbicide formulated and labeled for the application of granules to the soil for control of forest trees and shrubs.

Method of Application. Apply Velpar ULW using ground or aerial equipment appropriately modified to apply Velpar ULW. Adjust the rate of herbicide delivered to the soil based on soil texture, organic matter, and species susceptibility (Table 9). Always follow the labeled instructions.

Age and Size of the Tree. The amount of herbicide needed varies by soil texture and species susceptibility (tree size and vigor). That is, use lower rates on coarse-textured soils and soils low in organic matter and where the major hardwood components are susceptible species. Use high rates on fine-textured soils or soils high in organic matter and for species that are partially controlled or suppressed dominate the stand. The degree and duration of control is influenced by environmental conditions at and following treatment.

Timing. Apply Velpar ULW from early spring to early summer after trees have broken bud and before full leaf expansion. Rainfall dissolves the Velpar ULW granule, releasing the active ingredient, hexazinone, into the root zone where it is absorbed during periods of vigorous plant growth. Avoid soil treatments when heavy rainfall seems imminent.

Expected Results. Rainfall dissolves the Velpar ULW granules, releasing the active ingredient into the root zone, where it is absorbed during periods of vigorous plant growth. On herbaceous plants, symptoms usually appear within 3 to 4 weeks and on woody plants, 4 to 8 weeks after activation by moisture. Defoliation and refoliation may occur with susceptible plants killed. Avoid applications when excessive rainfall seems imminent or during extreme drought. Do not apply Velpar ULW in areas where roots of desired trees are present.

Necessary Product and Equipment. A modified backpack blower is recommended for ground applications. Aerial applications are best when the DuPont Simplex applicator is used. Acquire and use blank granules to calibrate equipment.

Area herbaceous release of pines with a band or broadcast application

The Concept. Broadcast or band-apply soil-active herbicide directly to the soil and over the top of newly planted seedlings. Roots of pre-emergent and roots, stems, and leaves of post-emergent unwanted herbaceous plants extending into the treated area absorb herbicide and are controlled. Arsenal AC+Oust XP, Oustar, Oust XP, and Oust

Extra are labeled and commonly used for this application (Table 10).

Table 10. Herbicide rates for herbaceous release of pine seedlings from unwanted herbaceous plants

Herbicide	Ounces of Product Per Treated Acre	Target Competitor
Arsenal AC+ Oust XP	4 + 2	Grasses and Forbs
Oustar (Medium-Fine soils)	13	Grasses and Forbs
Oustar (Coarse soils)	10	Grasses and Forbs
Oust Extra	3-4	*Rubus*, Grasses, and Forbs
Oust XP fall site prep	3 Apply Sep-Oct	Grasses and Forbs
Oust XP fall site prep	4 Apply Jun-Aug	Grasses and Forbs

Method of Application. Using a helicopter, skidder, tractor, or backpacks, apply the herbicide mixture over the top of pine seedlings within the treatment area. Always follow the labeled instructions.

Age and Size of the Herbaceous Weed. Small, rapidly growing annual herbaceous weeds are more readily controlled than established perennial weeds. The degree and duration of control is influenced by environmental conditions at and following treatment.

Timing. For post-plant herbaceous weed control, best results are achieved by applying herbicides in early spring to bare ground or when post-emergent weeds are less than 3 inches tall. For combining fall site preparation and herbaceous weed control in a single application, mix Oust XP herbicide in the site prep tank and apply during late-June through October. Rainfall moves soil-active herbicides into the root zone, where they are absorbed during periods of vigorous plant growth. Avoid soil treatments when heavy rainfall or severe drought seems imminent.

Expected Results. For pre-emergence timings, weeds may not appear for weeks or months depending on the rate and the plant species. For post-emergence timings, herbaceous plants commonly display symptoms within 3 to 4 weeks after application; control often peaks from 30 to 90 days after treatment with colonization occurring thereafter.

Necessary Product and Equipment. A backpack sprayer, skidder, ATV, or helicopters are recommended for applications.

Summary and Conclusion

Vegetation control should be conducted to fit within and enhance the overall objectives of a sound forest management plan. When preparing sites for planting, an effective land manager should consider prescribed fire, mechanical, and herbicidal treatments for their merits. Making a reasonable decision as to whether the use of herbicides is appropriate requires an understanding of their effects and limitations. Managers should plan for success, develop a detailed plan of action, and keep detailed records of successes and failures for future reference. Herbicides, prescribed fire, and mechanical treatments can be integrated for socially, environmentally, and efficaciously responsible silviculture.

Shortleaf Containerized Seedlings – Delivering Performance

Wayne Bell
International Forest Company

Abstract: The use of container seedlings has dramatically increased in recent years as a result of landowners requiring increased survival and growth of seedlings. A brief history will be given of International Forest Company's container seedling program and specifically the shortleaf production history. A description of the IFCO's container seedling production system and shipping procedures will be discussed. Shortleaf pine seedlings specifications for successful reforestation will be presented as well as genetic sources used in current shortleaf seedling production. Examples of field results using container seedlings will be shown.

Presentation: International Forest Company (IFCO) has been in the container nursery business since 1983 and currently produces more than 50 million total seedlings of loblolly, longleaf, shortleaf, slash, and Virginia pine. The company is located in Moultrie, Georgia.

Container seedling production has increased significantly in use over the last several years. This is due to survival issues with bareroot seedlings, species that have establishment issues, use of higher genetic value reforestation stock, and better field performance. Throughout the South numbers of all container production for all species of pines have been as follows:

2005-06:	36,300,000
2006-07:	64,359,000
2007-08:	69,401,000
2008-09:	124,697,000
2009-10:	132,000,000

IFCO has been the largest producer of shortleaf pine seedlings for the last few years. Production of shortleaf at IFCO has been as follows:

2005-06:	1,443,000
2006-07:	840,000
2007-08:	2,081,000
2008-09:	825,000
2009-10:	2,277,100
2010-11:	2,125,000

Seedling supply of shortleaf seedlings always tends to be limited since it is a niche species. In order to insure the best selection of seed sources and genetics, seedlings should be ordered in January through May of the year before the planting season. Due to longer seed preparations for sowing, it is best to have an order by January or February.

All seed grown by IFCO is vacuum machine sown for maximum precision and germination. This occurs generally in late March or April.

All seedlings are generally top pruned at least once during a growing season to insure seedling uniformity, controlled root-shoot ratio, and increased root development.

IFCO deploys an integrated pest management program in the nursery that includes water management, fungicides, insecticides, and herbicides. All of this is aimed at delivering a pest-free, high-quality seedling that survives and grows to its genetic potential.

Seedlings are packed for shipping in wax coated boxes with a polyethylene liner. Each box holds 300 seedlings. Large quantities of seedlings are usually shipped on refrigerated trucks. Seedlings can be stored in refrigeration from 6 to 8 weeks. IFCO recommends that seedlings be planted as quickly as feasible from the time of delivery.

Planting times for container shortleaf seedlings are from October 1 through May 1. The key element is having soil moisture before planting.

IFCO is a member of the following research cooperatives that add value on shortleaf production:

N.C. State Tree Improvement
Western Gulf Tree Improvement
Auburn Southern Forest Nursery Cooperative
N.C. State Forest Productivity

These cooperatives provide genetic data and research for producing the best seedlings.

IFCO produces currently first and second generation shortleaf seedlings. Seed sources are from North Carolina, Virginia, Arkansas, Texas and Louisiana. Shortleaf is found from New Jersey to Texas.

Shortleaf pine offers several attributes that are attractive to landowners. These include the following: excellent wood properties, strong resistance to fusiform rust, excellent tree form, small knots, drought tolerance, high-quality wildlife habitat, and fire tolerance

Shortleaf container seedlings should have the following specifications ideally:

Seedling height:	8 to 10 inches
Root collar diameter:	4.0 to 4.8 mm
Seedling root:	Firm and stays intact

IFCO produces shortleaf in various root plug sizes. Although there are no studies identifying an ideal plug size, our experience shows that a plug with 5.6 cu. inches or greater works well for nursery production and field performance.

A normal characteristic of shortleaf seedlings is a crook at the ground line for seedlings. As genetic programs have advanced, seedlings with normal straight stems are becoming more the norm. There is a current debate on why this is occurring. One theory is that loblolly and shortleaf are hybridizing in seed orchards. Genetic programs select trees for better growth, form, and disease resistance. Therefore, these programs could be favoring hybrids as they may grow faster. Most shortleaf breeding orchards are near loblolly breeding orchards, which could aid this process.

There is some concern over how deep seedlings should be planted. The current thinking has been to plant with root plugs about 1 inch below the soil surface. Some practitioners are questioning if the crook should be below the soil surface if resprouting is desired. This is another area for research.

One of the concerns is that if the crook is eliminated, sprouting after fire or damage could be reduced. This needs more research.

Field results with container-grown shortleaf pines have been very consistent with survival rates often in the high 80 percent to low 90 percent range. This has shown marked improvement over bareroot. The fact that container seedlings take 100 percent of the root system to the field provides better root establishment and less shock than bareroot.

Growth has been encouraging with trees in Arkansas being as tall as 8 feet in 3 years. Growth will depend on the quality of the soil and competition control at establishment.

