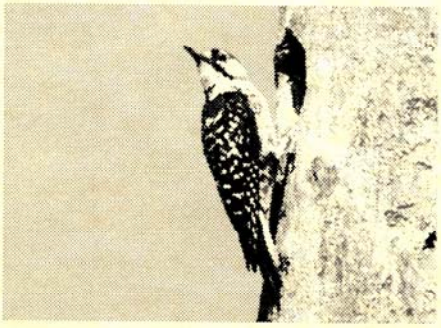
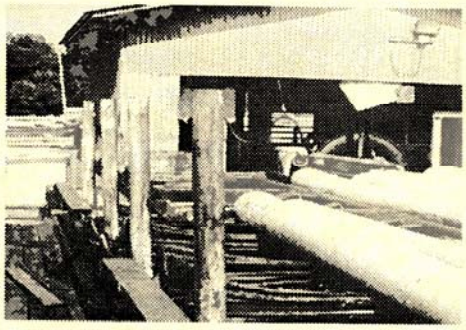

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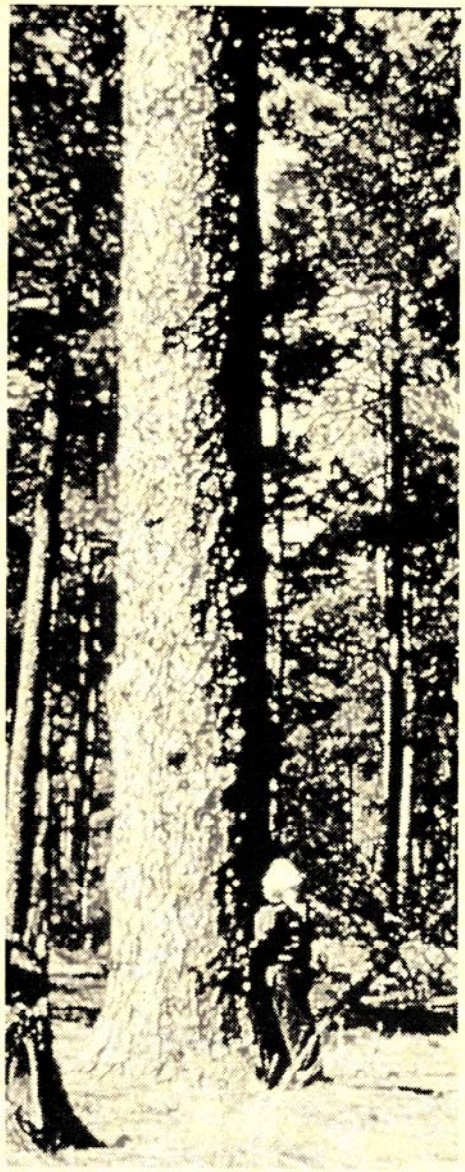

LONGLEAF PINE: A REGIONAL PERSPECTIVE OF CHALLENGES AND OPPORTUNITIES

MOBILE, ALABAMA
SEPTEMBER 17-19, 1996

LONGLEAF ALLIANCE REPORT NO.1

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Longleaf Alliance Conference

September 17-19, 1996
Adam's Mark Hotel, Mobile, Alabama

Longleaf Pine: A Regional Perspective of Challenges and Opportunities

PROGRAM

September 17, 1996

10:00 am Registration

Session I

Moderator: Charles McMahon, USDA Forest Service, Southern Research Station, Auburn, AL

1:00 pm -- Welcome and opening remarks: *A Regional Approach to Longleaf Recovery.* Tim Boyce, Alabama State Forester, Montgomery, AL

1:30 pm -- *The Longleaf Alliance*. Rhett Johnson and Dean Gjerstad, Co-Directors of the Longleaf Alliance

2:00 pm -- *Learning from the Choctawhatchee: 90 years of longleaf pine management*. Larry Earley, North Carolina Wildlife Research Commission, Raleigh, NC

2:45 pm -- Break

3:15 pm --*Longleaf fundamentals*: How longleaf develops, grows, and reproduces in relationship to various habitats and environmental conditions. Latimore Smith, Louisiana Department of Fish and Game, Baton Rouge, LA

3:40 pm -- *Longleaf pine and fire - A marriage of necessity*. Dale Wade, USDA Forest Service, Southern Research Station, Macon, GA

4:10 pm -- *Fire dependent communities*. Bruce Means, Coastal Plains Institute, Tallahassee, FL
4:40 pm -- Questions & Discussion

5:30 - 7:00 pm -- Poster Session & Social with hosted bar and hot hor d'oeuvres

Dinner on your own

September 18, 1996
8:00 am -- *"Longleaf Success stories"* Panel presentations and discussion. Each panel member will tell the story of their longleaf forest: how they planned, what they did, what worked and what failed.

Moderator: Roger Dennington, USDA Forest Service (Retired), Southern Region, Atlanta, GA

Panel members:
Earl Weaver, Huxford Trust, Brewton, AL
Rich Pouncey, Longleaf Foresters, Inc., Tallahassee, FL
Lynda Beam, Tree Farmer of the Year Honoree, Savannah, GA
Ike McWhorter, Pineywoods Conservation Initiative -The Nature Conservancy, Silsbee, TX
Todd Engstrom, Tall Timbers, Tallahassee, FL

10:00 Poster Session and Brunch

12:30 pm -- Buses depart for the Field Trip; *Longleaf successes, challenges, and opportunities*, Coordinators: Julie Moore, Mississippi Hertiage Program; Keville Larson, Larson & McGowin; Pat Waldrop, Alabama Forestry Commission. The field trip will consist of an easy walk (tennis shoes will be sufficient) in a longleaf forest with "Experts" located at various stations to discuss key issues related to the management and restoration of longleaf forests and related communities.

5:00 pm -- Social and the 'Best barbecue East of Texas' dinner in the piney woods

September 19, 1996 **Moderator: Lindsay Boring, Director, Joseph W. Jones Ecological Research Center, Newton, GA**

8:00 am -- *The Best Kept $ecret in Southern Forestry: New Perspectives on Longleaf Economics* -- Rod Busby, USDA Forest Service, Southern Research Station, New Orleans

8:30 am -- *Longleaf can Catch Up!* -- Bill Boyer, USDA Forest Service, Southern Research Station, Auburn, AL

9:00 am -- *Habitat Conservation -- Economic Incentives* -- Ralph Costa, US Fish and Wildlife Service, Clemson, SC

9:30 am -- Break

10:00 am -- *How to plan for success* --Dave Lewis, Southern Forestry Consultants, Monticello, FL

10:30 am -- *New Markets, Strategies, and Incentives* --Mark Megalos, North Carolina Cooperative Extension Service, Raleigh, NC

11:00 am -- *Ensuring success in your future longleaf ventures* -- Rhett Johnson & Dean Gjerstad

FOREWARD

This volume represents summary papers from invited papers and poster presentations given at The Longleaf Alliance Conference that was held on September 17-19, 1996 at the Adam's Mark Hotel in Mobile, Alabama. The theme of this conference was *Longleaf Pine: A Regional Perspective and Opportunities.* The conference consisted of general sessions and panel discussions with invited speakers, poster sessions with volunteer papers, and a field trip consisting of a walking tour through a longleaf forest. Some 250 registrants representing 10 states and Washington, DC were in attendance.

The conference was also the inaugural meeting for the Longleaf Alliance which is described in more detail in Rhett Johnson's welcoming address paper. In the beginning, we did not plan to initiate a regional organization like the Longleaf Alliance. The initial meeting that eventually led to this Conference and the development of the Alliance was held in May 1994 when 30 individuals from Alabama and SW Georgia met at the Solon Dixon Forestry Education Center to discuss the current state of knowledge regarding longleaf pine and its associated ecosystems. The meeting's objective was to stimulate an open discussion on all aspects of longleaf pine management to include timber, wildlife, environmental, social, and economic issues. Although various research and management suggestions were made at this meeting, the most significant recommendation was the need for a regional organization promoting longleaf pine. In October 1994, the US Forest Service sponsored a meeting in Atlanta entitled ***Longleaf Pine Ecosystem Restoration: Toward a Regional Strategy***. Major conclusions from this meeting were: 1) all involved were concerned with decline of the longleaf ecosystem, 2) a coordinated regional restoration strategy was needed, and 3) the formation of a regional organization was needed to communicate information on longleaf to all interested individuals and organizations. In November 1995 the Southern Group of State Foresters adopted a resolution in support of a regional Longleaf Initiative. They recognized the important role of longleaf pine and its associated ecosystem in the forests of the South and encouraged its voluntary restoration, regeneration, and management where appropriate to meet landowners' objectives. They also endorsed the formation of a Longleaf Alliance, recognizing the pivotal role its outreach and research coordination efforts could play in the recovery of this important component of the southern forests.

Although space does not allow me to recognition every individual who played an important role in developing The Longleaf Alliance Conference, some key individuals were: Tim Boyce, State Forester of Alabama, had a vision that a regional effort on longleaf was possible and provided funding through the Alabama Forestry Commission to initiate the effort; Julie Moore actively assisted in many of the organizational details and coordinated the field trip activities; Ralph Meldahl organized a most successful silent auction; Dwayne Tew and Clint Mancil provided musical entertainment at the barbecue along with premiering their latest hit song on longleaf; Kathryn Besong spent endless hours preparing materials and corresponding with speakers and attendees; and John Kush coordinated the poster session and served as editor of these proceedings. For many attendees, the highlight of the conference was the field trip to the Pierce Pasture Tract located just west of Mobile on the Alabama-Mississippi state line. Keville Larson, Jessica Larson, and Michael Andreu of Larson & McGowin, Inc. hosted and organized this memorable field trip and went the extra mile to ensure that the afternoon was most enjoyable to those attending. A beautiful sunny afternoon along with well-groomed walking trails leading to ten stations addressing various subjects related to the longleaf ecosystem made this a delightful experience.

Of particular note was the appetite of the attendees. Hotel personnel indicated that the consumption of food and beverages exceeded all expectations. The totals for the Conference were: 63-gallons of coffee and iced tea; 32 pitchers of juice; 1530 beverages; 27 dozen pastries; 2200 hor d'oeuvres; 410 pounds of ribs, chicken, and sausage; 22-gallons of beans and potato salad; 22 loaves of bread and 6 pans of peach cobbler.

It is our hope that this conference has stimulated partnerships among those interested in the management and restoration of the longleaf pine ecosystem. Hopefully such cooperative efforts will lead to better management practices and a reverse in the decline of longleaf.

Dean H. Gjerstad, Co-Director of the Longleaf Alliance

A Regional Approach to Longleaf Recovery - Welcome and Opening Remarks
Tim Boyce (State Forester, Montgomery, AL)

Good afternoon, and welcome to the great State of Alabama, and to this conference. First I'd be remiss if I didn't take this opportunity to say a few words about our State. Alabama stretches from the foothills of the Appalachian mountains to the Gulf of Mexico which makes us one of the most diverse states in the Union. We have approximately 22 million acres of forestland that is 95 percent privately owned. Seventy percent is owned by family forest owners - that's over 400,000 individuals. We have 14 pulp and paper companies and over 242 sawmills, which includes both pine and hardwood as well as plywood, pole and oriented strand board plants. And what's truly amazing is that our forest has doubled in volume since the 1950's.

Our story, like many other stories across the southern states, is a story of a tremendous comeback. Without a doubt it is truly an environmental and economic success story. The foundation on which much of the southern forest was built and the forest that supported the great southern industrial expansion was primarily a resource made up of longleaf pine. Along with this industrial progress also came fire prevention programs which brought with it the decline of longleaf pine ecosystem.

At the same time, emphasis was being placed on reforestation which called for trees that could be grown in nurseries easily and outplanted with high survival rates and accelerated growth. It was hard enough to grow loblolly and slash, but longleaf was even harder and success with outplanting was met with many failures.

In the early years, loblolly and slash also had their fair share of failure. That's why many recommendations called for stocking of over 1000 trees per acre. It was also thought that longleaf could not compete with slash or loblolly because of the years it spent in the grass stage. Needless to say, longleaf began to decline in popularity and only a dedicated few continued it propagation.

Today, we realize that longleaf pine can play an important role in our southern forest. The total longleaf ecosystem play an important role in the protection and ecology of many other plants and animals, some of which are on the threatened and endangered species list.

There are still many opportunities and challenges that lay ahead. As you will hear many times during this conference, the future of the longleaf and its assorted ecosystem looks promising. It will take a regional effort of collaboration, consultation and commitment to bring the longleaf back.

This is the major theme behind the LONGLEAF ALLIANCE which was recently started at the SOLON DIXON FORESTRY CENTER in Andalusia, Alabama. Ii is a regional effort to bring together various interests across the South, both industrial and environmental. In short, it is a clearing house for information on longleaf pine. We must share this information, or council with others who want to put this knowledge to work, and bring back our once abundant longleaf forest. It's important to understand that this effort is led by dedicated and committed researchers and practitioners in the culture of this wonderful species.

If one wanted to describe the perfect pine tree – straightness, disease free, insect proof, high volume and high quality, tolerant to fire, and one which supports one of the most diverse ecosystems in the world, it would be the longleaf pine – Alabama's state tree.

Your attendance here today shows your interest in this species. I hope you leave here ready to join our CCC Camp – A camp of collaboration, consultation and commitment to bringing back the longleaf pine as a major player in our southern forest ecosystem. Your involvement will make a difference.

The Longleaf Alliance

Rhett Johnson (Co-Director, LLA; Director, Solon Dixon Forestry Education Center, Andalusia, AL)
Dean Gjerstad (Co-Director, LLA: School of Forestry, Auburn University, Auburn University, AL)

Dean Gjerstad, Bob Mitchell, and I began to talk a few years ago about the growing interest in longleaf pine in the region at about the same time that our interest in the species began to coalesce. In our travels and interactions with other foresters, forest scientists, landowners, and others interested in natural resources we all had recognized that support for saving, restoring, and managing the species was widespread with interest being expressed by many different publics. The U.S. Forest Service, a longtime pioneer in longleaf forest science and led by researchers like Tom Croker, Bob Allen, Bob Farrar, Roger Dennington, Bill Boyer and a host of others, recently made longleaf a feature of their management of ecosystems on National Forests across its range. Department of Defense lands, like nearby Eglin AFB, contain many thousands of acres of longleaf and military managers are dedicated to managing that resource responsibly. State forests across the South contain rich longleaf resources. Florida's Blackwater River State Forest is a notable example, containing nearly 135,000 acres of the longleaf type under management. In addition, many state forestry agencies like the North and South Carolina Commissions, have initiated innovative and progressive programs in regard to the species. The Endangered Species Act focused the attention of land owners, land management agencies, and other professionals, including the U.S. Fish and Wildlife Service, on the forest type, since several listed species and species of special concern are either longleaf ecosystem obligates or are strongly associated with the type. Seminal research on the species and another associate, the bobwhite quail, has been going on at Tall Timbers Research Station for decades and new research institutions like the Joseph Jones Forest Ecology Research Institute at Ichauaway in South Georgia, the Belle W. Baruch Forest Science Institute in coastal South Carolina, and the Solon Dixon Forestry Education Center here in Alabama instigated research and management projects that were centered on the species and associated amenities. Conservation groups like The Nature Conservancy were active in the preservation and restoration of longleaf systems and supported and conducted groundbreaking research, particularly in restoration techniques. Private industries like Alabama's T.R. Miller Mill Co. were pioneers in the establishment and management of the species, leading the way for other private owners to successfully and profitably manage longleaf forests. Plantations in the Red Hills region of south Georgia and other parts of the south have featured the species in their management for quail and other resources, providing reservoirs for ecosystem components, virtual islands in a landscape being systematically depleted of longleaf. Finally, private landowners of all stripes retained and have continued to manage longleaf for reasons as diverse as the ecosystem itself.

The breadth of the interest in the declining forest type was heartening, but we didn't seem to be talking to each other except on almost random occasions. Lots of good things were going on but it was all uncoordinated and some of the old mistakes were repeated and new science was not being communicated to everyone. We all shared a common goal, the retention and restoration of the species as a viable component of the Southern forests, but there was no focal point, no place to go to find out what was going on with the species in other places.

With all that in mind, a group of Auburn School of Forestry faculty including Dean and myself, Dale Pancake, Ralph Meldahl, and John Kush, bolstered by support from Charlie McMahon and Bill Boyer from the U.S.F.S. Andrews Forest Science Lab at Auburn, conceived the idea of a statewide group to exchange information on longleaf matters. We convened a group of state and federal staffers, forestry consultants, forest nurserymen, researchers, industry foresters, and private landowners to test the waters. Several meetings ensued and the decision was made to take the effort to the regional level. With the assistance of critical support from the Alabama Forestry Commission, we held a meeting in Atlanta to which we invited longleaf enthusiasts from across the region and from a variety of backgrounds. Out of that meeting came a mission statement, a rudimentary organizational structure, and the plans for this kickoff meeting. At present, Dean Gjerstad and I are acting as unpaid co-directors of the Alliance. We have one paid full time employee, Mark Hainds, who was hired as our research coordinator, although he has filled many roles since his employment began. We anticipate filling one more full time position, Outreach Coordinator, within the calendar year. The Alliance is physically based at the Solon Dixon Forestry Education Center, primarily to be near the resource and to draw on our established support staff for assistance.

In a nutshell, let me tell you what we are and what we are not. We are not **the** longleaf experts, although we have gained some expertise through experience, research, and our contact with other longleaf managers and researchers. We are not consultants, although we do assist landowners and others on occasion. We are not a research organization, although we do conduct some research on-site and nearby. We **are** a partnership of state and federal agencies, conservation groups, research and teaching institutions, forest nurseries, forest industries, forestry consultants, and forest landowners. We all share an interest in longleaf pine - the tree and the forest system. The Alliance serves as a clearinghouse for longleaf information - a focal point for those with an interest in the species and a need to know what others are doing and to share what they are doing. We publish and make available to members and others literature on longleaf like the ones indicated in your registration packet. We will publish a periodic newsletter dedicated to new advances, pertinent information, and articles of general interest in the longleaf field. We are currently building databases on consulting foresters, forest nurseries, and forestry vendors with which to assist land owners and managers across the longleaf region. We have catalogued pertinent longleaf research results and are trying to keep up-to-date records on who is studying what where. We often serve as a liaison between researchers and user groups, researchers and other researchers, nurseries and seedling buyers, seed collectors and nurseries, consultants and landowners, landowners and environmental groups, and public agencies and private interests.

Our focus is on both the ecological and economic value of longleaf pine forests. We are not a preservationist group, although we certainly advocate retention of the longleaf resource we have today and all the diversity it contains. Our philosophy might be best expressed as a conviction that if economics are not considered, then longleaf will be relegated to public lands and a few scattered private holdings, essentially where it is today, museum relics in a fragmented landscape. If it is ever to again be a significant and viable forest component across the southern landscape, it will have to be restored on private lands. Museums preserve things that once were and won't be again. To maintain value and relevance, things must have demonstrated value to their owners. We feel that we can best save longleaf by using it, keeping in mind that wise use means keeping intact all parts and functions of the system. This meeting is the first of many. Please enjoy the ensuing presentations and learn from them and your fellow longleaf enthusiasts in attendance.

Learning from Choctawhatchee: Ninety Years of Longleaf Pine Management

Lawrence S. Earley (North Carolina Wildlife Research Commission, Raleigh, NC)

In 1908, President Theodore Roosevelt established the Choctawhatchee National Forest on a gently rolling, sandy wasteland in the western part of the Florida Panhandle. The forest contained small amounts of sand pine and minor stands of slash pine along the creek bottoms, yet on the deep sands grew an almost pure forest of longleaf pine. In 1940, the national forest was transferred from the Forest Service to the War Department and renamed Eglin Air Proving Ground. Today the forest has grown to about 464,000 acres, most of it in longleaf pine, making Eglin Air Force Base, as it is now called, the largest military base in the country (Eldredge and Recknagel 1912).

Choctawhatchee's forest managers created a forest management plan when it was first established and the plan was revised periodically. The first management plan was issued in 1912; the latest in 1993. These plans offer us vivid records of what several generations of managers did at Choctawhatchee and what happened as a result.

The cumulative effects of 90 years of forest management are plain to see today. Sand pine and slash pine occupy 90,000 acres of former longleaf pine sites, and most of the longleaf pine has been confined in a scrub oak strait-jacket. Managers are clearcutting the sand pine and slash pine plantations, and chain saws, herbicides and growing-season fires are being employed to remove the thickets of scrub oaks. A three- to five-year fire cycle has been planned for the sandhills section of the base, and 40,000 to 50,000 acres of forest will be burned each year in an effort to reestablish the natural fire frequency of the forest ecosystem (Eglin Air Force Base 1993).

Indeed, much of the energy in Eglin's present forest management lies in undoing the effects of previous forest managers. This is hardly unique to Eglin, of course -- much of what passes for today's innovative longleaf pine management across the South is mainly an attempt to reverse the effects of yesterday's bad management. It was bad judgment and worse policy about fire that led to millions of acres of longleaf pine being swallowed up in oak-infested thickets. It was bad judgment that led to ill-advised conversions of longleaf pine to slash pine on deep, sandy soils. Forest mismanagement may have had as destructive an effect on longleaf pine as any of the other factors that it was intended to eliminate -- destructive turpentining, free-range hogs, and cut-and-run logging.

In 1946, the eminent forester W.G. Wahlenberg complained, "Indeed, mismanagement has been the rule rather than the exception . . . ." (Wahlenberg 1946).

What are the lessons to be learned from the Choctawhatchee/Eglin story?

Lesson #1) Ideas have consequences. Some forestry notions and prejudices imported from Europe -- notably the horror of fire -- didn't fit the American conditions, and the results of these ideas on the longleaf pine forests were devastating.

Lesson #2) Forest management cannot succeed without failures along the way. As one forester at Eglin put it: "When they were planting slash pine and sand pine years ago, that was state-of-the-art management . . . . I hate to fault them if they were only doing what they thought was right." (pers. comm.)

American forestry is still a young "science," and at the time of Choctawhatchee's establishment it was an <u>infant</u> science. Bernhard Fernow, the German-born forester who was to become the first chief forester of the United States, acknowledged this in 1916. "Silviculture is still an empirical art, relying upon trial and experiment to find out a modus operandi," he wrote (Fernow 1916).

The history of any science is littered with the bones of discarded theories. The problem comes when particular ideas are elevated into a rigid and unyielding orthodoxy. This is what happened with fire in the South, when Forest Service administrators, in the interests of consolidating their agency's power, quelled dissent within their own ranks about the benefits of fire in southern forests Schiff 1962).

Lesson #3) It has taken the efforts of three generations of foresters and ecologists to learn how to plant longleaf and what the forest needs to regenerate itself, and it has taken this long not because of a lack of effort but because of the nature of the task. It is hard work. At the first fire conference at Tall Timbers in 1962 , Herbert Stoddard confessed:

"We ought to recognize that these are hard facts to get . . . . so I think we ought to try to . . . feel very humble. . . . Looking back today after forty years of progress [in understanding fire], we may well wonder how we could have been so dumb . . . . It's just as sure as wood grows and water runs that this will be the picture they'll have of us in twenty, thirty, or forty years from now. . . ." Stoddard 1962).

Lesson #4) Growing longleaf takes time. As early as 1890, Fernow put his finger on the dilemma of scientific forestry. "The main difference between forestry and other productive industries," he wrote, "is the long period of production. From the time of planting to the time of harvest many decades may pass and a century may not be too long." (Fernow 1890). As the requirements of pulp and paper mills have dominated southern forestry, we have grown impatient with this forest time-scale and introduced a human scale: a forest has to pay off now. Forester Leon Neel has complained, "Instant gratification is too long for some landowners." (pers. comm.). This is a dangerous notion.

Longleaf pine growers must accept the need for long-term management. Longleaf pine forestry can be quite profitable but if we want the timber quality that longleaf offers, if we want the beauty of a longleaf pine forest, if we want to provide for the values of a longleaf pine ecosystem, then we must let time do its work.

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Longleaf Fundamentals: How longleaf develops, grows, and reproduces in relationship to various habitats and environmental conditions

Latimore M. Smith (Community Ecologist, Louisiana Natural Heritage Program Louisiana Department of Wildlife and Fisheries)

In the mid-1800's, longleaf pine (*Pinus palustris*) forests and savannahs covered 70 to 90 million acres in the southeastern United States, ranging from southern Virginia to east Texas. Across this range, the longleaf system varied greatly from place to place in structure and composition, depending principally on local climate, landform, soil conditions and disturbance history.

Local climate is determined principally by latitude, elevation and proximity to the Gulf or Atlantic coast. Annual rainfall and temperature regimes, coupled with relative exposure to ice storms and tropical storms/hurricanes are the chief climatic conditions affecting longleaf systems. Landform and soil conditions are driven in large part by surface geology. Longleaf is found principally on acidic, nutrient-poor sands and loams, and occasionally on acidic clays.

While longleaf forests are found rarely at elevations approaching 2000 feet in mountainous terrain (in northern Alabama), historically they were common in the outer Piedmont in the eastern portion of its range, but most common on the hilly to rolling uplands and younger flatwoods of the outer Gulf and Atlantic coastal plains. In the hilly and rolling, generally sandy uplands of the coastal plain, essentially pure stands of longleaf pine dominated the landscape, broken occasionally by mixed forest types on steep slopes, along streams and on less-common substrates (e.g., calcareous clay) unfavorable to longleaf. Transitional zones to other forest types were characteristically narrow and often strikingly abrupt. In the uplands, natural structure and compositional variety in any one general area arose mainly from variations in physical soil/site conditions, longleaf regeneration dynamics and local disturbance history (e.g., fire, windstorms). In the flatwoods, two basic longleaf system variants that interdigitate on the landscape may be recognized: mesic (non-wetland) longleaf pine flatwoods on slightly higher, better drained ground, and wet longleaf pine flatwood savannahs in depressional, poorly-drained places. Mesic flatwoods were historically characterized by often dense stands of longleaf pine, while wet pine savannahs typically had very scattered trees resulting mainly from infrequent regeneration in low, often flooded positions. Associated ground cover plant communities differ significantly between the two types.

The longleaf system was born of fire and is absolutely dependent on frequent ground cover fires for its perpetuation. Among its myriad effects, fire controls competing woody vegetation and reinvigorates the ground cover plant community. All natural fire in the system was produced by lightning. Fires are estimated to have recurred naturally on the order of once every 1 to 5 (rarely to 10) years on average, depending on local lightning frequency, topography and site/fuel conditions. The majority of natural fires almost certainly occurred during the spring and summer from the increased incidence of lightning associated with isolated convectional thunderstorms. Most fires may have originated from longleaf pine snags (standing dead trees) being struck by lightning. In fact, some believe snags are struck preferentially over living trees (Bill Platt, LSU, Personal Communication). Fires in the longleaf system are tremendously variable in behavior—some are very intense while others are very mild. Relative fire intensity is related to ground cover/understory fuel types, fuel load, fuel moisture, landform, vegetation structure and climatic conditions (e.g., wind, humidity) when the fire is burning. Such variability in fire behavior produces variation in system structure and vegetative composition.

The original longleaf forests were characteristically variable in stocking of trees, varying over short distances from thickly stocked, to moderately stocked, to completely open with few if any trees (called "blanks" or "glades" by early observers). While local soil and site conditions are responsible for much natural variation in stand structure, heterogeneous stand density was often purely a product of natural forest dynamics (e.g., tree regeneration patterns, disturbance effects). The virgin longleaf forests in the western part of the range were more densely stocked in general than forests to the east. This difference may be attributable to the finer textured (and possibly more nutrient-rich) soils typical in the western range of longleaf.

The original forests were also primarily uneven-aged, individual stands usually comprised of trees of many ages. Absent catastrophic wind storms, longleaf regenerates characteristically in small, even-aged groups (cohorts) in small openings created by the death of one or a few large longleaf adults. In mature longleaf forests, larger longleaf trees are killed at a low, but steady rate by lightning (major source of mortality) and non-catastrophic wind storms, and the small openings created are sequentially colonized by

new longleaf cohorts. As they grow, even-aged cohorts thin out from competition over time, and the eventual surviving members of the cohort visually blend into the larger forest matrix. Longleaf can naturally regenerate into large-scale, mostly even-aged forests following devastating wind storms.

The largest longleaf pines in the virgin forest were 35 to 40 inches in diameter and about 120 feet tall. The oldest trees were mostly 350 to 400 years old, although longleaf can rarely live to around 500 years.

On average, longleaf begins to reproduce at about 20 to 30 years of age. Trees produce both mature pollen catkins and receptive female conelets in late winter/early spring; pollination occurs at this time. Conelets pollinated in one spring mature to seed-bearing cones the fall of the following year, or about 19 months later. However, the majority of conelets usually abort before maturation. Cones mature in mid-September through mid-November, depending on locale, and release seeds once they ripen. Cone and seed production is highly variable from tree to tree and from year to year; in general, larger/older trees produce more cones and seeds. Longleaf is a masting species and makes large seed crops only sporadically, perhaps every 3 to 8 years on average. Some locales have more frequent large seed crops than others. Seeds are winged and wind dispersed. The great majority of seeds fall within 100 feet of the parent tree, but some can be blown one-quarter mile or more, particularly from trees in exposed positions. Various rodents and birds are the primary seed predators and readily consume newly fallen seeds, at times decimating seed crops. Seeds generally require contact with bare soil to germinate and usually sprout within a week or two of landing on the ground. Seedlings grow over the first year into a stemless, many-needled young sapling that looks much like a grass, and is thus said to be in the “grass stage”. The grass stage may last 2 to several years as a consequence of local growing conditions and genetic capacity, and during this time the young sapling develops an extensive root system. Once the root-collar (stem diameter at the ground) is about one-third inch in diameter (usually by about 1.5 years of age), grass stage longleaf is resistant to fire. In fact, mid- to late spring fires encourage longleaf to leave the grass stage, more so than no fire or fires at other seasons. In addition, fires during the grass stage are essential for control of the major disease of longleaf pine, brown spot needle blight (*Scirrhia acicola*), a disease that almost exclusively attacks grass stage saplings. In general, young saplings begin height growth once the root collar is about one inch in diameter. Heavy competition and brown spot disease retard initiation of height growth. In very early height growth, young saplings are susceptible to fire damage, but once beyond 3 or 4 feet tall, they are exceedingly resistant to fire. After exiting the grass stage, young saplings usually grow very quickly, growing as much as 3 or 4 feet a year in favorable sites. Without excess competition, many saplings grow quickly on most sites into trees, often growing taller than 20 feet within 7 to 10 years after leaving the grass stage. However, growth rates of individuals in a natural stand differ dramatically due chiefly to genetics, micro-site conditions and the relative degree of competition with other saplings and trees. It is common for saplings or trees of the same age to vary widely in size. Once they exit the grass stage, longleaf can grow as fast or faster than other major southern pines on original longleaf sites.

As the tree grows, it develops a deep, stout taproot (except where restrictive soil layers or high water table are present) and extensive shallow lateral roots that extend outward a distance equal roughly to two-thirds the height of the tree. As the tree grows older, the form of the tree crown changes from sharp conical (“Christmas tree” form), to broad conical-columnar (more rounded crown), to broad flat-topped once older than about 100 years. The loss of terminal bud dominance produces the flat-topped character of older longleaf.

Some major soil conditions associated with the best growth of longleaf pine include: young soil orders (Entisols, Inceptisols), loamy surface texture, relatively thick surface layers, fine subsoil texture, deep effective rooting depth, well-drained but accessible summer water table, upper soil pH = 4.4 to 5.5, extractable phosphorus > 30 ppm, and high organic matter. Some major site location factors associated with the best growth of longleaf are: warm, rainy area; lower slopes and “high flats”; low elevation; some short duration flooding in winter and early spring; and mean annual water deficit < 2 inches.

Southern pine beetles (*Dendroctonus frontalis*) are rarely a problem for healthy longleaf pine, but they will attack low-vigor trees, such as those that have been weakened by excessive competition resulting from long absence of fire and heavy ingrowth of hardwoods and/or other pines.

Hurricanes play a major role in the long-term stand dynamics of longleaf systems of the outer Gulf and Atlantic Coastal Plain. Tropical storm and hurricane wind effects decrease with increasing distance from

the coast. The strongest hurricanes (Saffir-Simpson category IV, winds 131 - 155 mph; category V, winds > 155 mph) are typically the least common and have the longest average time between strikes at any one location, while the weakest hurricanes (category I, winds 74 - 95 mph) are most common, with relatively short average return times for a given place. It appears on average that at any given location within 50 miles of the coast, category I force winds may be expected every 20 to 50 years, while category IV force winds may be expected every 200 to 500 years. Category I winds will generally blow down only a small percentage of trees in a longleaf stand, usually some of the largest/oldest individuals. Storms of greater intensity blow down or break off more of the trees, but typically some trees are left standing in all but the strongest winds. Rarely are hurricanes forest-leveling events. Hurricane effects are greater in flatwoods and other areas where trees are shallow-rooted and more prone to wind-throw.

Much concern has arisen in recent years about the loss of longleaf pine systems and associated biota. Longleaf pine forests and savannahs support a diversity of species and level of endemism unsurpassed by any habitat in North America. Longleaf pine systems require ecological appreciation and careful management to sustain the wealth of native biodiversity found in them.

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Longleaf Pine and Fire -- A Marriage of Necessity

Dale Wade (USDA Forest Service, Southern Research Station, Macon, GA)

When managing longleaf pine ecosystems it is not a question of whether or not to use fire, but rather what frequency, season and intensity is needed to achieve specific objectives. Longleaf ecosystems evolved under a chronic fire regime and thus the continual presence of fire is required to keep them healthy. Frequent low-intensity fires maintain a two-tired stand that matches the mental image many of us have-an open overstory, expansive vistas, large-diameter flat-topped veterans of untold fires interspersed with small unobtrusive clumps of saplings, and a picturesque herbaceous groundcover providing a food web for the many species indigenous to this ecosystem.

The roots, bole and crown all posses traits that, in combination, make longleaf pine (*Pinus palustris)* one of the most fire resistant trees on our planet. These traits include: a juvenile grass stage where a taproot develops enabling the germinant to survive frequent dry spells that eliminate many competitors; a thick root collar which, along with the taproot stores enough food reserves so that when the seedling does bolt (begins height growth), it will grow several feet the first year often placing its terminal bud above the flames of the inevitable fire; enormous buds which have a high heat capacity that help keep cell temperatures below the lethal threshold; tufts of long needles concentrated at branch tips which shield the buds, and; thick bark that protects the cambium from heat once groundline stem diameter exceeds 1.5 inches.

Forest managers can take advantage of these traits to facilitate achievement of their objectives. Good mast years are infrequent, cones take two years to mature and longleaf seeds are fairly heavy so they are not widely dispersed by wind. Thus bumper seed crops can be observed and a mineral soil seedbed prepared by burning the second year prior to seed fall in the autumn. Late summer, early fall burns are not recommended because not enough time will elapse for groundcover regrowth to hide the seeds from predators whom are extra hungry because their alternate food source was just burned up. The seeds germinate as soon as moisture conditions are right. Seedlings are susceptible to fire (although they often resprout) until the root collar reaches a diameter of about 0.3" which usually occurs during the first year. Many fire-related factors combine to determine seedling survival. The first fire across a newly created forest opening will consume the needle litter fireproofing the site for a few years until the wiregrass provides enough dead material to again carry fire. Down tree boles can also act as fire dams to stop fire spread, especially when fuels are light..

Brownspot needle blight is perhaps the biggest hurdle seedlings must overcome. This fungus is generally not a problem under an overstory but can become severe enough to affect survival of open-grown seedlings in about 3-years. Fire controls Brownspot and stimulates height growth. If you wait until the seedlings become heavily infected, however, the foliage becomes an additional source of heat instead of protecting the bud. Use heading fires with adequate seedling-level winds (at least 1 mph at eye level [multiply 20-ft. winds by 0.25 in open stands and 0.4 in closed stands to covert to eye-level]) at this time rather than backing fires because low flames and slower spread rates concentrate heat at the groundline thereby increasing mortality. Fires during May have been found to stimulate height growth, however, if a large number of seedlings have just bolted, consider holding off a scheduled burn until the following year. Not all seedlings bolt the same year, so the next fire is more likely to kill those just beginning height growth thereby thinning the stand and favoring the largest diameter, fastest growing seedlings. Since other southern pine species require a minimum of 3 to 4 years before they can tolerate all but the lowest intensity burns, fire can be used within this time frame to favor longleaf over other pine germinantes. Once longleaf saplings outgrow this susceptible period (which may take a number of years unless in an opening), they become immune to <u>properly</u> conducted prescription fires.

A 2-year fire return interval will accomplish most natural resource objectives. Do not burn your entire acreage the same year and consider dividing the area to be burned during a given year into two or more blocks so it is not all burned at the same time. Burn variability should be the goal! Move burns around within the growing season and between the growing and dormant season and occasionally burn at shorter and longer intervals (See Appendix II Robbins and Myers 1992 for an example). Dormant-season and early growing-season burns prior to nesting season are the easiest to schedule and conduct and will topkill small hardwoods. Burning within a few days after passage of a cold front when windspeed is brisk (headfire rate-of-spread will always be less than windspeed on level ground) will hold flames close to the ground and result

in aesthetically pleasing low bark char, but utilize other burning conditions as well. Patchy burns are desirable. Burns during the first several months of the year will spread out the time of flowering of many forbs. Late spring-early summer burns tend to synchronize flowering. Avoid burning when a majority of the longleaf pine saplings are in candle; buds are more likely to be killed at this time because their protective foliage has not yet developed. Hardwood topkill, especially oaks, is promoted by early growing season fires. Having said the above, emerging results suggest that fire intensity has more affect on ecosystem plant dynamics than either timing or frequency of burns, although both can be used to help achieve the desired fireline intensity. Ignition using spot fires or line (strip) headfires can be used under a wide range of fuel and weather conditions; regulate fireline intensity by varying the spacing. Consult *A Guide for prescribed fire in southern forests* (1989) for more information on the mechanics of using fire.

Firing techniques and ignition patterns should be governed by on-site conditions the day of the burn. Fire intensity refers to the heat output of the fire. Fire severity refers to the impact of the fire on the site. Fires with the same fireline intensity can produce a wide range in severity depending simply upon the moisture content of the duff layer. Conversely a wide range of fireline intensities can produce the same fire severity depending simply on the age of the rough (number of years since the last fire). Sites with a good herbaceous component (generally the result of frequent fires under an open canopy) can be burned within hours after a rain with a brisk wind when backing fires will not carry. If fire has been excluded for more than 4 or 5 years on good sites, plant feeder roots will colonize the duff-soil interface where nutrient exchange is taking place. Fires that consume the duff layer (high severity) will damage the root systems of all plants including southern pines; this is the usual culprit when the pine overstory dies several months after a low-intensity fire that produced little if any crown scorch. Duff consumption is primarily regulated by its moisture content. Backing fires have low flames and are slow moving, thereby concentrating the heat released at the groundline. Backfires thus tend to do a better job of evaporating moisture from the duff than do headfires. However, headfires often consume standing vegetation that would not be consumed in a backfire, thereby releasing enough additional heat to negate any differences in the heat pulse to the forest floor. If duff consumption is not a problem, backing fires are often used where the objective is to control undesirable vegetation because they do the best job of girdling woody stems at the groundline. Sometimes headfires and a brisk wind are needed to push fire through the dense understory that develops with fire exclusion. In other fuel types such as palmetto/gallberry, extreme care must be exercised when using line headfires in heavy roughs (generally after 2 or 3 years). Even Ill-timed annual fires can cause excessive crown scorch. Expert opinion is recommended whenever fire is to be introduced after long periods of fire exclusion regardless of the fuel type (the local office of your state fire management agency is a good place to start).