Spatial and Temporal Trends of the Shortleaf Pine Resource in the Eastern United States

Christopher M. Oswalt
U.S. Forest Service

Abstract: Shortleaf pine (*Pinus echinata*), considered one of the more important pine species in the eastern U.S., is currently widely distributed across southern and eastern forests. The future of this important species is uncertain, however, according to many land managers, conservationists, and forest ecologists. Data from the forest inventory and analysis program of the USDA Forest Service were used to explore both temporal and spatial trends in shortleaf pine population dynamics of the eastern U.S. in order to better understand the potential future of the species. The current inventory of eastern U.S. forests includes observations of shortleaf pine (> 1 inch) on more than 5,000 plots. The shortleaf pine and shortleaf pine-oak forest types account for an estimated 3.3 million and 2.9 million acres, respectively. Shortleaf pine is a dominant species on approximately 6.2 million acres of forest land; however, shortleaf pine continues to decline across its natural range. Moreover, the species is largely concentrated in aging, large-diameter stands. It appears that disturbance patterns, different from those that regenerated many of the current shortleaf pine-dominated stands that exist today, continue to plague this important species.

Introduction

Shortleaf pine (*Pinus echinata*), considered one of the more important pine species in the eastern United States (US) is currently widely distributed across southern and eastern forests. The future of this important species is uncertain, however, according to many land managers, conservationists and forest ecologists. Altered disturbance regimes along with changing forest land ownership patterns are continuing to contribute to important transformations of the shortleaf pine resource of the eastern United States.

Shortleaf pine is found throughout the southern and eastern U.S. and is the second most important southern pine (McWilliams et al. 1986). The natural range of shortleaf pine, according to Little (1971), encompasses 22 states in the eastern and southern U.S. Shortleaf pine is widely distributed yet occurs less frequently than some other pines, particularly eastern white pine (*P. strobus*) in the northern portion of the range and loblolly pine (*P. taeda*) in the south, and is often found in association with other pine species (Guldin 2007). While forest land has increased since the 1960s and 1970s through most of its natural range, it has been documented that shortleaf pine and shortleaf pine-dominated forests have experienced declines during that same period (Moser et al. 2007). Therefore, it is important to continue monitoring this important species at a range-wide scale.

Methods

Broad-scale Inventory

Historical and contemporary data from the national Forest Inventory and Analysis program (FIA) of the U.S. Forest Service (Frayer and Furnival 1999, Bechtold and Patterson 2005) were examined. The FIA program is the primary source for information about the extent, condition, status, and trends of forest resources across all ownerships in the U.S. (Smith and others 2002). FIA applies a nationally consistent sampling protocol using a quasi-systematic design covering all ownerships in the entire nation (Bechtold and Patterson 2005). FIA operates a multi-phase inventory based on an array of hexagons assigned to separate interpenetrating, non-overlapping annual sampling panels (Bechtold and Patterson 2005). In Phase 1, land area is stratified using aerial photography or classified satellite imagery to increase the precision of estimates using stratified estimation. In Phase 2, one permanent fixed-area plot is installed in each hexagon that contains accessible forest land and meets FIA specifications. Data are collected for more than 300 variables across multiple scales (e.g. plot, subplot, condition, and tree) (USDA Forest Service 2008). Plot intensity for Phase 2 measurements is approximately one plot for every 6,000 acres of land (roughly 125,000 plots nationally).

The plot design for FIA inventory plots consists of four 24-foot fixed-radius subplots spaced 120 feet apart in a triangular arrangement with one subplot in the center. All trees with a diameter at breast height of at least 5 inches are inventoried on forested subplots. Within each sub-plot, a 6.8-foot radius microplot offset 12 feet from the sub-plot center is established. Within each microplot, all live tree seedlings are tallied according to species. Additionally, all trees with a diameter at breast height (dbh) between 1 and 5 inches are inventoried. Conifer seedlings must be at least 6 inches in height with a root collar diameter less than 1 inch. Hardwood seedlings must be at least 12 inches in height with a root collar diameter less than 1 inch.

Data

All inventory data are made publicly accessible through the FIA database (FIADB). Data for this study were taken from the FIADB, version 4.0 (see Woudenberg and others 2010 for description of FIADB). Data were summarized for two periods of time (Table 1)—hereafter referred to as the 1980 (time 1) and 2010 (time 2) inventories—roughly representing a 30-year span of time. A total of 63,017 and 53,235 forested plots were measured for the 1980 and 2010 inventories, respectively (Table 2), across 22 eastern states. At least one shortleaf pine stem greater than 1 inch dbh was observed on a total of 8,972 and 5,230 plots during the 1980 and 2010 inventories, respectively (Table 2). Summarized estimates are presented for both timberland (forested land available for timber production) and forest land. Timberland estimates were used for analyzing long-term trends due to the historical availability of estimates and the relative stability of the FIA definition of timberland. Forest land estimates (all forest-covered lands according to the FIA definition, see Woudenberg et al. 2010) were used to assess current condition and recent changes (for example, community forest type shifts and estimates of growth and removals).

Table 1. Inventory data available from the USDA Forest Service Forest Inventory and Analysis program for the period of 1980 and 2010

State	1980s	2010
Alabama	1982	2010
Arkansas	1988	2010
Delaware	1986	2010
Florida	1980	2010
Georgia	1982	2010
illinois	1985	2010
Indiana	1986	2010
Kentucky	1988	2010
Louisiana	1984	2005
Maryland	1986	2009
Mississippi	1987	2010
Missouri	1989	2010
New Jersey	1987	2009
North Carolina	1984	2010
Ohio	1991	2009
Oklahoma	1986	2010
Pennsylvania	1989	2009
South Carolina	1986	2010
Tennessee	1980	2010
Texas	1986	2010
Virginia	1985	2010
West Virginia	1989	2009

Shortleaf pine is most prevalent in two FIA-defined forest type groups (loblolly-shortleaf pine and oak-pine) as the shortleaf pine and shortleaf pine-oak forest types, respectively. These forest type groups and individual forest types are defined by the proportion of total stocking represented by various pine species and their associates. The shortleaf pine type is defined as forests in which pines accounts for at least 50 percent of the stocking of all live trees, with shortleaf pine the most common pine. The mixed shortleaf pine-oak forest type is defined as those plots in which pine species accounts for 25 to 50 percent of total stocking and shortleaf pine is the dominant pine species. Of the major forest types in the eastern United States, shortleaf pines are common associates of loblolly pine, oaks, hickories, and gums (Moser et al. 2007).

Results

Current Condition

Shortleaf pine was observed in a total of 21 states in the eastern U.S., covering an area from New Jersey and Pennsylvanian west to southern Missouri, and eastern Oklahoma and Texas (Figure 1). Shortleaf pine was found on approximately 10 percent of all forested plots in the 2010 inventories. In 2010, the shortleaf pine forest type was found on an estimated 3.3 million acres of forest land

Table 2. Number of forested plots collected across 22 states and number of plots where at least one shortleaf pine stem greater than or equal to 1 inch was observed

Plot condition	1980s n	2010 n
Forested	63,017	53,235
Shortleaf	8,972	5,230

while shortleaf pine-oak was found on an estimated 2.9 million acres for a total of 6.2 million acres across the eastern U.S. Approximately, 65 percent is found in the four states west of the Mississippi River and one-third of all shortleaf pine-dominated forests are currently found in Arkansas.

Shortleaf pine-dominated forests are largely found in private ownerships. Approximately 62 percent of all shortleaf pine-dominated forests in the eastern U.S. are owned by private individuals or corporations. An estimated 330 thousand acres (10 percent) of the shortleaf pine forest type have a planted stand origin. Only 57 thousand acres (2 percent) of the shortleaf pine-oak forest type appear to have been planted.

Shortleaf pine-dominated forests are heavily concentrated in the large diameter stand size class (Figure 2). Large diameter stands are those stands where greater than 50 percent of stocking is in large (at least 11.0 inch dbh for hardwoods and 9.0 inch dbh for softwoods) and medium diameter (at least 5.0 inch dbh and smaller than large diameter) trees, and the majority of stocking is in large diameter trees. An estimated 71 percent of all shortleaf pine-dominated forests were identified as belonging to large diameter stands and 93 percent were found to be in large and medium diameter stands combined. Very few acres of shortleaf pine or shortleaf pine-oak mix are in small diameter stands. Using stand size class as a proxy for stand development of successional stage (Trani et. al 2001, Franzreb et. al 2011) highlights the concern that very few acres of early-successional shortleaf pine-dominated forests exist on the landscape.

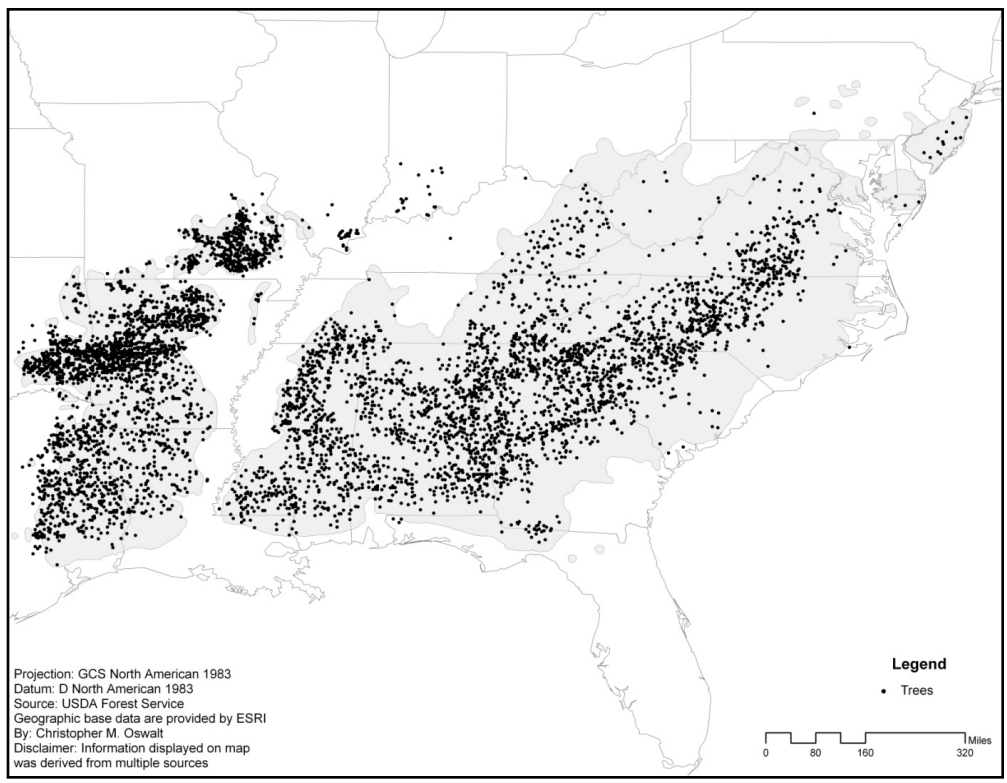

Figure 1: Approximate plot location of each plot where at least one shortleaf pine stem greater than or equal to 1 inch was observed during the 2010 inventory.

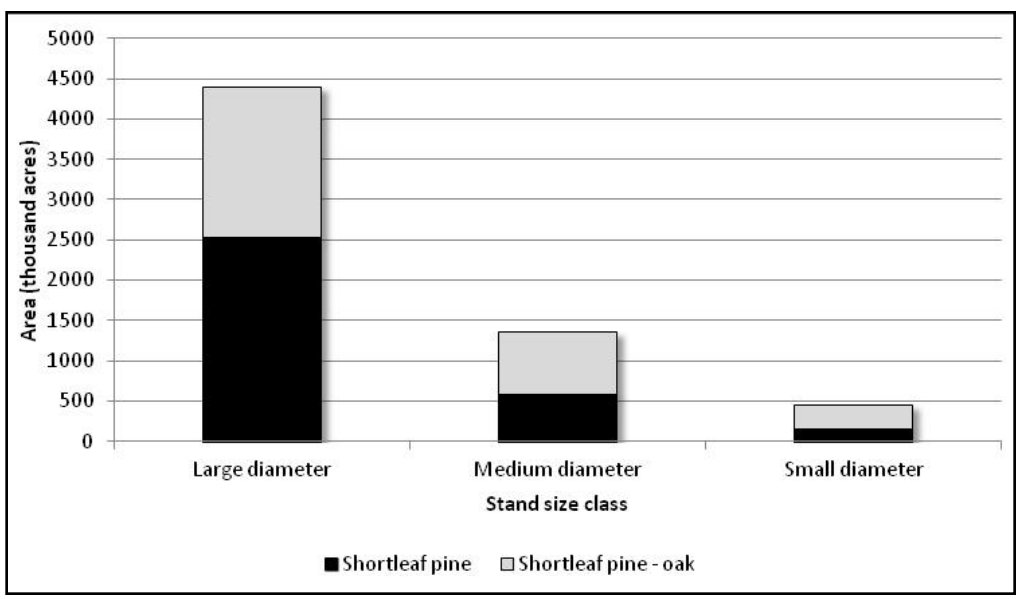

Figure 2: Area of shortleaf pine and shortleaf pine-oak forest types among three stand size classes for the 2010 inventory.

In 2010, shortleaf pine removals (cubic feet) exceeded net growth (gross growth – mortality) on private lands across all forest types. On public lands shortleaf pine growth outpaced removals by approximately three to one. On private lands, an estimated 0.65 cubic foot of wood volume was being grown for every 1 cubic foot being removed annually. Moreover, nearly 5 percent of the shortleaf pine standing volume (across all forest types) was being removed annually. Comparatively, less than 1 percent (0.67) of the standing volume on public land was being removed annually.

Historical Comparison

During the inventories of the 1980s, shortleaf pine (greater than 1 inch dbh) was observed on approximately 14 percent of all forested plots in the 22-state region explored. Estimates from the 1980 inventories indicate that 12.6 million acres of shortleaf pine-dominated forests existed on timberland, which is defined as forest land that has not been administratively removed from timber production through statute or law. (Data on timberland was collected during both the 1980 and 2010 inventories). Comparatively, in 2010, there were an estimated 6.1 million acres of shortleaf pine-dominated forests in the eastern U.S. The decline from the 1980s to 2010 equates to a 52 percent loss of shortleaf pine forests. Declines occurred in every state with the most significant declines occurring in states east of the Mississippi River.

Discussion

Shortleaf pine-dominated forests, as evidenced by a 52 percent loss in a real extent over the period between the 1980s and 2010, are in decline. Moser et. al (2007), in an analysis of earlier FIA data, pointed to a lack of regeneration across the shortleaf pine range and posited that the paucity of regeneration would result in a continued deterioration of the shortleaf pine resource. This forecast appears to be becoming a reality. Coupled with the fact that current shortleaf pine-dominated forests are overwhelmingly found in large diameter or late-successional stands, the future of shortleaf pine forest in the eastern U.S. poses a significant conservation challenge.

While range-wide declines are troublesome, there is a clear difference between the trends in shortleaf pine-dominated forests east of the Mississippi River and those forests west of the River. Declines in the extent of shortleaf pine forests in the east appear considerable and far greater than losses in the western states of Arkansas, Oklahoma, Missouri, and Texas. Moreover, the vast majority of current shortleaf pine-dominated forests are found within the borders of the four western states.

While broad-scale inventory data, such as that of the FIA program, can be used successfully to identify large conservation issues, many times the data are limited in capacity to address causal factors. Further examination of the tremendous amount of data compiled by the FIA program may help identify leading factors in the decline of the shortleaf pine resource.

References

Bechtold, William A.; Patterson, Paul L. [Editors]. 2005. The enhanced forest inventory and analysis program - national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p.

Franzreb, Kathleen E.; Oswalt, Sonja N.; Buehler, David A. 2011. Population trends for eastern scrub-shrub birds related to availability of small-diameter upland hardwood forests. IN Greenberg, Cathryn; Collins, Beverly; and Thompson III, Frank (Eds.). Ecology and Management of early successional habitats in the central hardwood region, USA Series: Managing forest ecosystems, Vol. 21, 1st edition. Springer, 180 p.

Frayer, W.E.; Furnival, G.M. 1999. Forest survey sampling designs: A history. Journal of Forestry. 97(12): 4-10.

Guldin, James M. 2007. Restoration and management of shortleaf pine in pure and mixed stands--science, empirical observation, and the wishful application of generalities. In: Kabrick, John M.; Dey, Daniel C.; Gwaze, David, eds. Shortleaf pine restoration and ecology in the Ozarks: proceedings of a symposium; 2006 November 7-9; Springfield, MO. Gen. Tech. Rep. NRS-P-15. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 47-58.

Little, E.L., Jr. 1971. Atlas of United States trees, volume 1, conifers and important hardwoods: U.S. Department of Agriculture Miscellaneous Publication 1146, 9 p., 200 maps.

McWilliams, W.H.; Sheffield, R.M.; Hansen, M.H.; Birch, T.W. 1986. The shortleaf resource. In: Proceedings of the symposium on the shortleaf pine ecosystem; 1986 March 31 – April 2; Little Rock, AR. Monticello, AR: Arkansas Cooperative Extension Service: 9-24.

Moser, W. Keith; Hansen, Mark; McWilliams, William H.; Sheffield, Raymond M. 2007. Shortleaf pine composition and structure in the United States. In: Kabrick, John M.; Dey, Daniel C.; Gwaze, David, eds. Shortleaf pine restoration and ecology in the Ozarks: proceedings of a symposium; 2006 November 7-9; Springfield, MO. Gen. Tech. Rep. NRS-P-15. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 19-27.

Trani, Margaret K.; Brooks, Robert T.; Schmidt, Thomas L.; Rudis, Victor A.; Gabbard, Christine M. 2001. Patterns and trends of early successional forests in the eastern United States. Wildlife Society Bulletin 29(2): 413-424.

Woudenberg, Sharon W.; Conkling, Barbara L.; O'Connell, Barbara M.; LaPoint, Elizabeth B.; Turner, Jeffery A.; Waddell, Karen L. 2010. The Forest Inventory and Analysis Database: Database description and user's manual version 4.0 for Phase 2. Gen. Tech. Rep. RMRS-GTR- 245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 336 p.