Do not become overconfident, fire can kill mature longleaf, particularly on hot windless days. Although total crown scorch will not directly result in the death of any of the major southern pine species except in early fall provided buds are not killed, the trees will be stressed, reducing growth and inviting *ips* and black turpentine beetle attack. Scorched foliage remaining after 5-6 weeks means the branch is dead. Bud damage is hard to visually discern but the following guidelines should prove helpful. If crown scorch is less than 75%, expected survival will approach 100%. With actual foliage consumption, the prospect of tree survival drops rapidly; as crown consumption exceeds 25%, survival can be expected to be less than 25 percent. All direct fire-caused mortality should take place by the end of the first post-fire growing season.

Often many objectives can be achieved with a single fire with a little compromising. For example, desired objectives often include retaining snags for wildlife, and a somewhat open stand both for vista effect and to promote sun-demanding groundcover species. Burn timing can be manipulated to enhance flowering plants such as wiregrass gentian, pitcher plants, and of course wiregrass (spring to early summer). Virtually all state and federally listed Threatened and Endangered flora and fauna indigenous to longleaf pine ecosystems are favored by the judicious use of fire.

Historically wet and mesic sites supported a chronic fire regime (1-3 years) while arid sand hills burned less frequently, perhaps every 3-8 years because of the slower accumulation of fine fuels. Lightning fires started in the longleaf ecosystem and spread to other fire-maintained communities such as canebreakes and seepage bogs which rapidly become choked with brush when fire is withheld. Landowners interested in enhancing biodiversity and ecosystem health will want to make sure fire has the opportunity to enter all communities adjacent to longleaf. After extended periods of fire exclusion, it may take several fairly intense burns to reestablish such plant communities. Avoid constructing plowlines and using hardlines

whenever possible because they create artificial ecotones. Instead let the fire create an ecotone which can change from year to year depending upon burning conditions, or use mowed or wet lines.

Recent legislation in many southern states affirms that prescription fire is a landowner right, but with this right comes added responsibility. If we want the “when” “where” and “how” of prescribed burning to continue to be in our hands, we must strive to follow Best Management Practices (BMP’s). We need to demonstrate to the general public that we know what we are doing and can be trusted with protecting human health and safety while being good land stewards. We need to look and act professional, make sure are crews are trained and that our equipment is in good working order. Practice good public relations: get all required permits and notify neighbors and other interested parties (e.g.; local law enforcement) on the day of the burn. Direct your smoke plume away from habited areas and roads, and manage residual smoke mopping up as necessary. If each of us uses fire wisely and does our share to educate the public and ensure good public relations, society, landowners, and the ecosystem itself will benefit.

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Longleaf Pine Forest: Importance to Biodiversity

D. Bruce Means (Coastal Plains Institute, Tallahassee, FL)

Longleaf pine forest was the principal upland vegetation covering the nearly 2,000-mile long Coastal Plain from SE Virginia to east Texas. It originally accounted for about 60.6 percent of the landscape of this large region, or about 82.5 million acres (Wahlenberg 1946, Ware et al. 1993). Incredibly, old-growth longleaf pine forest today totals no more than about 10,000 acres throughout its entire historic range—about 0.01% of its original extent (Means 1996). In the most recent count of 1990, all remaining tracts of longleaf pine totaled only about two million acres (Ware et al. 1993), representing a shrinkage to less than 2 percent of the landscape over a period of about 200 years. The loss of this important native vegetation was so extensively underway as far back as the Great Depression that Wells and Shunk (1931) were moved to lament that "The complete destruction of this forest constitutes one of the major social crimes of American history."

The loss of longleaf pine forest is tragic, ecologically—and a great loss to mankind—because of the decline of its high biodiversity. The number of groundcover plants, for instance, ranges up to 300 species per 2 ½ acres. The highest level of small-scale plant species diversity in North America—about 42 species per square foot—was reported from mesic longleaf pine savanna in the Green Swamp of North Carolina (Walker and Peet 1983). Hardin and white (1989) counted 191 species of rare vascular plant taxa associated with that portion of the longleaf pine forest range having wiregrass (*Aristida beyrichiana* and *A. stricta*). Using The Nature Conservancy's Natural Heritage Program methodology, 122 of these plants were considered endangered or threatened throughout their total ranges. Sixty-one taxa were listed as endangered or threatened by rare plant laws in three states, and seven taxa were listed or proposed as endangered by the U.S. Fish and Wildlife Service. Hardin and White (1989) estimated that 66 rare wiregrass associates are local endemics, a very high number of endemics for a regional ecosystem type in the U.S.

Animal biodiversity is high, too. The number of species of breeding birds was higher in old-growth longleaf pine forest than in other forest types in Florida (Engstrom et al. 1984). The highest species density of amphibians and reptiles in North America was mapped by Kiester (1971) over the geographic distribution of longleaf pine. At least 170 (59%) of the 290 species of amphibians and reptiles native to the Southeastern U.S. are found within the range of longleaf pine (Dodd 1995).

Longleaf pine forest plays a "keystone" role in maintaining between habitat diversity throughout the Coastal Plain (Means 1966). In the presettlement landscape, fires burned downslope from longleaf pine forest into seepage bogs or wet savannas frequently enough to keep them free from invasive but fire-sensitive wetland shrubs (*Cliftonia monophylla, Cyrilla racemiflora, Ilex coriacea, I. myrtifolia, Clethra alnifolia*, and others).

Southeastern herb bogs are characterized by a rich variety of grasses and forbs including one of the world's greatest assemblages of carnivorous plants (sundews, bladderworts, butterworts, pitcher plants). Herb bogs are fire-dependent ecosystems that normally burn every three to eight years, but succeed to shrub bogs in the absence of fire. Folkerts (1982) estimated that more than 95% of Gulf Coast pitcher plant bogs have been eliminated. The fires that maintain the ecological integrity of herb bogs come downhill from adjacent longleaf pine forests, not from the swamp forests downslope, and rarely from fires ignited in bogs, themselves.

Occasional fires that burned into shrub bogs prepared the peaty soils there for the establishment of slash pine (*Pinus elliottii*) or pond pine (*P. serotina*), both of which are intolerant of fire in the first decade or so of their lives. Pond pine stands are regenerated naturally by fire whcn seed is released from serotinous cones that open upon heating. Atlantic white cedar (*Chamaecyparis thyoides*) also depends upon occasional severe fires to raze old stands and prepare a seed bed with open sunlight conditions for seedling establishment.

Even on steep slopes fire coming down out of longleaf pine forests may have played an important role in the replacement dynamics of xeric hardwood forests of mockernut hickory (*Carya tomentosa*), laurel oak (*Quercus hemisphaerica*) and other oaks, with a sprinkling of loblolly pine (*P. echinata*). Eastern

redcedar (*Juniperus virginiana*) was found in this xeric forest, whose replacement dynamics also depend upon fore preparing a seed bed and eliminating competition from hardwoods.

Sand pine (*P. clausa*) forests exist in a matrix of longleaf pine forest. Sand pine also holds its seeds in serotinous comes, releasing them upon heating. After about 75 to 100 years, the relatively short-lived sand pine forests thin out and are invaded by shade-tolerant hardwood trees. Too much fire (every one to 10 years) kills young sand pines before they are old enough to produce cones and seed, but periodic fires every 10 to 100 years seem about the right frequency for the turnover and persistence of sand pine forests (Myers 1990). Fires in longleaf pine forest run into sand pine stands and regenerate them during times of severe drought, high temperatures, low humidity, and high winds.

Longleaf pine forest was the source of most fires because 1) Longleaf forest was the most extensive forest ecosystem in the region; 2) it occupied the highest, driest, most fire-prone sites in the landscape; 3) longleaf pine and its associated groundcover provided the most flammable litter that carried fire; and 4) by occupying the interfluves between catchments, longleaf facilitated fires that burned for weeks over a vast, contiguous habitat. Without fire, between-habitat diversity would decline as invasive hardwood species expanded their ecological distributions into coniferous forests and herb bogs. A landscape in which longleaf forest has been eliminated, therefore, is a landscape in which longleaf forest has been eliminated, therefore, is a landscape that has lost much of its biodiversity.

Indeed, the drastic reduction and fragmentation of the Southeastern U.S. Coastal Plain longleaf pine forest has had dire consequences for untold species of plants, invertebrates, and vertebrates that, like the endangered red-cockaded woodpecker, are highly adapted to the longleaf pine ecosystem and cannot survive in man-made environments or even in disturbed forests that grow up on abandoned lands. The biggest hope for preserving the within- and between-habitat diversity of the longleaf ecosystem is on publicly owned lands on national forests and large military bases where most of the large, contiguous tracts of second-growth longleaf pine remain. but enlightened ecological management is possible on private lands, too. Stands of longleaf pine can be regenerated naturally, saving the cost of mechanical site preparation and tree planting, for instance. New selection management techniques that mimic natural mortality can be adopted which maintain and sustain the natural longleaf pine ecosystem, preserve biodiversity, protect and recover endangered species, and produce commodities on a steady basis. It is possible to maintain a high quality environment that also produces income. A foresters, land managers, biologists, and private land owners, we must all work together to make this happen.

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Four Generation of one Family's Experience with Longleaf

Earl H. (Buddy) Weaver (Huxford Trust, Brewton, AL)

Let me begin by giving you a little background. The land that I'll be talking about is approximately 15,000 acres located from three to nine miles north and west of Brewton, Alabama along both sides of Alabama Highway 41 which is the Brewton to Repton to Monroeville highway.

The land first came into our family in 1932 when it was purchased by my wife's grandfather for a turpentine operation which was a business with which he had quite a bit of experience. For a number of years there was a full-blown turpentine camp complete with houses, a commissary, and a still. My wife's father later took over management of the land and depended mostly on timber sales for income though there were third parties still gathering sap as late as the 1960's. My father-in-law did actively manage the land and timber though perhaps not as intensively as most of you would recommend today.

In the mid-seventies he began to look for ways to pass the land to his descendants without getting killed by the IRS. Finally just prior to the massive tax law changes that some of you may remember at the end of 1976, he created a generation-skipping trust and gave the land to the C. C. Huxford, Jr. Grandchildren's Trust for the benefit of his six grandchildren with his four daughters, one of whom is my wife, as trustees of the trust.

Just as an aside, a small town Brewton lawyer and a small town Brewton accountant pulled a real slick deal on the IRS which allowed the land to be transferred for a very minimal gift tax. Of course that's another story for another day, but I'll be glad to discuss that individually with any of you who may be interested.

My father-in-law continued to manage the land until 1980 when he retired at which time the four trustees asked me to get involved. We quickly made a decision that we wanted to manage the timber much more intensively than had been the case. We knew we had mostly longleaf, so we asked Tom Croker, who was living in Brewton and retired from the U. S. Forestry Service as a longleaf specialist, to help us assess what we had and to ultimately put together a management plan for us.

We had a cruise done and found we had about fifty million board feet of sawlog and pole size trees, but along with that we also found that the forest had been considerably high-graded through the turpentine years, so we were beginning our management with predominantly sixty year old trees and in many areas not enough young vigorous growing stock. This meant many areas needed regenerating. Other problems included no burning program in prior years had allowed a considerable fuel hazard buildup on the forest floor and led to problems with competition control, particularly in areas where we wanted to use natural regeneration. Competition was both the brushy variety and mid-level variety. Our road system was also generally in bad shape.

By January of 1981 we were ready to put out management plan into operation and we have followed it pretty religiously up to now which I guess finally brings us to what Dean and Rhett really wanted me to talk about.

Let me say that we established a very conservative management plan and admit that we were able to take a very long-term view since, among other things, the grandchildren, the beneficiaries of the trust, were young enough that they wouldn't need substantial income for several years to come. This allowed us to plan to maximize the potential of the forest thirty to forty years in the future. Other advantages we had were that it was no more than ten miles to a market for every major product we wanted to produce. We have also had the advantage of a full-time graduate forester from the beginning who had prior experience with longleaf.

Now I'm the first to admit that you can't justify a full-time forester on 15,000 acres, but this is a unique individual who is not only a professional forester but is a laborer, a forest technician, a bulldozer and other heavy equipment operator, a mechanic, a carpenter, and whatever else you need him to be. He is, in fact, our only employee.

The first statement in our plan is that we will "continue to favor longleaf in order to grow high quality pole and sawlog timber with pulpwood and other minor products." We established a sixty year rotation with a goal of having one-sixth of our timber from zero to ten years of age, one-sixth from ten to twenty and so on up to one-sixth from fifty to sixty years of age. We set out to develop even-aged stands of roughly fifty to one hundred acres within each section using roads, streams, type lines, section lines, and property lines as boundaries where possible.

We used a detailed ten year management plan within our overall sixty year plan to control operations through 1990. We estimated with a five per cent growth factor we could grow 2.5 million feet per year and established our first ten year cutting plan with a volume control of 1.25 million feet per year which was roughly half our growth, which again I guess is pretty conservative. To accomplish the regeneration we needed we clearcut and planted where there were not enough seed trees for natural regeneration we needed we clearcut and planted where there were not enough seed trees for natural regeneration - by the way, we've never had a failure planting longleaf - but wherever possible we used a shelterwood cut and the resulting natural regeneration.

We immediately embarked on an intensive burning program for clean-up burns where we attempted to get over the entire land base every three years, with other specialized burns for seedbed preparation and the like as needed.

From the beginning we have had a John Deere 450 bulldozer that has a 6-way blade which we used immediately to improve our road system and for firelines, site prep, and other odd jobs. We have plenty of red clay gravel on our own land which we have used for road improvement

As our first intensive 10 year plan played out in late 1990 we did another cruise and assessed where we stood after our first ten years of management. We found that after taking off more than 13 million board feet of sawlogs and poles, we now had 4 million feet more of logs and poles in 1990 than we had in 1980. That's not as good as we had hoped for, apparently mostly due to an actual estimated growth of 3.5 per cent when we had predicted we would get 5 per cent growth.

During the ten year period we had sold just over 7 million board feet of logs, just under 6 million board feet of poles (that's 45 per cent poles), 28,500 cords of pine pulpwood, 12,500 cords of hardwood pulpwood, 36,500 board feet of barn poles, 1,290 cords of fence posts, 59,000 board feet of chip-n-saw, 15,000 board feet of hardwood logs, 115,000 board feet of hardwood veneer logs, 25 cords of dogwood, and 12,000 tons of sawdust from an old pile. All of that brought in approximately $3,200,000.00 during the 10 years. We had successfully clearcut and planted 1,300 acres and naturally regenerated about 1,000 acres which added together <u>does</u> approximate one-sixth of our acreage that is actually occupied by longleaf.

Against the odds we had three very good seed crops during the period 1981 through 1990. As a result, we established nearly 5,000 acres of natural seedlings under seed trees in the shelterwood cuts we had done. As mentioned above, we had gone ahead and taken the mother trees off of 1,000 acres thereby completing the regeneration cycle prior to 1990. That still left us with 4,000 trees needing to come off. Remember, though, our area control only allowed for regenerating 2,300 acres during the 1991-2000 management cycle. This has become the biggest problem we have had as far as strictly following our original plan. I've often referred to it as an "embarrassment of riches."

Going into 1991 we did another intensive ten year management plan which varied very little from the one ten years earlier. We left our volume control at 1.25 million feet per year and our area control at 230 to 240 acres per year although we knew from our earlier discussion that we would exceed the area figure.

One major change was that we had to be more cognizant of income. Since the grandchildren were now growing up, marrying, buying houses, etc., they were now quite interested in distributions from the trust. Fortunately the dramatic price increases over the past few years have allowed us to keep the beneficiaries happy while continuing the conservative management plan we established early on since the 1.2 million feet per year that produced maybe $300,000.00 in the 1980's is now producing more than double that in the 1990's.

From 1991 through today, we have done nothing bur do removal cuts of the seed trees on the 4,000 acres of established seedlings that we talked about earlier. As a result we are over on both volume and area controls. We will get the volume back in line before the year 2,000 and the overage on area control will get no worse since from 1997 through 2000 we will be doing nothing but thinnings from stands that have been left to grow since 1980.

Our forester and I have recently spent a good deal of time assessing where we are in mid-1996 and have concluded that we should experience no severe problems in continuing on beyond our second ten year plan to ultimately carry out the sixty year plan that we originally embarked on.

CONCLUSION

Longleaf has been the favored timber species on this privately owned family land base for more than sixty years. Longleaf has allowed four generations to meet their objectives for their ownership and it is the firm conviction of current management that longleaf is even more appropriate today and for the future than it has been in the past.

Longleaf Reforestation - Plan of Attack

Rich Pouncey (Longleaf Foresters, Inc., Tallahassee, FL)

Success with longleaf reforestation efforts requires careful planning well in advance of any field work. I like to divide the planning into three separate and distinct stages that I will call Strategic, Operational and Tactical Planning.

Strategic Planning is primarily the "serious thinking about it and considering it" stage. This is the time that the landowner should consider all of the options available to produce the end results that are wanted in land management at some point into the future. At a minimum the following things should be considered:

1) In view of the limited knowledge that we really have on growth and yield of longleaf, is it worth the gamble to attempt longleaf especially when so much is known about management, yield and potential; income of other pine species?
2) Are the higher establishment costs and delayed returns from at least the first thinnings acceptable?
3) Is the added assurance of increased resistance to fire, and insects and diseases and the probability of a higher rate of return farther into the future a viable part in the overall plan of managing the land.

After these and other important questions that the landowner may have are answered and the decision is made to establish longleaf, than the second stage, Operational Planning, comes into play.

Operational Planning addresses the options available on how to get the longleaf stand established and successfully through the first year at least, and possibly out of the grass stage. Decisions are made on site prep requirements and methods, and a plan is put into operation that will have this vital part done properly and on schedule. Decisions are made about the seedlings to be planted i.e. bareroot, containerized, and about planting methods - machine or hand planting.

A good operational plan identifies everything that is to be done, y whom it is to be done, and identifies when it is to be done and completed. This is the time in the planning stages to identify the best "team players," formulate and execute contracts. The time to work out a good operational plan is months in advance of the planning season. One year in advance is not unreasonable.

With the operational plan finalized and decisions made about what to do, when, how and by whom each part of the operation will be carried out, it is time to start planning the tactical methods.

The tactical plan will identify on the ground, both in advance and during the operation, how the operation will be done. For example assume that the operational plan has identified the required site prep to be an aerial application of herbicides followed by a controlled burn with V-blade planting bareroot seedlings.

The tactical planner with field assistants will take control of all aspects of making the operational plan a success. He or she identifies and marks the boundaries of the treatment area, locates the helicopter landing zone and oversees the herbicide application. The tactical person correlates the follow-up burn with weather conditions and smoke management requirements, has the seedlings delivered to the planter on schedule, and oversees the planting even to the direction to run the rows. By necessity the tactical planning is, for the most part, done on the ground in advance and during the operation, and it must have the flexibility to change as conditions change.

Strategic planning cannot change if the operational plan is in place. It may be aborted, but it cannot be changed. The operational plan should not be changed or altered, but on occasion it may be necessary to do so to adjust to unforeseen circumstances. The tactical plan is almost guaranteed to change, usually in minor ways, since ground conditions, weather conditions, delivery schedules, breakdowns, etc. will usually require changes infield operations.

To summarize in a brief few words: I can simply say this:

Make sure that you want to go with longleaf. There are some unknowns associated with it, but many of us who are good, conservative and prudent Southerners with a deep attachment to the land feel comfortable and easger to include longleaf in our reforestation efforts.

Plan to succeed with a good Operational Plan. Do this well in advance and explore all of the options addressing site prep, seedlings, and planting methods. Carefully assemble the right team of players to do the work, and supervise each phase of the operational plan.

Have a good tactical person on the ground to implement the operational plan - someone who is experienced and who recognizes that the wind has changed directions, or that the ground is frozen and therefore the tactical operation must also change.

These simple, highly important things will go a long way in assuring a high degree of success in longleaf reforestation efforts - any reforestation efforts really. This our method, and we have some outstanding failures, too, and usually our failures can be traced back to a flaw in the operational planning or the tactical execution of our plan.

Longleaf Pine on the Guerry Beam Farm

Lynda G. Beam (Tree Farmer, Savannah, GA)

FIVE GREEN KEYS TO SUCCESSFUL LONGLEAF PINE PLANTING:

1. WELL - PREPARED, COMPETITION FREE LONGLEAF SITE
2. HEALTHY, TOP QUALITY, FRESH PLANTING STOCK
3. METICULOUS CARE AND HANDLING OF THE STOCK FROM LIFTING TO PLANTING
4. PRECISION PLANTING
5. PROPER POST - PLANTING CARE

1. SITE SHOULD BE PREPARED BY:

* being free of competition by use of mechanical equipment, herbicides, prescribed fire or
* letting disturbed soils have summer and fall rains to settle and firm before planting
* sub - soiling in old fields with hardpans

2. BARE ROOT SEEDLINGS SHOULD HAVE:

* a root collar diameter of at least 0.5 inch!
* numerous 6 - 8 inch fibrous lateral roots with evidence of ectomycorrhizal development
* a stout 6 - 8 inch tap root that has been root pruned during growth in the nursery
* a winter bud with scales
* abundant, largely - fascicled needles that are disease free and fungicide treated
* been in a full state of winter dormancy when lifted from nursery beds
* been picked up by you at the nursery on the day they are lifted and planted within two days (accepted practice to plant within one week)
* grown at the best nursery that you can find
* seed source in same zone or region as the planting site

3. CARE AND HANDLING OF SEEDLINGS FROM NURSERY TO FIELD MUST INCLUDE:

* pick up from nursery the day lifted
* cool transportation to planting site (do not allow seedlings to dry out , heat up or freeze during shipment storage or planting)
* store in shaded , cool , well ventilated area
* cold storage at 35 degrees if planting can't be accomplished day after pickup (no cold storage is best)
* planting within one week
* having racks t separated bags to prevent crushing
* no exposure to sunlight or heat

4. PRECISION PLANTING

* take only enough seedlings to field for one day
* store in cool shade
* do not stack bags
* keep seedlings moist
* dip roots in terra Sorb before loading into planter - keep moist and covered
* keep bags sealed until use - repair any tears in bags
* do not root prune - they need them all!
* do not top prune
* use special longleaf planter with large coulter

* PLANT SLOWLY! (these are not loblolly!)
* plant in December or January in a misting rain
* do not plant when a strong cold front is moving in with low humidity, strong winds or low chill factor
* do not plant in frozen ground
* machine plant if possible
* compact soil to remove air pockets - close holes firmly from bottom to top
* when hand planting remove only one seedling at the time
* speak to each seedling
* place tap root straight down - no bending or angles
* bare - root seedling - plant with bud at or slightly below ground level - 0.5 inch below (soils vary) (rcd of 0.5 to 0.7 inch will push through soil by spring - container seedlings or rcd less than 0.4 may silt in)
* seedling containers must be covered with soil to prevent moisture loss
* plant on contour if land is erodible
* inspect planting at all times
* plant as early in season as seedlings are winter dormant (survival will lessen after bud break)
* leave no seedlings out during break or overnight
* throw away all seedlings left in planter at days end
* work up seedlings in the shade
* plant on square spacing = contented trees
* train all personal, even old trusted hands and family members - stress careful seedling handling - longleaf require "very special handling"

5. PROPER POST PLANTING CARE REQUIRES:

* careful inspection of seedlings to monitor erosion or silting - in during 1st winter and spring (soils settle)
* annual check for brown-spot disease and control until height growth has started
* check seedling survival and interplant with container seedlings if necessary
* control of competing vegetation until height growth has started
* enjoy planting longleaf pine!

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Longleaf Pine Restoration and Management at the Roy E. Larsen Sandyland Sanctuary: A Partnership for Ecosystem Conservation

Ike McWhorter (Pineywoods Conservation Initiative, The Nature Conservancy, Silsbee, TX)

The goal of restoring and managing the longleaf pine (*Pinus palustris*) ecosystem has become the focus of numerous conservation efforts throughout the Southeastern Coastal Plain of the United States. It is estimated that longleaf pine forests once dominated a landscape of more than 60 million acres stretching from Virginia to East Texas. During the last century, human development, intensive silvicultural practices, and fire suppression have reduced these forests to less than 5% of their original coverage. (Outcalt and Outcalt 1994)

The Nature Conservancy and Temple-Inland Forest Products Corporation have developed a partnership to conserve one of the last remnants of this vanishing ecosystem at the Roy E. Larsen Sandyland Sanctuary, a 5685 acre nature preserve in Hardin County, Texas. The Sandyland Sanctuary was established in 1977, by a gift of 2138 acres donated to the Nature Conservancy by Temple-Eastex, Inc., the predecessor company of Temple-Inland. This gift has now become the core of a larger, cooperative project that seeks to integrate sustainable forestry and ecosystem conservation.

The Sanctuary encompasses a wide diversity of plant and animal life as well as excellent examples of several natural community types representative of the Big Thicket ecoregion. Of special significance is the sandhill pine community (Harcombe and Marks 1981) found on the sandy alluvial terraces along Village Creek. The sandhill pine community is an open woodland of longleaf pine and drought resistant oaks. It is the driest of the longleaf pine community types found in the region and, like other longleaf communities, it consists of a highly diverse herbaceous ground cover. Thirty-one species of special concern have been identified at the Sanctuary, including the federally listed Texas trailing phlox (*Phlox nivalis ssp. texensis*) (Orzell 1989).

A history of logging and fire suppression has significantly altered the natural plant communities at the Sanctuary and resulted in a loss of habitat for many species of concern. In 1962, prior to the establishment of the preserve, over 700 acres were converted to non-native slash pine plantations. In time, these stands became stagnant and developed dense understories of shrubs and hardwoods. Some residual longleaf remained in these stands, but for the most part they had replaced the open longleaf pine forest which previously occurred on the site.

In 1984, The Nature Conservancy initiated a restoration program to re-establish the longleaf communities. It involves four components: re-introducing fire, removing the slash pine, promoting natural longleaf regeneration, and re-establishing longleaf through artificial regeneration.

The initial focus of the project was to re-introduce fire through a program of prescribed burning. Primary burning objectives were to reduce the accumulated fuels, to control encroaching hardwoods and shrubs, to stimulate the native ground cover, and in some cases to thin dense stands of slash pine.

Slash pine was primarily removed through selective thinning. The objective for thinning operations was to leave 40 to 60 basal area of pine including all longleaf. Due to the scarcity of longleaf in some areas, a high percentage of the remaining stand was composed of slash pine. These selective thinnings resulted in less impact to the site than a clearcut and posed less risk to the residual longleaf pines and other ecologically significant species. The remaining slash pines serve as a temporary, functional substitute for longleaf and provide the fuels necessary for future burns.

Following the selective harvests and the initial fuel reduction burns, an aggressive program of prescribed burning was initiated to control the vigorous sprouting of shrubs and hardwoods from established root systems. Early growing season burns on a 2 to 3 year frequency were preferred because of their effectiveness in controlling hardwoods and because they favored the recovery of the longleaf pines and the herbaceous species.

To date, the restoration efforts on the core preserve have been successful. Selective harvests have occurred on 300 acres, and a prescribed burning regime has been established on over 1500 acres. Sites that have been thinned and burned are now displaying the vegetative structure characteristic of the open longleaf pine woodland. Targeted elements have also responded well to the management treatments. Texas trailing phlox has made a significant recovery, and over 400 new occurrences have been found on the site.

The next step in the project will be to inventory the site in order to determine the regeneration potential for longleaf pine. Where there is an adequate seed source, we will promote natural regeneration by removing the remaining slash with periodic thinnings and by burning at the appropriate time to prepare seed beds. Where longleaf seed trees are lacking, we will create small patch clearcuts over time and replant with longleaf seedlings or with direct seeding.

The longleaf restoration efforts at the Sandyland Sanctuary are a critical first step in conserving the longleaf pine ecosystem. However, we understand that for longleaf conservation to succeed on a regional scale we must also demonstrate that longleaf pine can be managed on a sustainable basis that provides economic returns while protecting the biodiversity of the ecosystem. With this in mind, we approached Temple-Inland with the idea of working together to establish an ecologically compatible longleaf pine forestry program on their lands adjacent to the Sandyland Sanctuary.

Temple-Inland supported the idea, and in May 1994, they donated to The Nature Conservancy a conservation easement on 2800 acres surrounding the core preserve. They also donated fee ownership of an additional 380 acres within the core area along Village Creek. According to the terms of the conservation easement, Temple-Inland retained ownership of their land but relinquished the right to develop the area or to harvest hardwoods. They retained the right to continue pine forestry operations, but agreed to restore longleaf pine on suitable sites and to manage these stands with a program of ecologically compatible forestry developed in cooperation with The Nature Conservancy.

The easement served two important purposes. First, it established a cooperative longleaf pine forestry program. Secondly, it created around the core preserve a buffer which provides additional habitat for many important ecological elements and prevents future development from occurring directly adjacent to the core.

On the easement lands there are approximately 1800 acres of slash and loblolly plantations which will be converted to longleaf and managed for sustainable use. We will employ restoration strategies similar to those that have been successful on the core preserve. A key strategy will be to use prescribed burning to control problem hardwoods prior to canopy removal, thus eliminating the need for intensive site preparation that is so destructive to the native ground cover.

Once longleaf is re-established on the site, we will manage the stands through natural regeneration systems including long-rotation shelterwood and single-tree and group selection. Prescribed burning will be conducted on a frequent basis, and the protection of native herbaceous communities will be a high priority.

The partnership between The Nature Conservancy and Temple-Inland derives its strength from the fact that both share ownership in the project and each makes an equally significant contribution essential for success. The Nature Conservancy provides its knowledge of biodiversity and ecosystem processes and Temple-Inland provides its expertise in forestry and timber management.

The result is a conservation partnership that provides substantial benefits to all. We achieve a significant conservation goal by enlarging the size and scope of the Sandyland Sanctuary, and Temple-Inland is able to continue commercial forestry operations on their lands. Also, we are establishing a model of sustainable longleaf pine forestry that will have application throughout the Southeast. Through this project we are demonstrating how conservation partnerships can protect ecological values while providing for continued economic use.

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A Case History of Wildlife Management Success in Longleaf Pine

R. Todd Engstrom (Tall Timbers Research Station, Tallahassee, Florida)
Sharon M. Hermann (Tall Timbers Research Station, Tallahassee, Florida)
Leonard A. Brennan (Tall Timbers Research Station, Tallahassee, Florida)

The widespread decline of longleaf pine forests in the southeastern coastal plain has resulted in a concomitant decline in many wildlife species that rely on habitat provided by this forest type. A common thread among the major species of terrestrial vertebrates that have been experiencing population declines in the southeastern coastal plain is an affinity for habitat provided by frequently-burned, open, park-like pine stands. Longleaf forests once served as the "backbone" of this landscape from southern Virginia to east Texas. The decline and fragmentation of longleaf stands has been directly and indirectly linked with the widespread decline in species historically associated with longleaf pine such as northern bobwhite (Colinus virginianus), Bachman's sparrow (Aimophila aestivalis), gopher tortoise (Gopherus polyphemus), fox squirrel (Sciurus niger), and of course, the endangered red-cockaded woodpecker (RCW; Picoides borealis).

The current landscape of much of the coastal plain, dominated by high density stands of loblolly pine, modern, clean farming agriculture, and extensive encroachment from expanding suburbs, contains little room for bobwhite, RCW, and other species that require open stands of pine maintained by fire. While this situation is bleak, it is also not hopeless. Although fragmented and disjunct, some outstanding examples of high-quality longleaf habitat remain. Such areas provide concrete examples of how game, non-game, and endangered species can be maintained in longleaf over long periods of time. One of the most outstanding such examples exists on private shooting plantations in the Red Hills Region between Tallahassee, FL and Thomasville, GA.

Land Management Objectives

In general Red Hills shooting plantation landowners have four primary land management objectives: to produce populations of bobwhite to hunt, to provide an enjoyable and aesthetic experience for the owner and guests during hunts, to obtain revenue from timber to partially offset the costs of bobwhite management, and to maintain habitat for native plants and animals.

Measures of Success

In contrast to what we see elsewhere in the coastal plain, bobwhite, RCWs, gopher tortoise, fox squirrels and Bachman's sparrows are apparently doing quite well on the 300,000 acres of private land managed for bobwhite in the Red Hills. Long-term records from plantation game books show that bobwhite numbers have been stable in this area for decades. This is in stark contrast to declining bobwhite population trends shown by Christmas Bird Count, Breeding Bird Survey and state wildlife agency game harvests.

The Red Hills plantations support the largest population of RCW on private lands. It is the sixth largest RCW population anywhere. Demographic data show that RCW numbers are stable in this area, and not declining like they are in many other areas. RCWs are apparently thriving in the midst of frequent timber harvesting and hunting disturbances. Such observations show that the kind of forest management practiced on the shooting plantations may be applicable to public lands where timber harvest is being unnecessarily shut down because of the birds.

Gopher tortoise are common throughout this region. Studies of gopher tortoise distribution and abundance on private lands in south Georgia show that these animals have a direct affinity with open pine stands maintained by frequent fire and decline in pine plantations. Although we have not monitored fox squirrels or Bachman's sparrows, both are frequently seen throughout the Red Hills piney woods. The common thread that links these species of vertebrates is the dependence on the longleaf pine ecosystem.

Ingredients of Success

Reasons for success of the landowners in meeting their objectives can be found in the ecology, economics, and social relations within the community. The ecological basis for healthy populations of bobwhite and other longleaf associates is grounded in habitat management for northern bobwhite, the top landowner priority on the Red Hills shooting plantations. Good quail habitat management dictates frequent use of fire, the essential element in longleaf pine ecosystem management, and fire has been used on the

shooting plantations for decades. The longleaf pine ecosystem in the Red Hills has also benefited from the contiguity of the shooting plantations and similarity and consistency of management among the plantations. Open canopy stands of longleaf and other southern pines are maintained so that adequate sunlight can reach the ground and stimulate growth of plant and arthropod foods required by the quail. Maintenance of areas of native groundcover also makes management, especially the use of prescribed fire, easier.

Although aesthetically pleasing, these land holdings are working landscapes, not parks. They produce many wood products from continuously-standing forests that are usually maintained through single tree selection harvest and natural regeneration. Forest consultants and managers have an awareness of the annual cycle needs of the many longleaf associates, especially RCWs, and select timber for harvest accordingly. This has ecological and economic benefits. Ecologically, the standing forest provides habitat for many species of animals, and pine needles provide an important source of fuel for prescribed fire. Economic benefits include a standing resource that can be used when market conditions are optimal. This conservative approach to timber management allows a greater chance of achieving the multiple objectives of the landowners.

Landowners were able to maintain their forests though conservative timber management, in part, because they started with high quality forested lands. Regardless of the initial timber base, the ecological and economic principles of this timber management are widely applicable to private and public land.

A cultural tradition of more than 80 years has developed into shared management goals that directly benefit quail and indirectly benefit numerous other wildlife species. Landowners within the community take pride in the resources within the Red Hills, and this sense of community has tended to foster high standards of stewardship. The overall bottom line, is that **wildlife management dictates timber management** on these properties. When timber management dictates wildlife management, it makes it difficult, if not impossible, to achieve what has been accomplished in the Red Hills during the past 80 years.

Land management in the Red Hills can be seen as ecosystem management because the four land management objectives act as a system of checks and balances. Concentration solely on any one objective could potentially act to the detriment of others.

Conclusion

The data being accumulated on quail, RCWs, and other species, by scientists at Tall Timbers combine to tell a compelling wildlife management success story. Desirable wildlife species that are declining throughout much of their range seem to do quite well in many situations where relatively large (2,000-10,000 acres) stands of open, park-like longleaf forests are maintained.

Few extensive tracts of longleaf remain, however, and many of these are besieged by urban encroachment, fragmentation, fire exclusion, and numerous other insults. The Red Hills shooting plantations provide concrete examples of how to manage longleaf stands for multiple management objectives, including production of game and economic returns, and conservation of non-game and endangered species. The pressing question is how can we expand this kind of management throughout the region.

The Best Kept $ecret in Southern Forestry: Longleaf Pine Plantation Investments

R.L. Busby (USDA Forest Service, New Orleans, LA)
C.E. Thomas (USDA Forest Service, New Orleans, LA)
Richard E. Lohrey, Jr. (USDA Forest Service, Pineville, LA)

ABSTRACT

Investments in thinned longleaf pine (*Pinus palustris* Mill.) plantations are financially profitable based upon analysis of data gathered from Louisiana, Mississippi, and Texas. Site quality is a key determinate of results.

INTRODUCTION

Longleaf pine (*Pinus palustris* Mill.) once dominated the Southern pine landscape but acreage in longleaf stands have declined for many years. One major reason given for the decline has been the assumed poor economic returns from longleaf pine management. These perceptions were fueled by early difficulties in stand regeneration and excessive time the tree spends in the grass stage. Today, these difficulties have lessened, and it is appropriate to reexamine the financial returns of longleaf pine management.

METHODS

Individual tree data from 94 stands aged 40 yrs. (Mississippi), 45 yrs. (Texas), and 50 yrs. (Louisiana) were analyzed. The stands were originally planted with up to 2,500 trees/acre. Each stand experienced excessive mortality in stand establishment but were fully stocked by age 20. Given modern planting techniques, it was assumed plantings of only 726 trees/acre would be required to achieve the same survival. Stands were either left unthinned or were periodically thinned to target basal areas of 40, 60, 80, 100, 120, or 140 ft^2/acre, respectively, beginning at age 20. Final harvests were assumed to occur at ages 25 to 50. Land expectation values (LEVs) were calculated for each regime using a 5% real discount rate, and the LEV at the optimal final harvest age was used for comparisons. Costs and returns were assumed to change at the same rate as inflation.

Regional average stumpage prices from 1993 to 1996 were compiled as follows: poles and sawtimber, $388 and $274/MBF, Scribner, respectively; and chip-n-saw and pulpwood, $61 and $24/cord. Stand establishment costs of $148/acre were assumed to mimic the light site preparation treatment and plantings of the modeled stands. Other costs were assumed to be 10% of harvest revenues. Income tax rates were assumed to be 28% and 4% at the federal and state level, respectively. Property taxes were assumed to be $1.70/acre/yr.

A computer model was developed to simulate the merchandising of each harvested tree. Dynamic programming subroutines used a longleaf taper function developed previously from this data set.

RESULTS AND CONCLUSIONS

Optimal after-tax LEVs averaged $546/acre, with a range of $300 to $800/acre. The corresponding internal rate of return (IRR) averaged slightly over 10 percent, with values ranging from 8 percent to 12 percent.

The combination of thinning every 5 years and the production of high-valued poles allowed fairly long rotations to be economically efficient in the analysis. The average optimal rotation age was 40 years. Site quality was a key determinate of stand value; the higher the site index, the larger the LEV, and the lower the site index, the lower the LEV.