Managing Shortleaf Pine for Bobwhite Quail

Mike Black
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Abstract: Shortleaf pine originally covered more than 440,000 square miles and portions of 24 states. Due to frequent fire regimes from the earliest Native Americans to the more recent settlers, shortleaf was a common species across the landscape in nearly pure to mixed stands. Shortleaf sprouts at an early age following fire and, therefore, established a niche among southern yellow pine species. Shortleaf was often found in open savanna and woodland forests and provided outstanding habitat for bobwhite quail and other flora and fauna that utilized grassland and early successional habitats. Shortleaf pine has created new interest on federal and state lands under ecosystem management and also has an excellent opportunity to provide private landowners with both high-quality timber and wildlife habitat under proper management. The range of shortleaf pine when combined with that of longleaf pine covers most of the forested portion of the historical range for bobwhite quail. The management of shortleaf pine stands in a savanna-to-woodland gradient, including the frequent use of prescribed fire, presents an unprecedented opportunity to assist in the recovery of bobwhite quail, to provide habitat for other early successional species, to produce high-quality wood products and timber values, and to meet a myriad of other objectives on private and public lands.

Presentation: Shortleaf pine originally covered more than 440,000 square miles and portions of 24 states. Due to frequent fire regimes from the earliest Native Americans to the more recent settlers, Shortleaf was a common species across the landscape in nearly pure to mixed stands. It has the greatest range of any of the southern yellow pines, occurring over 800 miles north and south and from Maryland to Eastern Texas. Shortleaf pine appears to be at its best from 400 to 1500 feet in elevation, but occurs from 10 to 3000 feet in some areas. Shortleaf sprouts at an early age following fire and, therefore, established a niche among southern yellow pine species. Shortleaf was often found in open savanna and woodland forests and provided outstanding habitat for bobwhite quail and other flora and fauna that utilized grassland and early successional habitats.

Shortleaf pine has created new interest on federal and state lands under ecosystem management and also has an excellent opportunity to provide private landowners with both high-quality timber and wildlife habitat under proper management. The range of shortleaf pine when combined with that of longleaf pine covers most of the forested portion of the historical range for bobwhite quail.

Shortleaf pine thrived in the past and often shows up in historical records. Frequent fire return intervals combined with variable frequency and intensity strongly favored shortleaf in its historical range. Shortleaf continued to have a niche on abandoned farmland even as it began to disappear over other areas due to improved wildfire suppression. Prior to WWII and the advent of readily available commercial fertilizers, abandoned farmland often reverted to shortleaf pine over other southern yellow pines—particularly loblolly—since it could compete on worn out soils low on nutrients. The richer soils of abandoned farmlands since WWII often revert to loblolly pine, rather than shortleaf, as it can compete more effectively on rich ground.

Silviculturally, shortleaf responds well to thinning and is resistant to wind throw and drought when compared to Loblolly pine. Shortleaf is found in many soil types, but prefers acidic and well-drained soils. Site index values are about 68 on a 50-year index over most of the historic range, and this is about a difference of 20 on dry sites when compared to loblolly pine.

Shortleaf pine regenerates well at an early age with the use of prescribed fire, but a fire-free interval of at least 3 years is necessary to successfully recruit shortleaf seedlings. Shortleaf, like many other southern yellow pines, is quite tolerant of frequent fire at older ages—even fires of high intensity.

Shortleaf has suffered a decline due to changes in the historic vs. current fire regimes, early vs. later field abandonment, and strong recent interests in loblolly pine and longleaf pine. However, shortleaf pine is a strong contender as an over story species in a savannah-to-woodland gradient for the successful habitat management needed for Bobwhite quail. Shortleaf has a wide range and is adapted to drier sites than loblolly. It also has excellent sawtimber value and fits changing objectives on non-industrial private forest lands for trends towards sawtimber rotations rather than pulpwood. Shortleaf pine, when combined with a prescribed fire program, also fits the objectives under ecosystem management on many state and federal lands.

Successful tactics for managing shortleaf pine for bobwhite quail are to maintain open stands, in balance with other forest management objectives, through early and frequent thinning and the liberal use of prescribed fire. Basal areas of 20 at the low end to 70 at the high end can be considered. Fire return intervals should vary, but average a 2-year schedule—3 years at the higher end. Longer fire return intervals can be used on areas of less precipitation and slower forest succession.

The management of shortleaf pine stands in a savanna-to-woodland gradient, including the frequent use of prescribed fire, presents an unprecedented opportunity to assist in the recovery of bobwhite quail, provide habitat for other early successional species, produce high-quality wood products and timber values, and meet a myriad of other objectives on private and public lands.

Collaborative Landscape-Scale Fire Restoration Management and Planning in the Boston Mountains, Arkansas

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Abstract: Collaborative fire management restoration depends upon landscape managers finding common ground in their understanding of ecosystem structure and function and desired ecological conditions. The Ozark-St. Francis National Forest, the Nature Conservancy, Arkansas Game and Fish Commission, Arkansas Natural Heritage Commission, private landowners, and others are collaborating to restore oak-hickory and oak-pine ecosystems in the Boston Mountains, which have been degraded from past timber management and fire exclusion activities. There are substantially more closed canopy forests and less woodlands/savannas today than occurred under the region's historic fire regime, in which low intensity fires burned these systems about every two to 15 years. Plant and animal species, such as the royal catchfly, northern bobwhite, Bachman's sparrow, Diana fritillary, Indiana bat, and elk are adapted to the vegetation mosaics that this frequent fire regime maintained. This collaboration faces other challenges as well: red oak decline has impacted at least 300,000 acres of Ozark National Forest, including the big piney ranger district and intermixed private property, increasing hazardous fuels in the wildland-urban interface and threatening municipal water supplies. The big piney ranger district and many partners are implementing a long-term, landscape-scale ecosystem restoration project on 60,000 acres to increase forest health, restore fire dependent woodland ecosystems, protect municipal water sources and promote safety in the wildland-urban interface using periodic prescribed fire and forest thinning by commercial and non-commercial methods. A monitoring program is currently being implemented to track changes towards desired ecological conditions that were described using an ecological classification system.

Shortleaf Pine in North Carolina – Past, Present, and Future

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North Carolina Forest Service

Abstract: Shortleaf pine (*Pinus echinata*) was historically the most widely distributed of the seven pines found in North Carolina. Its distribution was shaped by edaphic and climatic influences such as elevation, drainage, soil type, annual precipitation, and ice-storm frequency. In North Carolina, shortleaf attains its best development and commercial value in the piedmont plateau. Prior to European settlement, fire was the primary disturbance that maintained the shortleaf forest. Land clearing, farmland abandonment, lumbering, and railroad construction had significant impacts on the extent of North Carolina's shortleaf forest. Today three-fourths of the shortleaf stands are found in the Piedmont region. A vast majority of the shortleaf forest type (94 percent) and shortleaf-oak forest type (79 percent) is privately owned. According to forest inventory analysis data, the combined area of shortleaf pine and shortleaf pine-oak forest types in North Carolina has declined by 59 percent since 1990. The basal area for both shortleaf pine forest types has declined by 47 percent. Since 1974 the age distribution has shifted towards a predominance of older aged stands and a decline in young replacement stands. For a variety of reasons, including slow growth, susceptibility to littleleaf disease, and lack of regeneration success, artificial regeneration of shortleaf pine has lagged behind other species. The N.C. Forest Service (NCFS) reports an average of 110 acres of shortleaf planted each year between 2005 and 2009. Declining area, decreasing basal area, and lack of regeneration have discouraging implications for the future of shortleaf pine. North Carolina has initiated several programs to maintain and restore shortleaf. North Carolina's Forest Development Program provides cost-share incentives by reimbursing landowners for 60 percent of the costs of planting shortleaf pine seedlings. NCFS and the USFS have agreed to exchange seed, scion material, and progeny test information for orchard establishment and genetic improvement. NCFS is one of several state forestry agencies participating in a USFS grant aimed at identifying knowledge gaps, mapping shortleaf's current and historic extent, providing management guidelines and tools, and training land mangers about shortleaf pine management.

Shortleaf Pine Opportunities for Landowners

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Alabama A&M University

Abstract: Shortleaf pine is a viable alternative for forestland owners especially for those who have an interest in establishing and increasing the population of this declining native species and its associated habitats. Establishment of shortleaf pine with a mix of other pine and hardwood species can produce a very productive timber resource and increase the aesthetics of timberlands. Mixed stands often produce a wider range of timber income potentials and a healthier forest, which leads to a wider variety of wildlife types and their associated habitat requirements. A well-thought-out and stand-specific resource management plan is the key to ensuring success in creating a healthy forest ecosystem that provides the greatest range of desirable outputs and increases the enjoyment for the landowner. The pride associated with forestland ownership and the often spiritual well-being that comes by observation of the changes associated with managing a forest in a sustainable manner lead to increased health benefits for the both the owner and the forest as well as the added benefit to our society at large.

Poster Abstracts

Effect of Switchgrass on Shortleaf Pine Growth in West-Central Arkansas

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Abstract: Growing switchgrass (*Panicum virgatum* l.) between rows of shortleaf pine (*Pinus echinata* Mill.) for biofuel may have potential as an agroforestry practice for landowners in west-central Arkansas. However, there is limited information on the growth and production of shortleaf pine from competition of switchgrass interplanted between the rows in subsequent years following tree establishment. The objective of our study was to determine the effect of switchgrass on growth and survival of shortleaf pine. The study was conducted at the USDA-Natural Resources Conservation Service plant materials center in Booneville, Arkansas, on a leadvale silt loam. Shortleaf pine was established in rectangular (14 x 14 foot), double row (8 x 8 foot), and single row (8 x 24 foot) tree designs in January 2006. Tree designs were planted as a randomized complete block with three replications. Length and width of rectangular, double row, and single row plantings were 154 x 376 feet, 152 x 376 feet, and 120 x 376 feet, respectively. The stocking rates for rectangular, double row, and single row tree designs were 222, 227, and 226 trees per acre, respectively. Switchgrass (cv. Alamo) was interplanted between rows of each tree design at a rate of 5 pounds of plants per acre on April 13, 2006. Above average precipitation during the late fall and early spring in 2007, 2008, and 2009 prevented extensive data collection. In November 2010, tree height and diameter measurements revealed that switchgrass did not influence the growth of the shortleaf pine on this site ($p<0.05$). Future studies will be expanded to determine the effects that various planting arrangements, canopy development, and management schemes will have on switchgrass production.

Managing for Shortleaf Pine and Woodlands in the Ouachita National Forest

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Abstract: Land use changes in the Ouachita Mountains during the last century and a half, mostly cutting of the original forests and fire exclusion, have resulted in the loss of open shortleaf pine woodlands. With the loss of these woodland habitats, their dependent flora and fauna declined or disappeared altogether. The Ouachita manages for the restoration of this fire-dependant ecosystem using a full toolbox of treatments. Partners include the following: University of Arkansas, University of Missouri, Oklahoma State University, Southern Research Station of the Forest Service, Arkansas Game and Fish Commission, Arkansas Natural Heritage Commission, Oklahoma Department of Wildlife Conservation, Oklahoma Biological Survey, The Nature Conservancy, Arkansas Audubon Society, National Wild Turkey Federation, Quail Unlimited, and Ouachita Timber Purchasers' Group.

Use of Forest Growth Simulator to Evaluate Economic Impacts of Conversion to the Shortleaf Pine-Bluestem Grass Ecosystem

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Abstract: Conversion of a portion of the Ouachita National Forest in western Arkansas and southeastern Oklahoma to the shortleaf pine-bluestem grass ecosystem is desired to provide habitat for the endangered red-cockaded woodpecker and to restore an ecosystem similar to that found prior to European settlement. An amendment to the forest plan allocated up to 10 percent of the Ouachita National Forest for conversion to this ecosystem. Compared to the traditional management regime for shortleaf pine on the forest, the new regime has longer rotations and utilizes prescribed burning to obtain an understory featuring vegetation such as bluestem grass. The Shortleaf Pine Stand Simulator (SLPSS) was used to simulate the results of conversion to the shortleaf pine-bluestem grass ecosystem. During a 100-year simulation period, a 25 percent decline in timber harvests was projected in the shortleaf pine-bluestem grass area. With a present-value analysis using 1996 dollars, this is equivalent to a loss of $137 million dollars in revenue from timber sales (approximately half what traditional management would have generated). However, on the Ouachita National Forest as a whole this results in only a 3 to 4 percent decline in harvest volumes, and a 2 to 3 percent decline in harvest revenue. Economic activity in the region would be projected to drop by 1 percent at most. Thus, there seem to be few negative economic consequences to conversion to the shortleaf pine-bluestem grass ecosystem on approximately 10 percent of the Ouachita National Forest. Given an objective of 400 breeding pair of red-cockaded woodpeckers, the implied value of one pair is about $10,500 per year in terms of timber sale revenue forgone.

Suitability of Shortleaf Pine for Redstone Arsenal: Overcoming the Littleleaf Myth

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Abstract: Sargent (1884) noted that shortleaf pine (*Pinus echinata*) was historically a dominant part of Alabama's landscape, representing 2.3 billion board feet of quality commercial forest products. Despite many qualities which made it an excellent choice for saw timber and other forest products, landowners and land managers have dismissed shortleaf pine as a viable management option due to the prevalence of littleleaf disease (*Phytophtora cinnamoni*) and the rapid early growth of loblolly pine (*Pinus taeda*). Using historical accounts, soils information, and range maps for shortleaf pine and littleleaf disease, a suitability map for shortleaf pine restoration on Redstone Arsenal in Huntsville, Alabama, was created. It is expected that this information will then be able to be expanded to the state of Alabama, providing information for Alabama landowners that will assist them in making an informed choice regarding the restoration of shortleaf on their forestland.

Shortleaf Pine Working Group: Bridging the Gap

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Abstract: In February 2011 a group of 12 individuals from state and federal agencies met at Auburn University to outline a mission, vision, and goals for conserving and restoring shortleaf pine throughout its natural range. This two-day meeting led to the development of a region-wide shortleaf pine conference at Monte Sano State Park in Huntsville, Alabama. In addition, the working group developed goals that address science, education, policy, and management of shortleaf pine.

The Trace of Fire in Eastern Native America

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Abstract: Written in the rings of trees is a history of fire in native America that tells of humans, drought, and their interactions. These fire histories in eastern native America move through generations and territories from 1600 to 1850. These quantitative histories are based on thousands of fire scars found on oak and pine trees. Each fire scar has a date, location, and associated human population. Here we examine the connections between the occurrence of wildland fire in native America and the people who lived there: the Algonquin, Cherokee, Chippewa, Osage, Menominee, and others. The documentation of fire history ranges from the ecosystems of Appalachia, the Great Lakes, the Southeast, and the Midwest. We found changes in fire frequency associated with native American populations in Alabama, Arkansas, Kentucky, Michigan, Missouri, Tennessee, Oklahoma, Ontario, Pennsylvania, and Wisconsin. Many fire regimes in eastern native America are found to have a temporal human "footprint," that is, an abrupt or rapid change in fire frequency not related to climate. The interactions of drought and human migrations and ignition are detected in the fire scar record. During years with large fires, severe drought is the predisposing factor, and human ignitions represent the inciting factor associated with the occurrence of widespread fires.

Mid-West Oak Woodland and Forest Fire Consortium

Keith W. Grabner[1], Mike C. Stambaugh[2], Richard P. Guyette[2], Daniel C. Dey[3], Gary D. Willson[4]
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Abstract: With respect to fire management and practices, one of the most overlooked regions lies in the middle of the country. In this region there is a critical need for both recognition of fire's importance and sharing of fire information and expertise. Fire science delivery is severely limited with dissemination of research results relying primarily on scientific publications or presentations, if the research is disseminated at all. Recently we proposed and were awarded funding by the joint fire science program to develop a final proposal for the Mid-west Oak Woodland and Forest Fire Consortium (MOWFFC). The purpose of the MOWFFC will be to promote the dissemination of fire information across the interior U.S. and to identify fire information needs of oak-dominated communities, such as woodlands, forests, savannas, and barrens. Geographically, the MOWFFC region will cover (1) the interior lowland plateau ecoregion in Illinois, Indiana, central Kentucky, and Tennessee, (2) the Missouri, Arkansas, and Oklahoma Ozarks, (3) the Ouachita Mountains of Arkansas and Oklahoma, and (4) the cross timbers region in Texas and Oklahoma. This region coincides with the southwestern half of the central hardwoods forest region. The tasks of this consortium will be to disseminate fire information, connect fire professionals, and efficiently address fire issues within our region. In the pre-proposal stage many of our objectives are related to gaining input from fire professionals and developing a final proposal for a consortium that will effectively meet the needs of its end-users.

MOWFFC objectives are as follows: (1) Develop a website to serve as a fire information clearing house for the MOWFFC region; (2) Highlight regional fire management or research; (3) Develop a searchable online fire bibliography; (4) Present quarterly webinars on regional fire management or research activities; (5) Organize fire management and fire science sessions at national, regional, and state natural resource conferences; and (6) Provide opportunities for fire managers and fire scientists to meet and discuss their respective needs

Shortleaf Pine Site Index Data Available through NRCS's Ecological Site Information System (ESIS)

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Background: Shortleaf pine (*Pinus echinata*) is reported to have the widest range of any pine in the southeastern United States (22 states from southeastern New York to eastern Texas). It is adapted to a wide variety of sites and soil conditions and is a major or minor component in at least 18 Society of American Foresters forest cover types (Eyre 1980). It would, therefore, seem reasonable that shortleaf should be the premier pine species in the South. In fact, a USDA bulletin written almost 100 years ago stated: "In a considerable portion of these regions (within its natural range) shortleaf pine excels all other coniferous species in value and profitableness as a timber crop. It is one of the more important commercial pines and promises to supply much of the future timber crop" (Mattoon, 1915). This prophesy, however, has not turned out to hold true. Changing forestry practices, fire suppression, and an attitude that favored other pines such loblolly (*P. taeda*) over shortleaf have resulted in a significant reduction in shortleaf acreage as well as status. Prior to the 1950s, shortleaf proliferated by naturally seeding into cutover and burned sites and abandoned farmlands. These stands have matured, been harvested, and usually replanted to other pine species (McWilliams, et al. 1986). Consequently over the decades, shortleaf has been decreasing in numbers and volume (Moser, et al. 2006). Recently there has been an interest in managing for more historically natural ecosystems, includ-

ing restoring shortleaf forest types. In some cases shortleaf restoration can be hampered by a lack of knowledge of where it can grow and how well it will do on a site. The USDA's Natural Resources Conservation Service (NRCS) and its predecessor, the Soil Conservation Service (SCS), have been collecting site index data for commercially important tree species as part of its soil survey program since the 1950s. Although the trees that were measured may no longer exist, the soil mapping units may exist, and the data do exist. The data are available to the public through the agency's Ecological Site Information System (ESIS). This poster describes the data that have been collected, where the data are stored, and how the data can be accessed. With the understanding that some data may need updating due to changes in mapping concepts and methods that have occurred over the years, the available data can be a valuable source of information for shortleaf restoration efforts.