Longleaf may be the best kept financial secret in Southern forestry. Conservative analyses show decent after-tax financial returns for longleaf management. Missing from these calculations are gains from intensive management such as intensive site preparation and fertilization, intensive utilization of the resource through pine straw harvesting, and the many highly-valued ecological values present in a thriving longleaf pine ecosystem.

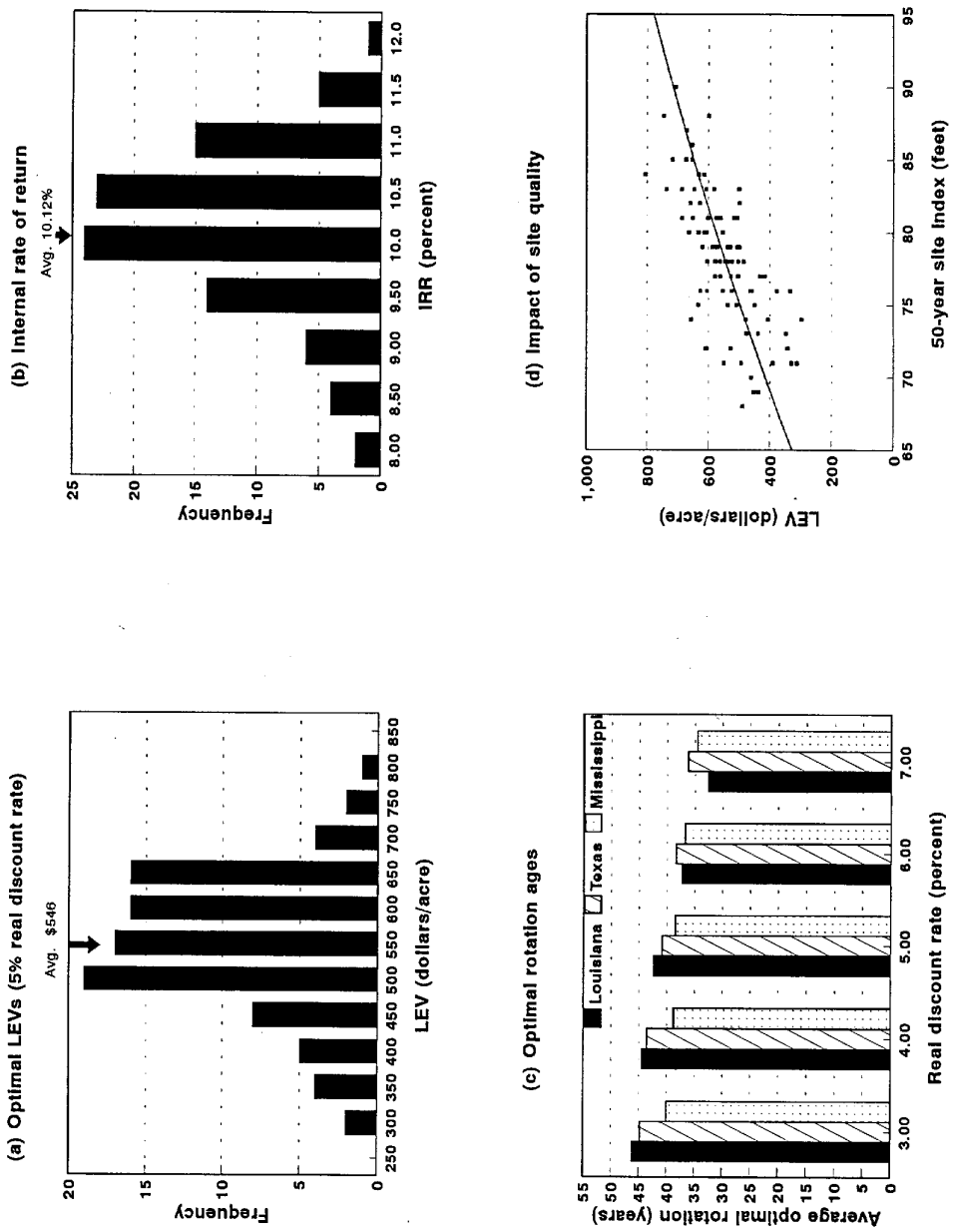

Figure 1.—Summary of key data on investments longleaf pine plantations.

William D. Boyer (U.S. Forest Service, Southern Research Station, Auburn University, AL)

Introduction

One of the principal southern pines, longleaf (Pinus palustris Mill.) is the key tree species in a fire-dependent ecosystem. In pre-settlement times, longleaf pine forests covered much of the southeastern United States. Once the most extensive forest ecosystem in North America dominated by a single species, longleaf pine now occupies only about 3 percent of its former range.

Longleaf pine is a very intolerant pioneer species. But it has none of the characteristics normally associated with early successional species that depend on prolific seed production, wide seed dissemination, and rapid early growth in order to quickly occupy and dominate an open site. Longleaf pine's adaptation to frequent fire, which its principal competitors cannot tolerate, has given this species its competitive edge, and has allowed it to maintain itself in place for thousands of years.

Longleaf pine has a reputation as a very slow growing species that is difficult to regenerate and so cannot economically compete with either loblolly or slash pines. This bias against the species plays a continuing role in its decline. But is this bias entirely justified? No, according to some evidence that has accumulated over the years.

An Inherent Bias Against Longleaf

A long-standing bias against longleaf pine is inherent in existing yield tables and site index curves which were derived from burned stands. While longleaf pine is a fire-dependent species, this dependence is not without its costs. Periodic fires slow the growth of longleaf, so these yield tables cannot reflect the performance of the species if free from fire. This bias has long been known but not widely recognized (Cary 1932, Stone 1942). Biennial burns in longleaf have resulted in significant reductions in both height growth and volume yield (Boyer 1994). Through stand age 36, cool winter burns have resulted in a 5-foot reduction in height, equivalent to a 6-foot reduction in age 50 site index. Total volume yield was 22 percent greater in unburned than burned stands. This is a substantial bias when comparing performance of longleaf with that of loblolly or slash pine.

Longleaf vs Longleaf

Longleaf pine is very sensitive to competition from any source. When free of competition, it is capable of relatively rapid early growth. Height-over-age curves for longleaf pine are significantly affected by degree of planting site competition control (Boyer 1983). By age 10, for plantations with an age 25 site index of 60 feet, longleaf on old fields will have a 5-foot height advantage over longleaf on unprepared cutover sites. This 5-foot advantage, however, disappears by age 25. Longleaf made up for its slow start by more rapid growth later on. This ability to make up for a slow start has also been observed with delayed release (Boyer 1985). Some naturally established seedling stands were released from overtopping hardwoods at age one, others at age 8. Delayed release retarded early growth, but a check at age 31 indicated no effect of delayed release on average tree height and diameter, or stand volume.

Longleaf planted on intensively prepared sites get a major jump on naturally established seedlings that must continuously compete with associated vegetation on the forest floor as well as with other seedlings, which may number from several to many thousands per acre. The growth of two plantations on intensively prepared sites was compared with development of natural regeneration (unburned, to remove that source of bias). At age 13, planted longleaf had a 13-foot height advantage over the natural stand. By age 26, the difference had closed to 5 feet. At age 13, volume of the natural stand was only 30 percent of that in the plantation. By age 20 it was 47 percent and by age 26 was 75 percent. At this rate, the naturals should catch up with their planted cousins by or shortly after age 30.

Longleaf vs Loblolly and Slash Pines

Much of the slow early growth of longleaf pine can be attributed to time spent in the grass stage. Loblolly and slash pines are free from such drawbacks, and their growth will far exceed longleaf for several to many years after establishment. However, an ability of longleaf to make up for its slow early start by more rapid growth in later years could reduce the apparent competitive edge of the other species on many sites. One example was from a study with side-by-side plantings of the three species on prepared sites in

Mississippi (Schmidtling 1987). While loblolly pine had an 8- to 9-foot height advantage at age 10, this advantage was gone by age 17, when longleaf passed loblolly, and was closing on slash pine by age 25. Another study had side-by-side comparisons of these species planted at 33 locations in Louisiana and Mississippi (Shoulders 1985). With yields adjusted for differences in initial planting survival, by age 20 there was no significant difference in volume yields between longleaf and loblolly pine at 82 percent, and between longleaf and slash pine at 53 percent of the locations. Yields of loblolly and slash were greater at the remaining locations. Of course, at age 20, longleaf is still making up for its slow start. This study indicated that as site quality declines, the performance of longleaf improves relative to the other species. In side-by-side plantings on sandhill sites in Georgia and South Carolina, longleaf had gained an average 6- to 11-foot height advantage over the other two species by age 28. (Outcalt 1993).

Conclusions

1. There is an inherent bias in existing yield tables and site index curves for natural longleaf pine due to growth reductions associated with periodic fires.
2. Slow early growth of longleaf is made up by more rapid growth later.
   a. Within-species comparisons. Longleaf can make up for:
      1) Early differences due to site preparation intensity.
      2) Early differences due to delays in release.
      3) Maybe differences between planted and natural stands.
   b. Comparisons with loblolly and slash pine.
      1) Good sites: longleaf growth poorer.
      2) Average sites: longleaf growth equal or better.
      3) Poor sites: longleaf growth better.
3. Early longleaf growth reduced by competition.
4. Later and ultimate longleaf growth reflects site quality.
5. Growth habits of longleaf are such that early growth differences, which reach a maximum at about age 10-12, are misleading and cannot be used to judge effects of cultural treatments or make valid species comparisons. Such judgments should be deferred until stands reach at least 25-30 years of age. By that time longleaf's catch-up mode should be fully revealed.

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An Incentive Program to Enhance Conservation of Longleaf Pine and Red-Cockaded Woodpeckers on Private Land: The Case of Safe Harbor

Ralph Costa (U.S. Fish and Wildlife Service, Department of Forest Resources, Clemson University, Clemson, SC)
Elizabeth T. Kennedy (Environmental Science and Policy Program, Strom Thurmond Institute, Clemson University, Clemson, SC)

INTRODUCTION

The concept of safe harbor was first implemented in the Sandhills physiographic province of North Carolina as an effort to enhance conservation of the endangered red-cockaded woodpecker (*Picoides borealis*) (RCW) and provide participating private landowners with alternative management opportunities in the future. The Sandhills of North Carolina is one of the few remaining areas of private land with extensive stands of longleaf pine. Approximately 25% of the RCW groups in the Sandhills occur on private lands while the remaining 75% reside on public land, including Fort Bragg military installation and the Sandhills Game Lands. The range of the RCW is closely tied to the distribution of the longleaf pine ecosystem in the southeastern US; currently 4694 groups are known (Costa and Walker 1995). Their present distribution is restricted to fragmented parcels of suitable pine forest in 12 southeastern states. RCWs are a territorial, non-migratory, cooperative breeding species, forming groups of up to 7-9 members, but more typically three to five with only one breeding pair per group (Lennartz et al. 1987, Walters et al. 1988). The RCW excavates roost and nest cavities in older living pine trees (typically 80-100 years old), and forages almost exclusively on pine.

In addition to the existing safe harbor permit in the Sandhills, the concept is presently being promoted with, and pursued by, at least three additional groups of private landowners: (1) industrial forest landowners seeking memorandums of agreement with the U. S. Fish and Wildlife Service (Service), (2) larger, non-industrial forest landowners, and (3) smaller, private landowners seeking inclusion in statewide safe harbor conservation agreements currently being developed in Alabama, Georgia, Louisiana, South Carolina, and Texas.

PURPOSE AND DESCRIPTION OF THE PROGRAM

By removing the fear of future regulatory, legal, and economic consequences, associated with additional RCWs becoming established on private property, the safe harbor program encourages conservation and restoration of longleaf pine habitat, which in turn can lead to increases in RCW populations. It is a proactive strategy which encourages voluntary habitat improvements by private landowners in advance of any specific project that could adversely affect RCWs. The safe harbor program is designed to result in at least no net loss of existing RCWs over time on the participating landowner's property.

Landowners who wish to participate sign a cooperative agreement with, and are issued a permit by, the Service or a representative state agency which states what RCW habitat enhancement actions will be carried out on the property. The habitat enhancement activities may include clearing hardwood midstory trees, prescribed burning, and installing artificial roost/nest cavities. Upon ensuring the protection and management of habitat for existing birds on the property (called "baseline" responsibilities), landowners can in the future, develop, harvest trees, or pursue other uses of their property, unencumbered by legal responsibilities for any new groups of RCWs created on, or attracted to, the land because of the habitat improvements (U.S. Fish and Wildlife Service 1995). In other words, participating landowners are required to maintain only the habitat for the number of RCW groups, if any, initially documented on their property (e.g., the "baseline") at the time of signing the agreement.

The primary incentive of the safe harbor program is to reduce the uncertainty of future land management options for the private landowner with existing or potential RCW habitat. It removes the regulatory disincentives that currently prevent many landowners from carrying out actions that could benefit the bird and other species in the longleaf pine ecosystem (U.S. Fish and Wildlife Service 1995). The plan provides security for the landowner's investments in the timber stand and RCW habitat. Specifically, a safe harbor permit guarantees a landowner that any additional RCWs that occupy his/her property, as a result of the landowner's beneficial land management practices, will not result in any additional Endangered Species Act (ESA) responsibilities (U.S. Fish and Wildlife Service 1995). Essentially, the landowner has a permit for future incidental take of RCWs not currently occupying their property.

If new RCW groups become established on any participating landowner's property, and the landowner in the future desires to utilize the land for purposes that would adversely affect these new, non-baseline, RCW groups, the landowner must only adhere to three requirements: (1) RCWs may not be shot, captured, or otherwise directly "taken", (2) the activity must be scheduled to take place outside the breeding season unless otherwise authorized by the Service, and (3) the landowner must give the Service a 60-day advanced notice and an opportunity to capture and translocate any RCWs that may be potentially affected by the habitat altering activities (U.S. Fish and Wildlife Service 1995).

RESULTS

The success of the Sandhills safe harbor program is impressive. In the first 22 months of its implementation, 24 landowners have enrolled 21541 acres in the program. These landowners currently harbor, in whole or in part, the nesting and foraging habitat of 46 RCW groups and can potentially support in the future an additional 61 groups. An additional 13 landowners currently preparing to enroll in the Sandhills safe harbor program, harbor in whole or in part the nesting and foraging habitat for 11 RCW groups, and can potentially support another 21 groups on their 9002 acres. Most of the existing baseline groups are part of the designated Sandhills of North Carolina RCW recovery population. Their protection and management, via incorporation into the safe harbor program, substantially increases the security of this potential recovery population and therefore the probability that it can indeed reach recovery status. The creation of additional RCW groups, e.g., above the baseline, under the program will further stabilize this important recovery population.

DISCUSSION

Conservation Benefits

The safe harbor program provides several tangible and intangible conservation benefits. First and perhaps most importantly, it has resulted in direct habitat improvement and maintenance for all baseline RCW groups enrolled in the program; this habitat management is a condition of the permit. Second, and perhaps as important, the program will result in at least a short term, but more likely a long term, increase in the number of RCW groups in the population. These increases, even though potentially transitory in nature, help to stabilize existing populations, while simultaneously buying time for the investigation and development of other, perhaps more permanent, conservation strategies and measures (U.S. Fish and Wildlife Service 1995). Additionally, the program promotes conservation and management of significant local and regional longleaf pine habitat, even if RCWs do not currently occupy the property/habitat enrolled.

In addition to the above conservation/ecological benefits, Costa and Kennedy (in press) point out that the safe harbor program has also produced several intangible benefits:

1. elimination or reduction of fear often associated with federal laws and/or policies regarding endangered species conservation/recovery,
2. minimization of the negative attitudes and rhetoric that are sometimes associated with either a listed species or the ESA itself, when recovery programs come into conflict with real or perceived human needs and values, and
3. cooperation among and between the private, state, and federal sectors interested in, and/or responsible for, conservation of the RCW, resulting in consensus via effective communication between, and thoughtful compromise among, the parties involved.

Economic Benefits

Costa and Kennedy (in press), suggest that from an economic perspective, the safe harbor program can provide the following benefits:

1. reduction of uncertainties of current direct costs, opportunity costs, and future protection costs,
2. promotion of a "good neighbor" policy, which reduces the probability of imposing a negative externality on neighbors of landowners with RCWs,
3. potential for increased and/or diversified revenues by encouraging a more complete range of forest management options to private landowners, and

4. potential for participating landowners to receive direct income by serving as a mitigation bank under a habitat trading program (Bonnie and Bean 1996).

Application

While there is no doubt that the safe harbor concept could be used with other listed species and their habitats, there are several factors to be considered in assessing its application for other species. Cantrell et al. (in review) point out that it is important to:

1. understand the life history and ecological requirements of the target species,
2. assess the role of private land habitat to the recovery of the species in question,
3. evaluate the need for active versus passive habitat management,
4. be sensitive to the needs of the landowners sharing their property with the listed species, and
5. identify and secure funding sources sufficient to successfully implement the conservation program.

Cantrell et al. (in review) offer some precautions regarding the application of safe harbor on private lands:

1. there may be no compatible land use options for which landowners may voluntarily improve habitat for some species or natural communities,
2. conservation programs should not rely solely on voluntary and transient habitat protection for listed species recovery, and
3. beware of habitat sinks.

Recommendations

It is important to note that the success achieved to date with RCW conservation using the safe harbor concept has been accomplished without any specific written policy or new legislation. The viability and success of this process was founded in the mutual understanding that all parties with an interest in the outcome of the conservation planning process would be allowed, and indeed encouraged, to participate. Similarly, potential and existing private sector partners (i.e., safe harbor participants) should be further encouraged and rewarded through the development of additional incentives for voluntarily acting in a manner which enhances the protection and conservation of RCWs and other listed species (for example, see The Keystone Center 1995, Kennedy et al. 1996). Several key elements which incentive-based programs, designed to further listed species conservation and recovery, should consider, are:

1. encouraging cooperative partnerships (i.e., statewide RCW conservation coalitions) between multiple stakeholders which allow ownership in a conservation incentive program and its implementation,
2. providing legal and financial certainty for landowners, which allows them to base investment decisions on sound information and future predictability,
3. ensuring that incentive programs are financially feasible for the landowner, relevant government agencies, and other involved parties, and
4. designing programs to be easily understood and implemented, consistent yet flexible, and voluntary.

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Plan for Success with Longleaf Pine

David S. Lewis (Southern Forestry Consultants, Monticello, FL)

Every forest landowner should have a management plan, preferably a written one. This is especially true when dealing with longleaf pine because it requires more care and precision than the other major Southern commercial species, slash and loblolly pine. This is a lot like comparing cattle and horses -- cattle require basic needs such as feed, water, and salt, but horses require more attention in order to flourish. Such is the case with longleaf pine. A landowner needs to plan ahead and cover all of the requirements of the species in order for it to flourish. It is not that difficult of a task if the proper planning is done.

First of all, before longleaf pine is planted or encouraged, is it the best species for the given situation? Growing longleaf pine generally requires more patience and a longer perspective to reap its benefits. Is the site well-drained enough for longleaf to grow? It will eventually catch and outgrow slash or loblolly pine on sandy sites, but it usually takes it at least ten years to do so. it will produce higher grade products than sand pine, but it will take more years to get to that point. So, a landowner must have the patience to establish and manage longleaf and to wait for it to mature enough to produce the high grade sawtimber and pole timber that it is noted for.

The landowner should examine his or her objectives and expectations carefully to see how longleaf fits into their picture. For example, if a landowner enjoys quail hunting, longleaf may be a good choice because it does not grow as densely or as evenly in height. However, for the landowner looking to thin before age fifteen, longleaf is going to be a poor choice. The landowner must also be prepared to be meticulous and persistent as well as flexible. The practices may be needed to ensure success, such as herbicide treatments or prescribed fire. The landowner should be prepared to take the necessary steps to successfully grow longleaf and to follow through. A landowner generally cannot just plant it and forget about it for many years, and managing a natural stand through natural regeneration requires constant attention and manipulation. some landowners just aren't up to that.

Longleaf growers can be divided into two categories -- Those who have existing longleaf stands and those who wish to establish new longleaf stands. Some landowners fit both of these descriptions. In most cases, forest landowners with existing longleaf stands should develop an uneven-aged management strategy while relying on natural seeding to regenerate the stand. This is accomplished though the use of regular prescribed fire, light but frequent harvests, and possibly the use of other silvicultural tools such as herbicides or mechanical equipment. The timing and intensity of prescribed burns can be crucial to promoting and protecting natural regeneration. Harvests must be done with great care to select the right trees to cut and to protect existing regeneration.

Those landowners wishing to start a new longleaf stand or replace one that has been clearcut should have a plan in place that will do everything possible to ensure success. Each site is different and may require different treatments; however, this writer has found that there are several keys to success in planting bareroot longleaf. They are:

(1) Plant early in the planting season, if possible
(2) Plant fresh trees only ("hot plant")
(3) Find good medium sized seedlings
(4) Use a planting contractor experienced with longleaf
(5) Machine plant with a non-automatic (old style) planter
(6) Plant on an undisturbed or packed site (i.e., scalped field or herbicide site)
(7) Depth must be precise

The best action a private forest landowner can take to ensure his or her success is to develop a management plan to accomplish the goals they wish to attain. This should be done with the help of a consultant or other resource professional who is experienced and familiar with planting, growing, and managing longleaf pine. How does a landowner know who to hire? They should start by reviewing their credentials? Do they have conflicts of interest? Most importantly, do they have experience with longleaf? A landowner should ask to see other longleaf stands that the practitioner has established or been managing. They should talk with other landowners or clients the consultant has worked for and is currently working with.

the landowner should keep in mind that the person they are hiring should be experienced with longleaf pine specifically. Remember, this is a different animal that is being dealt with. Look for the proof that is in the results of their work.

There are many benefits from retaining the services of a good consultant. He or she can take care of many of the details that are involved in establishing and managing longleaf. often this requires daily supervision or effort to carry out such practices as timber harvesting, prescribed burning, tree planting, and herbicide application. The consultant should also be certified to prescribed burn and apply herbicides. He or she will also be knowledgeable of and sensitive to increases and decreased in the timber market, and will be able to advise the landowner when market conditions are favorable. The consultant will often be able to obtain a better price for the timber because he can time the market better, has a more thorough knowledge of who the buyers are, and will command more respect from prospective buyers. The consultant will also have more leverage as to performance from logging, planting, site preparation, and other contractors. These contractors know that future work hinges on their performance which gives them an incentive to do a better job, and often do the work at a better price. In general, a consultant will more than pay his or her way by getting jobs done more efficiently and more cost effectively.

Once the landowner has settled on who they want to help them reach their goals and objectives, they should develop a plan of action or management plan. This plan should be very specific but at the same time flexible. For example, the plan may call for a prescribed burn but should specify what type and under what conditions it should be conducted. However, if the fire is for seedbed preparation to encourage natural regeneration and there is a poor cone crop, it should probably be postponed for a year. Or if the plan calls for a selective harvest of a mature natural stand but the timber market is in a slump, the sale might be postponed until the market improves. So the landowner should be persistent but still remain flexible in carrying out his/her plan.

The landowner should rely on his professional help to guide him or her as the plan is followed. It should be updated every five years in most cases. The landowner should be honest and forthright about his or her goal, objectives and expectations. A regular channel of communication should exist between the landowner and the resource professional and periodic inspections of the property should be carried out. the resource professional should be aware of new research findings, market conditions, cultural practices, harvesting options, and weather trends, and he or she should relay these to the landowner. Ideally, a scheduled meeting on the property should take place at least once a year. this allows questions to be asked, information to be disseminated, objectives to be reviewed, and plans to be modified. It keeps that channel of communication open.

CONCLUSION

Planning is always a pre-requisite to success, but this is especially true when dealing with longleaf pine. the needs of the species are unique and more specific than slash or loblolly pine. Every landowner should have a written management plan developed with help of a qualified resource professional. in the case of dealing with longleaf pine, that resource professional should have experience and knowledge in dealing with longleaf. The plan should be specific in its recommendations but remain flexible in its application. Adjustments to the plan should be made at annual (or more frequent) reviews of the property.

Markets, Strategies, and Incentives*: A North Carolina Perspective*

Mark A. Megalos (North Carolina Cooperative Extension Service, Raleigh, NC)

ABSTRACT: The resurgence of longleaf pine in North Carolina has resulted from a coordinated effort from a varied group of conservation groups, agencies and industry groups. A significant increase in acres planted in longleaf has occurred through a combination of market forces (longleaf pinestraw production), advances in longleaf seedling cultural practices, seedling quality control, an emphasis on containerized seedling and proactive reapportionment of reforestation incentive programs. The N.C. Cooperative Extension Service and a host of partners have supported a strong longleaf pine restoration educational effort to guide and strengthen a statewide longleaf initiative. This paper reviews the collective action of a dedicated group of professionals and interested individuals who have made longleaf a viable and even preferred choice for many N.C. landowners.

Background: North Carolina has a had a long and varied history of use, abuse and exploitation of the longleaf forest resource. From the early naval stores production, unrestricted logging and uncontrolled grazing large expanses of longleaf were pushed to droughty, low productivity, fire-prone Sandhill areas. As stated in the recent N.C. Division of Forest Resources internal restoration of longleaf pine initiative document:

"Heavy cutting of the original forest began in the 1800's as land clearing for agriculture and culminated in the intensive lumbering of the first two decades of the 20th century. Less than 200 hundred years ago the longleaf pine ecosystem was dominant in the Coastal Plain and lower Piedmont, covering an estimated 8.3 million acres. Today the longleaf pine timber type has dwindled to a mere 255,000 acres. As a result, the environment in North Carolina has lost much of the incredibly rich and diverse flora and fauna which were adapted to the conditions that accompanied the longleaf pine forest. Moreover, the economy of the state has lost the extremely valuable asset of the multiple forest products which can , with management, flow from this single species."

THE AWARENESS STAGE: The community of longleaf supporters in North Carolina, while presently fairly unified, had its most vocal start from the professionals who had studied and revered it the most, primarily botanists and taxonomists. These forward looking individuals marveled at the complexity and diversity of the states dwindling longleaf forests. In the vast effort to classify and document the extent and condition of longleaf forest in the state, they soon realized the need to protect, restore and increase the public's awareness and support for restoring longleaf to its former glory. Largely due to the efforts of the staff of the N.C. Natural Heritage Program and interested biologists from the N.C. Wildlife Resources Commission, the first longleaf workshop was held in the Sandhills in the late 1980's. Several meetings followed and a consensus soon formed for the need to manage and "protect" the longleaf forest. The reasons for protection and restoration were as varied as the disciplines that were represented: for the botanists - it was the plant community; for the biologist - it was the wildlife, endangered and game alike; for the foresters - it was the timber; for the farmer/landowner - it was the pinestraw; and for the developer/realtor - it was the beauty that brought them to the table.

THE SUSPICION STAGE: All was not always cooperative among groups within the longleaf camp. The impacts of extractive uses were a concern to many in North Carolina and across the region. It was clear that more information was needed about the true impacts of pinestraw harvesting upon plant communities and nutrient pools within longleaf pine systems. There was an almost universal call for research. In fact, the production oriented pine needle producers were some of the first to offer research funds to probe some of the pressing issues regarding nutrients and plant diversity following repeated harvesting and the use mechanical systems within the longleaf forest.

A meeting of researchers and others concerned with the future of the longleaf resource was held at N.C. State in the early 1990's. Research concerns were aired and priorities established. Outcomes included a masters level study of nutrient management in longleaf stand and a doctoral dissertation on plant communities that both indicated that pinestraw raking, when judiciously conducted, need not harm the longleaf ecosystem.

THE COOPERATION STAGE: With exciting research and technology transfer occurring in the field it was important to have an avenue to deliver the new information to all interested parties. A series of statewide longleaf workshops were held in cooperation with various agencies and, organizations and industry

supporters through the NC State University, College of Forest Resources Office of Outreach and Continuing Education and Extension Forestry. Over the last five years workshops with attendance of 200- 250 interested individuals have become the focal point of the longleaf restoration and management movement within the state. Initial topics focused on the need for restoration of longleaf, the importance of the resource and research findings. This year's focus will be quality control and successful artificial longleaf regeneration.

The process has nearly come full circle in the last 6 or 7 years when the focus was solely on awareness and a call to action....now the emphasis is on the concrete steps needed to reestablish longleaf pine effectively and across all acres. The strong message is that we can have it all....pinestraw production, diverse wildlife habitat, thriving plant communities, and endangered species, provided we get the longleaf canopy in place and thriving first.

THE LONGLEAF INITIATIVE: Great things don't happen in a vacuum, nor without the insight and daring of committed individuals. While longleaf has clearly advanced on the merits of many individuals, one stands out above the crowd. State Forester, Stan Adams, has been the vocal proponent of a longleaf initiative that has called for the cooperative steps required to reestablish longleaf in a prompt, deliberate manor.

The initiative has two basic goals:

1) Expand the longleaf timber type through reforestation, and
2) Expand Production of bareroot and containerized seedlings.

Accomplishments:

Workshops and training targeted to landowners, foresters and tree planters.

Expanded containerized seedling capacity to 2.5 million seedlings.

Developed an additional 10 acres for field production of seedlings.

Purchased additional outside seed and identified new seed production areas.

Table 1. LONGLEAF PLANTING ACREAGE BY YEAR

1992	1993	1994	1995
2,500	**3,592**	**4,164**	**5,862**

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POSTER PRESENTATIONS

September 17, 1996
5:30 - 7:00 pm

September 18, 1996
10:00 am - 12:00 pm

Pregnant Bubbles: A Video-Graphics Approach to Smoke Management

Gary L. Achtemeier (USDA Forest Service, Southern Research Station, Juliette, GA)

ABSTRACT - Fire is a fundamental component of the Longleaf Pine ecosystem. As land managers seek to restore the Longleaf Pine at sites throughout the South, prescribed fire will be an integral part of their plan. However, the effects of prescribed fire on air quality are a serious concern. Visibility reductions caused by smoke or a combination of smoke and fog have been implicated in multiple-car pileups, numerous physical injuries, heavy property damage, and fatalities. As the Southern states become more populated and the numbers of tourists driving to resort areas in Florida and along the gulf and Atlantic coasts increases, the number of accidents related to smoke and fog can only be expected to increase. The mild, mostly snow and ice free winters make the Southern climate ideal for the development of retirement communities. Thousands of older people, many with respiratory problems, have relocated into southern communities. Many of these retirees have little or no experience with forestry practices. As many new subdivisions are built into forest lands, the wildland/urban interface problem becomes one of smoke in addition to wildfire. There is now a great deal of interest in restoring longleaf pine to many of the sites where it originally grew. Unless more prescribed burning is done during marginal burn conditions, increasing the use of prescribed fire for ecosystem management will add smoke to that already produced by existing burning programs. In either case, the smoke problem may place in jeopardy plans to restore fire-dependent ecosystems such as the longleaf pine. We have developed a numerical smoke movement prediction model called Pregnant Bubbles to simulate the nighttime movement of smoke over complex networks of ridges and valleys and shallow drainage basins characteristic of the Piedmont and Coastal Plain of the South. The convergence of faster, bigger computers with Internet information systems makes models of the complexity of Pregnant bubbles a reality. The first operational version, expected to be ready by the end of 1997, will monitor smoke movement. When numerical weather prediction data become available from the National Weather Service over the Internet, Pregnant Bubbles will be configured to give short-term forecasts of smoke movement. The prototype model successfully simulated movement of smoke over 14 hours to two locations in different drainage basins thus proving the modeling concept workable. Computer simulations from both the prototype and operational versions will be demonstrated.

INTRODUCTION

There is now a great deal of interest in restoring longleaf pine to many of the sites where it originally grew. Longleaf pine was once the predominant species in the lower coastal plain of the South. However, the longleaf pine ecosystem is a fire-dependent ecosystem and unless more prescribed burning is done during marginal burn conditions, increasing the use of prescribed burning is done during marginal burn conditions, increasing the use of prescribed fire for ecosystem management will add smoke to that already produced The probability of smoke “incidents” rises in either case of increased atmospheric loading or burning during marginal burn conditions. Thus the smoke problem may place in jeopardy plans to restore fire-dependent ecosystems such as the long-leaf pine.

The effects of prescribed fire on air quality are a serious concern. Visibility reductions caused by smoke or a combination of smoke and fog have been implicated in multiple-car pileups, numerous physical injuries, heavy property damage, and fatalities. As the Southern states become more populated and the numbers of tourists driving to resort areas in Florida and along the Gulf and Atlantic coasts increases, the number of accidents related to smoke and fog can only be expected to increase.

The mild, mostly snow and ice free winters make the Southern climate ideal for the development of retirement communities. Thousands of older people, many with respiratory problems, have relocated into southern communities. Many of these retirees have little or no experience with forestry practices. Furthermore, some developers make their subdivisions more attractive by promoting them as adjacent to managed private and national forest - the big back yard concept. Land managers face a dilemma. As many new subdivisions are built into forest lands, the wildland/urban interface problem becomes one of smoke in addition to wildfire.

Understanding and eventually predicting the movement of smoke at night over lands of differing elevation and varying land use requires knowledge to answer the following three questions:

1) Where does the smoke go?
2) How much gets there?

3) What kind is it?

Winds at night can become extremely weak. However, there is no such thing as “calm”. Air is always in motion and smoke will always be carried somewhere. During a typical 10-hour nocturnal period, a wind of 1 mph will carry smoke 10 miles. That’s enough to bring smoke across a roadway in most areas of the South.

Pregnant Bubbles - Model Description

Pregnant Bubbles combines a wind prediction model and a particle plume model to answer the firest two questions. The wind model, named SNAF for Slow Nocturnal Air Flow, was designed to follow “the pathways smoke follows” through valleys and basins, particles from the burn site, particles which are carried by the near-ground winds. Then, to improve on diffusion and dispersion at these very slow wind speeds, the particles periodically give birth to “daughter” particles which can be carried away in diverging air currents. The concept of a multiplicity of particles of “bubbles” having been birthed from existing particles, gave rise to the name “Pregnant Bubbles”.

A theoretical description of Pregnant Bubbles is beyond the scope of this paper. Those interested in some of the mathematics of the model should refer to Achtemeier [(1991), (1993)].

The concept of Pregnant bubbles was tested with a case for which smoke was implicated as a factor in an accident in western Georgia on October 20, 1986 (Achtemeier and Paul, 1994). This area of the Piedmont is cut by numerous streams. Elevations between stream basins and ridge tops ranged from 80-150 ft. With actual weather data as input, Pregnant Bubbles simulated smoke movement near the ground from just before sunset on October 19 to 7AM on October 20. The model correctly placed smoke at the accident site at the time of the accident and also at the site of an observer on a different road at the time smoke was observed.

Pregnant Bubbles showed us that the meteorology of drainage flows through shallow basins of the Piedmont is at least as complex as the basins through which the air flows. Factors such as orientation of side valleys with main valleys and orientation of these with respect to prevailing winds were critical to the solution. Intruding ridges that narrowed valleys locally, and small gaps in ridges separating valleys acted to complicate smoke movement. These positive result encouraged us to expand Pregnant Bubbles into an operational model.

During the past 5 years, advances in computer and communications technology have caught up with the data and computational requirements of Pregnant Bubbles. We are planning to assemble Pregnant Bubbles into an user-friendly modeling system that can link weather data through Internet with the user’s GIS elevation and land-use data bases to monitor and/or predict smoke movement at night. This plan is summarized schematically in Figure 1. At present, observed weather data are available to allow accurate forecast weather data should become available for Pregnant Bubbles to predict smoke movement.

Role of Land Use on Smoke Movement.

Under clear skies and light wind conditions at night, drainage flows can be fairly predictable. But in areas of the coastal plain with little or no variation in elevation, differing land use factors such as aerodynamic drag and radiation excite weak air currents that can transport smoke to unexpected locations. One example, a computer simulation of airflow over an open rectangular field surrounded on four sides by forest, was presented at the meeting of the Longleaf Alliance in Mobile, Alabama, in September 1996. This empirical data set contained no elevation. The only variable was land use.

The results of one simulation are shown schematically in Figure 2. Initially, in the well-mixed conditions of late afternoon, strongest winds blew left to right across the field and through the trees at the right (top panel). Larger aerodynamic drag caused by trees caused by trees forced the air to rise above the trees in addition to blowing through the trees. Smoke was carried downwind across the field and though and above the trees beyond it.

Vertical mixing ceased after sunset (second panel). Winds continued to blow from left to right across the field although aerodynamic drag greatly slowed wind speeds. A weak inversion formed over the field in response to greater outgoing radiation (faster cooling) there. Cooled air dammed up next to the trees at the

downwind end of the field. Some smoke continued through the trees but most became trapped over the field.

In the third panel, weak pressure forces within the cold air trapped at the downwind end of the field overcame the prevailing flow. The cold air surged back across the field from right to left carrying smoke with it. The wave passed the burn site (bottom panel) and smoke was carried with it into the woods in the previously upwind direction. The wave dissipated after penetrating the woods by approximately 100 m leaving in its wake weak, disturbed circulation's within the inversion over the field.

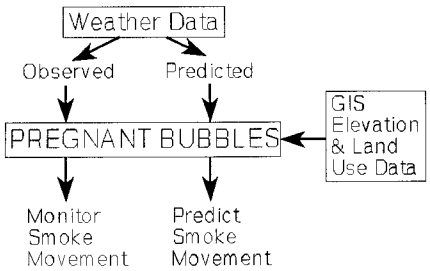

Figure 1. GIS elevation and land use data will be combined with weather data to monitor and/or predict smoke movement.

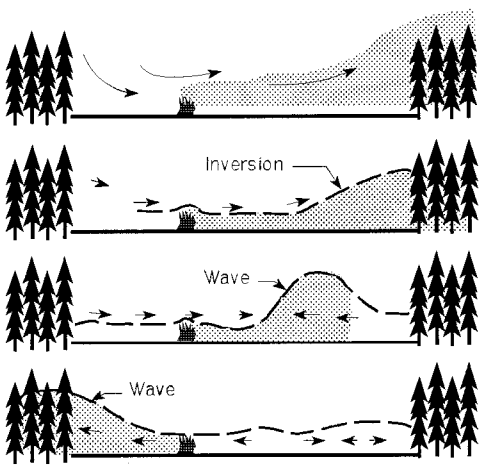

Figure 2. Schematic showing winds across an open field during day (top panel), smoke entrapment and inversion formation (second panel), surge of cold air with smoke back across the field (third panel), and movement of smoke into trees upwind of burn site (bottom panel).

SUMMARY

Our investigation into the movement of air over the Piedmont and the Coastal Plain during near-calm conditions at night using Pregnant Bubbles continues to uncover small circulation's that can transport smoke into unexpected directions. Whether many of these circulation's actually exist remains to be verified. The model simulations increase our understanding of local nocturnal circulation's and will help us educate operational foresters on local wind-generating phenomena. However, specific information on where smoke goes on any given night awaits an operational version of Pregnant Bubbles linked to current weather data and GIS elevation and land use data.

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Operational Longleaf Pine Management at Ichauway

Jimmy Atkinson (Joseph W. Jones Ecological Research Center, Newton, GA)
Jean Brock (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Robert Smith (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)

ABSTRACT - The Joseph W. Jones Ecological Research Center at Ichauway is a 29,000-acre site in southwest Georgia managed for research, education, and conservation. There are almost 15,000 acres of longleaf pine dominated sites (approximately 10,000 acres have a wiregrass component in the understory) along with other pine species, xeric and mesic hardwoods, associated wetlands, and a variety of other habitats. The pine forests were important resources for the timber and naval stores industries through the early 1900's. The area was managed for quail, timber, and agriculture from 1928 through the early 1990's. Current management emphasizes applied ecological research while making sustainable use of the property. Ten to fifteen thousand acres are prescribed burned each year; currently most fires are applied in the traditional dormant season, though an increasing number are in the growing season. Natural regeneration, bareroot seedlings, and containerized seedlings have been used to regenerate longleaf pine. Annual longleaf cone collections are made to provide seed for direct seeding and contract production of containerized longleaf pine seedlings. Operational trials for restoration of agricultural fields using containerized longleaf pine and wiregrass seedlings have been conducted. Timber harvesting is currently limited to special circumstances while management plans are being finalized. Research support, native ecosystem maintenance, quail management, deer management, and endangered/threatened species management are some of major management emphases on the property.

INTRODUCTION

The Joseph W. Jones Ecological Research Center at Ichauway is a 29,000-acre site in southwest Georgia managed for research, education, and conservation. The site has almost 15 thousand acres dominated by longleaf pine with the remaining acres supporting associated wetlands, slash pine, upland and bottomland hardwoods, and a variety of other habitats. The site contains a mixture of virgin groundcover and oldfield groundcover; there are almost 10,000 acres with a wiregrass component in the understory.

For management purposes, the property is being divided into two types of zones. The traditional zones will be managed to maintain and enhance harmonious, inter-related patterns of land use and sustainable productivity of game and non-game wildlife, timber, and agriculture. The benchmark zones will be managed to conserve the natural ecosystems and associated elements of biological diversity over time, and to restore, to the extent possible, the structure and function of a natural landscape. Currently, the landscape is managed for research, endangered/threatened species, and bobwhite quail. A timber management component will be added in the future.

Historical Property Management

The longleaf pine and other forests on site were important resources for the timber and naval stores industries through the early 1900's. The first commercial timber harvesting probably occurred in the mid- to late 1800's. Babcock Timber Company maintained a narrow gauge railroad for timber harvesting from the late 1800's through 1910 on the site. The area was also heavily turpentined as is evidenced by piles of thousands of turpentine cups found in the woods. Peckerwood sawmill operations and timber sales were scattered through the site from 1928 until at least the mid-1950s.

From 1928 through 1991, the property was managed primarily as a quail shooting plantation with revenue from agriculture and timber harvest. There were timber sales on the property every year from 1962 until 1984 with average annual harvests ranging between 1 and 2 million board feet. From 1988 to present, harvest has been limited to firewood, trees that threatened roads or powerlines, and clearing for construction.

From 1991 to present, the property has been managed primarily for applied ecological research while making sustainable use of the property. The intention is to manage a portion of the property mimicking natural structure and function and a portion of the property featuring timber and wildlife utilization without negatively impacting potential long-term ecologic values.

Fire

An average of 10 to 15 thousand acres is burned each year. The intention is to keep the fire type habitats under a three-year rough until the management plan is finalized. Currently most fires are applied in the traditional dormant season, though an increasing number are growing season fires for research or wiregrass seed production. Approximately 8000 acres were burned in the summer of 1987 for seedbed preparation during a large longleaf pine mast event.

Regeneration

Natural regeneration, bareroot seedlings, and containerized seedlings have been used to regenerate longleaf pine on the Ichauway site. During 1978 and 1988 significant acreage of bareroot longleaf and bareroot slash pine were planted in agricultural fields with lower productivity and in unused pasture. During the 1987 seed year approximately 8000 acres were naturally regenerated using a summer site preparation fire.

Annual longleaf pine cone collections have been made since 1991 to provide seed for research, direct seeding, and contract production on containerized longleaf pine seedlings. From 1992 to present, containerized longleaf pine seedlings produced from on-site seed have been planted. These seedlings have been used for both research and operational planting. Operational trials or restoration of agricultural fields using containerized longleaf pine and wiregrass seedlings have been conducted. These seedlings are typically hand-planted in spirals approximating a 12 x 15' spacing. Strips of longleaf pine have been planted across agricultural fields to reduce field size, improve quail habitat, and increase connectivity of pine stands. These operational plantings are typically machine or hand planted in rows at approximately a 10 x 12' spacing. Entire agricultural fields near the river and creek and fields that are counter productive have been planted. A visual screen has been planted adjacent to major roads in agricultural fields.

Site preparation in agricultural fields typically consists of harrowing to level field and allowing soil to settle and soil moisture to increase. When sites were sub-soiled and containerized seedlings planted in the furrow, survival was decreased, apparently because of air pocket development around roots. When seedlings are planted in a furrow now, they are typically packed using rubber-tired equipment after planting. In some fields, the site is prepared and wheat is drilled before the seedlings are planted. Competition control is maintained as necessary by mowing, harrowing, or chemical application until fire is prescribed for the stand.

More containerized planting, natural regeneration, and direct seeding is planned, especially on longleaf sites that are now dominated by off-site pines, hardwoods, or agricultural fields.

Harvests

Timber harvesting is currently limited to special circumstances while management plans are being finalized. Trees that are likely to cause a problem along major roads, powerlines, and building areas may be harvested. Trees that were in the footprint of buildings and roads at the new facilities were harvested. The timber from those trees was milled and used in construction of the new facilities.

Invasive hardwoods at old house sites, along field edges, and immediately adjacent to roadways are being selectively removed to restore fire-maintained vegetation in those locations. Pine plantations have also been thinned for a restoration research project.

As the management plan is finalized, we plan to implement uneven-age management system(s) in the traditional area. These systems will probably be based on patch/single tree selection.

Research support

Management of some of the longleaf pine on this site is to support specific projects that our research staff are conducting with longleaf pine, associated plant and animal species, endangered species, prescribed fire, or a combination of these and other topics. An area that was previously used as a pasture is now managed for longleaf cone collection; other areas are managed for wiregrass seed production. The seeds or seedlings produced from them are used in operational plantings and restoration research. Other work has looked at the plant diversity in longleaf stands on different sites. Some areas were burned seasonally, and oak seedlings and saplings excavated. Plots containing American chaffseed, an endangered plant species, were burned and mowed at different seasons to further our understanding of how to manage this species. With fire playing such an important role in longleaf management, most of the

studies, including many of those above, have a fire component. Fire impacts have included: fire exclusion, fire return interval, comparison of fire effects in old fields and in wiregrass, and season of burn characterizations including chemistry, temperature, and vegetative responses. Other work has involved thinning longleaf plantations and planting wiregrass plugs and seeds. Operational plantings have been made in October and January using both bareroot and containerized longleaf seedlings with varying herbicidal release treatments to provide for long-term research opportunities. All of the prescribed burns and seedling plantings are mapped and included in the Center's geographic information system for long-term documentation, management information, and production of maps.

Multiple Use Management System

Longleaf pine management and research are important components of the Joseph W. Jones Ecological Research Center at Ichauway. The research results being generated have impacts on: timber management, quail management, natural area management, restoration, prescribed fire management, and many other fields. The multiple use management system currently in place at Ichauway provides multiple resources. The principle resource provided is a diversity of habitats and conditions available for research projects to use to address basic and applied ecological and natural resource management questions.

The current standing stock of longleaf pine timber growing on the site is increasing. Highly productive quail and deer populations provide recreational or economic opportunities. Diverse non-game wildlife populations are also present. There are approximately 50 species on site that we consider to be endangered, threatened, special concern, or otherwise protected; many of them, including red-cockaded woodpeckers, indigo snakes, gopher frogs, flatwoods salamanders, and American chaffseeds, are associated with longleaf pine habitats.

CONCLUSIONS

Ichauway contains a diversity of habitats grading from longleaf uplands through hardwood uplands and slash pine flatwoods to bottomland hardwoods and grassy and cypress-gum limesink ponds. The rich cultural history and management of Ichauway has resulted in a landscape that is becoming increasingly rare today. Integrated management of the various habitats on site is necessary to meet the research, conservation, and education objectives of the Jones Center. Management of the longleaf system with fire, regeneration, restoration, and timber harvests is necessary to provide research opportunities, educational demonstrations, game and non-game wildlife habitat (including that for protected species), and timber in a productive and aesthetically pleasing environment.

Conservation Easements: Another Valuable Tool in Longleaf Pine Ecosystem Conservation

W. Wilson Baker (Red Hills Program, Tall Timbers Research Station, Tallahassee, FL)

ABSTRACT - For some large private landholdings, a conservation easement is a viable method of long-term conservation of longleaf pine forests. Easements can be a substantial financial incentive to the landowner and heirs. Within the Red Hills region between Tallahassee, Florida, and Thomasville, Georgia, more that 30,000 acres of mostly forested land on game plantations is under perpetual conservation easement agreement. Longleaf pine forest especially with intact natural understory vegetation is one of the main assets when assessing the conservation value of a property. These plantations are "working" landscapes, in that the traditional land use is perpetuated under the easement. Timber is selectively harvested to help pay for management of lands held mainly for recreational hunting. The characteristics of longleaf pine forest that are used to evaluate conservation value when a conservation easement is being considered are presented.

Measuring and Predicting Longleaf Pine Productivity

V. Clark Baldwin, Jr. (USDA Forest Service, Southern Research Station, Pineville, LA)

ABSTRACT - A key to understanding longleaf pine ecosystems is first understanding the growth dynamics of the overstory. The Southern Research Station of the USDA, Forest Service, has installed and currently maintains several active long-term studies comprising more that 200 research plots to measure and model the growth and yield of planted or direct-seeded longleaf pine. Most of the studies emphasize management by control of the pine density. Many of the study plots are located in stands more that 50 years old where individual tree measurements have been repeated every 5 years for more than 30 years. The data from these studies have been used to develop longleaf pine biomass component prediction equations, bole volume and taper equations, and growth and yield prediction systems. A new prediction system for thinned longleaf pine plantations will soon be available as part of the COMPUTE series of growth and yield models. This poster summarizes the history, extent, and objectives of the long-term studies, lists important publications and prediction models already obtained, and outlines the modeling work in process.

INTRODUCTION

Stand and tree productivity or growth and yield (G&Y) models are essential tools for the management of forest ecosystems to meet any objective. Even in nontimber-oriented management models, knowledge of the status of the overstory stand is required to predict the status of all associated flora and fauna. Therefore, G&Y continues to be one of the high priority research topics of industrial, non-industrial, and government natural resource organizations.

The most important requirement of a reliable and accurate G&Y prediction system is useful and accurate data. The most useful data are obtained from long-term growth plots wherein each tree is measured repeatedly over a full rotation, and the plots are installed in stands representing as many sites as possible within the region of interest for any given management objective.

Studies

Plantation

More than 200 plantation and direct-seeded longleaf pine G&Y research plots are currently maintained and remeasured regularly by the Southern Research Station, USDA, Forest Service. The five active plantation studies (160 plots) are located on poor, medium, and good sites in eastern Texas, Louisiana, and Mississippi. Initial planting densities ranged from about 250 to 2700 trees per acre. Some plots were left unthinned, but most were selectively thinned to target basal areas per acre from 40 to 120 ft^2 between ages 17 and 25, and rethinned regularly to maintain their target densities. In some cases trees were also pruned or fertilized. All stands are control-burned periodically. Most of the trees in these studies are now more than 50 years old (the oldest are 62), and have been remeasured periodically (usually every 5 years) as many as seven times.

Direct-Seeding

Direct-seeding was done either in rows or by broadcasting the seed. There are two row-seeded (36 plots) and two broadcast-seeded studies (39 plots). Density was controlled in the row seeded stands by varying row width and within-row spacing between the seeded spots. Thus, these stands resemble plantations. Seedling density in the broadcast seeded stands varied by seed application amounts, but in nearly all cases regeneration was very dense (exceeding 3000 stems per acre), so early precommercial thinning to various residual densities was applied. Most of the stands in these studies are about 30 years old.

Modeling

Biomass, Volume, Stem Taper

Several papers have been published providing equations to predict measures of quantity or stem form in plantation-grown trees (Baldwin and Polmer 1981, Lohrey 1982). The most difficult to obtain were the equations to predict the green or dry weight of the above-ground individual tree components (bole wood and bark, branch wood and bark, foliage) as a function of tree diameter at breast height and total tree height (Baldwin and Saucier 1983, Thomas et al. 1995). Recently, papers have been written emphasizing the great value of longleaf pine products from thinned stands (Busby et al. 1993), the dendroecological history of some of these pine stands (Eriksson 1993), and minimization of the costs associated with restoration of longleaf pine ecosystems (Busby et al. 1996).

Tree and Stand Growth and Yield

A stand level prediction system for unthinned stands is currently available (Lohrey and Bailey 1977), and one that predicts weight and volume by diameter classes in unthinned stands is near completion. Analysis of data for prediction systems for thinned stands, and direct-seeded stands, is in process. One interim publication reporting the modeling in process for thinned stands is available (Thomas and Lohrey 1990). The completed prediction systems will be published as part of the COMPUTE series of G&Y models (Baldwin 1989), and include numerous density management options.

CONCLUSIONS

Sufficient data are available to model the G&Y in thinned and unthinned stands, and to model the effects of early pruning. Data are also available to model the effects of fertilization at mid-rotation in planted stands. The studies providing these data will be continued indefinitely, given sufficient funding. The direct seeding studies are being closed, but the data through about age 30 are more than sufficient to model the G&Y of these stands given their early density treatments. However, all of these data are only valid for West Gulf stands.

Models to predict individual tree volume, weight, and stem form in planted longleaf pine stands have been completed and published.
next 1 to 2 years.

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Comparison of First-Year Survival Between Container-Grown and Bareroot Longleaf Pine Seedlings Outplanted on a Site in Southeast Texas

Brad Barber (Texas Forest Service, College Station, TX)
Pete Smith (Texas Forest Service, College Station, TX)

INTRODUCTION

Longleaf pine (*Pinus palustris Mill.*) is an historically important species in Southeast Texas. While there are several reasons why this species has seen a significant decline in the number of acres it is present on, one of the primary reasons is lack of success in planting longleaf seedlings. Recent demonstrations have shown that longleaf planted as container-grown seedlings exhibit higher survival than the traditionally planted bareroot seedlings. This study was established to provide further comparison of these two seedling types and to serve as a demonstration for non-industrial private forest landowners.

Methods

The study was located in Tyler County in Southeast Texas on a tract that had been seed tree cut in 1993 (Figure 1). The soil was a Darco loamy fine sand. Treatments included:

- fall planted container-grown longleaf (planted 8 Dec 94)
- winter planted container-grown longleaf (planted 13 Mar 95)
- bareroot longleaf (planted 1 Feb 95)
- bareroot loblolly pine (planted 1 Feb 95)

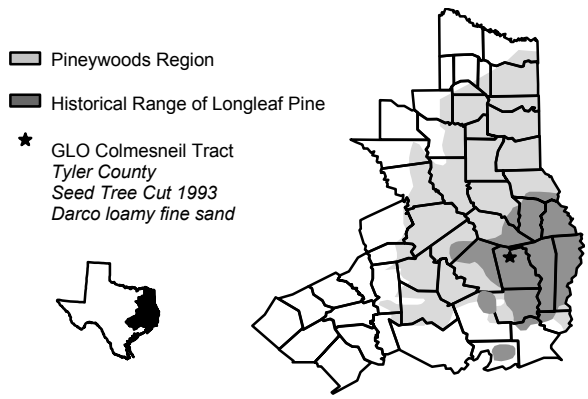

Figure 1. Map showing location of study area.

The container-grown longleaf was produced by International Forest Seed Company and the bareroot seedlings were produced by the Texas Forest Service at the Indian Mound Nursery. All seed sources were from Texas.

In addition, the site was divided in to thirds to which a different site preparation treatment was applied to each third. Site preparation treatments included:

- a check where no preparation was done,
- mechanical preparation (shear and pile),
- chemical preparation which involved spraying 0.5% Arsenal®AC (imazapyr) in water as a directed spray using a backpack sprayer (approximately 16 oz/ac of product).

Originally, a prescribed burn was planned as a site preparation treatment and because of the logistics involved with burning, site preparation treatments were not replicated. However, due to weather conditions, an adequate burn was not obtained, and a mechanical treatment replaced the site preparation burn.

There were 18 (3 site preparation treatments × 6 blocks) plots per seedling type (Figure 2). Each plot contained 45 seedlings at a spacing of 5 by 9 feet. Analysis of variance on plot means was conducted and treatment means were compared using the Ryan-Einot-Gabriel-Welsch mutiple-range test (SAS's REGWQ test).

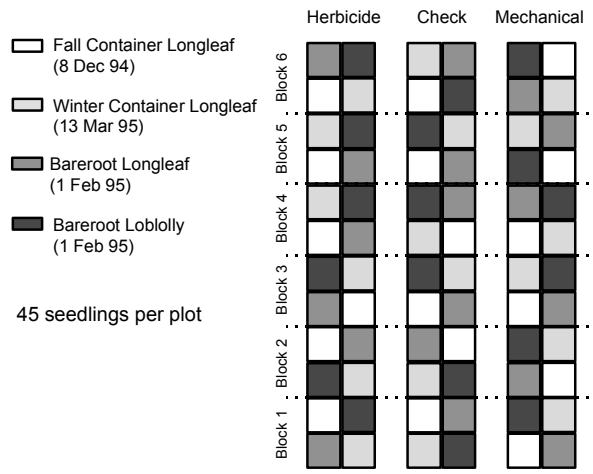

Figure 2. Treatment/plot layout.

Results and Discussion

Although little difference occurred in first-year survival between fall- and winter-planted container-grown seedlings, there was a highly significant difference (P<0.0001) in survival between container-grown and bareroot longleaf seedlings (Figure 3). Survival was 93, 91, and 12 percent for the fall-planted, winter-planted container-grown longleaf, and bareroot longleaf, respectively. This compared to 42 percent for bareroot loblolly which was significantly less than container longleaf but greater than bareroot longleaf seedlings. Although differences in survival were evident among the three site preparation treatments, *viz.* Herbicide > Mechanical > Check, no statistical inferences can be made since site preparation treatments were not replicated.

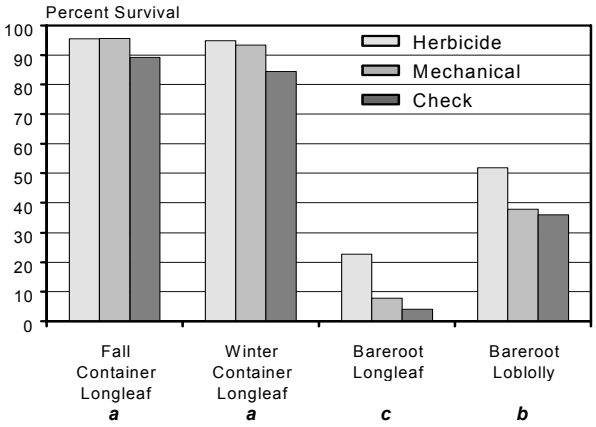

Figure 3. Survival by seedling type and site preparation method. (Seedling types having common letters below label are not significantly different.)

Conclusions

Container-grown longleaf pine seedlings provide landowners the opportunity to successfully establish this important species on their land. Although the cost of these seedlings compared to traditional bareroot seedlings is about three times as mush, this additional cost can be somewhat offset by reducing planting density while still achieving adequate stocking.

Longleaf Pine Cone Collection and Seed Conditioning Guidelines

Jill Barbour (USDA Forest Service, National Tree Seed Laboratory, Dry Branch, GA)

ABSTRACT - The National Tree Seed Laboratory personnel have developed longleaf pine cone collection and seed conditioning guidelines to assist the South's forestry professionals in maximizing their effort to collect and clean longleaf pine seed. The guidelines have been chosen by seedlab personnel through their experience working with longleaf pine seed, the valued opinion of their customers, and published research. A longleaf pine bumper cone crop is anticipated this fall. This creates many opportunities but also some obstacles in logistics for organizations. Specific criteria are outlined to alert the collector on the steps that are critical to insure good germination of longleaf pine seed. Five topics are outlined as bullet reminders highlighting the important steps in longleaf pine seed collection and conditioning. The five criteria are: longleaf pine cone collections criteria; seed extraction criteria; seed dewinging criteria; seed conditioning criteria; and seed testing criteria.

Each topic's bullet statements are expanded into a small guidelines handbook for use by forestry professionals who handle longleaf pine seed. Copies of the guidelines handbook are available by contacting the National Tree Seed Laboratory, Route 1, Box 182B, Dry Branch, Georgia 31020-9696, phone: 912-751-3551, FAX: 912-751-3554.

I. Longleaf Pine Cone Collection Criteria - 1. Cones cannot be collected early. 2. Cone collection starts from October 1st until the end of October. 3. The best collection time is around October 15th. 4. Wait until you see some cones begin to crack open before starting collection. 5. Cones left on the ground overnight might be attacked by fungus. 6.A bushel contains about 50 cones with a range between 25 to 75 cones. 7. Skip trees with small cones: it may be a hybrid with loblolly. *. Bumper crop yields range between 0.75 to 1.0 lbs of seed per bushel.

II. Seed Extraction Criteria - Fungal growth, seed deterioration, and premature germination are encouraged when cones are left outside. 2. The best temporary storage is on screens one layer thick under a shelter where cones can air dry. 3. Seed extraction needs to be completed within 30 days of harvest. 4. Seed is shed from the cones at high moisture. The seed needs immediate moisture testing and drying.

III. Seed Drying Criteria - 1. Dry seed in a seed dryer after tumbling cones. 2. Dry seed to a moisture content below 10 percent. 3. Use a seed dryer so the cone kiln is free to dry cones. 4. Once dried, put seed in moisture proof containers and place in cold storage. 5. After drying, the seed can be stored and conditioned at a later date. 6. Keep seed in cold storage to retard seed deterioration.

IV. Seed Dewinging Criteria - 1. Longleaf pine seed is easily damaged! 2. The seed can be easily cracked by removing too much of the wing or removing the wing too harshly. 3. Damaged seed will not store well and germination will be low. 4. Monitor dewinging process continually. 5. Train personnel on proper operation of dewinging procedure. 6. Only dewing seed that is below 10 percent moisture content. 7. If available, take X-rays during dewinging to check for seed damage.

V. Seed Conditioning Criteria - 1. Basic cleaning after dewnging is done with air cleaners. 2. Make arrangements to have your seed run over a gravity table to remove malformed and damaged seed to raise germination and remove cone scales and other trash. 3. Size seed so gravity table can be used to remove damaged seed. 4. The seed can be sized by width with round hole screens and by thickness with oblong screens. 5. Properly processed seed can be easily sown with a precision seeder.

VI. Seed Testing Criteria - 1. Germination tests of seed are necessary for nursery sowing rates. 2. Stratified germination tests more accurately reflect nursery performance. 3. Stratified seed has on average about a 15% greater germination than unstratified seed. 4. Stratify seed for 14 days at 3 degrees C. 5. Degraded seed promotes mold in the germination dishes which muddles the test results. 6. Stratified seed germinates more quickly and uniformly than unstratified seed.

Artificial Regeneration of Longleaf Pine: Reevaluation of Technique.

James P. Barnett (USDA Forest Service, Southern Research Station, Pineville, LA)
J. David Haywood (USDA Forest Service, Southern Research Station, Pineville, LA)
Mary Anne Sword (USDA Forest Service, Southern Research Station, Pineville, LA)

ABSTARCT - Although longleaf pine is a highly desirable species, resisting fire, insects and diseases, and producing quality solid-wood products, regeneration of the species has been difficult. Natural regeneration is feasible only on a small portion of the area considered to be longleaf pine type. Regeneration by direct seeding or planting has not been highly successful, so the renewed interest in longleaf pine has caused us to reevaluate these approaches to seedling establishment. If direct seeding is to be successful, repellent coatings are needed to limit predation. A new rodent repellent has the potential of making direct seeding a more effective option for landowners wanting to economically reforest relatively small acreage. The knowledge and technology to reestablish longleaf pine by planting bareroot nursery stock has improved significantly in the last decade. However, numerous studies show that container seedlings survive and grow better than bareroot stock. Additional studies are underway to refine these techniques and provide a better understanding of the unique physiological attributes of longleaf pine root systems that may allow us to improve regeneration success by planting.

INTRODUCTION

Longleaf pine (Pinus palustris Mill.), although widely distributed in the presettlement forests of the southern Coastal Plain, now occupies about 5 percent of its original range. It is a highly desirable species, resisting fire, insects and diseases, and producing quality solid-wood products. Natural regeneration is feasible only on a small portion of the area considered to be longleaf pine type. Artificial regeneration by direct seeding or planting has been difficult and renewed interest in longleaf pine has caused us to reevaluate these approaches to seedling establishment.

DIRECT SEEDING

Direct seeding in an inexpensive reforestation option, particularly suitable for small landowners, because spot or broadcast seeding by hand equipment is easy and effective (Derr and Mann 1971). However, the use of seeding has declined because the seedcoat repellent needed for protection of seeds from rodents has been restricted and repellents for birds and rodents are essential for seeding success. Thiram is an effective bird repellent, but endrin, which is registered for rodent protection, is no longer available. Recent tests of other candidate chemicals, Anipel^{R} and oleoresin capsicum, have been evaluated as a replacement for endrin. Results of the evaluations of Anipel indicate that it has little potential as an repellent (Barnett 1995). However, oleoresin capsicum does have potential as a deterrent to rodent predation. Further evaluations are needed for confirmation.

PLANTING

The knowledge and technology to reestablish longleaf pine by planting bareroot nursery stock has improved significantly in the last decade. The components of successful regeneration include: 1) well-prepared, competition-free sites, 2) healthy, top-quality, fresh planting stock, 3) meticulous care of stock from lifting to planting, 4) precision planting, and 5) proper post-planting care (Barnett and Dennington 1992). It is essential that all five of these elements come together for successful planting of bareroot stock. It is difficult to control all of these factors, therefore, planting success with bareroot longleaf pine stock remains elusive. Although these components for successful regeneration apply to container stock, success in establishment is markedly better with container material (Barnett and McGilvray 1993). Primarily for this reason, most silviculturists prefer to plant container longleaf pine seedlings.

Numerous studies have demonstrated that under adverse planting conditions, such as, poor sites, conditions of moisture stress, and out-of-season planting, container seedlings survive and grow better that bareroot stock. This is generally attributed to the fact that the root systems of container plants remain intact, while those of bareroot plants are severely damaged during lifting (Brissette et al. 1991). Thus, container seedlings have a significantly shorter period of transplant shock or readjustment than bareroot seedlings.

COMPETITION CONTROL

Longleaf pine seedlings have no early epicotyl growth and are, therefore, very sensitive to competition. The seedlings' initial height growth occurs most quickly in full sunlight. Studies have shown that site preparation that delays competition development over an extended period, prescribed fire 1- or 2-years after planting, and/or post-planting competition control by mechanical or chemical means will allow height initiation within 1 to 3 years after planting. New techniques that are more environmentally friendly, such as mulch mats, also facilitate early growth.

SEEDLING ESTABLISHMENT

Longleaf pine seedling establishment is, in part, dependent on the rapid development of new roots after planting. Soil temperature and moisture, together with the carbohydrate relations and morphology of the root system influence seedling root growth potential (Sword 1995). Seedling quality can be manipulated to improve the root growth potential and establishment of planted seedlings. For example, current planting guidelines recommend that root collar diameters be at least 0.4 inch and that seedlings possess a minimum quantity of primary lateral and fibrous roots. Past research has shown that root growth potential and successful establishment of pines is strongly influenced by root-zone temperature and water availability. Perhaps manipulation of the longleaf pine regeneration environment to affect these soil variables at the time of planting could be used to increase early root growth. In an effort to understand how new root growth of longleaf pine responds to the planting environment, we tested the main and interaction effects of root-zone temperature (55, 64 and 73°F) and water availability (well-watered condition, mild-water stress and moderate-water stress) on the new root growth of container longleaf pine seedlings 28 days after planting in a greenhouse. Treatments are representative of potential soil conditions in the central Louisiana planting environment.

An increase in root-zone temperature from 55 to 64°F caused 6- and 12-fold increases in the number and project surface area of new roots, respectively. Elevation of root-zone temperature from 64 to 73°F caused 1.8-fold increases in both number and projected surface area of new roots. Decreases in water availability caused significant but small differences in water potential of the needles and reduced the number and surface area of new roots.

These results suggest that manipulation of the regeneration environment to maximize soil temperature after planting will increase the new root growth of planted longleaf pine. Advanced root growth during winter and early spring could improve longleaf pine seedling establishment and growth.

CONCLUSIONS

Regeneration by direct seeding or planting has not been highly successful, so the renewed interest in longleaf pine has caused us to reevaluate these approaches to seedling establishment. If direct seeding is to be successful, repellent coatings are needed to limit seed predation. A new candidate chemical offers potential for making seeding a more effective option for landowners. The knowledge and technology to reestablish longleaf pine by planting bareroot stock has improved significantly in the last decade. However, numerous studies show that container seedlings survive and grow better than bareroot stock. Additional studies are underway to refine these techniques and provide a better understanding of the unique physiological attributes of longleaf pine root systems that may allow us to improve regeneration success by planting.

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Fire, Nutrients and Atmospheric Influences in Longleaf Pine Woodlands

Lindsay R. Boring (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Robert J. Mitchell (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Carlos A. Wilson (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Greg A. Houseal (Iowa Department of Transportation, Cedar Falls, IA)

ABSTRACT - Fire is an important ecological factor influencing the structure and function of longleaf pine ecosystems, including forest floor and groundcover nutrient pools and availability, forest to atmosphere interactions, and potential nutrient controls on productivity. However, little is known about interactive effects of seasonality of fire, litter types and mass upon forest floor N and P losses, or their atmospheric influences. This paper reports results from comparative summer and winter burns conducted in different groundcover types with different manipulated fuel loadings, as well as effects from ambient fuel accumulations of 1-3 years following the last fire. Peak fire temperatures and severity of burning were similar across groundcover types and seasons, but higher pine litter loadings produced elevated temperatures not exceeding 800º C. More N was lost from growing season burning since summer biomass had higher N content. Although C and N losses were 80-94% of total litter and groundcover pools, P losses were negligible in any of the experimental burns probably due to temperatures remaining below 800º C. Important aspects of N cycling processes and regulatory influences on productivity as affected by fire in longleaf pine ecosystems need further examination. These include within site conservation and redistribution of N during burning, influences of burn season on legume populations and N inputs through biological fixation. We also must thoroughly characterize atmospheric emissions from both prescribed and wildfire scenarios, and attempt to relate them to historic, baseline atmospheric processes that previously existed in the southeastern coastal plain.

The Escambia Experimental Forest: Fifty Years of Research on the Ecology and Management of Longleaf Pine

William D. Boyer (USDA Forest Service, Southern Research Station, Auburn University, AL)
George A. Ward (Escambia Experimental Forest, Brewton, AL)
John Kush (Auburn University, School of Forestry, Auburn University, AL)
T.R. Miller Mill Company (Brewton, AL)

ABSTRACT - The Escambia Experimental Forest was established in 1947 on land leased form the T.R. Miller Mill Company, of Brewton, Alabama. This 3000-acre tract was typical of natural second-growth longleaf pine forests on sandy coastal plains of the Gulf South. Today this Experimental Forest constitutes a unique example of longleaf pine ecosystems in all stages of development. The combinations of stand ages, sites, and conditions found here exist nowhere else. Due to its central location in the longleaf pine belt that stretches from the Carolinas to eastern Texas, the Experimental Forest is well situated for research on this ecosystem. Nearly 20 percent of the remaining longleaf pine is within 60 miles of this location. About 80 percent of the forest is in the upland longleaf pine type and the remainder in slash pine-hardwood bottoms. Average age of most second-growth longleaf pine is now 85 years (± 9 years). Since management began, about 1200 acres have been naturally regenerated to longleaf pine, and contain stands ranging in age from 3 years (1993 seed crop) to 49 years (1947 seed crop). Research on the Escambia has investigated many longleaf problems. These include regeneration, stand management, growth and yield, site evaluation, fire ecology, woods grazing, and some studies of the slash pine-hardwood branch bottoms. Most of the research and development of the shelterwood system for longleaf pine natural regeneration was done on this forest.

INTRODUCTION

The Escambia Experimental Forest was established in 1947 on land leased from the T.R. Miller Mill Company, of Brewton, Alabama. This 3000-acre tract was selected as typical of natural second-growth longleaf pine forests on sandy coastal plains of the Gulf South. Today the Experimental Forest constitutes a unique example of longleaf pine ecosystems in all stages of development. Listed as an established Scientific Ecological Reserve, the combinations of stand ages, sites, and conditions found here exist nowhere else. Due to its central location in the longleaf pine belt that stretches from the Carolinas to eastern Texas, the Experimental Forest is well situated for the study of this species. Probably close to 20 percent of the remaining longleaf pine forests are within 60 miles of this location.

The forest was selectively logged to water during the last quarter of the 19th century. Creeks were ditched and logs floated to a mill on the nearby Conecuh River. Some ditches and a dam for a storage pond can still be seen. Railroad logging removed the remaining merchantable old-growth between 1900 and 1919.

About 80 percent of the forest is in the upland longleaf pine type and the remainder in slash-hardwood bottoms. Site quality for longleaf is extremely varied, but averages about 70 feet at 50 years. When the Experimental Forest was established, the pine stand in the 4-inch and larger DBH classes averaged 73 trees, 32 square feet of basal area and a volume of 690 cubic feet/acre. Average age of the second-growth longleaf pine then was 35 years (± 9 years) and is now 85 years. Since management began, about 1200 acres have been naturally regenerated to longleaf pine, and contain stands ranging in age from 3 years (1993 seed crop) to 49 years (1947 seed crop). Through 1995, a total of 3.86 million cubic feet of pine and 228 thousand cubic feet of hardwood have been harvested.

Research on the Escambia over the years has investigated many problems associated with the management of longleaf pine forests. The forest supports continuing long-term research and also many management demonstrations. Research has included:

1: All aspects of natural regeneration. This included flowering, seed production and dissemination, and seedling establishment, survival and growth, and methods of competition control before and after seedling establishment. Most of the research and development of the shelterwood system for longleaf regeneration was done on the Experimental Forest.

2: Stand management and management alternatives including even-aged, two-aged, and all-aged management methods.

3: Growth and yield of natural stands in relations to stand age, site quality, and stand density.

4: Site quality evaluation for longleaf pine, including effects of soils and topographic position.

5: Fire ecology, including effects of season and frequency of prescribed fire (or fire exclusion) on growth of dominant pine overstory, as well as long-term effects on composition and structure of the hardwood midstory and both woody and herbaceous vegetation on the forest floor.

6: Floristic studies, including plant collections for a herbarium covering longleaf pine ecosystems of the central Gulf coastal plains.

7: Forest grazing, including forage yields in relation to management methods.

8: Management of slash pine-hardwood branch bottoms.

RESEARCH ON THE ESCAMBIA EXPERIMENTAL FOREST

REGIONAL LONGLEAF PINE GROWTH STUDY

In 1964-1967, the U.S. Forest Service established a regional longleaf pine growth study (RLGS) in the Gulf States. The original objective of the study was to obtain a database for the development of growth and yield predictions for naturally regenerated, even-aged longleaf pine stands. The RLGS database is based on a rectangular distribution of cells formed by five stand age classes ranging from 20 to 120 years, five site-index classes ranging from 50 to 90 feet at 50 years, and five density classes ranging from 30 to 150 square feet/acre. The study now consists of 305 permanent measurement plots located in central and southern Alabama, southern Mississippi, southwest Georgia, northern Florida, and the sandhills of North Carolina. The Escambia Experimental Forest maintains 149 of these plots.

FARM FORTY

Forty acres of understocked (39 square feet/acre of basal area) second-growth longleaf pine forest were set aside in 1947 for a demonstration of small woodlot management. The initial goal was to produce high quality poles and logs on a 60-year rotation. The rotation has since been extended to 80 years. Over half (22 acres) of the “forty” has been harvested and naturally regenerated to longleaf pine and now supports stands ranging in size from grass-stage seedlings to small sawlogs.

SEASON OF BURN AND OVERSTORY DENSITY: EFFECT ON UNDERSTORY DEVELOPMENT

Burning treatments in this study were initiated during the 1970 summer. The 14th burning cycle was carried out in 1996. This study is testing four fire treatments: biennial burns in winter; spring; summer; and an unburned check. They are being carried out under each of four pine shelterwood densities: 20; 30; 40; and 50 square feet/acre of basal area. After 26 years, treatments had affected development of understory pines and hardwoods. Longleaf pine seedling development was better with spring than summer or winter burns. Hardwood development was inhibited and virtually non-existent with spring burning. Development of longleaf pine, and to some extent hardwoods, was inhibited with increasing overstory density. Under low overstory density, periodic spring burning appears to be the best combination for maximum development of longleaf pine regeneration with minimum hardwood encroachment.

UNEVEN-AGED MANAGEMENT

Three demonstrations of uneven-aged management possibilities for longleaf pine have been established on the Escambia Experimental Forest. The oldest established in 1977 is regulated under a volume-guiding diameter limit. The second stand, set up in 1981, is regulated under the basal area/maximum DBH/q method. These more sophisticated methods of selection management require that group selection be employed, with proper timing of prescribed burning, to insure reproduction in all gaps. The third method, established in 1991, is regulated under the primitive selection method of a strict diameter-limit, modified so that a basal area of about 60 square feet/acre is always left after cut.

NATURAL REGENERATION

Several examples that the shelterwood system can be used to regenerate longleaf pine naturally at low cost and with a high degree of success if specific and necessary cultural measures are timed properly and executed. Any natural regeneration method for longleaf pine must provide three essential elements: (1) sufficient desirable well-distributed parent trees; (2) favorable understory and seedbed conditions for establishment, survival and growth of seedlings; and (3) protection from livestock, wildfire, brown-spot. The amount of seed necessary to ensure a new stand depends on the condition of the seedbed, predator pressure, soil, understory conditions and existing seedling stocking. Ideally, at least 50,000 seeds/acre are

needed on a well-prepared seedbed to get a good stand of seedlings established. This requires roughly 1,000 cones/acre or 35 to 50 cones/seed tree.

SUMMARY

Research on the Escambia Experimental Forest over the years has investigated many problems associated with the management of longleaf pine forests. Work here has contributed significantly to the understanding of longleaf pine. To date, research on the Experimental Forest has provided information for 159 publications.

The forest supports continuing long-term research and also many management demonstrations. Visitors are welcome, and tours covering research and management demonstrations are regularly given for students, foresters, landowners, and other interested parties. An Escambia forest map and book describing 18 different tour stops where one can see/visit on a “self-guided” basis or with an informed discussion leader is available from the USDA Forest Service, Southern Research Station.