Although soil surveys can trace their history back more than 100 years, it wasn't until 1951 that the SCS was given overall responsibility for all soil survey activities in the USDA. With the national soil survey program, emphasis for soil mapping changed from individual farm maps to county surveys. Unfortunately earlier surveys in counties in which forestry might have been a minor land use (less important than cropland) may not have had tree site index data collected. However, a map of the counties in which shortleaf pine site index data was collected as part of the survey process closely matches the Burns and Honkala map of that species natural range (1990).

While the NRCS/SCS mapped the soils of a county, supporting data were also gathered. Depending on the land use, the data could include crop yields; forage production; and where timber was considered important, site index information. These data have typically been collected by an NRCS forester and an accompanying soil scientist to ensure that the data were collected on a representative soil mapping unit.

The forestry data include plot location information, age and height measurements of at least five dominant or co-dominant trees, basal area and canopy estimates or measurements, and a listing and subjective estimates of the relative abundance of understory plants. The site index for the plot on which the data are collected is determined from curves listed in the National Registry for Site Index Curves. Plot data are stored in the Ecological Site Inventory (ESI) portion of ESIS. The site can be accessed through the NRCS home page.

Data retrieval can be limited to a Major Land Resource Area (MLRA), state, county, soil series, or to a tree species level. The data elements (columns) that can be requested are:

- Each plot's identifying number, state and county (FIPS codes), and the year the data was collected
- The stand's SAF cover type, basal area, and canopy density
- The soil series name, texture type, slope, and the site's aspect
- The plot's average site index and the curve number used to determine the SI

Limitations of the data:

- The forestry data in ESIS is a legacy data set of quantitative field data, collected mostly between the 1950s and the 1990s.
- A soil description was prepared concurrently with the collection of the site index data. The concept of the named soil series may have changed since the data were collected. For example in the table above, the Cecil soil series is shown to have been mapped in three major land resource areas. Normally a soil series is MLRA specific.
- The data set provided to the public is a composite of the soil map unit component and is spatially linked to the extent of the soil map unit within the soil survey area.
- When site index information for specific, known locations is needed, NRCS's Web Soil Survey is a more direct source.

References:

Burns, R.M.;B.H. Honkala, tech. coords., 1990. Silvics of North America: 1. Conifers. Agricultural Handbook. 654. USDA - Forest Service, Washington, DC. Vol. 1, 675 p.

Eyre, F.H., ed. 1980. Forest Cover Types of the United States and Canada: Society of American Foresters, Washington DC. 148 p.

Mattoon, W.R. 1915. Shortleaf Pine: Its Economic Importance and Forest Management. Bulletin of the US Department of Agriculture, No. 308. Washington, D.C. 66 pp.

McWilliams, W.H., et al. 1986. The Shortleaf Resources. In: Proceedings of Symposium on the Shortleaf Pine Ecosystem. Monticello, AR, 3/31 – 4/2/1986: Arkansas Cooperative Extension Service. 9-24.

Moser, W.K. 2006. Shortleaf Pine Composition and Structure in the United States. In: Shortleaf Pine Restoration and Ecology in the Ozarks: Proceedings of a Symposium. Springfield, MO. 11/7-9/2006. US Forest Service General Technical Report NRS-P-15. 19 – 27.

Appendices

Appendix 1: Conference Agenda

September 20-22, 2011, Monte Sano State Park, Huntsville, Alabama

Tuesday, September 20, 2011

10:00 a.m. - 10:10 a.m. Welcome and Introduction

10:10 a.m. - 10:20 a.m. Kent Wilborn (Monte Sano State Park) – Welcome to the State Park

10:20 a.m. - 11:05 a.m. Ron Masters (Tall Timbers Research Station) – Keynote Address: Wildlife and Restoring the Shortleaf Pine-Grassland Ecosystem

11:05 a.m. - 11:50 p.m. Clarence Coffey (Tennessean Wildlife, retired) – The History of Shortleaf Pine on the Cumberland Plateau

11:50 p.m. - 1:00 p.m. Lunch

1:00 p.m. - 1:25 p.m. Rod Will (Oklahoma State University) – Factors Affecting the Re-Sprouting of Shortleaf Pine Following Prescribed Fire

1:25 p.m. - 1:50 p.m. Mike Stambaugh (University of Missouri) – Historic Fire Intervals in Shortleaf Pine Ecosystems

1:50 p.m. - 2:15 p.m. John Conn (Tennessee Nursery) – Nursery Production of Shortleaf Pine at the East Tennessee Nursery

2:15 p.m. - 2:40 p.m. Jaime Hernandez (Land Between the Lakes) – Shortleaf Pine Restoration at the Land Between The Lakes National Recreation Area

2:40 p.m. - 3:05 p.m. Jane Fitzgerald (Central Hardwoods Joint Venture) – Building an Initiative for Shortleaf Pine Restoration in the Interior Highlands

3:05p.m. - 3:30 p.m. Break

3:30 p.m. - 3:55 p.m. Tim Albritton (NRCS) – Shortleaf Pine Planting for Diversity and Production

3:55 p.m. - 4:20 p.m. Don Burdette (Alabama State Parks) – Forest Management at Lake Guntersville State Park

4:20 p.m. - 4:45 p.m. Eugene Brooks (U.S.F.S) – Shortleaf Management in the National Forests in Alabama

4:45 p.m. - 5:00 p.m. Joey Skinner (Redstone Arsenal) – Redstone Arsenal's Current Management Regime

5:00 p.m. - 5:15 p.m. John Dondero (U.S.F.S.) – The Importance of Shortleaf Pine to the Southern Region: The Perspective from Cooperative Forestry

5:15 p.m. - 7:00 p.m. Poster Session Immediately Following

Wednesday, September 21, 2011 --Field Tour--

8:00 a.m. - 5:00 p.m. Redstone Arsenal – Shortleaf Pine Restoration, Silvopasture with Shortleaf Pine, Loblolly – Shortleaf Pine Comparisons, wildlife/browse damage

Lunch

Bankhead National Forest – Demonstrations of Shortleaf Pine Restoration Efforts, Impacts of Competition on Shortleaf Pine, Invasive and Restoration Efforts, Shortleaf Pine Stand Dynamic

5:00 p.m. - until Poster Session and Supper/Dinner

Thursday, September 22, 2011

8:00 a.m. - 8:25 a.m. John Stewart (Oklahoma State University) – Increase in Bidirectional Introgression between Loblolly Pine (*Pinus taeda* l.) and Shortleaf Pine (*P. echinata* Mill.)

8:25 a.m. - 8:50 a.m. Rod Will (Oklahoma State University) – Is There a Morphological or Physiological Explanation for the Dramatic Increase in Hybridization Between Loblolly and Shortleaf Pine?

8:50 a.m. - 9:15 a.m. Jimmy Yeiser (Stephen F. Austin State University) – Using Herbicides to Restore Shortleaf Pine Systems

9:15 a.m. - 9:35 a.m. Wayne Bell (International Forest) – Shortleaf Containerized Seedlings – Delivering Performance

9:35 a.m. - 9:50 a.m. Break

9:50 a.m. - 10:15 a.m. Chris Oswalt (U.S.F.S.) – Spatial and Temporal Trends of the Shortleaf Pine Resource in the Eastern United States

10:15 a.m. - 10:35 a.m. Mike Black (National Bobwhite Conservation Initiative) – Managing Shortleaf Pine for Bobwhite Quail

10:35 a.m. - 10:55 a.m. Mcree Anderson (The Nature Conservancy) – Collaborative Landscape-Scale Fire Restoration Management and Planning in the Boston Mountains, Arkansas

10:55 a.m. - 11:15 a.m. Bill Pickens (North Carolina Forest Service) – Shortleaf Pine in North Carolina – Past, Present, and Future

11:15 a.m. - 11:35 a.m. Daryl Lawson (Alabama A&M University) – Shortleaf Pine Opportunities for Landowners

11:35 a.m. - 12:00 p.m. Wrap-up and safe travels home

Appendix 2. Field Trip Report

Redstone Arsenal

At the recent Shortleaf Pine Conference, 70 participants were able to view some of Redstone Arsenal's current management strategies for its forest and wildlife resources. One such management strategy is an innovative approach that combines forestry, wildlife, and agricultural practices into a one-site working system, namely an agroforestry system. During the scheduled field stop, participants viewed and discussed a research project that Redstone Arsenal and Auburn University's School of Forestry and Wildlife Sciences has partnered in conducting. This research is focused on agroforestry techniques to promote the establishment of shortleaf pine and of a shortleaf soil suitability map for the Arsenal and to provide non-industrial private landowners and other government officials a view of an often under-utilized system for this area. Attendees were then treated to a window tour of the Arsenal by a Redstone official that offered a closer, more in-depth view of the Arsenal's daily operations and a discussion of the current tenant missions.

Bankhead National Forest

One field trip attended by most participants was conducted on the Bankhead National Forest, located about 50 miles southwest of Huntsville. Ranger Elrand Denson met each group and provided background information on the forest. The Bankhead National Forest is about 181000 acres and has an active prescribed fire program, burning about 20,000 acres annually. Much of the forest was converted to loblolly pine following agricultural abandonment or to improve timber production prior to the 1990s.