Seeing the Forest Beyond the Trees

Mark A. Cantrell (US Fish & Wildlife Service, Southern Pines, NC)
Janice Nicholls (US Fish & Wildlife Service, Asheville, NC)
Hilary A. Vinson (US Fish & Wildlife Service, Asheville, NC)

ABSTRACT - The Sandhills Region of North Carolina is renowned for its cultural history—challenging golf courses, beautiful resorts and horse farms have attracted thousands of visitors since the early 1900s. The region's natural history is equally impressive. The Sandhills is recognized as one of the last remaining strongholds of the longleaf pine in the entire southeastern United States. The longleaf pine tree was once the dominant tree species throughout the Southeast. Blanketing the landscape from Virginia to Texas, longleaf covered an estimate 92 million acres. Many visitors to the region admire the towering longleaf pines in the Sandhills, especially around Southern Pines and Pinehurst. There is obviously a local appreciation of this majestic tree. While many residents and visitors see the beauty in these large pines, few really see the forest as a whole. The longleaf forest is complex and diverse and includes much more than trees. To learn more about the natural secrets of the longleaf forest, we must take a closer look. This Sandhills exhibit is an audio-visual tour through The Forest, uncovering what turns out to be a treasure trove of biodiversity. We are guided through an explanation of the importance of fire to the longleaf forest, its inhabitants, and natural processes. The future outlook is not totally bleak, especially if we heed the importance of the interconnected pieces in making the connection, and follow the plea to act locally.

The Sandhills Region of North Carolina is renowned for its cultural history; challenging golf courses, beautiful resorts, and horse farms have attracted thousands of visitors since the early 1900's. The region's natural history is equally impressive, and largely responsible for having convinced many to stay. The Sandhills is recognized as one of the last remaining strongholds of the longleaf pine in the entire southeastern United States. The longleaf pine was once the dominant tree species throughout the Southeast. Blanketing the coastal plain landscape from Virginia to Texas, longleaf covered an estimated 92 million acres. Many visitors to the region admire the towering longleaf pines in the Sandhills, especially around the Village of Pinehurst and Southern Pines, North Carolina. There is obviously a local appreciation of this majestic tree and the forest it presides over. While many residents and visitors see the beauty in these large pines, few really see the forest as a whole. The longleaf forest is complex and diverse and includes much more than trees. To learn more about the natural secrets of the longleaf forest, we take a closer look.

What is the Sandhills? Wedged between the coastal plain and the piedmont, the Sandhills is a physiographic region in North and South Carolina. Once considered part of a large inland dune system, the Sandhills is now believed to have been carved out of an ancient delta plain. The delta was formed millions of years ago when sediment-laden rivers flowed from the mountains and piedmont and emptied into the sea in this area. Stream and wind erosion over the past 40-50 million years has created the hilly topography visible today.

Fire! Renews the forest. Without fire, scrub oaks and other hardwood trees grow to shade out many understory plant species, thus changing the face of the forest. Many plant species, including longleaf pine and wiregrass, have evolved with fire, and are dependent on it for their reproduction and survival. Aside from land conversion, fire suppression is the greatest threat to the conservation of longleaf pine forest.

Fire as a tool. Fire is a tool used by land managers to maintain the existing longleaf forest. Today, fires are carefully planned and often help reduce dangerous accumulations of fuel that could trigger disastrous wildfires.

Fire through time. The whole longleaf pine ecosystem is directly tied to fire. Fires probably occurred naturally in the Sandhills every 2-7 years, due to summer lightning strikes, and more recently, native peoples. Fire would often sweep across vast areas, driven by an abundance of highly flammable ground fuels such as longleaf pine needles and wiregrass on the uplands and cane and gallberry in the moist areas. This produced a mosaic of intensity, duration, and effect.

Fire renews the forest. A forest has recently burned may look destroyed, but will recover quickly. Fire in the longleaf forest is beneficial. Fire recycles nutrients, making them available to a new generation of plants and wildlife. Fire opens gaps in the forest, bringing in sunlight and allowing new plants to grow.

Wildlife feed on the abundant new growth. Fire creates snags, or dead trees, that serve as home for many wildlife species.

Making the connection. The longleaf forest is an intricate puzzle of interconnected pieces. In order to protect the forest, the pieces must be considered as a whole- the longleaf pines themselves and the processes such as fire that maintain the system, as well as the other plants, animals and people who live there.

Rare species of the Sandhills. The Sandhills is home to many familiar species such as white-tailed deer, wild turkey, and bobwhite quail. However, many animal and plants species of the Sandhills are declining and several are Federally listed as endangered such as the red-cockaded woodpecker, the Saint Francis' satyr (a butterfly), and 3 plant species, American chaffseed, Michaux's sumac, and rough-leaved loosestrife. A dozen or more others are listed as endangered, threatened or special concern by the states, such as Sandhills pyxie-moss, the northern pine snake, Carolina crawfish frog, Sandhills chub, and the pinewoods darter. The southeastern fox squirrel, though still legal game in some portions of the area, is unique and spectacular, feeding on the large cones of the longleaf pine. Efforts to protect the entire Sandhills ecosystem may well provide protection to numerous species that inhabit the longleaf pine forests there.

The Carolina Longleaf Forests exhibit was part of an initiative to develop and implement a conservation strategy for the red-cockaded woodpecker, its habitat, and other native biota in the North Carolina Sandhills physiographic region. The exhibit was created to increase the awareness and knowledge of the diversity of the Sandhills region, particularly the longleaf pine ecosystem. It is designed to be mobile, for use at county fairs, libraries, golf tournaments, schools, and wherever people in the North Carolina and South Carolina Sandhills might be interested in learning about the uniqueness of the region. The Carolina Sandhills exhibit is an audio-visual tour through the longleaf forest, uncovering what turns out to be a treasure trove of diversity. We are guided through an explanation of the importance of fire to the longleaf forest, its inhabitants, and natural processes.

Acknowledgments. The Carolina Longleaf Forests exhibit was developed with the advice of Kim Hyre; Weymouth Woods State Nature Preserve, Ricky Ingram and Larry Williams; Carolina Sandhills National Wildlife Refuge, Darryl Jones; Sandhills State Forest, Ruth Kirby; Natural Resources Conservation Service, Eugene Maples; Turfgrass Council of North Carolina, and Ed Seivers; Sandhills Area Land Trust. The exhibit was assembled by Wilderness Graphics, Inc., of Tallahassee, Florida, specialists in information and education projects dealing with natural resources. We thank Donna Stanek, Interpretive Specialist, U.S. Fish and Wildlife Service, for special assistance in design and contracting.

Ecological Land Classification in the Uplands of the Southern Loam Hills of South Alabama

Robert E. Carter (Auburn University, School of Forestry, Auburn University, AL)
Mark D. MacKenzie (Auburn University, School of Forestry, Auburn University, AL)
Dean H. Gjerstad (Auburn University, School of Forestry, Auburn University, AL)

ABSTRACT - A landscape scale classification of ecosystems was undertaken on the Conecuh National Forest and Solon Dixon Forestry Education Center. The classification procedure follows the hierarchical framework of ecological units developed by the US Forest Service. In this study, identification and classification of sites was achieved by interrelating soils, vegetation, and landform variables. The three landtype associations (Pine Hills LTA, Dougherty Plain LTA, and Wet Pine Flatwoods LTA) identified by the Forest Service as part of their ecological framework were found to be valid. The major environmental variables distinguishing the LTAs were A and B horizon depths, A horizon P (%), B horizon silt (%), B horizon fine sand (%), and water table depth. Within each LTA, two to four landtype phase (LTP) units were identified along an environmental gradient from xeric to mesic. The diagnostic variables in the Pine Hills were landform index, slope, B horizon depth (in.), B horizon N (%), A horizon fine sand (%), and A horizon silt (%). Dougherty Plain diagnostic variables were slope, A horizon fine sand (%), B horizon clay (%), and A horizon Ca (ppm). In the Wet Pine Flatwoods, the diagnostic variables were landform index, slope, B horizon clay (%), and depth to mottling (in.). Identifying and describing these ecological units will aid in the management and restoration of longleaf pine ecosystems.

Introduction

A key step of natural resource management is the delineation of land units that are similar relative to type, structure, and productivity of vegetation. Ecological Land Classification (ELC) accomplishes this by simultaneously interrelating vegetation, soils, and landform variables (Barnes and others 1982). This reveals diagnostic vegetation, soil, and landform variables that can be used to classify land into its appropriate ecosystem. Following the hierarchical framework of ecological units initiated by the USDA Forest Service to identify ecologically similar land units, Landtype Associations (LTAs) are delineated primarily on the basis of hydrology, geology, and topography. LTAs are composed of Landtype Phases (LTPs) delineated primarily on the basis of vegetation, soils, and landform (USDA Forest Service 1993).

The ELC approach was applied in the uplands of the Southern Loam Hills of south Alabama. This area is part of the longleaf pine (*Pinus palustris*)[a] belt that extends from Virginia to Texas (Wahlenberg 1946). It previously covered 24 million hectares (Croker 1990) but presently occupies 1.5 million hectares (Kelley and Bechtold 1990). Although there have been numerous descriptions of the vegetation and soils of longleaf pine ecosystems (Marks and Harcombe 1981, Pessin 1933, and Gilliam and others 1993), few studies have attempted to identify and describe the variation in the function and structure of the ecosystems (Palik and others 1995). Restoration and management of longleaf pine ecosystems is hindered by these deficiencies in information. This research addresses the present deficiencies in information pertaining to the structure and function of longleaf pine ecosystems in the Southern Loam Hills by 1) delineating ecosystems, 2) determining the soil and landform variables related to the ecosystems, and 3) producing discriminant functions for predicting ecosystems based on soil and landform variables.

Methods and Analysis

The study area included the uplands of the Conecuh National Forest and Solon Dixon Forestry Education Center. This represented an area of approximately 36,450 hectares. The study area is located in the Southern Loam Hills Subsection of the Lower Coastal Plain and Flatwoods Section of the Outer Coastal Plain Mixed Forest Province (McNab and Avers 1994). Stream and river floodplains and shrub bogs were excluded from the study. One-hundred eighteen circular 0.04 ha plots were established throughout the study area. Vegetation, soils, and landform variables were sampled at each plot. Vegetation strata sampled were trees, saplings, seedlings, shrubs and vines, and herbs. Soil variables sampled were the depth of the A and B horizons, depth to the argillic horizon, depth to mottling, depth to the water table, Oe and Oi horizon thickness, and drainage class. Soils samples were taken for later analysis that included soil texture determination, total N and C (%), and P, K, Ca, and Mg in ppm. The landform variables included landform index, terrain shape index (McNab 1990), slope gradient, and aspect.

Ecosystems were determined through a combination of ordination and cluster analysis. Ordination was performed using canonical correspondence analysis (CCA) (ter Braak 1987). CCA utilizes a combination of species importance values and environmental variables to arrange sample units (plots) along axes (Jongman and others 1995). This results in vegetatively similar plots clustering together and dissimilar plots separating. Cluster analysis was performed using TWINSPAN (Hill 1979). This program uses species importance values to divide the plots into successively smaller clusters of similar vegetation. Ordination was used in conjunction with cluster analysis to avoid subjectivity in delineating ecosystems.

Once the ecosystems were delineated, stepwise discriminant analysis was used to determine which environmental variables were related to the ecosystems (diagnostic variables) and to create discriminant functions (SAS Institute 1990). The ability of each discriminant function to correctly classify an ecosystem was tested with cross validation (SAS Institute 1990).

Results

Nine landscape scale LTPs were identified in the uplands of the Southern Loam Hills within three LTAs. The LTAs had previously been identified by the U. S. Forest Service based on hydrology, geology, and topography (USDA Forest Service 1995). They are the Pine Hills, Dougherty Plain, and Wet Pine Flatwoods. These LTAs were found to be valid with significant differences in the vegetation, soils, and landform. The diagnostic soil and landform variables were A horizon depth, B horizon depth, presence of the water table within 203 centimeters of the surface, B horizon P, A horizon Ca, percent A horizon sand, and percent A horizon clay. The success rate for classing the LTAs with discriminant functions was 76%.

Three LTPs were identified in the Pine Hills along a gradient from xeric to intermediate. On xeric sites the vegetation was a longleaf pine-bluejack oak (*Quercus incana*)-morning-glory (*Ipomoea sp.*) type. The diagnostic vegetation was *Q. incana*, *Ipomoea sp.*, *Cornus florida*, *Stylisma humistrata*, *Q. margaretta*, and *Q. falcata*. On subxeric sites, the vegetation was a longleaf pine-post oak (*Q. stellata*)-winged sumac (*Rhus copallina*) type. The diagnostic vegetation included *Q. stellata*, *Rhus copallina*, *Pteridium aquilinum*, *Q. falcata*, and *Vaccinium myrsinites*. The vegetation of the intermediate sites was a longleaf pine-shiny blueberry (*Vaccinium myrsinites*)-meadow beauty (*Rhexis alifanus*) type. The diagnostic vegetation species were *Vaccinium myrsinites*, *Rhexia alifanus*, *Carphephrorus odoratissimus*, *Pteridium aquilinum*, *Gaylussacia dumosa*, and *Pityopsis graminifolia*. The discriminating landform and soil variables were landform index, slope, B horizon depth, percent B horizon N, percent A horizon fine sand, and percent A horizon silt. The classification success rate was 80%.

For the Dougherty Plain, xeric and intermediate LTPs were identified. On xeric sites, there was a longleaf pine-bluejack-elephant's foot (*Elephantopus tomentosus*,) type. The diagnostic vegetation included *Q. incana*, *Elephantopus tomentosus*, *Q. virginiana* , *Diospyros virginiana*, *Hibiscus aculeatus*, and *Aristida stricta*. The vegetation of intermediate sites was a longleaf pine-highbush blueberry (*Vaccinium corymbosum*)-Pinweed (*Lechea minor*) type. Diagnostic species include *V. corymbosum*, *Lechea minor*, *Silphium compositum*, *Crotolaria purshii*, and *Smilax glauca*. The discriminating landform and soil were depth to mottling, A horizon Ca, and percent B horizon fine sand. The classification success rate was 88%.

In the Wet Pine Flatwoods, four LTPs were identified along an environmental gradient from xeric to bogs. On xeric sites, the vegetation was a longleaf pine-winged sumac-Jackson-brier (*Smilax smallii*) type. The diagnostic vegetation included *Rhus copallina*, *Smilax smallii, V. myrsinites*, *Diospyros virginiana*, *Q. falcata*, *Symplocos tinctoria*, *Hibiscus aculeatus,* and *Aristida stricta*. The vegetation of intermediate sites was a longleaf pine-deerberry (*V. stamineum*)-Virginia creeper (*Parthenocissus quinquefolia*) type. The diagnostic species were *V. stamineum*, *Parthenocissus quinquefolia*, *Hibiscus aculeatus*, *Symplocos tinctoria*, *Q. hemisphaerica*, *Lechea minor*, *Prunus umbellata*, and *Aristida stricta*. The vegetative type of mesic sites was a longleaf pine-slash pine (*Pinus elliottii*)-deerberry type. The diagnostic vegetation was *Pinus elliottii*, *V. stamineum*, *Smilax glauca*, *Drosera brevifolia*, *Acer rubrum*, and *Aristida stricta*. The vegetation of the bogs was a longleaf pine-slash pine-sweet pepperbush (*Clethra alnifolia*) type. Diagnostic species included *Pinus elliottii*, *Clethra alnifolia*, *V. myrsinites*, *Liquidambar styraciflua*, *Drosera brevifolia*, *Gaylussacia mosieri*, and *Aristida stricta*. The discriminating landform and soil were slope, presence of the water table within 203 centimeters of the surface, mottling depth, percent B horizon clay, and drainage class. The classification success rate of 85%.

Discussion

Within each LTA, two to four LTPs were identified along an environmental gradients from xeric to mesic. The discriminant functions derived through the ELC process will aid in the recognition of ecological site units within the Southern Loam Hills. Due to the integrated nature of ELC, it will improve not only productivity predictions, but it also has implications for wildlife and endangered species management, regeneration techniques, harvesting, pest damage susceptibility, and successional pathways. As forest lands require more intensive and innovative management techniques, ELC can provide the detailed information necessary for making appropriate decisions. The information can be integrated into a GIS to further improve natural resource management.

Future research plans for the Southern Loam Hills include describing the successional pathways of the nine LTPs and mapping LTPs through GIS.

[a] Nomenclature follows Clewell (1985) and Godfrey 1988).

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A Systems Approach for Longleaf Pine Ecosystem Restoration

Terry R. Clason (Hill Farm Research Station, Louisiana Agricultural Experiment Station, Louisiana Agricultural Center, Louisiana State University, Homer, LA)
Donald P. Reed (School of Forestry, Wildlife and Fisheries, Louisiana Agricultural Experiment Station, Louisiana Agricultural Center, Louisiana State University, Baton Rogue, LA)
Latimore M. Smith (The Louisiana Natural Heritage Program, Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA)

ABSTRACT - Louisiana Agricultural Experiment Station is initiating longleaf pine ecosystem restoration research at the Lee Memorial Forest in Sheridan, Louisiana. The objective will be to develop conservation management systems that are environmentally sound and cost effective for longleaf pine ecosystem restoration. The study area is a 50 acre mature, mixed pine stand of longleaf, loblolly, slash, and shortleaf pine having a understory vegetation rich in species in diversity. In 1996, each overstory pine will be stem mapped by species and size, and the understory vegetation will be inventoried by composition and density along transect lines placed at 40 foot-centers. Growing season burns will be applied to the entire stand in 1996 and 1997. A seed tree harvest in the fall of 1997 will leave a residual longleaf overstory basal area of 15 ft^2. The study will include longleaf pine reforestation treatments and understory vegetation management treatments. Reforestation treatments which include natural regeneration, direct seeding and seedling planting, will be initiated in the winter of 1997. Understory vegetation treatments include growing season burns and banded herbicide applications combined with growing season burns. These treatments will be applied in early spring of 1998. Treatment impact on the ecosystem will be monitored for 5 years from 1998 to 2002. Data collection will include residual seed tree growth and seed production, seedling survival and growth, and impact of herbicide on understory vegetation.

INTRODUCTION

Longleaf pine ecosystem restoration means restoring species composition, biological structure and functional dynamics that characterized the longleaf system. These characteristics are influenced by soils, topography, hydrology, and geographic location; and vary throughout the natural range of longleaf pine. Since species composition influences both structure and dynamics of the system, establishing and maintaining the plant species matrix is the key to a successful restoration program. A longleaf pine ecosystem restoration research project is being initiated by the Louisiana Agricultural Experiment Station at the Louisiana State University, Lee Memorial Forest, in Sheridan, Louisiana. Forest management practices that include prescribed burning, competing vegetation suppression, and longleaf pine reforestation methods will be used to develop environmentally sound, cost-effective, conservation management systems for longleaf pine ecosystem restoration.

METHODS

The study area is a 30 acre mature, mixed pine stand of longleaf, loblolly, slash, and shortleaf pine having a understory vegetation rich in species diversity. In 1996, each overstory pine will be stem mapped by species and size, and the understory vegetation will be inventoried by composition and density along transect lines placed at 40 foot-centers. Growing season burns be applied to the entire stand in 1996 and 1997. A seed tree harvest in the fall of 1997 will leave a residual longleaf overstory basal area of 15 ft^2/acre.

Following the seed tree harvest, the study area will be divided into three equal sized stands. These individual stands will be assigned one of the following prescribed burning regimes: 1) Annual growing season burns from 1999 to 2004, 2) Biennial growing season burns from 2000 to 2004, and 3) Triennial growing season burns from 2001 to 2004. These burning regime treatments will be used to determine the impact of burning frequency on longleaf seedling growth and understory species matrix development.

Three longleaf pine reforestation treatments, which include natural regeneration, direct seeding, and planted seedlings, will be replicated three times in each burning regime treatment. Direct seeding and planting will be done along the understory inventory transect lines with a planting rate of 100 direct seed spots or 100 seedlings per acre. Competing vegetation management treatments will be replicated three times for each reforestation-burning regime combination. In the spring of 1998, three vegetation management treatments, sulfometuron-methyl, metsulfuron-methyl, and untreated check, will established along the understory vegetation transect lines in 4-foot wide bands 100 feet long. Treatment application rates have not been selected.

Treatment impact on the ecosystem will be monitored for 8 years from 1998 to 2005. Data collection will include residual seed tree growth and seed production, seedling survival and growth, and impact of herbicide on understory vegetation. Initial longleaf seedling survival and growth data will be collected in the fall of 1999, and an understory vegetation inventory will be taken in the spring of 2000. This data collection schedule will continue annually through 2005.

RESULTS

Initial understory vegetation inventory identified 160 plant species distributed within 105 genera. There were 10 arborescent genera that accounted for 16 species. The remaining plants in the species matrix were non-arborescent, forbs, and grasses. The overstory contained loblolly, slash, longleaf, shortleaf, and spruce pine. Loblolly, slash, and longleaf were the predominate pines having a combined stocking density and basal area of 37 trees/acre and 27 ft^2/acre.

CONCLUSIONS

The diversity of the understory plant species matrix combined with the pine overstory provides an excellent opportunity to develop a systems approach for restoring longleaf pine ecosystems.

Techniques to Restore Off-Site Slash Pine Stands on Deep, Sandy Soils to Longleaf Pine Using Artificial Regeneration

Vernon S. Compton (Florida Division of Forestry, Blackwater River State Forest, Milton, FL)

ABSTRACT - Longleaf pine (*Pinus palustris* Mill.) is best suited to deep, excessively drained soils like those found on portions of the Blackwater River State Forest. Several means of artificial regeneration to restore longleaf pine back to sites consisting of off-site slash pine (*Pinus elliottii* Engelm) are discussed. Emphasis is placed on minimum disturbance during site preparation. Survival using winter planted containerized longleaf has averaged 95%. Survival of bareroot seedlings following mechanical site preparation averaged 52% due to droughts after planting. On public or private lands that have uneven-aged management of longleaf pine as the goal, planting of containerized longleaf pine using contract crews may be the best alternative. This method of regeneration is cost effective while at the same time allows for diverse planting techniques. With hand planting, tubelings may be randomly spaced and planted in non-uniform size and density patches which mimics a naturally regenerated longleaf stand.

INTRODUCTION

- Longleaf pine (*Pinus palustris* Mill,) is best suited to deep, excessively drained soils like those found on portions of the Blackwater River State Forest.
- Several methods of artificial regeneration to restore longleaf pine sites consisting of off-site slash pine (*Pinus elliotti* Engelm.) are discussed.

OBJECTIVES

1. Minimum disturbance is emphasized during site preparation to prevent soil loss and to protect wiregrass (*Aristida stricta* Michx.) and other vegetation.
2. With uneven-aged management of longleaf pine as the goal, artificial regeneration systems that mimic naturally regenerated stands are favored.
3. Maximize benefits of reforestation and ecosystem management while minimizing costs of artificial regeneration.

STUDY AREA

Blackwater River State Forest is located approximately 15 miles northeast of Milton, Florida. This is the largest state forest in Florida consisting of more than 183,000 acres, stretching from Conecuh National Forest in Alabama to just north of Eglin Air Force Base. Longleaf pine stands comprise over 145,000 acres of this forest. A portion of the remaining acreage consists of off-site slash pine plantations planted in the 1950's. These plantations are exhibiting poor growth rates less than 1/3 cord/acre/year. The Division of Forestry's long range goal is to convert this acreage back to longleaf pine as funding is available. To date the following areas have been converted:

1992 Heritage Forest I - 300 acres
1993 HeritageForest II - 113 acres
1994 Heritage Forest IIIA - 98 acres
1994 Heritage Forest IIIB - 97 acres
1995 FGT Phase I - 382 acres

METHODS

Longleaf pine is very intolerant to competition and is difficult to regenerate without effectively controlling competing hardwoods. Fire used during the growing season every 3-5 years will keep woody vegetation under control. However, either mechanical or chemical site preparation will be necessary to artificially regenerate a longleaf pine stand in areas where fire has not been used effectively.

The following methods of site preparation have been used on Blackwater River State Forest:

Heritage Forest I - Spot rake 2"+ material
Heritage Forest II - Light root rake and windrow
Heritage Forest IIIA - Double tandem chop

Heritage Forest IIIB - Single tandem chop
FGT Phase I - Herbicide (Velpar ULW™ at 2.0, 1.75 or 1.5 lbs.ai/acre.)

Bareroot longleaf pine seedlings were machined planted on all Heritage Forests. Longleaf pine tubelings were hand planted on FGT Phase I.

RESULTS

Minimal site and groundcover disturbance site preparation techniques are favored. Wiregrass and other vegetation are critical in providing fuel for fires in the longleaf pine fire-climax community. Herbicide treatment (Velpar ULW™), light rot raking, and spot raking appear superior to single or double tandem chopping for reducing hardwood competition while maintaining wiregrass.

Seedling survival was 95% for winter planted longleaf pine tubelings. Survival of bareroot seedlings following mechanical site preparation averaged 52%. This low survival appeared due to extended droughts after planting. Tubelings seem to allow high survival even under severe moisture stress conditions, an important consideration to remember on sandhill sites. Survival may also be increased by planting earlier in the fall and winter season, allowing the seedling to develop a good root system before drought conditions set in.

CONCLUSIONS

1. On public or private lands that have uneven-aged management of longleaf pine as the goal, planting of containerized longleaf pine using contract crews may be the best alternative. This regeneration method is cost effective and allows for diverse planting techniques.
2. Survival of tubelings on deep, sandy sites is very high even when planting is followed by drought conditions.
3. With hand planting, tubelings may be randomly spaced and planted in patches of non-uniform size and density, thereby mimicking a naturally regenerated longleaf stand.
4. Single or double tandem chopping produces good control of competing vegetation. However, these sites seem to even drier, probably a result of excessive soil disturbance and loss of vegetative cover and root mass. This may be a factor in the lower seedling survival of bareroot seedlings on these sites.
5. Wiregrass, which is so critical for carrying a fire in the longleaf pine community, is also greatly reduced by single or double tandem chopping. Fire is a very economical management tool for land managers but it's effective use could be diminished because of chosen site preparation techniques. Light root raking or spot raking appear to be the best mechanical site preparation techniques for the combination of hardwood control and native groundcover protection; which increases the likelihood of an effective prescribed burn program in the future.
6. Selective use of herbicides such as Velpar ULW™ offers effective woody vegetation control and minimal site disturbance. A recommended use is on sites with little to no remaining native groundcover due to previous site preparation techniques and/or types of plantings. On Blackwater River State Forest, rates of 2 lbs. ai/acre or less, appear to have little effect on the relict wiregrass cover.

Regeneration Problems of Longleaf Pine Caused by the Pitch Canker Fungus, *Fusarium subqlutinans* f. sp. *pini*

L. David Dwinell (USDA Forest Service, Southern Research Station, Athens, GA)
S.W. Fraedrich (USDA Forest Service, Southern Research Station, Athens, GA)

ABSTRACT - Pitch canker, caused by *Fusarium subglutinans* f. sp. *Pini*, is a serious disease that can adversely affect the regeneration of pine species. The pitch canker fungus infects vegetative and reproductive structures at different stages of maturity that results in a diversity of symptoms. Two primary symptoms are associated with vegetative structures of planted longleaf pine (*Pinus palustris*). A classic symptom is a bleeding, resinous canker on the trunk, terminal, and large branches. The wood beneath the canker is deeply pitch-soaked. Dieback can result from infections that develop on the current-year growth, eventually girdling the shoots. This fungus also causes mortality of female strobili from the time of inception through maturity of the cone. Deterioration of the endosperm and embryo of seed, and extensive contamination of the seedcoat by *E. subglutinans* f. sp. *pini* has been reported in state, federal, and industrial seed orchards. Furthermore, the pitch canker fungus has created problems in the production of longleaf pine seedlings in bare-root and container nurseries. Our research is targeted at developing integrated pest management practices to assist land managers in the production and establishment of longleaf pine. The fungus, *E. subglutinans* f. sp. *pini,* poses a serious threat to successful production of longleaf pine seed and seedlings. Presently, our research is focusing on the acquisition of information to prevent future problems as well as developing remedial treatments to manage diseases caused by *E. subglutinans* f. sp. *pini*. We are currently working on aspects of seed and seedling diseases in seed orchards, nurseries, and regeneration sites.

Recent interest in longleaf pine (Pinus palustris) restoration and management has brought diseases of this pine species, including those caused by Fusarium subglutinans f. sp. pini, which is the pitch canker fungus, to the forefront. Pitch canker is a serious disease of planted pines. The disease was first described in 1946, affecting Virginia pine (P. virginiana), shortleaf pine (P. echinata), and pitch pine (P. rigida) (Hepting and Roth 1946). In 1950, Hepting and Lindgen referred to pitch canker on longleaf pine as a "common southern forest tree disease." Furthermore, they suggested the disease inhibited the establishment of both planted and natural stands of longleaf pine. Interest in pitch canker was rekindled in 1976, when the disease became epidemic in the southeastern United States on slash (P. elliottii var. elliottii) and loblolly (P. taeda) pines (Dwinell et al. 1985). Subsequently, researchers have determined that most, if not all, southern pines are hosts of the pitch canker fungus. During the last two decades, the pitch canker disease has progressed from regional significance to national and international import. Pitch canker has been reported on planted Monterey pine (P. radiata) in California, and has reportedly damaged pines in Haiti, Japan, Mexico, and South Africa.

The pitch canker fungus infects vegetative and reproductive structures at different stages of maturity, which results in a diversity of symptoms. Two primary symptoms are associated with vegetative structures of planted longleaf pine. The classic symptom is a bleeding, resinous canker on the trunk, terminal, and large branches. The wood beneath the canker is deeply pitch-soaked. Infections that develop on the current-year growth eventually girdle the shoots resulting in dieback.

The fungus also causes mortality of female strobili from the time of inception through maturity of the cone. However, information is limited on the mechanisms of infection of longleaf pine cones by the pitch canker fungus. Infected loblolly pine cones tend to be misshapen and smaller than normal. Scales of infected green cones of slash and loblolly pine at harvest have purple discoloration (Broaddus 1987). Shortleaf pine cones, however, show little external evidence of internal infection by the fungus (unpublished data).

Deterioration of the endosperm and embryo of seeds and extensive contamination of the seedcoats by F. subglutinans f. sp. pini has been reported in state, federal, and industry seed orchards. Internal seed tissue infected by the fungus can range from potentially sound (based on a radiograph) to badly deteriorated. In slash pine seed, radiographs of many infected seeds show the gametophyte shrunken from the seedcoat and a slight deterioration of the embryo (Broaddus 1987). However, radiographs of pine seeds have not been reliable for determining whether the seeds are contaminated. In a study on the contamination of three

longleaf pine seedlots, we found the fungus was more frequently isolated from the seeds with seedcoat (20%) than from those without seedcoats (2-6%) (unpublished data).

The pitch canker fungus has created problems in the production of longleaf pine seedlings in bare-root and container nurseries. Infection or contamination of pine seeds by the pitch canker fungus may result in pre- or post-emergence damping-off. In 1994, Carey and Kelley reported that the fungus was isolated from diseased longleaf pine seedlings in nurseries that had extensive late-season mortality. Furthermore, they reported that the pitch-soaked tissue characteristic of the pitch canker disease was generally absent in longleaf pine seedlings. In South Africa, the pitch canker fungus causes a root rot of container-grown P. patula seedlings (Viljoen et al. 1994).

Carey and Kelley (1994) previously postulated that infections in longleaf pine nurseries would require wounding. Any fresh wound, regardless of cause or location, provides an infection court for the pathogen. Insects, for example, may serve as vectors of the pathogen as well as wounding agents. We tested the pathogenicity of four isolates of the pitch canker fungus by challenging wounded and unwounded longleaf pine seedlings. Basically, we confirmed that a wound was required for infection (unpublished data).

Two factors complicate the pitch canker disease picture in longleaf pine in nurseries: (1) the pathogen can be seedborne, and (2) fumigation with methyl bromide to prevent soilborne pest problems will be banned in the United States after January 1, 2001. In our attempt to find alternatives to methyl bromide fumigation, we are currently examining the treatment of seeds with chemicals and/or biocontrol organisms. We have established several experiments to evaluate the efficacy of a naturally occurring, nonphytotoxic, nonpathogenic soil bacteria Burkholderia cepacea strain RAL-3 as a seed treatment in controlling Fusarium-related diseases associated with longleaf pine seeds. To date, the results have been non-conclusive. We believe the best strategy for eradicating seedborne diseases caused by F. subglutinans f. sp. pini will involve preventing seed infection and seedborne contamination in the seed orchard.

In summary, our research is targeted at developing integrated pest management practices to assist land managers in producing and establishing longleaf pine. The pitch canker fungus, F. subglutinans f. sp. pini, poses a serious threat to successful production of longleaf pine seed and seedlings. Our current research focuses on acquiring information to prevent fungus-caused diseases and on developing remedial treatments to manage these diseases. We are working on aspects of seed and seedling diseases in seed orchards, nurseries, and regeneration sites.

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Red-Cockaded Woodpecker Response to Selection Timber Harvest in a Longleaf Pine Forest: Preliminary Results

Todd R. Engstrom (Tall Timbers Research Station, Tallahassee, FL)
B. McCulloch (Tall Timbers Research Station, Tallahassee, FL)
S. Crafts (Tall Timbers Research Station, Tallahassee, FL)
C. Hess (Apalachicola National Forest, Bristol, FL)

ABSTRACT -The longleaf pine ecosystem provides critical habitat for many plants and animals, including the endangered Red-cockaded Woodpecker (Picoides borealis). In an effort to develop timber management practices that are ecologically sound and provide adequate habitat for the Red-cockaded Woodpecker, the U.S. Forest Service initiated an experimental timber harvest to move a primarily even-aged longleaf pine forest toward an all-aged structure on 700 acres (283 ha) in the Apalachicola National Forest in north Florida. The principal objective of this project is to determine if a selection timber harvest within the context of uneven-aged timber management has a detrimental effect on Red-cockaded Woodpeckers. Comparisons of home range, group size, foraging behavior, annual productivity, and provisioning rate will be made between woodpeckers in treatment (8 groups) and control (6 groups) areas before and after timber harvest. Pre-treatment data were collected between May 1994 and July 1995. The selection timber harvest was completed in two phases: the first started in October 1995 and was completed in March 1996, and the second started in August 1996 and was completed in September 1996. Preliminary results of this project indicate that uneven- or all-aged timber management in longleaf pine forests has ecological characteristics that are consistent with the emerging concept of ecosystem management. Selection harvest within uneven-aged timber management holds promise for public and private land managers who are interested in conservation of ecosystem function and biological diversity and timber production.

INTRODUCTION

Uneven-aged management has been practiced on a broad scale (approximately 100,000 ha) on private shooting plantations in the Tallahassee, FL-Thomasville, GA, region for more than 50 years. Although the primary land management goal has been to provide high quality Northern Bobwhite (Colinus virginianus) hunting on these lands, the uneven-aged management methods used to manage these forests have maintained a relatively large and apparently stable population of Red-cockaded Woodpeckers (Picoides borealis) as a by-product of bobwhite habitat management (Engstrom and Baker 1995). A formal procedure for managing longleaf within an uneven-aged system has been developed and evaluated (Farrar and Boyer 1991).

Uneven- or all-aged timber management of longleaf pine forests has many desirable ecological and economic characteristics (Engstrom et al. 1996). For example, (1) standing forest that provides stable habitat for animals associated with longleaf forest, (2) small openings in the canopy that mimic small-scale disturbances caused by wind or insects, (3) minimal habitat fragmentation, (4) minimal groundcover disturbance, (5) an even distribution of needles, which are an important fuel base for fire, and (6) a sustained flow of timber products.

In an effort to develop timber management practices that are ecologically sound and provide adequate habitat for the Red-cockaded Woodpecker, the U.S. Forest Service initiated an experimental timber harvest to move a primarily even-aged longleaf pine forest toward an all-aged structure on 700 acres in the Apalachicola National Forest in north Florida. The principal objective of this project is to determine if a selection timber harvest within the context of uneven-aged timber management has a detrimental effect on Red-cockaded Woodpeckers.

STUDY AREAS AND METHODS

The study is located on a 700-acre (283-ha) treatment area and a 450-acre (182-ha) control area in the Apalachicola Ranger District of the Apalachicola National Forest in north Florida. Timber was marked and the harvest treatment administered according to the bdq method (basal area/dbh/q; Farrar 1984; Farrar and Boyer 1991). One modification of this method for this project was to eliminate the diameter limitation.

The effects of the first selection harvest on Red-cockaded Woodpeckers were measured by comparing home range, group size, foraging behavior, annual productivity, and provisioning rate

in eight woodpecker groups in the treatment area and six woodpecker groups in the control area before and after timber harvest. Pre-treatment data were collected between May 1994 and July 1995. The selection timber harvest was started in October 1995 and will be completed in September 1996.

Forest structure data were collected for both the treatment and control areas by measuring seedlings (1" at root collar) within 0.001-acre circles, saplings (1-3" dbh) within 0.01-acre circles, and all trees ≥ 4" dbh within a 0.01-acre. Centers of the 0.1-acre circles were located on a 3 chain x 3 chain grid over both the treatment and control areas.

RESULTS

We found no differences between Red-cockaded Woodpecker groups in the control (n=6) and treatment (n=8) areas before selection harvest in: the number of adults per group (1990-1995), clutch size (1990-1995), the number of chicks at banding age (1990-1995), the number of fledglings (1990-1995), year-round home range (1994-95), and the number of cavity trees per cluster (1996). Red-cockaded Woodpecker cavity trees were at the upper end of the tree size class distribution.

In 1996, the first year after a partial harvest, there were no dramatic changes in productivity, if anything, the treatment groups were slightly more productive than the controls. Pre-harvest stand characteristics were 98 trees (>3 in. dbh)/acre and 59 sq. ft. BA/acre. Projected composition post-harvest is 87 trees/acre and 50 BA/acre.

DISCUSSION

Preliminary results indicate that selection harvest does not have an adverse affect on Red-cockaded Woodpeckers, although more data are needed to strengthen this conclusion. One of the most desirable qualities of uneven-aged timber management is its inherent flexibility. The selection harvest allows most of the forest to be retained between harvests, which provides stability in ecological and economic benefits. One aspect of the bdq method, the diameter limit, was eliminated in this application, because the woodpecker makes its cavities in the largest trees available. We are in the process of collecting additional data on aspects of forest regeneration and growth and the economics of uneven-aged management.

A selection system that results in an uneven-aged structure has been used to provide habitat for a variety of plants and animals in the Red Hills for decades. This model, on private land, suggests that conservation of ecological resources and production of timber resources can be compatible.

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Montane Longleaf Pine Forests on Fort McClellan, Alabama

B. William Garland (Directorate of Environment, ATZN-EM, Fort McClellan, AL)

ABSTRACT - Longleaf pine is usually associated with the Atlantic and Gulf Coastal Plains where vast forests formerly dominated much of the landscape. Today, much of our knowledge and understanding of this disappearing ecosystem have come from research on the coastal plain. Historical and recent accounts of longleaf pine distribution, however, often describe an extension of this forest type into the mountains of northeast Alabama and northwest Georgia. Within this isolated area, longleaf pine sites significantly differ from the deep, sandy soil environments encountered on coastal plain. In these montane forests longleaf pine has become well adapted to shallow, rocky soils along steep mountain slopes and ridges. Fort McClellan, Alabama provides a particularly interesting example of this regional forest type. Although extensively logged to support local charcoal iron furnaces during the 1880s, remnant old-growth stands appear to have survived on remote mountain slopes. Shortly thereafter, this land was leased for artillery training by the Alabama National Guard and subsequently purchased by the Army as an active training installation in 1917. One of the unintentional benefits of this ownership has been the persistence of wildfire from military training operations. Much of these mountainous forests have been exposed to frequent and recurring wildfires for the past hundred years. This has allowed the formation of a more natural fire maintained forest system then is encountered on surrounding lands. The structure and composition of these forests significantly differ from those found on the coastal plain. The forest is composed of mosaic of forest types, with longleaf pine dominating southern and western slopes. Slope, aspect and elevation appear to be significant factors influencing fire intensity and the distribution of longleaf pine in these mountain regions. Recent studies by Auburn University have identified Fort McClellan as containing the finest remaining example of montane longleaf pine forest.