Following the introduction to the forest, the group traveled to the Walston Ridge Forest Health Restoration Project area. At this stop, former Forest Silviculturist Stephanie Love described a bit of the recent history of the forest. The fairly young, dense stands of loblolly pine were attacked by southern pine beetle in the late 1990s, creating a patchwork of open areas and remaining dense, overstocked stands. The Bankhead's 2003 Forest Health and Restoration Project Plan addresses both conditions through the restoration of native plant and animal communities, including shortleaf pine and mixed shortleaf pine-oak woodlands. Thinning and prescribe burning have been applied to several areas to restore native communities, improve forest structure, reduce the potential for further insect outbreaks, and improve wildlife habitat. One of these areas is the Walston Ridge Demonstration area. On one side of Walston Ridge Road, a stand of 100-year pine and hardwood was thinned from approximately 120 square feet of basal area to 50 to 60 square feet in 2007 and burned in 2001, 2004, 2008, and 2009 while the other side of the road was left untreated to demonstrate treatment effects on forest structure. The thinning removed much of the loblolly pine and midstory trees, leaving an oak-pine woodland demonstrating the desired future condition of mature woodland.

Forester Jeremy McDonald rode with the bus between field stops and pointed out several young shortleaf pine stands planted in southern pine-beetle damaged spots and discussed difficulties in achieving competition control, especially with landscape-level burns. Small inclusion forests such as these bug-spot shortleaf stands are difficult to include within larger burns due to their different fuel loads and tolerance to fire. He was also able to point out several stands that have received varying thinning and burning treatments as part of the Forest Health and Restoration Project on Bankhead.

The final stop included two areas on Holmes Chapel Road where the group was able to see shortleaf regeneration practices and additional woodland restoration treatments. Forester Jeremy McDonald described shortleaf pine regeneration on Bankhead including site preparation techniques (roller drum chopping and burning), planting densities, and planned mechanical release treatments. The group discussed the effectiveness and economics of mechanical and prescribed burning site preparation and mechanical release compared to chemical treatment methods for dealing with competition. Then the group turned around to observe woodland structure restoration in progress in an existing loblolly pine stand. At that location, Wildlife Biologist Allison Cochran, Fire Management Officer Kerry Clark,

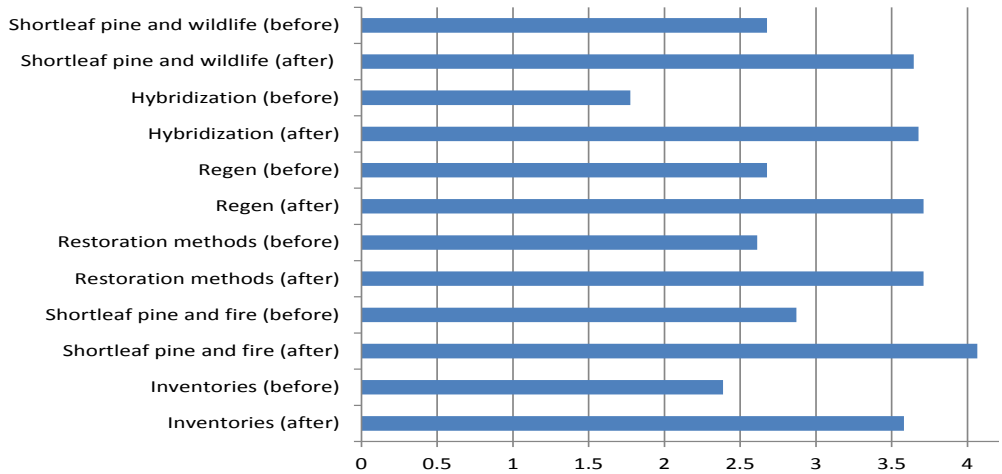
and Assistant FMO Paul Gilliland described in more detail the desired woodland conditions across the various pine stands. Bankhead is restoring woodland structure in mature loblolly pine stands until shortleaf pine conversion is implemented at a later date. Cochran discussed mid-story removal treatments (mulching machine versus hand operated tools) to restore the open woodland structure and its benefits for various wildlife. Clark and/or Gilliland described both the forest's prescribe burning program that ranges from frequent (two- to three-year return interval) to infrequent (5- to 10-year return interval) burns that are alternated between dormant fuel-reduction burns and growing season vegetation control burns. On Bankhead, the natural resources staffs are working together to remove midstory and understory shrubs and restore desired understory vegetation before opening the canopy through midstory removal and prescribed burning. Once these loblolly stands have a woodland structure, loblolly pine will be replaced with shortleaf pine over time. The group again discussed the effectiveness of restoring woodland structure, controlling hardwood saplings and midstory, and encouraging native herbaceous understory using mechanical tools (like mulching) versus using herbicides.

After this stop, the group traveled to the Brushy Creek Recreation Area for a locally catered barbeque lunch and enjoyed the beautiful recreation area and the lake.

Appendix 3. Summary of Conference Participants Survey

In November 2011, surveys were sent to participants of the shortleaf conference that was held September 19-21, 2011 at Monte Sano State Park in Huntsville, Alabama. Sixty-six surveys were mailed out and 31 returned for a response rate of 47 percent. The following is a summary of those responses.

Respondents were asked to rate their knowledge level of various topics related to shortleaf pine timber and management prior to and after the meeting. Ratings were on a scale of 1 (low level of knowledge) to 5 (high level of knowledge).



The figure above illustrates the average ratings topic as reported by respondents. Greatest knowledge level increases were reported on the topics of shortleaf hybridization (1.9 point increase), shortleaf inventories (1.2 point increase), and shortleaf restoration methods (1.2 point increase).

An assessment of the program quality was also completed by respondents. More than 99 percent of all respondents stated that they either "agreed" or "strongly agreed" that the program was a quality program providing useful information that they will use in the future.

The table below Provides average response rankings to the questions asked in this section where 1 was "strongly disagree" and 4 was "strongly agree".

Assessment of Program Quality by Those who Participated in the 2011 Shortleaf Pine Conference

Addressed needs I have	Quality program	Quality presentations	Useful materials	Glad I participated	Good value for money	Will utilize materials
3.2	3.5	3.4	3.1	3.5	3.3	3.4

Finally, respondents were asked to answer several questions regarding their thoughts on future needs and opportunities in shortleaf pine management, education, and research. The following pages summarize those responses by question.

Q: What do you think are the most significant barriers to increasing the number of acres planted in shortleaf pine throughout its naturally occurring range?

• Landowner willingness and money
• Economics
• It would have to look as monetarily appealing as planting crops
• Lack of knowledge of practitioners, funding
• Landowners and forest managers do not want SL or aren't considering SL as preferred pine
• Adam Smiths's The Wealth of Nations. The slower growth makes it a less inviting investment.
• Landowners being more familiar with loblolly
• Lack of understanding, loblolly pine, lack of success and demos
• Seedlings
• The robust adaptions of loblolly pine to diverse sites including shortleaf
• Economics smoke management
• Hype regarding loblolly and longleaf
• Public perception - slow growth, perceived value
• Shorter range planning horizon of landowners and foresters favors faster growth loblolly; raw economics
• Slow growth rate
• Landowners and forester's knowledge of the economic aspects and what sites work best for shortleaf
• Perceived lack of value compared to loblolly (rapid growth, disease resistant) or longleaf (ecological)
• Return on investment compared to loblolly pine
• Landowner education regarding shortleaf is low
• Littleleaf disease, growth rates
• rx fire, risk vs growth. A barrier for private individual.
• Lack of awareness regarding shortleaf numbers. Fire use restricted due to smoke mgt and other issues. People scared of herbicides and uneducated as to their benefit
• Disease, incentives
• Industry
• Selling state and consulting foresters to learn about shortleaf and promote it
• Growth habit
• Poor economic incentives, not much emphasis of shortleaf pine in forestry or landowner circles, poor availability of quality seedlings, relatively slow growth of shortleaf pine
• Availability of seedlings, landowner interest costs and returns

Q: Who are key partners (agencies, NGO's, academic institutions, etc.) that must be engaged in shortleaf pine/oak savanna restoration efforts in order to make these efforts successful?

• Recreational landowner groups - quail and turkey especially
• USDA Forest Service - funding and leadership
• State and Federal
• County, State, and Fed Agencies
• NPS, USGS, FWS, MSU, Auburn, U of A, other colleges, The Nature Conservancy, etc.
• State Forestry Agencies, State wildlife agencies, USFS, USFWS and others
• Land grant universities, USFS, NBCI
• USFS
• NRCS state and federal wildlife and forestry agencies
• State agencies, consulting foresters, colleges
• Appropriate state wildlife and forestry agencies, USFS, NBCI, Joint Ventures, The Nature Conservancy, NRCS
• All NRCS, State forestry and wildlife agencies, Research
• Public agencies that own land and NGO s initially
• Forestry schools/extension/ACF
• All state, federal, NGO, and private and universities
• US Forest Service, Wild Turkey, various state Dept of Natural Resources, various state forestry agencies, forest nurseries for seedling production
• Consulting foresters, state forestry commissions, NRCS/FSA
• NRCS, US fish and wildlife, conservation mitigation bankers, and the Nature conservancy
• State Forestry, USDS NRCS and FSA, Universities, Nurseries
• Tennessee, Auburn, Oklahoma State Univ. NC State Univ., Mississippi State Univ, USDA Forest Service, State level DOF
• NRCS, USFS, Alabama Forestry Commission, Auburn ACES
• Need partnership with rx fire council, longleaf alliance
• State forest service and ag extension
• Landowners, public lands
• State forestry, USFS, USFWS, NPS, NCS
• EVERYONE, this has to be a collective push
• Forest landowner association, USFS, FWS Quail unlimited
• USFS, State and industrial forestry associations, landowner assoc. Southeastern association of state foresters, ecosystem restoration organizations (i.e. Nature Conservancy)
• Beyond NF lands, key partners will be NRCS, wildlife NGO's like NWTF, and state smoke mgt agencies. Academic institution support will also matter

Q: What knowledge/research/technology gaps exist that limit the success of shortleaf pine/oak savanna ecosystem restoration?