Longleaf pine *(Pinus palustris)* is usually associated with the Atlantic and Gulf Coastal Plains where vast forests formerly dominated much of the landscape. Today, most our knowledge and understanding of this disappearing ecosystem has come from research on the Coastal Plain. Both historic and recent accounts of longleaf pine distribution, however, describe an extension of this forest type into the mountains of northeast Alabama and northwest Georgia. Within this isolated area, longleaf pine sites significantly differ from the deep, sandy soil environments encountered on the Coastal Plain. In these montane forests longleaf pine has become well adapted to shallow, rocky soils along steep mountain slopes and ridges.

Fort McClellan is a 40,000 acre army training facility located in north-central Alabama. Only 12,000 acres of the installation, however, are covered by this rather unique montane forest association. This area of rugged topography includes steep ridges that occasionally exceed 2,000 feet in elevation. Most accessible areas within these mountains were timbered in the late 1800s to produce charcoal for the local iron industry. After purchase by the Army in the early 1900s, timber harvesting no doubt continued in some areas. Steep slopes and isolated ridges, however, contain relict trees and isolated old growth stands of longleaf pine. Recent studies by Auburn University have recorded isolated stands that average 180 years in age, as well as, individual relict trees that are 250 years old (J. Kush, pers. commun.).

The first detailed biological inventories of these lands were conducted by the Alabama Natural Heritage Program (1994) during the late 1980s and early 1990s. These studies documented the distribution and unique composition of this longleaf pine montane forest. Further studies have been programmed through Auburn University (Maceina 1996) to more fully investigate the significance and ecological importance of these forests. Historical accounts have been compared to existing forest conditions in an effort to document changes that have occurred in these forests. The results of this analysis revealed that Fort McClellan contains the finest remaining example of a montane longleaf pine ecosystem. The Army is continuing to study these unique forests to more fully understand management and protection requirements. Because forest structure is but one aspect of the total ecosystem, additional studies have also been programmed or accomplished to more fully characterize other biotic components. Research projects on birds (Summerour 1992, Webb 1995, Hill 1996) and vascular plants (Whetstone et al. 1996) provide additional information for better understanding the dynamics of the entire forest system. Research in progress includes reptile and amphibian surveys, mollusk inventories, and gray bat (*Myotis grisescens*) habitat suitability studies.

The steep inaccessible slopes along these mountain ridges provide a good example of a multi-aged longleaf pine forest. Lightning, insects and weather have eliminated old-growth trees at scattered locations.

The existing forest contains numerous dead and dying trees that eventually fall and create openings within the forest. The loss of individual old-growth trees appears to be the primary process of renewal within this forest. Small openings provide the seedbed for regenerating new longleaf pine stands. The resulting forest is composed of many isolated small stands of varying ages. Some of the larger stands in the forest may owe their origin to devastating wildfires that have occurred on these steep slopes in the past.

Military training with pyrotechnic and explosive devices has occurred within these forests since the turn of the century. While suppression and public education decreased wildfires in the surrounding region, military training assured that this fire regime was maintained on Fort McClellan. These montane forests have been exposed to frequent and recurring wildfires for the past hundred years. This has allowed the formation of a more natural fire maintained forest system then is encountered on surrounding lands. The structure and composition of these forests significantly differ from those found on the Coastal Plain. The forest is composed of a mosaic of forest types, with longleaf pine dominating southern and western slopes. Slope, aspect and elevation appear to be significant factors influencing fire intensity and the distribution of longleaf pine in these mountain regions.

These forests contain a highly diverse assemblage of species and biological communities. This high species diversity can be attributed to both geographic and physiographic factors. The Ridge and Valley Physiographic Province and a southern disjunct of the Blue Ridge Physiographic Province introduce a decidedly Appalachian influence into the region. A large number of species reach the southern terminus of their range on these lands. At the same time, the region is also influenced by proximity to the Piedmont and Coastal Plain. The widespread existence of longleaf pine and, in particular, a northern disjunct population of turkey oak (*Quercus laevis*) are particularly significant.

CONCLUSION

Fort McClellan contains the finest remaining example of a naturally maintained montane longleaf pine ecosystem. This can primarily be attributed to historic ownership and subsequent military training practices. Although historic accounts indicate several tracts of this unique forest type existed in the region after 1900, all have since disappeared or have been severely altered. A number of factors unique to Fort McClellan contribute to the ecological importance of this forest: (1) existence of relict old-growth stands; (2) historic fire regime related to military training; (3) land use restrictions associated with firing range safety fans; (4) configuration of large un-fragmented forest tracts; and (5) the presence of numerous undisturbed unique local environments (acid seeps, calcareous outcrops, etc.).

Because Fort McClellan has been selected for closure by the Base Realignment and Closure Commission, it is particularly important to assess the ecological significance of these lands. An Environmental Impact Statement is currently in preparation on the reuse of these lands.

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Comparing Competitive Success of Three Southern Pine Species

Dean Gjerstad (Auburn University, School of Forestry, Auburn University, AL)
Mark Hainds (Auburn University, Solon Dixon Forestry Education Center, Andalusia, AL)
Rhett Johnson (Auburn University, Solon Dixon Forestry Education Center, Andalusia, AL)
Robert Mitchell (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)

ABSTRACT - Three duplicate studies are located in the Middle Coastal Plain of south Alabama. The study sites included a dry site typical of droughty, coarse textured, nutrient poor upland conditions, an upland site richer in nutrients and having greater water holding capacity, and a wet site common to the lower slopes. Three tree species (*P. elliottii, P. palustris,* and *P. taeda*) and four plant community neighborhoods were included in the study. Plant communities were: 1) pine+hardwood+herbaceous, 2) pine+herbaceous, 3) pine+hardwood, and 4) pine. Survival varied among the three species but was not affected by plant competition or site conditions. Under all plant competition and site conditions, longleaf pine survival was 50% while both loblolly and slash pine were near 85%. The dry site had the least herbaceous cover and senescence of those species occurred much earlier than the other sites. Woody biomass was greatest on the wet site primarily due to the abundance of non-arborescent species. Greatest volume growth for loblolly and slash occurred on the dry site likely because summer rainfall was above average for both the first and second growing seasons. Approximately 50% of longleaf seedlings were out of the grass stage on treatments where herbaceous and woody non-arborescent plants were not present. The greatest hindrance to growth for all species during the first two years was competition from herbaceous and woody non-arborescent plants.

A Historical Perspective on Longleaf Pine Groundcover Vegetation in the Francis Marion National Forest

Jeff S. Glitzenstein (Tall Timbers Research Station, Tallahassee, FL)
Donna R. Streng (Tall Timbers Research Station, Tallahassee, FL)
James MacBride (Pineville, South Carolina - deceased 1817, age 33)
Dale D. Wade (USDA Forest Service, Hitchiti Experimental Forest, Southern Research Station, Juliette, GA)
Eric Kjellmark (Department of Biology, University of North Carolina, Chapel Hill, NC)
Patrick McMillan (Department of Biology, University of North Carolina, Chapel Hill, NC)
Robert K. Peet (Department of Biology, University of North Carolina, Chapel Hill, NC)

ABSTRACT - Longleaf pine groundcover vegetation is characterized by high levels of species richness and local endemism. Also species composition varies distinctively by region. Unfortunately, much longleaf groundcover vegetation has been lost or altered by fire suppression and other abuses. Management and restoration of this unique vegetation therefore requires some conception (i.e., a template) of floristics and species abundances in the original (i.e., "old growth") forests. One approach to producing such a template is to consult historical sources. In this poster we compare modern vegetation samples from the Francis Marion National Forest (FMNF) and vicinity with species lists for the same general area prepared by local botanists between 1810-1850. Particularly of interest is an unpublished list of what would now be termed "indicator species" of different types of habitats prepared by Dr. James Macbride c. 1812-1814. Approximately 60-90% of Macbride's longleaf species, depending on habitat, were encountered in our own samples. Similar results were obtained using other more comprehensive lists (e.g., Bachman's 1832 list of plants in the vicinity of Charleston, and F.P. Porcher's 1847 list of plants of St. John's-Berkeley Parish). We conclude that longleaf pine groundcover vegetation in the FMNF is not old field vegetation but rather an important remnant of the original old growth groundcover. The absence of some species from our modern samples may indicate deterioration of groundcover quality or a need for a more comprehensive survey to better compare with the 1800's data.

INTRODUCTION

Longleaf pine groundcover vegetation is characterized by high levels of species richness and local endemism. Also, species composition varies distinctively by region. Unfortunately, much longleaf vegetation has been lost or altered by fire suppression and other abuses. Management or restoration of longleaf groundcover vegetation in any given region therefore requires some conception (i.e a template) of the original old growth groundcover in that region.

One approach to producing such a template is to consult historical sources. In this paper, we begin the process of constructing such a template for the Francis Marion National Forest (FMNF), SC, one of the largest areas of contiguous longleaf pine forest remaining in the Atlantic Coastal Plain. We then compare our partially constructed template to vegetation samples from existing longleaf pine forests in the FMNF. Our objective is to determine whether the existing groundcover vegetation is badly disturbed old field vegetation or remnant old growth groundcover.

METHODS

Historical Vegetation

The FMNF is located in Charleston and Berkelely Counties, SC, just north of the city of Charleston. In the period prior to 1850, this area was home to several dedicated botanists. "Flora Caroliniana", one of the first botanical manuals in North America, was published in 1782 by Thomas Walter, who lived near St. Stephens close to what is now the northwest corner of the National Forest. Thirty years later, between the dates of 1816 and 1824, Stephen Elliott, one of the preeminent botanists of his time, published his landmark "Sketch of the Botany of South Carolina and Georgia". This was the first regional flora to adequately treat the grasses and sedges of the Carolina Lowcountry.

James Macbride was a young medical doctor who lived in Pineville, another town in the vicinity of the modern FMNF. He was also a competent botanist and a close friend of Stephen Elliott's. Based on Elliott's notations in the "Sketch", as well as his acknowledgments, it is clear that Macbride provided much information on plants around the area where he lived. Macbride died in 1817 at the age of 33, helping to treat

an outbreak of yellow fever. The genus Macbridea was named in his honor by Elliott. Two species in this genus, alba and caroliniana are now considered endangered plants of longleaf pine savannas.

Among Macbride's contributions to Elliott's work was an unpublished list (available on microfilm, along with other Elliott materials, from the Harvard Library), found among Elliott's personal papers after his death, of what would now be considered indicator species of various types of habitats . Three of these, "sand ridge", "high pine" and "moist pine barrens", are directly relevant to our investigation of longleaf pine groundcover vegetation.

One difficulty with Macbride's list, and other early species lists and floras, is the archaic scientific nomenclature. Many of the plant names have changed repeatedly since the early 1800's. Thus, the process of translating the old names into modern scientific nomenclature is tedious in the extreme, involving much cross-checking among botanical manuals published during the intervening years.

Nevertheless, we have now completed our "translation" of Macbrides list. In addition, we have largely completed work on another old list, this one published by F.P. Porcher in 1847 as part of his medical dissertation. Porcher entitled his work "A Medical-Botanico Catalogue of the Plants of St.-John's Berkeley Parish". This area encompasses much of modern day Berkeley County, and thus overlaps considerably with the Francis Marion National Forest. In contrast with Macbride's list, Porcher's list was not organized by habitat types. Nevertheless, Porcher did provide habitat notations for many of his species.

In addition to these lists by Macbride and Porcher, we also have in our possession several other early lists, including lists by John Bachman and H.W. Ravenel. However, we are still in the early stages of translating the species names on these lists into modern nomenclature.

Modern Vegetation Data

There are three sources of modern data to compare to the historic information. (1) We maintain four permanent study areas (PSA) in the FMNF as part of ongoing fire ecology studies: the Tiger Corner (TC) plots maintained by Dale Wade, as well as 62 one ha permanent plots set up by Donna Streng and Jeff Glitzenstein in 1991-1992. The Streng-Glitzenstein (SG) plots are arranged into 3 sets of 21 plots, with each set in one of three different types (wet, mesic, dry) of longleaf pine dominanted habitats (see Streng et al. this volume). We have species lists for Tiger Corner and for each of the Streng-Glitzenstein areas. (2) Bob Peet and colleagues Kjellmark and McMillan (PKM) sampled 14 0.1 ha plots in the Francis Marion National Forest as part of a broad scale study of longleaf pine dominated vegetation. (3) Richard Porcher's (1995) recently published book "Wildflowers of the Carolina Lowcountry".

RESULTS

Macbride listed 28 species as characteristic of his dry longleaf pine habitats ("high pine" and "sand ridge"). Half of these occur today in the SG dry PSA. No additional species were found in the two PKM plots located on dry soils. However, inclusion of four additional species known to occur in the FMNF brings the total to 64%. If we further include a few more species from other nearby sites, the regional total is 71%.

Interestingly, many of the missing species are characteristic of the sand ridge habitat type. The probable explanation is that true sand ridge sites are rare in the FMNF. Also, most such sites appear to have a history of fire exclusion, and are presently dominated by closed canopies of turkey oak. We suggest that substantial restoration may be warranted for this particular community.

According to Macbride (unpublished notes associated with his list) "moist pine barrens occupy about one half of the land". Also, "I cannot designate any species of oak except Quercus phellos (willow oak)...peculiar to these woods The pine is palustris (longleaf) intermingled with pond pine". Thirty six groundcover species were listed by him as characteristic of this "moist pine barren" habitat type. Of these, 78% presently occur in the SG wet and mesic PSA's. The twelve PKM plots from moist soil types also encountered a high percentage of Macbride's moist site species (69%), including two species not found in the SG plots. Inclusion of a few more species from the remainder of the forest, including the rare Schwalbea americana (American chaffseed), brings the total to a respectable 89%.

The results to date from Porcher's (1847) list are similar to the above. Thus far, we have identified 172 species on this list as longleaf pine associates. This includes species of various types of "pine barrens",

as well as species associated with soil types generally dominated by longleaf (e.g. “dry soils”, “sandy soils”). However species associated with ruderal habitats were specifically excluded, even if they occurred on the appropriate soils (e.g. “dry soils in fields”). Of these 172 spp, 115 (67%) occur in the SG plots. The total from the Forest as a whole, including data from all sources, is 129 species, or 75%.

CONCLUSION

We conclude that the modern FMNF contains important remnants of old growth longleaf pine groundcover and should be managed accordingly. The apparent absence of some species is troubling, however, and may indicate some loss of biodiversity on a Forest wide level. A systematic search of the FMNF is warranted in order to thoroughly test this possibility.

Species Introductions in Longleaf Pine Groundcover Vegetation

Jeff S. Glitzenstein (Tall Timbers Research Station, Tallahassee, FL)
Donna R. Streng (Tall Timbers Research Station, Tallahassee, FL)
Dale D. Wade (USDA Forest Service, Southern Research Station, Juliette, GA)

ABSTRACT - Longleaf pine groundcover vegetation is uniquely species rich at small to medium spatial scales. However, species richness has been reduced in many locations by a history of fire suppression and soil disturbance. It is therefore of interest to determine whether groundcover species can be successfully introduced into appropriate habitats without intensive site preparation which might further damage those habitats. We have been testing two methods for introducing species into longleaf pine groundcover vegetation in the Francis Marion National Forest: (1) as seeds, collected by machine from several sites inside and outside of the National Forest. (2) as nursery grown seedlings. The only site preparation is fire. Results indicate that wiregrass (*Aristida beyrichiana*) is readily introduced from seed (i.e., seedlings are present and increasing in size 2 years after the initial introductions), particularly in high light microhabitats without excessive woody competition. However, seed introductions are rarely successful for other species. In contrast to the seed introduction treatments, we have had good success introducing 1-2 year old seedlings. In addition to nursery grown seedlings of wiregrass, we have also outplanted toothache grass (*Ctenium aromaticum*), Indiangrass (*Sorghastrum nutans*) and the rare forb *Parnassia caroliniana*. In all cases, seedlings have shown good survival (generally > 80%). Parnassia seedlings have demonstrated the capacity to withstand periods of flooding lasting > 7 days and are increasing rapidly in size (i.e., measured as clump basal area). We conclude (1) that seedling introductions may be a useful method for enhancing species richness of longleaf pine groundcover, and (2) sites managed with frequent fire and minimal soil disturbance may serve as refugia for artificially established populations of rare groundcover plants.

INTRODUCTION

Longleaf pine groundcover vegetation is uniquely species rich at small to medium spatial scales. However, species richness has been reduced in many locations by a history of fire exclusion and soil disturbance. It is therefore of interest to determine whether groundcover species can be successfully introduced into appropriate habitats without intensive site preparation which might further damage those habitats.

METHODS

The study area is the Francis Marion National Forest (FMNF), north of Charleston, SC. There are three study sites (henceforth wet, mesic, dry) representing different types of longleaf pine dominated habitats within the Forest. Each study site is subdivided into 21 1 ha plots. Every plot is randomly assigned to one of three groups (A,B,C). Within sites and groups, plots are randomly assigned one of three burn treatments: (1) no burn, (2) burn every 2 yrs in winter, (3) burn every 4 yrs in winter, (4) growing season burn every 2 yrs, (5) growing season burn every 4 yrs, (6) growing season burn on average every 2 yrs, but with random between fire intervals, (7) growing season burns on average every 4 yrs, but with random between fire intervals. Treatments were initiated in 1993 for plots in group A. Treatments in Groups B and C were initiated in 1994 and 1995 respectively. Results described below are limited to Group A plots only.

Seed Introductions

Seeds introduced into Group A plots were obtained from five donor sites: (1) Webb Wildlife Center, Hampton County, SC. (2) Tilman Sand Ridge Preserve, Jasper County, SC (3) Venture Plantation, Williamsburg County, SC, (4) Yawkey Wildlife Center, Georgetown County, SC, (5) areas in the FMNF outside of our study plots. Donor sites were selected which had high quality groundcover including at least one species not present inside our study plots. Seeds were collected in October-December 1992. Collections at Webb and Tilman coincided with peak germinability of wiregrass (Aristida beyrichiana), the dominant grass at those two sites. Wiregrass does not presently occur within the FMNF.

Within each main fire treatment plot (see above) are randomly located six 1.5 x 2.0 m subplots. Half of these are randomly chosen for seed introductions, while the other three serve as controls. Each subplot is subdivided into 48 25 cm x 25 cm cells.

Pretreatment data were collected during the summer of 1992, prior to introducing the seeds. These data consisted of lists of species for each cell within every subplot. Thus, the abundance of each species in a subplot was determined as the percentage of cells in which it was found.

Seeds were introduced following 1993 treatment fires. Seeds in no burn plots were introduced at the same time as seeds in winter burn plots. In each subplot, seeds were introduced only into the central 0.5 x 2.0 m strip. This was to allow us to monitor movement, if any, of introduced species into surrounding areas.

Subplots were recensused 2 yrs later, during the 1995 growing season.

Seedling Introductions

Grasses: Three subplots were randomly located within each main fire treatment plot for grass seedling introductions. These subplots are 1.5 m x 4.0 m, also subdivided into 25 cm x 25 cm cells. One year old wiregrass and toothache grass (*Ctenium aromaticum*) seedlings, grown in a nursery at the Santee Experimental Forest, were outplanted into these subplots during January and February 1994. The grasses were planted alternately into the central 0.5 m x 4.0 strip of each subplot, leaving one open cell between each grass plug. Outplanted grasses were checked for survival in late winter 1995 and again in late winter 1996. In addition, tiller numbers were determined in 1996 for each outplanted seedling.

Parnassia caroliniana: Grass-of-Parnassus (*Parnassia caroliniana*) is a rare forb throughout the range of longleaf pine. In South Carolina it appears to be exceedingly uncommon (S1 state rank). The following chronology summarizes the activities associated with this species:

1993 Seeds

12/93	Three mature capsules collected at Bates Hill Plantation, N of Georgetown, SC
3/93	Capsule 1 seeded onto wet-soil in a growing tray at nursery
4/94	Seedlings begin to germinate.
5/94	Seeds from capsules 2-3 placed into growing trays. Most seeds fail to germinate, suggesting that germination requires a period of cool temperatures.
11/94	18 plugs outplanted into test subplot at the wet site.
12/94	Censusing initiated for leaves and clump area (estimated as area of best fitting ellipse) of outplanted plugs.
1/95	Seedlings survive two periods of heavy rain and flooding
5/95	Very dry spring; supplemental water added on three occasions.

1994 Seeds

12/94	24 capsules collected from Bates Hill Plantation (17 already open and dispersing seed; 8
12/94	2090 seeds from 17 open capsules placed into growing trays in nursery. Seeding densities and arrangements experimentally varied to test for effects on germination.
2/95	Seeds begin to germinate; seedling emergence monitored.
11/95	249 plugs planted into 7 subplots in 4 main plots at the wet site; also 56 plugs planted haphazardly within a large canopy gap in a fifth main plot.
6/95	Plugs (and seedlings within plugs) checked for overwinter survival, surface area, and leaf numbers.

RESULTS

Seed Introductions: Two yrs after the seed introductions, wiregrass seedlings were present in many (38%) of the subplots. However, few seedlings were introduced for other species. Indeed, when wiregrass was removed from the dataset, a statistical analysis (CANOCO ordination) failed to demonstrate any difference between species composition in introduction and control subplots.

The above results suggest that direct seeding of wiregrass is possible. However, we should also acknowledge that wiregrass seed introductions were not uniformly successful. To begin with, no wiregrass seedlings were established in no burn plots or at the dry study area. Also, few seedlings were present at the wet study area following seed introductions after growing season fires. The most successful rates of seedling

establishment occurred at the mesic study area (over 80% of subplots had at least one seedling), regardless of season of introduction, and in the wet study site when seeds were introduced following winter burns.

Grass Seedling Introductions: After 1 yr, wiregrass plug survival was close to 100% at all three study sites. Toothache grass survival was also high, on average, though there were distinct differences among the sites. Survival of this species was lowest at the dry site and highest at the wet site. This is not too surprising, since toothache grass is normally restricted to wet savannas.

Two yrs after outplanting, wiregrass survival was still close to 90% at the wet and mesic sites, even in reburned plots. Wiregrass survival at the dry site was equivalently high, except in reburned plots, where survival averaged less than 60%. Toothache survival patterns were similar to those from the previous year, except that site differences were accentuated in the post-burn plots.

Parnassia Introductions: Of the 18 Parnassia plugs in the initial test plot (see the chronology above) all but one survived the first winter and sprouted again the following spring. Another plug succumbed in the drought that spring. Plants derived from the 16 surviving plugs have suffered no additional mortality and have continued to increase in size (as measured by surface area and leaf numbers). Plugs outplanted in autumn 1995 also showed high (> 90%) overwinter survival and early observations suggest they will be as successful as the seedlings outplanted in the first trial.

CONCLUSIONS

1. Direct seeding of wiregrass appears possible under certain conditions, even when the seedlings are subjected to competition from previously established plants. However, seedling establishment is severely depressed on dry soils and when seeds are introduced too late in the growing season.
2. Direct seeding appears much less feasible for other species, particularly when seeds are introduced into previously established vegetation.
3. Seedling introductions were much more successful, both for grass plugs and for the rare forb Parnassia caroliniana. However, observations over several years will be required to determine the ultimate success of these newly established populations.

Legume Population Dynamics in a Frequently Burned Longleaf Pine-Wiregrass Fire Ecosystem

Mark J.Hainds (Auburn University, Solon Dixon Forestry Education Center, Andalusia, AL)
Robert J. Mitchell (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Lindsay Boring (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Brian Palik (Forestry Sciences Lab, Grand Rapids, MN)
Dean Gjerstad (Auburn University, School of Forestry, Auburn University, AL)

ABSTRACT - Longleaf pine-wiregrass ecosystems once covered most of the southeastern Coastal Plain, but this ecosystem type has been greatly reduced in range and extent. Fire has historically played an important role in species distributions and soil chemical dynamics of this diminished longleaf pine-wiregrass ecosystem. This frequently burned ecosystem may sustain large losses of N through volatilization by fire. Through symbiotic N-fixation, legumes may play an important role in sustaining N levels. However, the temporal and spatial distribution of legumes in longleaf pine-wiregrass ecosystems has been little studied. A series of plots were established across a frequently burned-complex gradient in a longleaf pine-wiregrass ecosystem, and surveyed monthly over a one year period to assess temporal variation. Legumes were surveyed by species for presence, cover class, and stem density. The peak month in species richness was selected for further multivariate statistical analysis to assess spatial variation in relation to several environmental variables measured across the complex environmental gradient. The number of legume species reported here is much greater than other reports from the southeastern Coastal Plains. Legume populations decreased slightly at the xeric end of the environmental gradient, and decreased steeply at the hydric end of the gradient, with virtually no legumes being found in the wetlands sampled. Some species appeared more tolerant of periodically inundated soil conditions (i.e. *Lespedeza angustifolia*), while others occurred most frequently on very xeric soils (i.e. *Petalostemon pinnatum*). Legume stem densities and cover class values appeared to be correlated with soil moisture, pH, extractable PO_4, extractable Ca, extractable Mg, and extractable K. From this study, it appears that legume populations in undisturbed, fire maintained, longleaf-wiregrass ecosystems, are larger and more divers than previously documented. The large number of species (43), high stem densities (119,460 legume stems ha^{-1}), and large cover classes, indicate that legumes may play important roles as faunal food sources. From the large number of legumes found across the complex gradient, there is the potential for these legumes to fix a large amount of N in this system. Furthermore, this study is the first to document the spatial and temporal distributions of many of these species across a complex environmental gradient.

INTRODUCTION

Frequent fires in longleaf pine-wiregrass systems may lead to substantial nutrient losses through volatilization, ash convection, erosion, runoff, or leaching. Losses of N through volatilization in fire dominated communities have been relatively well documented (see Christensen 1987). However, mechanisms that maintain soil N levels have not been as rigorously examined. Large populations of herbaceous legumes have been observed on frequently burned southern pine sites. Through long term inputs, biological fixation may replace N losses in part or total due to burning (Boring et al. 1990). While it is generally accepted that legume populations increase with increasing fire frequency and can be an important source for N inputs, quantifying the functional control that legumes exert on maintenance of nitrogen in frequently burned longleaf pine ecosystems has not been attempted.

Longleaf pine communities span a wide ecological amplitude from xeric sandhill communities to the edge of wetlands. As soil resources vary across sites, the magnitude of N inputs from symbiotic fixation could vary due to changes in population (both changes in species and abundance of individuals), or as resources become limiting, the individual rate of N fixation may decline. No estimates of fixation from native legumes in longleaf ecosystems have been published. Before this type of investigation can be conducted, more information is needed on the species of legumes present and their abundance throughout the longleaf pine landscape, as well as the factors that are likely to be important in regulating legume populations. The objective of this study was to quantify variation in legume populations in frequently burned longleaf pine-wiregrass communities that varied from deep sands to depressional wetlands, and determine which specific environmental variables were correlated with variation in legume populations.

METHODS

This study was conducted at the Joseph W. Jones Ecological Research Center at Ichauway in southwest Georgia. The study site has nearly 6,000 hectares (about 15,000 acres) of longleaf pine-wiregrass savannas that have been frequently burned (return interval varied from annual to every three years) during the dormant season for approximately 70 years. Longleaf pine wiregrass sites at Ichauway span the range from deep sandhills, to the edge of wetlands in which standing water is present throughout much of the year.

Eighty-five plots were established throughout a xeric to seasonally hydric gradient. Initially, soil classification maps were used for transect placement within mapped soil types. Seventeen areas were selected for transect establishment: 4 dry sites, 4 wet sites, and 9 intermediate site. Each site showed evidence of frequent burning and no evidence of prior tillage (i.e. wiregrass was the dominant grass present). Of the remaining plots, five were randomly selected at each of the 17 sites for a total of 85 plots. Each plot was 20x20m and had five 1x2m nested subplots, four located in each corner, and one in the center of the plot.

Beginning in August 1993, all 85 plots were surveyed for legumes. Surveys continued on a monthly basis for one year. The March 1994 survey was omitted while the plots were prescribed burned and the July 1994 survey was omitted due to floods from Tropical Storm Alberto.

Legumes were identified to genus and species, or to a species complex in the case of some *Desmodiums*. The number of species present in each 400 m^2 plot was recorded. In addition, the presence of gopher tortoises (*Gopherus polyphemus)*, and important legume herbivore, was estimated by quantifying the number of burrows and distance of burrows form sub-plots (to a maximum distance of 10m). Lastly, basal area of pines and oaks were recorded to provide some data on relative openness and light availability to the understory.

To assess soil fertility, fifteen to twenty soil cores (2.5 cm diameter) were collected from the surface horizon of each plot. The cores were combined into one bulk sample per plot and sieved (<2mm). Subsamples of soil were dried at 100°C for 48 hours to determine percent moisture content. Soil samples at field moisture content were used for chemical analysis, and the quantity of soil was converted to dry weight from the subsample as described above. Soil analysis followed standard methods. Gopher tortoise abundance and activity were measured on all plots.

All analyses were conducted with CANOCO 3.10, a multivariate statistical package (ter Braak 1987). June survey data sets were selected for analysis of legume populations because June was at or near peak abundance for legume cover values, stem densities, and species number. Fifteen plots from the three wetland sites thrown out of the analysis because there were no legumes present in the wetlands. Legume diversity and abundance was analyzed using stem density, percent cover, and presence/absence (PA) data.

Multivariate analysis provides statistical methods for study of the joint relationships of variables in data that contain intercorrelations. This multivariate analysis is based on ordination, by which sites and/or species are arranged along environmental gradients. Principle components analysis (PCA) was used to ordinate sites and environmental variables. Correspondence analysis (CA) was used to determine species turnover across complex environmental gradients, and canonical correspondence analysis (CCA) was used to proportion variance in species turnover over the gradient with variation in edaphic site factors.

RESULTS

The peak abundance as measured by number of stems occurred in June 1994. Of these 41 species, several were indistinguishable from one another. Two species of *Galactia* were put in the *Galactia spp*. class because of insufficient taxonomic keys and resultant difficulties in determining the correct species designation (*G. mollis* and *G. volubilis*). Additionally, *Desmodium marilandicum, D. obtusum*, and *D. ciliare* were placed in the D. ciliare complex. Hybridization of *Desmodiums* was apparent across the environmental gradient sampled. Similar problems with hybridization and subsequent difficulty in assigning individual species were observed for several members of the *Lespedeza* genera (personal communication with A. Clewell, and *Galactias* personal communication with A. Gholson). Legumes not identified to a specific species were not included in the analysis. Thirty-seven species were used in all analyses after all ambiguous species were removed.

Some genera were notably more abundant in cover values, stem values, and numbers of species present. The two genera with the largest number of species encountered during the June survey were *Desmodium* (7) and *Lespedeza* (6). Several measures of abundance (species presence/absence, stems per plot, and mean cover class) were used in assessing legume distributions.

Within the complex gradient sampled, an average of 119 stems for a 10-m^2 plot (119,000/ha) were found during peak abundance. Legume abundance was distributed across a wide range of species with 3.1 species found in 2-m^2 subplot, and 8.1 and 9.8 for 10-m^2 and 400-m^2 plot areas. Ninety four percent of all 2-m^2 subplots contained at least one legume species and up to eight legume species were found in individual 2-m^2 subplots. Thus, legumes were both diverse and widely distributed.

In addition to variable soil moisture relations, soils were quite variable in their chemical composition. Extractable Ca^{+2} exhibited the greatest range of all soil chemical variables quantified. Levels of Mg^{+2} were closely correlated to those of Ca^{+2}. Furthermore, K^+ levels were correlated (r^2=0.30) with extractable Ca^{+2}, heavier textured soils with greater CEC tended to have greater cation concentration than deep sands with low organic matter and clay content. Mineralizable N varied from a mean of 4.2 ppm N on xeric sites to 1.1 ppm N on low flats, and in general mineralization rates tended to decrease from xeric to mesic sites. Phosphorus pool (extractable and microbial P) varied as much as 8-fold through the study area with greater extractable P in xeric sand ridges and declines in extractable P as sites became more mesic; however, microbial P showed the opposite relationship (greater microbial P pools on wetter sites and declines as sites became more xeric). Soils were uniformly acidic with pH ranges from 5.9 on sand ridges and slopes to 5.3 in pond margins.

Principal Components Analysis (PCA) was run with three sets of environmental variables: physical soil variables, chemical soil variables, and both data sets. The physical soil data set yielded the highest eigen values and percent variance explained: 87.6% of the variance was accounted for by axes 1-4 of the PCA analysis. Depth-to-mottling and soil moisture were the most important environmental variables defining axis 1, while percent coarse-sand and fine-sand were the most important variables defining axis 2. Wet-mesic plots ordinated to the right side of the graph and xeric plots ordinated to the left. Percent silt and clay predominantly influenced axis 3, and axis 4 was largely defined by percent medium sand.

The PCA summary analysis of the chemical soil data set resulted in a slightly smaller cumulative variance (85.1%) explained by axes 1-4 than for the physical soil variables. Axes 1 and 2 of the physical soil data set explained more variance (66.9%) and had higher eigen values than axes 1 and 2 of the chemical soil data set. Mg and Ca were the most important variables defining axes 3 while mineralizable N was them most important variable in defining axis 4. When chemical and physical soil variables were combined, the total percent of variation explained among plots on the first four axes dropped to 68.5%. Ordination of the combined data set (soil physical and chemical variables) was similar to the ordination of the physical data set in that xeric plots were ordered to the left and mesic plots were found to the right on Axes 1 and 2.

A plot of the sum of species cover values per plot and the PCA axis 1 scores from the full environmental data set illustrates legume cover values across the complex gradient. The most xeric plots (mostly sand ridges) received the lowest PCA axis 1 scores, illustrating a hydrological and extractable P gradient. Legume cover was variable across the gradient but appeared to increase slightly as sites became more mesic, then decline rapidly at the more hydric end of the gradient.

The legume species distribution was ordinated using correspondence analysis (CA). Three legume species data sets were analyzed with CA: species present, cover class by species, and stem density of each species. The stem density data set yielded the highest cumulative unconstrained eigenvalue (5.91) and percent variation of species data explained (41.3%) on the first four axes. Ordination of legume species by stem density (axes 1 & 2) resulted in three species outliers strongly influencing the ordination and obscuring most species in the plot origin. The three species were *Lespedeza angustifolia*, *Galactia microphylla*, and *Petalostemon pinnautum*. *L. angustifolia* was one of the few legumes, in some cases the only legume found on the frequently inundated pond margin sites. On the opposite extreme *G. microphylla*, and *P. pinnautum* occurred nearly exclusively on the most xeric sites. While these species were segregated along the gradient, most of the other species encountered were not as strongly influenced by site variation. The ordination of species located near the origin of the above mentioned plots became more discernible when the outliers are excluded. There was a more continuous gradient of species turnover across the environmental gradient: xeric site species were in the lower right (i.e., *Psoralea lupinellus*, *Tephrosia florida*,

Lespedeza hirta, and *Cassia deeringiana*) quadrant: mesic site species (*Lespedeza capitata* and *Cassia fasciculata*) ordinating in the upper left quadrant: and intermediate site species *Tephrosia virginiana, Psoralea canescens,* and *Desmodium laevigatum* found in the lower left quadrant of the plot of axis 1 and 2.

Canonical Correspondence Analysis (CCA) with the stem density data set and the full environmental data set yielded the highest unconstrained (5.91) and constrained eigenvalues (2.61), and the greatest total species variation explained (27.5%) , as compared to the cover class and species presence data sets. Similar to the cover and species presence ordinations, xeric site species (*G. microphylla* and *P. pinnautum*) were located in the upper left quadrant while mesic site species were found in the upper right quadrant of the bi-plot, with *L. angustifolia* removed as an outlier) axis one was largely defined by soil moisture and depth to mottling, while axis 2 was most strongly influenced by Ca, Mg, and pine basal area.

DISCUSSION

Legumes are rich in species, ubiquitous in abundance, and are widely distributed throughout the complex gradient inhabited by longleaf pine-wiregrass ecosystems. The number of species reported in this work (43) is much greater than reported by Walker and Peet (1983): they reported eight species of legumes encountered throughout a xeric to hydric gradient in longleaf wiregrass savannas in the Green Swamp. In fact, the number of legume species reported for this study rivals that reported by Peet and Allard (1993) in a regional study of longleaf pine savannas east of the Mississippi in which they report only 42 legume species.

One reason for the high degree of species richness may be the wide ecological gradient sampled and the frequent dormant season burning that occurred on the study site. Although large variation in sites were documented, abundance of legumes and species distributions of legumes were not very sensitive to site variation, except at the extremes of the gradient. Legume abundance increased from xeric sites and decreased rapidly at the hydric extreme in the gradient. In addition, most species ordinated near the origin of CA and CCA analysis with the exception of three species *L. angustifolia* on the wet end and G. microphylla and P. pinnatum on the dry end. Savannas in this study were burned frequently during the dormant season (return intervals varying from 1-3 years). White et. al. (1990) reported that frequent dormant season burning increased legume populations in southern pine forests, although fires during the growing season at the same frequency tended to reduce legume abundance. They reported as many as 28,000 legume plants per plot (.1ha^{-1}) in the annual dormant season burning treatment. Although we were unable to clearly identify individual plants due to the clonal nature of many of the legumes encountered, the 119,000 stems ha^{-1} average across the entire gradient suggests similar abundance to that reported by White et. al. (1990). In addition to generally increasing abundance of legumes, frequent fires may increase the ecological amplitude of legumes by precluding competitive exclusion. In addition, legumes are preferred forage for many herbivores in this ecosystem. Herbivory may be acting to reduce abundance and presence of species on sites that are capable of supporting that species. Thus disturbance may be acting in diametrically opposite ways; fire increasing the range of sites occupied, and herbivory reducing presence on particular sites, but both acting in concert to reduce the coupling between variation in site factors and population characteristics.

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Arthropods on the Bark of Longleaf Pine: Potential Prey of the Red-Cockaded Woodpecker

Jim Hanula (USDA Forest Service, Southern Research Station, Athens, GA)
Kathleen E. Franzreb (USDA Forest Service, Southern Research Station, Clemson University, Clemson, SC)
Kirsten P. New (USDA Forest Service, Southern Research Station, Athens, GA)

ABSTRACT - We examined arthropod diversity, abundance and biomass on 50-70 year old longleaf pine (*Pinus palustris*) tree boles, a primary foraging substrate of the red-cockaded woodpecker (*Picoides borealis*), to determine where the prey biomass comes from and how it varies with time. Traps that captured arthropods crawling on the bark, flying to it, and crawling on the ground were operated continuously for 12 months. Flight and crawl traps were placed at different heights, and half of the trees with crawl traps were fitted with a barrier to prevent arthropods from crawling up from the ground. The overall arthropod community on the bark included high numbers of omnivores and detritivores, and high biomasses of those groups as well as predators and herbivores. However, crawl trap captures were the most representative of *P. borealis* prey use. Arthropod fauna captured in crawl traps has a 58% similarity to the fauna captured in pitfall traps and a 60% similarity with flight trap captures. Flight and pitfall trap captures had a 10% similarity. Barriers to arthropod movement up the tree reduced the arthropod biomass on the bole of the trees by 40-70%. Arthropod biomass was highest in the fall and winter, and lowest in the summer. The data are discussed in relation to management of RCW foraging habitat.