• Tried and true tree planting densities and methods
• Not many foresters/practitioners have knowledge or experience with shortleaf pine
• Mixed stand regeneration techniques for each unique region
• Hybridization
• Economics and growth and yield, decision support
• Fire
• Site definition, unique ecosystem
• Probably use more cost/benefit studies
• Don't know
• Practices to convert from current forest stands to shortleaf economically, economic tradeoffs and quantified benefits
• Awareness
• The hybridization is huge; we need more genetics research and ecosystem research
• Economic and ecological worth
• Getting the site captured successfully with adequate stocking a reasonable cost is vital. Littleleaf disease must be controlled and better managed
• Reaching out and education landowners and the general public
• Not gaps as much as need for herbicide and fire to bring back fire
• Smoke mgt.
• Fire ecology of shortleaf systems
• Knowledge, research, technology gap
• Public outreach
• Insufficient documentation of prevalence of shp through prehistory and after, shortage of seedlings
• Case studies of successful mgt could be valuable. Growth and yield research on shortleaf pine is also limited. Yield comparisons between bare root and container shortleaf seedlings would be useful

Q: What do you think are the most realistic opportunities available to increase the acreage of shortleaf pine in its naturally occurring range over the next 5 years?

• State land
• Private non-industrial landowners
• Increasing shortleaf on Federal lands
• Funding – cost share
• Wildlife management areas and other gov't land
• Cost share programs
• Federal cost share, training, and tech transfer
• Fire
• Drought and wildfire created/defined opportunities
• Public lands management
• For folks more interested in a longer rotation, could be key to using shortleaf
• You need a range wide plan like longleaf, need buy in from Sec. of Agriculture (AGD) like longleaf, need funding like longleaf
• Public lands, stands with remnant shortleaf where low-cost natural regeneration practices are feasible
• Increase prescribed fire
• Increasing awareness through conferences such as this, webinars, publications on ecology and management of shortleaf that are widely disseminated shortleaf website
• USFS could plant more and more state lands could be converted. Cost share programs for landowners could also make a difference
• There are huge opportunities in the eastern U.S. but there must be financial incentives to landowner to restore the range on a larger scale
• Increase assistance like they are doing for longleaf
• NRCS programs
• Need to look at keeping shortleaf in stand that exists as longleaf/shortleaf. Get message out to registered foresters, consultants, NRCS
• Public land and RCW mgt
• No clue
• Public lands management
• On public lands (federal and state) much more than on private lands (industrial and non-industrial)
• Federal lands present the most realistic opportunities. Privately owned lands may be a much more difficult sell.

Q: What is the MOST IMPORTANT information/tool resource managers could use to promote shortleaf establishment and management on private lands?

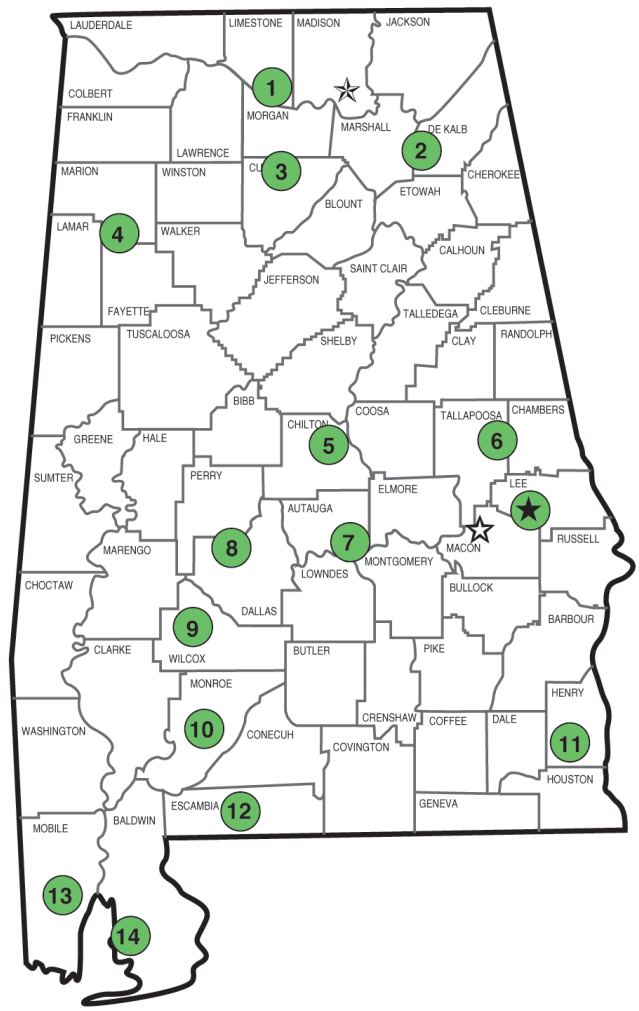
• Demonstration sites
• Wildlife benefits
• Emphasize its tolerance to fire
• Forest management options
• Information on the economics of SLP management. Allowing landowners to view the tradeoffs between shortleaf and other species, including non-market values, could increase adoptions. Focus on calculating some of the positive values like wildlife habitat.
• Cost share programs
• Economics and growth and yield, technical management guides and tools, brochures and information for landowners
• Website
• The drought cycle in the wg region
• Cost/benefit analysis of shortleaf
• State agencies forester outreach
• From my standpoint it is wildlife values
• Cost share programs
• Quantified benefits to landowners and the resource when choosing shortleaf over other species, and the economic tradeoffs you can expect
• Economic models would help. Seminars to education landowners or speakers at forestry programs would also help
• More future quality workshops like the Huntsville event. Get the messages out to foresters, state forestry associations, tree farmers, Extension agents, and the general public.
• NRCS and Alabama Forestry Commission
• NRCS - promote as a priority longleaf pine and shortleaf pine in best areas
• Research material and education of mature as well as young people
• Long-term benefits (rotation) superior forest product, wildlife benefit (grass understory, prescribed burning)
• Declines recently observed
• Restoration of southern natural heritage ecosystems (including associated plants and animals)
• Successful examples and hard limits on liability with rx burning

Appendix 4. List of Conference Attendees

William (Blake)	Addison	Judy	Jones
Tim	Albritton	Caleb	Jones
Kurtis	Atkinson	John	Kush
Colin	Bagwell	Keri	Landry
Becky	Barlow	Clyde	Leggins
Haven	Barnhill	Thomas	Lynch
Amity	Bass	Adam	Maggard
Wayne	Bell	Ronald	Masters
Mike	Black	Travis	McDonald
John	Blanton	Jeremy	McDonald
Joe	Brown	John	McGuire
Chuck	Byrd	Gary (Craig)	Moore
Jeremy	Callicutt	Gary	Myers
Jack R.	Chappell	Ron	Myers
Kerry	Clark	Barry	New
Wayne	Clatterbuck	Christopher	Oswalt
Allison	Cochran	Bill	Pickens
Barbara	Crane	Paul	Reynolds
Elrand	Denson	Ken	Roder
Jason	Dockery	Henry	Sansing
Trent	Duncan	David	Schnake
Jason	Ellis	Martin	Schubert
Terrance	Fletcher	Andy	Scott
John	Gilbert	Richard	Shelfer
Douglas (Paul)	Gilliland	Richard	Smith
Galen	Grider	Ray	Stoner
Todd	Groh	Kimberly	Sykes
Kevin	Guthrie	Curtis	Walker
Larry	Heggemann	Lorenzo	Walton
Sharon	Hermann	Lynn	Washington
Geoffrey	Hill	William (Patrick)	Whalen
Arthur J.	Hitt	Tom	White
Jeanne Marie	Hokett	Traci	Wood
Rick	Hollis	Jimmie	Yeiser
Carrie	Johnson		

Alabama's Agricultural Experiment Station
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the state has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
★ Alabama A&M University.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Research and Extension Center, Belle Mina.
2. Sand Mountain Research and Extension Center, Crossville.
3. North Alabama Horticulture Research Center, Cullman.
4. Upper Coastal Plain Agricultural Research Center, Winfield.
5. Chilton Research and Extension Center, Clanton.
6. Piedmont Substation, Camp Hill.
7. Prattville Agricultural Research Unit, Prattville.
8. Black Belt Research and Extension Center, Marion Junction.
9. Lower Coastal Plain Substation, Camden.
10. Monroeville Agricultural Research Unit, Monroeville.
11. Wiregrass Research and Extension Center, Headland.
12. Brewton Agricultural Research Unit, Brewton.
13. Ornamental Horticulture Research Center, Spring Hill.
14. Gulf Coast Research and Extension Center, Fairhope.