INTRODUCTION

The Red-cockaded Woodpecker (RCW), *Picoides borealis*, is an endangered species, frequently associated with longleaf pine forests in the South, that forages almost exclusively on the bark of living pines trees. It prefers to forage on trees that are at least ten inches in diameter and 30 years old (Porter and Labisky, 1986 and ref. therein). RCW foraging habits and habitats are well documented. However, very little is known about what RCW select as food, the nature of the arthropod community on the bark of live pines trees, or how that community is affected by forest management practices.

In 1992, the Department of Energy, Savannah River Site (SRS) and the USDA Forest Service, Savannah River Forest Station supported a research project on the arthropods associated with the bark of longleaf (*Pinus palustris*) and loblolly pine (*P. taeda*). The purpose of this research is to determine what arthropods occur on the bark of southern pines, how they are distributed, where they originate from in a stand, which arthropods are utilized as food by the RCW, and how they are affected by stand and tree characteristics. The following is a summary of completed and ongoing studies.

RCW Prey

We considered traditional methods of diet analysis for birds to be too harsh for an endangered species so we developed an automatic camera system that records adult birds and the prey they carry as they return to their cavity tree to feed nestlings (Hanula and Franzreb 1995). We utilized four cameras on the SRS in 1993 to record 12 adults making over 3000 nest visits. Prey in 28 arthropod taxa were recorded on the photographic slides. Wood roaches in the genus (*Parcoblatta)* made up 69.4% of the prey fed to nestlings. Other common prey items were wood borer larvae (Cerambycidae or Buprestidae, 5.4%), Lepidoptera larvae (4.5%), spiders (Araneae, 3.6%) and ants (Formicidae, 3.1%). Wood roaches were the only prey items consistently taken by all four groups of birds; they made up 63.3 to 81.6% of the prey observed. Often, other common prey were taken in large numbers only by a single group of woodpeckers or an individual bird.

In 1994 and 1995, two of the cameras were operated on the Baruch Forestry Institute forest in Georgetown, SC (Hanula and Lipscomb, unpublished data) or the Piedmont National Wildlife Refuge in Round Oak, GA (Hanula and Loeb, unpublished data). The remaining two cameras were operated on the SRS both years. Wood roaches were the most commonly recorded arthropod used as food for nestlings at all three locations in both years. During the three years of this study (1993-1995) over 50% of the nest visits were recorded with wood roaches. We saw little difference in the diet of RCW nestlings among the three physiographic regions despite the fact that the foraging habitat in the Piedmont was composed of loblolly pine stands with a significant hardwood component. Our observations show that RCW utilize relatively few common arthropods to feed nestlings and we suspect that adults utilize similar prey as well.

Source and Distribution of RCW Prey

We examined arthropod diversity, abundance and biomass on 50-70 year old longleaf pine tree boles at the SRS to determine where the prey biomass available to RCW comes from, and how prey availability varies over the tree surface and seasonally. Traps designed to capture arthropods crawling on the bark (crawl traps) (Hanula and New 1996), alighting on the bark (flight traps), and crawling on the ground (pitfall traps) were operated continuously for 12 months. Flight and crawl traps were placed at different heights. Half of the trees with crawl traps were fitted with a barrier to prevent arthropods from crawling up from the ground. Arthropods were identified to genus from one weekly sample per month and subsamples were oven-dried and weighed to obtain biomass estimates. The arthropod community on the bark included high numbers and biomasses of omnivores and detritivores, although predators and herbivores were also abundant. Crawl trap captures were the most representative of RCW prey utilization. Arthropod fauna captured in crawl traps had a 58% similarity to the fauna captured in pitfall traps and a 60% similarity with flight trap captures. Flight and pitfall trap captures had a 10% similarity. Barriers to arthropod movement up the tree reduced the arthropod biomass on the bole of the trees by 40-70%. Arthropod biomass was highest in crawl traps at the base of the tree and varied seasonally with the highest biomass captured in the fall of the year. These data show that relatively little of the arthropod biomass available to RCW lives exclusively on the bark and that a large portion of the potential prey are crawling up from the soil/litter layer.

Effect of Prescribed Burning on RCW Prey

Investigations of the effects of dormant and growing season prescribed burns on the prey of RCW were undertaken, since these are common management practices in RCW foraging habitats that would likely impact the arthropod community in the soil/litter layer. The study was conducted in mature longleaf pine stands on the upper Coastal Plain of South Carolina (New 1995). Plots were established in stands burned in the winter of 1991, 1992, 1993, and in the summer of 1992. Four types of traps were used to sample arthropods in the litter layer (pitfall traps), herbaceous understory (pan traps that capture low flying or hopping insects), and on the bole of pine trees (flight and crawl traps). Arthropod abundance and biomass were sampled weekly from June 30, 1993 to June 30, 1994 while overall arthropod diversity was measured for one week per season in June, October, January, and April.

The different trap types had similar diversity (H') and evenness (J'), but they caught dissimilar fauna indicating that the traps effectively sampled different parts of the arthropod community. When we combined captures from all trap types for each plot we saw no differences among winter burned plots, or between winter 1992 and summer 1992 burned plots . However, differences among burn treatments were evident when trap or prey types were examined separately. For example, spider (Araneae) diversity and evenness were similar among winter burns for all trap types, but diversity for the summer 1992 pitfall trap captures was higher than the winter 1992 pitfall captures. Among winter burns, spider abundance and biomass were highest in winter 1991 pitfall trap samples, i.e. in the plots where spider populations had the longest time to recover. Comparison of winter and summer 1992 burned plots showed that the winter 1992 burn had higher spider and ant (Hymenoptera: Formicidae) biomass on the tree boles. Spiders appeared to be the only group affected by winter burning while spiders and ants were affected by summer burning. Roaches were not affected by either dormant or growing season burns. In general, prescribed burning had little effect on the arthropods commonly used as prey by RCW.

Arthropod Abundance in Relation to Stand and Tree Characteristics

Arthropods are the most diverse group of organisms in longleaf forests. Therefore, it is very unlikely that all of them will respond in the same way to forest management practices or changes in forest conditions. We initiated a study in 1994 to examine the interrelationships of arthropod abundance and biomass with stand and tree characteristics. The study was conducted on the Escambia Experimental Forest near Brewton, AL and the Blackwater State Forest near Munson, FL. Eight age classes ranging from 20-90 years old were chosen and four stands were selected per age class. Crawl traps were attached to the boles of 10 trees per stand and a pitfall traps was installed in the ground 5 m from each tree. The traps were operated continuously for one year. Stand and tree characteristics were measured during the study.

Over 15,000 arthropod specimens have been identified thus far. The laboratory portion of the study is being completed.

Summary

A large part of the arthropod resource on the bark crawls on to the tree from the soil/litter layer. It is these crawling arthropods, and not the actively flying insects, that the RCW uses as its primary prey. Although much of the RCW prey is associated with the soil/litter layer, neither dormant or growing season burns has a large impact on prey availability in longleaf pine stands. Studies on the effects of stand age, tree density and understory diversity on arthropods are ongoing.

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Harvesting Longleaf Pine Straw on the Kistachie National Forest

James Haywood (USDA Forest Service, Southern Research Station, Pineville, LA)
Michael Elliott-Smith (USDA Forest Service, Southern Research Station, Pineville, LA)
Robert Knight (Texas A&M University, College Station, TX)
Catalino Blanche (Agricultural Research Service)
Finis Harris (Kisatchie National Forest, Pineville, LA)

ABSTRACT - Pine straw is a renewable resource that has traditionally been harvested for mulch. Adding straw to timber and forage as products of management can increase profits substantially, and the income from straw may exceed that from timber. Despite the immediate economic opportunities, repeated removal of the forest floor can have adverse effects. A randomized complete block split-plot study was established in a 38-year-old stand of direct-seeded longleaf pine (*Pinus palustris* Mill.) to determine how pine straw harvesting practices influence longleaf pine productivity, straw yields, needle fall patterns, soil bulk density, and plant and soil nutrition. Practices included no fertilizer or 50 kg ha^{-1} N and 56 kg ha^{-1} P as the main plot treatments and fire, mechanical cutting of understory vegetation, and baling and removal of straw as subplot management practices. Crown scorch caused premature senescence of some needles, but the monthly trends in needle fall and the total annual amounts of needle fall were unaffected by management practices. Harvesting pine straw removed most of the forest floor, exposed the mineral soil, and increased soil bulk density. Harvested sites should be fertilized periodically with 150 to 200 kg ha^{-1} N and 56 kg ha^{-1} P and the mineral soil should not be exposed. Soils with more that 10% slopes and stream side areas should be avoided. Pine straw harvesting lessens fire hazard and can increase total farm income. Part of this extra income should be used to prevent or correct any site damage.

INTRODUCTION

Farmers world-wide use mulches and crop residues to control weeds and manage soil moisture in field and horticultural crops. Pine needles (straw) have traditionally been gathered for mulch. In the southern United States, adding pine straw production to timber and forage as products of management on small land holdings can increase profits substantially, and the income from straw may exceed that from timber. Despite the immediate economic opportunities, repeated removal of the forest floor can adversely affect pine tree growth and yield. Since timber prices are high and expected to remain so for several years, any loss in stand productivity may be important to the landowner. The objective of this study was to determine how pine straw harvesting practices influence longleaf pine (*Pinus palustris* Mill.) productivity, straw yields, needle fall patterns, soil bulk density, water infiltration, soil sedimentation, and plant and soil nutrition.

Procedures

The 40-ha study site is a gently rolling area in Rapides Parish, Louisiana, with Ruston and Smithdale fine sandy loam soils. The site supports longleaf pine stands that originated from direct seeding in 1956 and were 39 years old from seed in 1995. The site was continually prescribed burned as part of a range management program, which retarded development of woody vegetation in the understory.

We installed a randomized complete block split-plot design with four 1.3-ha blocks as replicates in the spring and early summer of 1990. The understory vegetation was rotary mowed to create uniform understory conditions and to facilitate plot establishment. In total, there are 32 0.16-ha subplots (4 blocks by 2 main plots by 4 subplots). The two main-plot treatments within each block were: (1) no fertilizer applied and (2) 50 kg/ha N and 56 kg/ha P broadcast evenly over the entire main plot on April 23, 1991, as 280 kg/ha diammonium phosphate fertilizer. Management of the subplots for pine straw includes: (1) Check—no treatment after 1990; (2) Burned only—the subplots were burned with strip headfires, which were monitored to determine their intensity, in March 1991 and February 1994; (3) Burned and two harvests—in addition to treatment 2, the subplots were rotary mowed and the straw was harvested in early 1992 and 1993 with no harvesting thereafter, and (4) Burned and four harvests—the subplots were thinned and mowed in 1990, burned in August 1991, and rotary mowed and harvested annually in early 1992 through early 1995; a fifth harvest in early 1996 did not influence these results.

The straw was harvested by first collecting it in windrows with a tractor mounted straight-bar rake. Large limbs and cones were removed before the straw was mechanically baled. The bales were weighed and a sample taken to determine moisture content and dry matter production.

An interior 0.09-ha area within each subplot was used for measurement and sampling purposes. In January 1991 and 1996, dbh (diameter of stem 1.4 m above the ground) and tree height of longleaf pines over 10 cm dbh were measured, and the inside-bark volume per tree was calculated. Five 0.91-m^2 litter traps were systematically located within each 0.09-ha measurement area for the monthly collection of needle fall samples. Nutrient analyses were done for soil and living needle samples randomly collected to a depth of 15 cm and from the upper crowns of dominant longleaf pine trees. Bulk density samples of the mineral soil were randomly taken to a depth of 10 cm. A rainfall simulator was used to determine infiltration and runoff water quality from about a 0.4 m^2 subplot. Runoff from each plot was regularly pumped into tared containers. Differences among main plot and subplot treatments in longleaf pine needle fall, nutrition of living foliage, growth over five growing seasons, and soil bulk density were subjected to appropriate statistical analysis.

Needle fall and straw harvest

From 1991 through 1995, 18% of the longleaf pine straw fell from January through July (720 kg/ha) and total annual needle fall averaged 4,040 kg/ha. The low amount of needle fall from January through July was consistent through the 5-year period. Where the straw had not been gathered a year earlier, there was higher than normal needle fall after the March 1991 and February 1994 burns because of crown scorch. Other variations in needle fall were associated with mild droughts which can cause early senescence and Hurricane Andrew in August 1992. There were no statistical differences among the fertilization or stand management treatments in the total yearly needle fall from 1991 through 1995. So, straw harvesting practices do not influence needle fall, which is also the contention of most pine straw harvesters.

Actual yields of harvested pine straw did not decline with management. The two annual harvests treatment produced 5,260 kg/ha/year. The four annual harvests treatment produced 5,952 kg/ha/year. Older forest floor material was being removed during each harvest, and the eventual loss of the forest floor is common after burning and removal of pine straw.

Soil bulk density, water infiltration, and sedimentation

In July 1994, bulk density was significantly greater after two harvests (1.39 g/cm^3) than on either the check (1.33 g/cm^3) or burned only treatment (1.34 g/cm^3). Bulk density was significantly greater after three harvests (1.44 g/cm^3) than after two harvests. Water infiltration was reduced by harvesting. Water infiltration averaged 10.3 cm/h on the no-harvest treatments, 6.4 cm/h after two harvests, and 5.5 cm/h after four harvests. Sediment loss, as an index of erosion, and sediment concentration were increased by harvesting. Sediment loss averaged 35 kg/ha and sediment concentration averaged 0.08 g/l on the no-harvest treatments. After two harvests, sediment loss averaged 125 kg/ha and sediment concentration averaged 0.15 g/l. After four harvests, sediment loss averaged 360 kg/ha and sediment concentration averaged 0.39 g/l.

Soil and longleaf pine nutrition

The application of phosphorus increased available soil phosphorus concentration to 8.63 mg/kg, as compared to a concentration of 2.56 mg/kg on the unfertilized plots. As a result, fertilization also significantly increased the concentration of phosphorus in the living needles. The concentration of foliar phosphorus was 0.70 g/kg on the unfertilized plots and 0.89 g/kg on the fertilized plots. Pine straw harvesting did not influence soil or foliar phosphorus concentrations.

Soil potassium was greater on the harvested treatments (34 mg/kg) than on the no-harvest treatments (25 mg/kg). Perhaps since the forest floor was destroyed by straw harvesting practices, it was unable to buffer the potassium leached from the trees, or less organic matter in the soil was allowing for greater nutrient availability. This may be symptomatic of future adverse effects if mineralization is too rapid in these nutrient-poor soils.

The concentration of soil potassium was not affected by treatment. However, the concentration of foliar potassium was slightly less on the plots burned in March 1991 and February 1994 (3.3 g/kg) than the average for the check and August burned treatments (3.6 g/kg), but we do not know why. We did not measure soil nitrogen levels, but foliar nitrogen averaged 8.9 g/kg across all treatments. We applied less nitrogen than others have recommended for managing pine stands for straw production and future fertilizer applications should perhaps include 100 to 150 kg/ha N as urea.

Longleaf pine yields

On the unfertilized plots, four straw harvests reduced longleaf pine growth by nearly 8 m^3 i.b./ha over a 5-year period when compared to the no-harvest treatments. However, broadcasting 280 kg/ha diammonium phosphate fertilizer coupled with four straw harvests increased longleaf pine growth by almost 2 m^3 i.b./ha when compared to the fertilized-no-harvest treatments. The 39-year-old longleaf pines averaged 215 m^3 i.b./ha of wood volume across all treatments. It is believed that the continual harvesting of straw provided weed control, and the combination of fertilizer and weed control is known to increase pine productivity.

Conclusions

Crown scorch caused the premature senescence of some needles, but the monthly trends in needle fall and the total annual amounts of needle fall were largely unaffected by management practices. Harvesting the pine straw removed most of the forest floor, exposed the mineral soil, increased soil bulk density, soil movement, potassium concentrations in the mineral soil, and water turbidity and reduced water infiltration and longleaf pine growth. However, the economic value of the straw may outweigh the cost in site damage.

Broadcasting 280 kg/ha diammonium phosphate fertilizer increased phosphorus concentrations in the soil and living longleaf pine needles and increased longleaf pine productivity where the pine straw was annually harvested. The increase in pine yields after fertilization and harvesting was believed to have resulted from the positive benefit of combining nutrient enhancement with weed control associated with the harvesting of the straw.

These results support the recommended best management practices for lands where pine straw is harvested—periodically fertilize with 150 to 200 kg/ha N and 56 kg/ha P, avoid soils with more than 10% slopes and stream side areas, and carefully mow and rake to expose less mineral soil. Pine straw harvesting lessens fire hazard, provides annual revenue, and if done properly can increase total farm income. Part of this extra income should be used to correct any site damage.

RESTORATION OF NATIVE PLANT COMMUNITIES IN LONGLEAF LANDSCAPES ON THE KISATCHIE NATIONAL FOREST

J. David Haywood (USDA Forest Service, Southern Research Station, Pineville, LA)
Alton Martin (USDA Forest Service, Southern Research Station, Pineville, LA)
Finis Harris (USDA Forest Service, Southern Research Station, Pineville, LA)
Michael Elliott-Smith (USDA Forest Service, Southern Research Station, Pineville, LA)

ABSTRACT - Historically, fire was essential in the formation and continuation of many southern pine ecosystems. Today, prescribed burning is important in developing and maintaining the structure and diversity of these fire-dependent native plant communities to restore natural old-growth forests, sustain native plant communities, and protect red-cockaded woodpecker habitat. In January 1993, the Kisatchie National Forest and Southern Research Station began cooperative Ecosystem management Projects to monitor how prescribed burning affects overstory and midstory trees and shrubs and understory shrub and herbaceous vegetation and to demonstrate how group selection cutting and retained irregular shelterwoods can be used to restore old growth attributes in longleaf pine (*Pinus palustris* Mill.) forests. One important conclusion is that herbaceous plant community health should not be based on production but on plant diversity. To this end, indicator plants can be used. On upland longleaf sites, for example, indicators of understory health would include:

1. Uniolas (*Chasmanthium* spp.) are the dominant grasses – poor understory conditions, remedial action is needed.
2. Pinehill bluestem (*Schizachyrium scoparius* var. *divergens*) is the dominant grass – good understory conditions, no action is needed.

These plants can be recognized in the field during most of the year with limited training. Use of indicator plants would help forest managers determine sites needing corrective action or those sites where no action is required, which would help managers better allocate their resources.

INTRODUCTION

Historically, fire was essential in the formation and continuation of many southern pine ecosystems. Research conducted on the Evangeline Ranger District concerning the long-term effects of fire showed how important prescribed burning is in developing and maintaining the structure and diversity of these fire-dependent plant communities to restore old-growth characteristics, sustain native vegetation, and protect red cockaded woodpecker habitat. In January 1993, the Kisatchie National Forest and Southern Research Station began cooperative Ecosystem Management Projects to monitor how prescribed burning affects overstory and midstory trees and shrubs and understory woody and herbaceous vegetation and to demonstrate how group selection cutting and retained shelterwoods can be used to restore old growth attributes in longleaf pine (Pinus palustris) forests.

Season of burning

Our season of burning project sites on the Vernon Ranger District include Compartment 10. This longleaf pine forest crosses a gradient from Malbis fine sandy loam on gently rolling uplands to Briley loamy fine sand in the intermittent drainage's. The forest was last prescribed burned in 1991, May 1993, and March 1995. There are 169 longleaf pine trees per acre with a few scattered shortleaf pines (P. echinata). The total basal area is 98 ft^2/acre. The 13 common species are represented by poison-oak (Toxicodendron toxicarium), blackberry (Rubus spp.), and longleaf pine seedlings. The woody plants averaged under 1 foot in height. The herbaceous community includes 21 common grasses, 3 grass-likes, 17 composites, 9 legumes, 17 other forbs, and 2 ferns represented by pinehill bluestem (Schizachyrium scoparium var. divergens, 45%), low panicums (Dichanthelium spp., 16%), swamp sunflower (Helianthus angustifolius, 4%), Virginia tephrosia (Tephrosia virginiana, 1%), poor-joe (Diodia teres, 3%), and braken fern (Pteridium aquilinum var. pseudocaudatum, 2%). Percentages are frequency of occurrence.

On the Catahoula Ranger District, our season of burn project sites are in need of restoration. One such site is a longleaf pine forest that crosses a gradient from Ruston fine sandy loam on rolling uplands to Smithdale fine sandy loam in the intermittent drainages. The forest stands were last prescribed burned in 1990, July 1993, and May 1995. There are 62 longleaf pine trees per acre with scattered loblolly pines (P.

taeda); southern red (Quercus falcata), blackjack (Q. marilandica), post (Q. stellata), and black (Q. velutina) oaks; mockernut hickory (Carya tomentosa); and blackgum (Nyssa sylvatica). The total basal area is 106 ft^2/acre. A woody understory of 41 common species is represented by dewberry (Rubus trivalis), Japanese honeysuckle (Lonicera japonica), greenbriar usually Smilax glauca, longleaf pine seedlings, oaks, flowering dogwood (Cornus florida), blackberry, blueberries usually Vaccinium stamineum, southern bayberry or waxmyrtle (Myrica cerifera), and shining sumac (Rhus copallina). The woody plants average about 2 feet tall. A population of 18 common grasses, 4 grass-likes, 24 composites, 14 legumes, 17 other forbs, and 3 ferns is represented by pinehill bluestem (8%), low panicums (13%), swamp sunflower (4%), grassleaf goldaster (Heterotheca graminifolia, 4%), tickclover (Desmodium spp., 1%), flowering spurge (Euphorbia corollata, 2%), and braken fern (17%).

Group selection to restore old growth attributes

Our group selection demonstration sites are on five Ranger Districts. On the Kisatchie District, the longleaf pine forest crosses a gradient from Anacoco loam on gently rolling uplands to Kisatchie soils in the intermittent drainages. Portion of this landscape is in need of restoration. On that portion, there are 20 common woody species, but Carolina jessamine (Gelsemium sempervirens) is over half of the stems. The most common grasses are pinehill bluestem (16%) and low panicums (13%). The low frequency (%) of pinehill bluestem suggests that the foreground needs to be burned more often and the overstory thinned. Intermittent hardwood drainages dissect this landscape. Other portions of the landscape are open savanna of longleaf pine with desirable bluestem grasses (Schizachyrium spp.) dominating the understory. This savanna type is the desired future condition for upland forests in this landscape.

On the Winn District, the longleaf forest crosses a gradient from Ruston fine sandy loam to Sacul gravelly fine sandy loam on rolling uplands and in the intermittent drainages. Initially, the basal area ranged from 60 to 150 ft^2/acre and the dominant species was longleaf pine. The loblolly pine was selectively cut and small openings created where needed for longleaf seedling recruitment. This begins the restoration of the natural uneven-aged character inherent in old-growth longleaf pine forests.

Retained shelterwood

On the Catahoula District, we are monitoring seed crop and understory vegetation in a longleaf pine forest that crosses a gradient from Ruston fine sandy loam on rolling uplands to Smithdale fine sandy loam in the intermittent drainage's. The forest stands were prescribed burned 11 times in the past 25 years. The overstory is a longleaf pine shelterwood, 34 ft^2/acre, retained for red cockaded woodpecker habitat. The birds have moved into this stand during the last 3 years. A diverse understory of 20 common grasses, 7 grass-likes, 24 composites, 21 legumes, 30 other forbs, and 2 ferns is represented by pinehill bluestem (83%), fringe nutrush (Scleria ciliata, 6%), grassleaf goldaster (58%), pencil flower (Stylosanthes biflora, 34%), Texas dutchmanspipe (Aristolochia reticulata, 12%), and braken fern (56%).

Indicator plants

These monitoring efforts have provided interesting findings on herbaceous plant productivity and community health. Statistics from several sites that have been prescribed burned several times, but not within the last two growing seasons, are given in table 1. These results and research by Harold Grelen support several conclusions about herbaceous plant productivity: (1) Herbage productivity in the native pastures is probably near the maximum for upland soils in central Louisiana without fertilization, (2) Herbage yields rapidly decrease with increasing overstory basal area, and (3) Once a pine overstory has reached full stocking, efforts to increase understory herbage production by rotary mowing or burning will have marginal success. Shading by the overstory and its competition for water and nutrients and soil productivity are the main factors limiting herbage production. If hardwood brush or a midstory is present, herbaceous productivity will decline even further (table 1).

Table 1. Stand information relating overstory and understory woody plant density to herbaceous plant productivity.

Stand description	Overstory basal area	Understory (pine seedlings were not counted)	Current-year herbage production
Native pastures, Catahoula RD	no overstory	6,900 stems/acre 2.3 feet tall	2,607 lbs/acre
Shelterwood, Catahoula RD	34 ft^2/acre	low shrub cover	1,690 lbs/acre
Season of burn	98 ft^2/acre	12,500 stems/acre	1,464 lbs/acre
Season of burn Catahoula RD	106 ft^2/acre	65,200 stems/acre 1.7 feet tall	672 lbs/acre

Therefore, herbaceous plant community health should not be based on production. Rather, the focus should be on plant diversity. To this end, indicator plants can be used as barometers of herbaceous community health. For example, if the most common grasses are pinehill bluestem and slender bluestem (Schizachyrium tenerum) the understory plant community is healthy and no change in management activities is required. The Vernon Ranger District and the retained shelterwood on the Catahoula Ranger District do not need remedial treatment because pinehill bluestem is well distributed in the herbaceous understory (frequency of occurance is 59% and 83%, respectively). The season of burning stand on the Catahoula District needs remedial treatments because pinehill bluestem and slender bluestem occur infrequently as do most other herbaceous plants.

CONCLUSIONS

The Kisatichie National Forests is actively managing its longleaf pine stands to restore old-growth characteristics, sustain native vegetation, and protect red cockaded woodpecker habitat. Indicator plants would help forest managers quickly recognize sites needing treatment or those sites where none is required, and managers could best allocate their resources. With limited training, plants such as pinehill and slender bluestem can be recognized year-round in the field. The use of pictures and computer images could help with identification.

Small-scale disturbances in an old-growth longleaf pine forest: coarse woody debris

Sharon Hermann (Tall Timbers Research Station, Tallahassee, FL)

ABSTRACT - Estimates of extant old-growth longleaf pine forest constitute less than 0.00001% of the area occupied at the time of European settlement. Because this forest type is distinguished by an open canopy, second-growth longleaf stands may project patterns of vertical and horizontal structure similar to that of old-growth. There are, however, other consequences of having large, old trees on site; these include substantially different kinds of coarse woody debris than is found in second-growth that may alter ecosystem function. Few modern longleaf stands are destine to be managed for old-growth conditions but understanding this state provides insight into needed management for ecologically significant second-growth forests. Long-term studies on the Wade Tract Preserve indicate that the presence of coarse woody debris (large, downed trees) results in patches in the ground cover that are significantly different from surrounding areas. This difference is often magnified by interaction with fire. Areas associated with logs that are consumed in a fire may be devoid of vegetation for many months, due to prolong, intense heating of the soil. Species that colonize these sites have some tolerance of low nutrient conditions. Unburned areas, associated with fire shadows also created by logs, have a special significance as safe sites for establishment of longleaf pine. Juvenile trees growing near logs emerge from the grass-stage significantly faster than non-log juveniles.

Preliminary efforts in restoration of longleaf pine-wiregrass ground cover: wiregrass seed viability and mechanical dispersal

Sharon Hermann (Tall Timbers Research Station, Tallahassee, FL)
Scott Powell (Tall Timbers Research Station, Tallahassee, FL)
Nancy Jordan (Tall Timbers Research Station, Tallahassee, FL)

ABSTRACT - Currently there is strong interest in restoration of longleaf pine-wiregrass habitat. Although foresters have the knowledge to successfully replant trees, land managers lack sufficient information to restore even a few of the 300+ plant species that may be native to a site. Of special concern is wiregrass, *Aristida stricta* (*A. beyrichiana*). This bunch grass is viewed as one of the most important ground cover species, in part, because of the contribution it makes to a site's fine fuel load, necessary to re-introduce effective prescribe fire management. Scientific data on the species' biology is surprising limited. Low seed viability, often less than 25%, and lack of effective seed dispersal methods have hampered restoration efforts. We report on a revised view of wiregrass seed germination. Usually, seed is tested for viability by germinating small collections at the time of collection (primarily November-December). Data from the current project indicates after-ripening plays an important in predicting seed viability. In one case, seed that tested at 20% germination in January exceeded 50% in April. Spring is obviously too late to decide what sites to collect from during the previous fall. We suggest a simple morphological test for filled endosperm at the time of collection. In addition, we describe trials using a relatively inexpensive, modified motorized broadcast seed spreader.

Impact of land use practices on gopher tortoise density

Sharon M. Hermann (Tall Timbers Research Station, Tallahassee, FL)
J. H. Waddle (Tall Timbers Research Station, Tallahassee, FL)
C. Guyer (Auburn University, Auburn University, AL)

ABSTRACT - We found significant differences in gopher tortoise (*Gopherus polyphemus*) densities based on current land use practices in upland areas of seven southern Georgia counties. In sampling 63 randomly selected private properties, we found the highest mean density of burrows (2.3/ha) associated with open-canopied pine forests. These were usually naturally-regenerated longleaf pine stands used for production of quail and/or saw timber. Management was often limited to frequent fire. Pine plantations, primarily slash pine, were as common as open stands but supported, on average, half the number of burrows. Most sites had been site prepped and prescribed burns were infrequent. Upland mixed pine-hardwood stands, the result of fire suppression, and agricultural sites were less frequently encountered; both habitat types supported, on average, less than 0.5 burrows/ha. Although the modal size of tortoises (suggested by burrow width) was the same in al habitats, only open pinelands supported tortoise populations at densities comparable to that reported from other studies. Results of the current project suggest that tortoises can persist on lands managed for bobwhite quail and/or pine saw timber. Unfortunately, the work also indicates that tortoise numbers have declined more than 80% in the last fifty years. For gopher tortoises to survive in the region, there must be a decrease in the conversion of open, naturally-regenerated longleaf pine forests to pine plantations and agriculture fields.

Effective Education for Longleaf Pine Ecosystem Management on Department of Defense Lands

Susan K. Jacobson (Department of Wildlife Ecology and Conservation, Program for Studies in Tropical Conservation, University of Florida, Gainesville, FL)
Susan B. Marynowski (Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL)
Carl Petrick (Natural Resources Division, AFDTC/EMSN, Eglin AFB, FL)

ABSTRACT - A longleaf pine ecosystem management education program targeted at specific audiences and developed with data from baseline surveys and input from natural resource managers and other key stakeholders was designed for Eglin Air Force Base in northwest Florida. A comprehensive education model resulted in significantly improved knowledge and attitudes among important constituencies – recreational users and neighboring citizens – of this large, multiple-use public land holding. The targeted longleaf pine ecosystem education program at Eglin included 1128 treatment and 1127 control subjects in a randomized experimental design. The education program focused on four major content areas: (1) native and endangered species; (2) fire ecology; (3) forest resources and habitats; and (4) ecosystem management. Evaluative surveys revealed that both direct and mass media educational approaches were effective in building knowledge, and mass media contributed most to changed attitudes. We include recommendations for effective communication strategies to increase understanding, concern, and support for longleaf pine ecosystem management on public lands.

The 463,000-acre Eglin Air Force Base, in the Florida panhandle, has the largest contiguous longleaf pine forest in the Southeast. The maintenance and restoration of healthy longleaf pine systems is a major focus of Eglin's ecosystem management program.

An ecosystem management education program targeted the half-million neighboring citizens and 10,000 recreational users of Eglin. Following a comprehensive educational model, the program was developed with data from baseline surveys and input from natural resource managers and other key stakeholders. The program involved 2,255 treatment and control subjects in a randomized experimental design. Educational materials focused on four major content areas: (1) native and endangered species; (2) fire ecology; (3) forest resources and habitats; and (4) ecosystem management. Educational media tested included brochures, posters, youth materials, mass media, and a public exhibit.

The model Eglin education program resulted in significantly improved knowledge and attitudes among neighboring citizens and recreational users of this large, multiple-use public land holding. Evaluative surveys revealed that both direct and mass media educational approaches were effective in building knowledge, and mass media contributed most to changed attitudes. Recommendations for effective communication strategies to increase understanding, concern, and support for longleaf pine ecosystem management on Eglin include: (1) identifying and targeting key audiences through the collection and application of useful social data; (2) improving audience knowledge and attitudes through continuous, repetitive, targeted educational programs; and (3) monitoring short- and long-term outcomes to document program effectiveness. A long-term monitoring survey is being developed for the Eglin ecosystem management education program, and military personnel have been targeted in the second phase of the program.

Evaluation of the Frequency of Prescribed Fire in a Longleaf Pine Ecosystem

Lance Jones (College of Forestry, Stephen F. Austin State University, Nacogdoches, TX)
M.S. Fountain (College of Forestry, Stephen F. Austin State University, Nacogdoches, TX)

ABSTRACT - An understanding of the relationships among longleaf pine (*Pinus palustris*), its associated woody and herbaceous vegetation, and fire is critical to the continued health of the longleaf pine ecosystem. We examined the impact of 3 different burning regimes on the development of longleaf pine stands and the vegetation associated with these stands. Data were collected on the density and spatial distribution of the longleaf pine overstory and the diversity of associated understory (woody shrub and herbaceous) vegetation as impacted by the frequency of burning. Data are currently being analyzed and results will be completed by the middle of August 1996; preliminary analysis suggest that there are differences in plant community characteristics among burning regimes.

INTRODUCTION

Longleaf pine (*Pinus palustris*) has played a major role in the history of the southern United States. Fernow (1892), as cited by Wahlenberg (1946), estimated that the original longleaf pine belt extended from the Atlantic Coast to eastern Texas, contained over 200 billion board feet of lumber, and covered between 30 and 40 million acres (12 and 16 million ha). Throughout most of its range, Wahlenberg (1946) believed that the forests were essentially pure longleaf. However, in 1991, there were only 702,900 acres (284,460 ha) of longleaf pine/slash pine forests remaining in the region. Only 192,900 (78,066 ha) of these acres were in natural stands (Rosen et al. 1991).

Numerous examples of recent descriptive studies of plant communities within various geographic, physiographic, or even political subdivisions of the lower coastal plain can be found (Peet and Allard 1993, Harcombe et al. 1993, Beckett and Golden 1982, Gaddy 1982). Pearson et al. (1987) provided a detailed description of the vegetation in a longleaf/slash pine dominated site in Vernon Parish in the Kisatchie National Forest. This site is adjacent to the Fort Polk Military Reservation. All of these recent studies have failed to include the effects of fire frequency into their conclusions. Therefore our objectives were to assess: 1) the density and spatial distribution of the longleaf pine overstory, and 2) the diversity of associated understory (woody shrub and herbaceous) vegetation as impacted by the frequency of burning.

METHODS

It is important that land managers understand the complex interactions that will maintain longleaf pine and thus the longleaf pine ecosystem. The U.S. Army (Fort Polk Military Reservation) is faced with these challenges, the Land Condition-Trend Analysis (LCTA) program was developed. This program uses standardized methodology to collect, analyze, and report natural resource data (Tazik et al. 1992). The study reported here utilized these standardized procedures.

To meet the first stated objective of this study, 42 special use plots were established within upland longleaf pine communities. The standard LCTA permanent plots (core or special use) is a rectangular quadrat which measures 100 m X 6 m and has a 100 m line transect forming the longitudinal center axis (Tazik et al. 1992). The quadrat (belt transect) was used to measure woody vegetation and the line transect was used to measure all living ground cover and ground disturbance. Of these 42 plots; 9 were located in areas burned annually, 23 were in areas burned on a 3-5 year cycle, and 10 were located in areas unburned. To meet the second objective, plant specimens were collected, pressed, and mounted. Only flora that were tallied within the study plots were collected.

Estimates of density and dominance were obtained for each species in each vegetative categories i.e..(herbaceous, shrubs, and trees). Importance values were then calculated for individual species in each vegetative category in each plot based on a combination relative density and relative dominance values. Null hypotheses of no differences among means of importance values per species, of no differences among mean basal areas (BA) per species between burning cycles, of no differences among mean number of stems (ST) per species between burning cycles, and no differences among total BA/ha and total ST/ha between burning cycles were tested (alpha = 0.05 for all tests).

SUMMARY

Our results indicate that in the > 1.0-4.0 m height class, mean basal per hectare (BA/ha) and stems per hectare (ST/ha) for all species combined increased as the frequency of burning cycles decreased. In the > 4.0-8.5 and > 8.5 height classes there were no statistical differences between burning cycles among mean BA/ha and ST/ha for all species combined.

Three grass species (*Schizachyrium scoparium* (IV = 31.2), *Andropogon virginicus* (IV = 15.9, and *Panicum spp.* (IV = 15.3)) had relatively high importance values (IV) in the annually burned areas as compared to the 3-5 year and no burn areas. Hardwood species decreased as the frequency of fire increased. These findings were similar to those of Croker and Boyer (1975).

In conclusion, hardwood recruitment and development was reduced in areas that were burned on frequent cycles i.e.. (3-5 year, annual). Annual burns produced a park-like setting with numerous herbaceous species (especially grasses) dominating the understory. This condition should allow longleaf pine to regenerate naturally without competition from other woody species if canopy openings were created. Frequent burning is essential to aid in the restoration of the longleaf pine ecosystem.

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The Importance of Site History on Ground Cover Species of Longleaf Pine Systems: Implications for Restoration

*Sharon E. King** (Johnson Controls World Services, Inc. Lafayette, LA)
S.L. Grace (National Biological Service, Lafayette, LA)
C.W. Hedman (International Paper, Bainbridge, GA)

ABSTRACT - A cooperative research study involving the National Biological Service and International Paper examined 49 forest stands to determine the impacts of different land uses and management on vegetation structure and composition at International Paper's Southlands Experiment Forest, Decatur County, Georgia, in 1995. Historically, these sites were longleaf pine forest, but many have undergone alteration for agriculture or plantation forestry. Currently, all stands are managed for timber production ,and the primary overstory trees are loblolly pine (22 stands), longleaf pine (17 stands), and slash pine (10 stands). Ordination and classification were used to identify variation in groundcover vegetation and to correlate this with environmental parameters including overstory type, land-use history, and management (site preparation, burning, herbicide use, etc.). We found that longleaf, slash, and loblolly stands may all exhibit ground cover layers comprised of typical longleaf forest species such as *Aristida stricta*, *Pteridium aquilinum*, and *Dyschorlste oblongifolia*. Under differing management regimes, (mechanical site preparation, chemical applications), groundcover responses varied by treatment intensity. However, the greatest deviation from typical longleaf pine forests was exhibited in stands previously used for agriculture. These results suggest that the potential for successful restoration of longleaf ground cover species may depend on the previous land-use of the restoration site.

The decline of longleaf pine forests in the Southeastern U.S., due mainly to conversion of these lands to other land uses such as agriculture and plantation forestry, has raised concerns about the loss of diversity of native ground cover species. Critics of plantation forestry claim that loblolly (*Pinus taeda*) and slash (*P. elliotii*) pine forests managed for timber production are devoid of native groundcover. To address these concerns, a cooperative research study was developed between the National Biological Service and International Paper which examined 49 forest stands to determine the impacts of different land uses and management on vegetation structure and composition at International Paper's Southlands Experiment Forest, Decatur County, GA, in 1995. Historically, these sites were longleaf pine forest, but many have undergone alteration for agriculture or plantation forestry. Currently, all stands are managed for timber production, and the primary over story trees are loblolly pine (22 stands), longleaf pine (17 stands), and slash pine (10 stands).

We used ordination (Non-metric multi-dimensional scaling) and classification techniques to 1) identify variation in ground cover vegetation and 2) correlate ground cover variation with environmental parameters including over story type, land-use history, and management (site preparation, burning, herbicide use, etc.).

Our results suggest that land-use history may be the most important factor influencing ground cover composition and abundance. Stands previously used for agriculture were the least similar to typical longleaf pine forests in ground cover layers. Burning regime may also be influential, and was positively correlated to stands with typical longleaf forest ground cover layers. Overstory type (longleaf, slash, or loblolly pine) had little influence on ground cover; we found stands of all overstory types supporting herbaceous assemblages typical of longleaf pine forests.

CONCLUSIONS

The results of this study suggest that the potential for successful restoration of ground cover species typical of longleaf pine forest may depend on the previous land use of the restoration site and land-use history should be evaluated by land managers planning restoration efforts. In evaluating the effort required for successful restoration, the land manager should consider the degree of previous site disturbance. More satisfying results may be achieved if native groundcover species remain on site, or have the potential to re-establish.

Much additional research is needed on longleaf pine systems and their components. This study identifies many questions concerning native ground cover that should be addressed, including: 1) how soon can native ground cover species recover after intensive stand management has ceased? 2) can native ground cover species be re-established on sites where they have been eliminated, such as old agricultural fields, 3) Can treatments such as seeding, planting, and burning accelerate the recovery of ground cover species in longleaf pine restoration efforts?

* Current affiliation: University of Southwestern Louisiana, Lafayette, LA.

Describing Differences of Habitat Between Sandhill and Scrub Upland Fragments in Central Florida

Robert A. Kluson (University of South Florida, Biology Department, Tampa, FL)
Henry R. Mushinsky (University of South Florida, Biology Department, Tampa, FL)
Earl D. McCoy (University of South Florida, Biology Department, Tampa, FL)

ABSTRACT - We compared vegetation and soil components of sandhill habitat fragments containing longleaf pines to scrub and scrubby flatwoods habitat fragments in the "Bone Valley" of central Florida. Principal components analysis, based on tree species' densities, revealed that the sandhill sites were well-separated floristically from scrub/scrubby flatwoods, but that scrubby flatwoods were a subset within the bounds described by scrub sites. Sandhill vegetation differences were also demonstrated by analyses of ground coverage, physiognomy, vertical canopy closure, and tree species' densities by height and DBH classes. Soils were analyzed for comparative differences in both physical and chemical properties. For example, sandhill soils only had slight but significant topsoil depths. On the other hand, increases in compaction of sandhill soils with greater depth was much less, starting at a 22.5 cm depth. Unlike texture, soil chemistry differed substantially in sandhills at both topsoil and subsoil depths. For example, levels of phosphorous, organic matter, and nitrogen tended to be higher in sandhills. This data was part of a larger study explaining the differences in vertebrate assemblages and habitat quality of unmined xeric uplands compared to reclaimed xeric uplands from phosphate mined lands in the "Bone Valley".

INTRODUCTION

There is ample evidence of a serious decline in the quality and quantity of habitats for wildlife in Florida during this century from urbanization, agricultural and mining activities. For example, by 1981, xeric habitats such as those of sandhill communities with longleaf pine and of scrub communities with sand pine and/or oaks have been reduced to about 65% of their original coverage in central Florida (1). The current status of these xeric habitats is patchy, reflecting, in part their irregular establishment during past geological times of elevated sea levels, but mostly, recent fragmentation (2). Most upland habitats, in contrast to wetland habitats, have not been afforded protection by government regulations, or at least not until very recently. Therefore, xeric upland habitats should be a primary focus for restoration efforts in Florida.

About 5180 square kilometers in central Florida's "Bone Valley" have economically large phosphate resources which have been mined beginning in the 1880's and continue to be so (3). The phosphate mining industry represents both a major disturbance and a major restoration potential of xeric habitats in central Florida. The 1978 state law (Florida Statutes, Chapter 378) requiring reclamation of all lands mined after 1975 recognized the values of native ecosystems, such as the provision of habitat for their rare and indigenous species (4). Reclamation of xeric habitats was promoted by requirements of "a minimum of 10% of upland areas had to be replanted with a variety of indigenous hardwoods and conifers" (in contrast to the wetland requirement of 100% reclamation in equivalent area).

The goal of this study has been to accumulate knowledge that facilitates restoration of xeric habitats on phosphate mined lands to natural conditions. By "natural", we mean that the uplands are typical and representative of the range of ecological variation in a particular habitat. In addition, by "restoration" we mean the rehabilitation to or approximation of pre-disturbance condition, not necessarily their duplication. In time, rehabilitated lands may form fully restored habitats, that is, habitats capable of supporting the full range of flora and fauna.

MATERIALS AND METHODS

We conducted study sites located in Hillsborough, Polk, & Manatee counties in central Florida. There were 30 unmined xeric upland habitats, i.e. 8 sandhill sites, as well as 15 scrub and 7 scrubby flatwoods sites, and 30 reclaimed sites with different reclamation histories of substrate, e.g. overburden vs sandtailings and of revegetation , e.g. mulch, replanted woody & herbaceous techniques.

The vegetation was characterized in replicated plots of 10 X 10 m size which were randomly placed within habitat boundaries of each site (up to 5/site). Ground coverage was measured for the life-forms of woody species, wiregrass other grasses, legumes, forbs, litter, bareground, and crust, using the line-intercept technique. Vegetation structure was described by measuring the heights of the foliage strata of ground, shrub, midstory and upper canopies, as well as any intervening gaps, using a clinometer. Plant density was calculated for all counted trees and identified to species.

The soils were characterized chemical and physical properties at different depths. For example, chemical tests included total nitrogen (Kjeldahl), available phosphorous and potassium (Mehlich-1), pH and electrical conductivity (2:1 water:soil ratio), and organic matter (Walkley-Black dichromate). The physical tests included texture (Bouyoucos hydrometer), sand particle sizes (dry sieving) , and compaction at 0-40 cm depth (cone penetrometer under standardized "wetted" field conditions).

RESULTS

Principal components analysis, based on tree species' densities, revealed that the sandhill sites were well-separated floristically from scrub/scrubby flatwoods, but that scrubby flatwoods were a subset within the bounds described by scrub sites. Sandhill vegetation differences were also demonstrated with increased ground coverage of wiregrass. Vegetation structure of unmined sites in general showed a similar trend of present midstory foliage strata in contrast to reclaimed sites (i.e. all revegetation techniques). Reclaimed sites in general maintained much greater ground coverage by other grasses and forbs compared to unmined sites while replanted woody and herbaceous sites had greater legume coverage.

Soils analyses in sandhills compared to scrub and scrubby flatwoods showed only slight but significant differences in texture and sand particle sizes at subsoil but not topsoil depths. On the other hand, increases in compaction with greater depth of sandhill soils was much less, starting at a 22.5cm depth. Unlike texture, soil chemistry differed substantially in sandhills at both topsoil and subsoil depths. For example, levels of phosphorous, organic matter, and nitrogen tended to be higher in sandhills. Reclaimed sites in general had elevated P, K, and pH levels, as well as dramatic compaction increases at shallow depths, compared to unmined sites (especially sandhills). Reclaimed overburden soils had greater clay percentages, and reclaimed sites in general had decreased percentages of the very fine sand particle size class.

CONCLUSIONS

Our investigations of the soil and vegetation components have demonstrated important differences between sandhill habitats containing longleaf pines and both other unmined and reclaimed xeric uplands. These findings are part of our continuing research to understand differences in vertebrate assemblages on these habitats (5). In terms of successful restoration on phosphate mined lands, the data on soil differences in particular indicates a critical area for consideration. Soil factors should be determining vegetation properties which will impact habitat quality for wildlife. These differences are especially more characteristic of sandhill habitats compared to scrub and scrubby flatwoods, and merit closer evaluation and manipulation in all future restoration efforts.

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Effects of Prescribed Fire on the Regional Distribution of Longleaf Pine Needle Fall

John S. Kush (Auburn University School of Forestry, Auburn University, AL)
Dean N. Jordan (University of Nevada-Las Vegas, Las Vegas, NV)
Ralph S. Meldahl (Auburn University School of Forestry, Auburn University, AL)

ABSTRACT - In the mid-1960s, the US Forest Service established a regional longleaf pine growth study in the Gulf States. Today, the study consists of 301 plots located in central and southern Alabama, southern Mississippi, southwest Georgia, and northern Florida. A study utilizing these plots examined the effects of competition and climatic factors on the productivity of natural stands of longleaf pine. As a part of the study, litter traps were set up on 205 of the 301 plots. Needle fall of longleaf pine has been collected every 4-6 weeks since summer, 1992. At some of the plot locations fire is used as a management tool to curb hardwood competition and facilitate natural regeneration of longleaf pine. Between 1992 and 1995, plots with litter traps were burned 0 to 2 times. Litter fall data combined with monthly climate data and intra-specific competition indices can be used to understand foliar senescence in this system. In the absence of herbivory or fire-related consumption of foliage, annual litter fall is also an approximation of annual needle production, and may be extrapolated to an index of stand vigor.

INTRODUCTION

Prior to the arrival of settlers to the United States, natural communities dominated by longleaf pine (*Pinus palustris* Mill.) and maintained by natural periodic fires occurred throughout most of the southern Atlantic and Gulf Coastal Plains. These communities once covered an estimated 24-36 million ha or two-thirds of the area in the Southeast (Vance 1895, Chapman 1932). Exploitation of longleaf pine-dominated forests and conversion to other land use has led to a steady decline of its acreage (Frost 1993). Today, estimates indicate that less than 1.3 million ha exists.

The longleaf pine ecosystem has diminished because these forests depend on fire (Means 1996). Without fire occurring every few years, these ecosystems are invaded by other pines and fire-intolerant hardwoods. Active forest fire suppression and the reduced burning tendency of hardwood litter relative to longleaf litter results in very limited longleaf pine regeneration.

The range of longleaf pine covers a broad arc along the coastal plain and portions of the Piedmont from southern Virginia, south to central Florida, and west to eastern Texas, extending further inland in the Cumberland Plateau and Ridge and Valley physiographic provinces in Alabama and Georgia . Unlike the other southern pines, longleaf pine tolerates a wide variety of habitats. It is found growing on dry mountain slopes and ridges in Alabama and northwest Georgia, to the low, wet flatwoods, as well as the excessively drained sandhills found along the coast and fall line between the Piedmont and Coastal Plain. Chapman (1932) commented that longleaf pine covered more acreage than any other North American mono-specific-dominant ecosystem.

METHODS

Raw Data Collection

From 1964 to 1967, the U.S. Forest Service established the Regional Longleaf Pine Growth Study (RLGS) in the Gulf States (Farrar, 1978). The original objective of the study was to obtain a database for the development of growth and yield predictions for naturally regenerated, even-aged longleaf pine stands. Plots were installed to cover a range of ages, densities, and site qualities. The study has been expanded to relate the productivity of natural longleaf pine stands to intra-specific competition and climatic factors. The RLGS now consists of 305 permanent measurement plots located in central and southern Alabama, southern Mississippi, southwest Georgia, northern Florida, and North Carolina.

Cooperators are asked to prescribe burn their plots on a 3-year cycle, utilizing cool, winter burns. A majority of plots are burned on this schedule. However, some have seen fire at very irregular and lengthy intervals. Other plots have undergone growing season burns in efforts to reduce hardwood competition, mimic natural events, or provide suitable site conditions for natural regeneration of the species .

As part of a Southern Global Change Program project, litter traps were set up on 205 of the 301 plots within the RLGS between June and August 1992 to cover the range of age, density, and site classes . Three or four 0.8 m^2 traps were established on these plots in the cardinal directions at a random distance from plot center. Needles were collected from each trap on a 4-6 week interval. They were oven-dried at 70° C for 72 hours and weighed. Needle fall from three full years of data was used in this analysis .

Climatic data from weather stations located within 35 miles of every plot in the RLGS were obtained from the National Climatic Data Center (NCDC). These data included monthly minimum temperature, monthly maximum temperature, and monthly total precipitation . During the litter collection period, month and year of burn were added to the data set. Cooperators also provided the month and year of burn of the most recent burn prior to the establishment of litter traps. There was no measure of the severity of burn. Most plots were burned under the coolest conditions in efforts to minimize growth loss or tree mortality. The cool burning conditions usually resulted in little observable needle scorch .

Data Analysis

Litter trap data were extrapolated from 0.8 m^2 traps to a hectare basis. Plot data were interpolated from the 4-6 week sampling intervals to monthly estimates on each plot. Monthly observations of plot litterfall were fit in a linear regression model for month, region (location of plots), basal area/hectare, stand age, maximum temperature, minimum temperature, precipitation, and a log-transformation of site index and trees/hectare. All of the variables were significant but stand age. The residuals from this model were examined for any remaining patterns of variation. Specifically, the residuals were analyzed with respect to the time (in months and in years) since the last prescribed burn.

RESULTS

High Temporal Resolution (Monthly litterfall)

During the month immediately following a burn, significantly more litter was observed in litter traps than would be expected based on seasonality or climatic conditions for the site. This likely represents accelerated litterfall due to needle damage or death from the burn event. Four of the months over the next 12-month period exhibited significantly less litterfall than would otherwise be expected, while only one monthly period exhibited more litterfall.

This anomalous litter drop approximately 9 months following the burn is probably driven more by seasonality than the burn event, as most burns were performed in late winter and the highest rates of litterfall are expected in late autumn. The anomalous high litterfall is observed at the same time each year for three years following the burn. This suggests that although seasonality (month) was a factor in the initial linear model used to reduce variability, seasonality of litterfall may interact with burning treatments to accentuate peak litter drop in the autumn.

Low Temporal Resolution (Annual litterfall)

The immediate litterfall was analyzed separately from the following 12-month periods, as it was directly impacted by the burn event. The immediate litterfall (month 0) was significantly greater than the average monthly litterfall in the 3 years following a burn. The litterfall in the first year following a burn was slightly depressed below expected levels, and showed a recovery trend over the next two years.

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Recovery Efforts in the Flomaton Natural Area

John S. Kush (Auburn University, School of Forestry, Auburn University, AL)
Ralph S. Meldahl (Auburn University, School of Forestry, Auburn University, AL)
William D. Boyer (USDA Forest Service, Southern Research Station, Auburn University, AL)
Foster Dickard (Champion International Corporation, Cantonment, FL)

ABSTRACT - Recovery efforts are underway in a virgin stand of longleaf pine located just east of Flomaton, Alabama. At the turn-of-the century the stand was set aside by the Alger-Sullivan Lumber Company to preserve a remnant f the pre-settlement longleaf pine forest. As part of the preservation efforts, the stand was regularly prescribed burned. When the company was sold in the 1950s, the policy of preservation continued but the burning regime ended. The Society of American Foresters (SAF) recognized the stands' importance in 1963 when they designated it a "Natural Research Area." Champion International Corporation, the current owner, has designated it as one of their "Special Places in the Forest." A cooperative agreement has been signed by several organizations concerning what is now being called the Flomaton Natural Area. The major objectives of the agreement are to restore, monitor and manage the stand as an old-growth longleaf pine habitat. Biological research on the area will provide information on old-growth stand dynamics and assist future ecological restoration. Plans are to use the stand for educational and demonstrative purposes. Completed and on-going restoration efforts will be discussed.

INTRODUCTION

Before the arrival of settlers to the United States, natural communities dominated by longleaf pine (*Pinus palustris* Mill.) and maintained by periodic fire occurred throughout most of the southern Atlantic and Gulf coastal plains. These communities once covered an estimated 80-90 million acres in a broad arc from southeast Virginia, south to central Florida, and west to eastern Texas with extensions further inland in Alabama and Georgia.

Due to a number of factors, including logging, clearing for agriculture and purposeful or accidental conversion of longleaf pine stands to other species, that number has been reduced to less than 3 million acres at present. Of this, only an estimated 1000 acres of virgin, old-growth longleaf pine remain. Just east of Flomaton, AL is a 60 acres stand of virgin, old-growth longleaf pine owned by Champion International Corporation. It is the only known virgin stand in existence in Alabama and 1 of 5 reported stands left in the United States.

The importance of the stand was recognized by the Society of American Foresters (SAF) in 1963 when they designated what was then the St. Regis Tract as the E. A. Hauss Old Growth Longleaf Natural Area The SAF's definition of a natural area is "a tract of land set aside to preserve permanently in unmodified condition a representative unit of virgin growth of a major forest type, with the preservation primarily for scientific and educational purposes".

Champion International realized the significance of the stand when they placed the Flomaton Natural Area in their *Special Places in the Forest* program. The goal of this program is to permanently preserve the most unique areas on their lands.

The Alger-Sullivan Lumber Company, one-time owner, dedicated the stand to preservation at the turn of the century. As part of the preservation effort, the stand was regularly control burned until the early 1950's when the lumber company was sold. Subsequent owners discontinued the burning regime. This 40+ year absence of fire had permitted shortleaf, loblolly, and slash pine to grow into the overstory. A substantial shrub layer dominated by shrub species and a hardwood midstory dominated by oak species had developed.

In an effort to restore the longleaf pine habitat, an agreement has been entered into by and among Auburn University School of Forestry, Champion International Corporation, the Southern Research Station of the USDA Forest Service, Alabama Forestry Commission, The Nature Conservancy, and the Alabama Natural Heritage Trust of the Alabama Department of Conservation and Natural Resources to cooperate with respect to restoration, management, research, education and the transfer of information and technology involving the tract.

The major objectives are to restore, monitor and manage the stand as an old-growth longleaf pine habitat and to conduct biological research which will provide information on old-growth stand dynamics and future ecological restoration work.

PARTNERS IN RESTORATION

The School of Forestry at Auburn University, the USDA Forest Service, the Alabama Forestry Commission in agreement with Champion International Corporation are implementing a program for restoring the longleaf pine ecosystem. Fire was re-introduced to approximately half the stand in January, 1995 and the other half in April. The same burning regime was followed in 1996. Initially, winter burns have be used to reduce the fuel load. Beginning in 1997, yearly spring burns will be used in efforts to reduce and eventually eliminate hardwood sprouting.

In April-May, 1996, a fuelwood operation was conducted by the Easterling Brothers of Brewton, AL. They removed 1350 tons of hardwood chips and inflicted very little damage to the residual stand.

AUBURN UNIVERSITY

Auburn University established forty-two, 1/5-acre circular measurement plots to record stand conditions prior to restoration efforts. Data recorded for every tree on the plots included: azimuth and distance from plot center, DBH, crown height, total height and litter depth at the base of the tree. Woody stems less than 0.5 inches DBH but larger than 1-foot tall were tallied by species in 1-foot height classes. Age (ring count at 4 feet) of longleaf pines larger than 3 inches DBH is being determined and ground cover vegetation was being surveyed by species. Efforts are underway to tag all of the longleaf pine. They will be stem mapped and monitored over time. Regeneration of longleaf pine and re-appearance of herbaceous species will be followed.

CHAMPION INTERNATIONAL CORPORATION

A Memorandum of Understanding (MOU) entered into by the cooperators and Champion to restore the original longleaf ecosystem. This MOU has resulted in the implementation of a successful prescribed burning, hardwood removal, and research program that is already making significant progress towards restoring the forest ecosystem.

The Flomaton MOU is a successful model for cooperative efforts in natural resource management. Some important keys to this success are:

- landowner commitment to sustaining the unique qualities of the resource
- providing a forum through an MOU for developing and exchanging ideas and empowering participants to make and implement important management decisions
- cooperators who are committed to work toward the common goal of managing the resource to restore its unique qualities

USDA FOREST SERVICE

The U.S. Forest Service with the assistance of the Alabama Forestry Commission has been instrumental in conducting the prescribed burns. Given the difficulties presented in re-introducing fire to the stand after 40 years, their expertise and the care taken with the first two burns was invaluable. To date, there has been no mortality of longleaf pine due to the fires.

Additionally, the U.S. Forest Service - Southern Research Station recognized the importance of the restoration efforts for the stand. As part of their *Longleaf Pine Ecosystem Restoration and Management* program, they are providing limited funding to stem map all of the longleaf pine, age the larger trees, and monitor the re-appearance of herbaceous vegetation.

THE NATURE CONSERVANCY

The Nature Conservancy of Alabama has listed the Flomaton Natural area as one of their projects. As the Conservancy grows within the State, it is expected that their involvement in efforts associated with the stand will increase.

SUMMARY

The cooperative efforts of several organizations have implemented a plan to restore the Flomaton Natural Area. Significant progress has been made in these efforts. In addition to the research efforts being

conducted by Auburn University and the U.S. Forest Service, the stand would be available for other research efforts if it will not endanger the stand.

Plans are to use the stand for research, educational and demonstration purposes. Interpretative trails may be developed to provide visitors with a glimpse of the past. Visitors are welcome to walk through the stand any time.

ACKNOWLEDGMENTS

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W.W. Ashe Nursery

Rebecca Ladnier (USDA Forest Service, DeSoto Ranger District, Wiggins, MS)

ABSTARCT - W.W. Ashe Nursery is the Forest Service's only tree nursery in the Southern region and grows both bareroot and containerized seedlings for southern National Forests and other agencies. Hand outs or brochures on W.W. Ashe Nursery's operations and capabilities will be provided.

Effects of Prescribed Burning Frequency on Avian Communities in a Longleaf Pine Ecosystem

Kenneth J. Laterza (College of Forestry, Stephen F. Austin State University, Nacogdoches, TX)

ABSTRACT - Management of longleaf pine (*Pinus palustris*) requires the use of prescribed fire to minimize the encroachment of competing hardwoods. Frequency of prescribed burning can determine the extent of the hardwood component within the stand. Thus, the reduction or elimination of hardwoods by frequent burning within a stand may detrimentally impact birds that use this vegetation for food, nesting, or cover. An ongoing study being conducted at Fort Polk Military Reservation near Leesville, Louisiana is attempting to determine the effects of prescribed burning frequency on avian communities in longleaf pine ecosystems. Six study areas, located on the military base and within the adjacent Kisatchie National Forest, have been chosen on the basis on prescribed burning regime. Two study areas have annual burning regimes, 2 areas have 2-3 year burning regimes, 1 has a 4-7 year burning cycle, and 1 study area is unburned. Four 200 x 100 m strip transects have been constructed at least 100 m apart in each study area and are marked at 25 m intervals. Nine morning samples are being performed during winter (January-mid-February) and spring (mid-May-June) sample periods for 2 years. Each observer samples 2 study areas each morning beginning at sunrise. All avifauna are recorded if they are observed within the transects, flying into or out of the transects, or flying over the transects and seem to be influenced by the vegetation. Data recorded are species, number of individuals, sex (if determinable), distance along the transect, and distance from the observer to the bird(s). Study areas will be contrasted using statistical analyses to identify significant differences in number of species and number of individuals.

Management of longleaf pine (Pinus palustris) is impractical without the use of prescribed burning (Wood and Niles 1978). Control of hardwoods is often necessary for adequate regeneration and optimum development of this species, which is particularly sensitive to competition (Boyer 1990). Frequent prescribed fires in a longleaf pine forest results in a pine-grassland savannah with little or no hardwood midstory or understory. Elimination of hardwoods can significantly influence species composition (Dickson et al. 1993) and abundance (Landers 1987) in forest bird communities. Burning benefits those species that are closely associated with pine-grassland savannahs or early successional vegetation; however, it dicriminates against species dependent on deciduous canopy vegetation, midstory and understory trees and shrubs, or accumulated litter (Dickson 1981, Dickson et al. 1993).

Objectives of this study are to evaluate effects of burning regimes on species richness and abundance of migratory and resident birds as represented by wintering and breeding populations. The results of this study will add to the pool of information available to resource managers and aid in the development of silvicultural plans that balance the need to manage longleaf pine using prescribed fire and the vegetational requirements necessary to conserve the endemic avifauna.

This study is being conducted on the Fort Polk Military Reservation, which is approximately 20km southeast of Leesville, Louisiana. Six study areas have been established. Two study areas are burned annually, 2 are burned on a 2-3 year cycle, 1 is on a 4-7 year cycle, and 1 area has been unburned for at least 20 years. Within each study area, 4 200x100m fixed-width transects were marked with plastic flagging; distances along the transects are marked at 25m intervals.

Bird counts have been conducted for 1 winter and 2 spring seasons. Nine morning counts were performed each season on good weather days. Birds were recorded if they were inside the transect, flew into or out of the transect, or flew over the transect and appeared to be influenced by the vegetation. Data recorded for each observation included species, number of individuals, sex (if distinguishable), observer to bird distance, and distances along and from the center line of the transect.

Vegetation measurements have been performed in order to characterize the vegetation within each study area. Parameters measured include the number of trees per hectare, basal area per hectare, canopy closure percentage, forest floor vegetation density, numbers of snags and vines per hectare, and numbers of understory and midstory tree and shrubs per hectare.

Preliminary results for the spring 1995 and 1996 and winter 1996 sampling periods indicate that numbers of species and individuals generally decreased with increased frequency of prescribed burning (Table 1). During spring, increased frequency of prescribed fire resulted in an increase in 9 species, a decrease in 17 species, and had no effect on 3 species; 15 species were too uncommon to evaluate. For

winter birds, increased frequency of fire reduced the numbers of 18 species, increased those of 9 species, had no impact on 9 species, and had unknown effects on 3 species.

Final results are pending the collection of data for winter 1997 and subsequent statistical analysis. However, preliminary results suggest that increasing the frequency of prescribed burning decreases the numbers of species and individuals and thereby influences the avian community composition in a longleaf pine ecosystem.

Table 1. Number of bird species and individuals recorded in a longleaf pine forest subjected to 4 burning regimes

	Study area burning regime						
Season and year	Annual	Annual	2-3	2-3	4-7	Unburned	Total
Spring 1995							
No. species	15	20	19	20	24	25	38
No. individuals	113	124	107	124	167	205	840
Spring 1996							
No. species	12	15	21	19	29	22	39
No. individuals	115	110	133	107	205	312	982
Winter 1996							
No. species	17	14	20	20	20	24	33
No. individuals	131	130	158	129	142	467	1157

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Effects of Cogongrass, an Invasive Non-native Species, on Mortality and Growth of Longleaf Pine Seedlings

Carol Lippincott (Department of Botany, University of Florida, Gainesville, FL)

ABSTRACT - Cogongrass (*Imperata cylindrica*), considered one of the world's worst weeds, arrived in the southeastern United States from southeast Asia in the early 1900s. It has since spread throughout the region and is considered undesirable by managers of roadsides, farms, pine plantations, and natural areas. Cogongrass is found in most publicly-owned sandhills remaining in Florida, arriving as rhizome segments in fill soil or by seed. The native understory of these longleaf pine forests is dominated by short (about 20 inches) clumping grasses such as wiregrass. In contrast, cogongrass is tall (about 60 inches) and spreads by extensive underground growth of rhizomes, forming dense swards that displace native plants and animals. I studied the effect of cogongrass on mortality and growth of longleaf pine seedlings. A slash pine plantation with a band of cogongrass along the road edge was clear cut and roller-chopped, spreading cogongrass rhizomes across the planting area. The following winter, bareroot longleaf pine seedlings were planted on a 6 foot by 8 foot grid. Four years after planting I counted and measured height of surviving longleaf pines along twenty-four 295 foot transects, half in dense cogongrass and half in adjacent sandhill without cogongrass. There was 50% higher mortality of pines in the cogongrass-dominated sandhill. Surviving pines in the cogongrass were shorter (average 2 inches) than pines in the sandhill without cogongrass (average 8 inches). Thus, cogongrass significantly increased mortality and decreased height growth of planted longleaf pine seedlings. These effects should warrant budgeting for control of cogongrass in longleaf pine forests.

INTRODUCTION

Imperata cylindrica, cogongrass, is considered one of the world's worst weeds (Holm et al. 1977, Eussen and Soerjani 1975). In the early 1900's it was introduced into the southeastern United States from southeast Asia, for use as forage and in soil stabilization (Hall 1983). Cogongrass has since spread throughout the region and is considered undesirable by managers of roadsides, farms, pine plantations, and natural areas such as sandhill (Willard 1988, The Nature Conservancy 1994). Consequently, Imperata cylindrica is now on the Federal Noxious Weed List (Westbrooks and Eplee 1989).

Sandhill, once the dominant forest type in the southeastern United States, has been reduced to less than 1% of its historic range in the last century. Sandhill has an exceptionally rich understory plant diversity and is habitat for endangered animals such as the red-cockaded woodpecker (Ware et al. 1994, Myers and Ewel 1990).

Cogongrass is found in most publicly-owned sandhill ecosystems remaining in Florida, arriving as rhizome segments in roadfill soil or by wind-blown seed. The native understory of these longleaf pine (Pinus palustris) forests is dominated by short (about 20 inches) clumping grasses such as wiregrass, Aristida stricta. In contrast, cogongrass is tall (about 60 inches) and spreads by extensive underground growth of rhizomes, forming dense swards.

I hypothesized that invasion of cogongrass in Florida sandhill would affect regeneration of longleaf pine by reducing survival and growth of seedlings. I tested this by measuring survival and growth of planted longleaf pine seedlings in sandhill with and without cogongrass.

METHODS

I conducted this study in a sandhill ecosystem in west-central peninsular Florida, in the Citrus Tract of the Withlacoochee State Forest in Citrus County. This forest is located on the Brooksville Ridge, an elevated sand ridge underlain by clay deposits at varying depths (Webb 1990).

Sandhill in this forest has been repeatedly logged over the last century. Although large areas of the forest have been managed for natural regeneration of longleaf pine, some sandhill sites were converted to slash pine plantation. Current forest management calls for gradual replacement of slash pine with longleaf pine (Blanchard 1994).

Cogongrass probably arrived in this forest as rhizome segments in clay roadfill, with sporadic spread by wind-dispersed seed. Cogongrass has become prevalent in the area since it's introduction by the nearby U.S.D.A. Plant Introduction Station in Brooksville in the early 1900's (Westbrooks and Eplee 1989).

This study was carried out in a pine plantation in the sandhill. Prior to logging, the plantation consisted of dense slash pine with a band of cogongrass established along the road edge. The slash pine was clear cut in 1987 and the site was roller-chopped in the summer of 1990 in preparation for planting of longleaf pine. Roller-chopping spread cogongrass rhizomes across the site. The following winter, bareroot longleaf pine seedlings were planted on a 6 foot by 8 foot grid (908 pines/acre), both mechanically and by hand using prison labor.

Cogongrass soon formed a dense sward over approximately 5 acres of the plantation. Four years after the longleaf pine were planted, I counted surviving seedlings and measured their height (from ground to growing tip) along 295 foot long transects following planting rows. Twelve of the transects were dominated by dense cogongrass and twelve were randomly located in adjacent plantation without cogongrass.

RESULTS

I compared survival of longleaf pines, assuming that one seedling had been planted every 6 feet in the rows. Of the 568 pines planted in each treatment (with and without cogongrass), only 25% survived in the dense cogongrass while 53% survived in the sandhill with no cogongrass. A two-sided t-test detected a highly significant difference between the two treatments in mean percent survival (n=12 transects, alpha=.05, p<.0001, power=1.0).

Forty-five percent of the 139 surviving pines in the cogongrass were still in the “grass stage”, with no measurable height since the growing tip was concealed below the soil. The tallest pine in the cogongrass was only 12 inches in height. In contrast, 90% of the pines in sandhill without cogongrass had already grown out of the grass stage, with the tallest pine already reaching 63 inches.

Surviving pines in the sandhill without cogongrass were taller on average (8 inches) than pines in dense cogongrass (2 inches). I compared median height of surviving pines in the two treatments using a Mann-Whitney Rank Sum test and found a highly significant difference (n=12 transects, p<.0001).

CONCLUSIONS

Cogongrass growing in a longleaf pine plantation significantly decreased survival and height growth of four year old planted longleaf pine seedlings. In cogongrass, 28% fewer longleaf pine seedlings survived and survivors were 6 inches shorter on average than in sandhill without cogongrass. The significant reduction of longleaf pine yield due to competition from cogongrass should justify budgeting for control of cogongrass in longleaf pine forests. Site preparation procedures such as roller chopping that spread cogongrass rhizomes should be reconsidered if cogongrass is present.

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Ecosystem Restoration on the Apalachicola National Forest

W.V. McConnell (W.V. McConnell Land Management Planner/Forester, Tallahassee, FL)
Andy Colannino (USDA Forest Service, Apalachicola Ranger District, Bristol, FL)

ABSTRACT - The Apalachicola National Forest in Florida contains about 16,600 acres of deep sand soils, originally supporting a longleaf pine/wiregrass ecosystem and which is now occupied by other timber types or sparsely stocked longleaf with a scrub-oak understory.

Slash Pin Plantations	10,400 acres
Scrub Oak	2,700
Sparse Longleaf (w/hdwds)	1,900
Pine/Hdwd, Hdwd/Pine	1,600
Restoration Needed	16,600 acres

In 1994, the US Forest Service decided to restore these areas to the original ecosystem, tentatively over a 20 year period, using commercial timber sales to remove unwanted stems and to finance needed cultural treatment. The material to be removed includes 17 MMBF of sawtimber, 175,000 cords of pine poletimber and 180,000 green tons of hardwood energywood with a total estimated value of about $12 million.

Three principal problems were anticipated:

1. Securing the support of the timber industry in removing the very large volume in unmerchantable hardwoods in the form energywood along with conventional forest products.
2. Securing the support of the environmental community, state and federal wildlife management agencies and the general public for a program which would involve extensive clearcutting of pine and hardwood stands. This cutting was proposed for areas with high public visibility and in some cases, would be in violation of the regional standards for red-cockaded woodpecker habitat management.
3. Securing the in-service acceptance and support by functional staff for an “ecosystem restoration” project which crosses over functional boundaries and, in some cases, does not conform to traditional concepts or management standards.

The Forest Service joined with the Liberty County rural Development Action in working through the first two problems with workshops, publicity and personal contacts. The FS is now preparing an environmental assessment and inter-agency acceptance of the recommended alternative has yet to be secured. The third anticipated difficulty has not, with minor exceptions, materialized.

The Apalachicola National Forest in Florida contains about 16,600 acres of deep sand soils, originally supporting a longleaf pine/wiregrass ecosystem and which are now occupied by slash pine plantations or scrub hardwoods.

In 1994, the U.S. Forest Service decided to restore these areas to the original ecosystem, tentatively over a 20 year period, using commercial timber sales to remove unwanted stems and to finance needed cultural treatment. The material to be removed includes 17 MMBF of sawtimber, 175,000 cords of pine poletimber and 180,000 green tons of hardwood energywood with a total estimated value of about $12 million.

The Liberty County Rural Development Action Team joined with the Forest Service to further this project as an economic development measure. The sponsors expected that the principal problems which would be encountered would be people related, rather than technical in nature. Three principal problems were anticipated:

- Securing the support of the timber industry in removing the very large volume of “unmerchantable” scrub hardwoods. The Forest Service hoped to sell this as “energywood”, a product not previously included in National Forest timber sales in Florida.
- Securing the support of the environmental community, state and federal wildlife agencies and the general public for a program which would involve extensive clearcutting of pine and hardwood stands. This cutting was proposed for areas with high public visibility and in some cases, would be in violation of the regional standards for red-cockaded woodpecker habitat management.

- Securing the in-service acceptance and support by staff for an “ecosystem restoration” project which crosses over functional boundaries and, in some cases, does not conform to traditional concepts or management standards.

The Forest Service joined with the Rural Development Action Team in working through the first two problems with workshops, publicity and personal contacts. The Forest Service has prepared an environmental assessment for the project’s first timber sale and will seek public and inter-agency approval of the recommended alternative. To date, the third expected difficulty has, with minor exceptions, not materialized.

The District expects to offer the first timber sale in December of 1996.

QUESTIONS CONCERNING LONGLEAF ECOSYSTEM RESTORATION ON THE APALACHICOLA NATIONAL FOREST:

WHAT: A project designed to restore the longleaf/wiregrass ecosystem on 16,600 acres of sandhills now supporting plantations of off-site slash pine, scrub oak stands and understocked longlaef pine with a hatrdwood understory.

WHERE: Forest Service lands in Leon, Wakulla, Franklin and Liberty Counties, Florida within the Apalachicola and Wakulla Ranger Districts of the Apalachicola National Forest. The major concentrations of restoration land lies south and west of Tallahassee in the area known as the Munson Sandhills.

WHO: The U.S. Department of Agriculture, Forest Service with the assistance of Florida’s forest industries and the Liberty County Rural Development Action Team coordinating with the U.S. Fish and Wildlife Service and the Florida Game and Freshwater Fish Commission. The project is supported by the area environmental community and the Tallahassee Area Chamber of Commerce.

WHY: The area to be treated supports a complex of dysfunctional ecosystems, unsuited to the soils and producing less than optimum outputs of commodity, recreation and game and non-game wildlife resources. The objective is to return the land to a condition approximating that found before European settlement in terms of composition, structure, function and resiliency - modified to meet the needs of today’s society.

HOW: The governing strategy is restore and manage the land to meet today’s needs without compromising the ability of future generations to meet theirs. The process will follow this sequence:

- Secure the consensus of concerned interest groups on management goals and broad management strategy.
- Examine and evaluate the conditions on each tract.
- Determine management alternatives and select the preferred alternatives.
- Secure public approval for specific management proposals.
- Remove unwanted vegetation, retaining a permanent component of relict longleaf pine and hardwood for stand diversity, wildlife habitat and esthetics. The tentative output of forest products includes: 175,000 cords of pine pulpwood, 17 million board feet of pine sawtimber, 180,000 green tons of hardwood energywood; adding to a total value of over $10 million.
- Establish a new longleaf pine/wiregrass ecosystem by planting or through natural regeneration.
- Manage the new forests, using prescribed fire and other cultural treatments.

WHEN: The Forest Service currently is accomplishing the first two of these elements through an aggressive information and education program, a series of consultations and workshops, and intensive field examinations. To identify alternatives and select preferred alternatives, the ranger district staff has prepared the first of a series of Environmental Assessments, each of which will involve public comment and interagency consultation. This long-term project may extend over the next 20 years with the first timber sale expected to be offered in late 1996.

Containerized Seedling Longleaf Production

John McRae (International Forest Seed Company, Odenville, AL)
Tom Starkey (International Forest Seed Company, Odenville, AL)

ABSTRACT - This paper will discuss the production activity and the history of the containerized longleaf seedling production in southeastern United States. The containerized longleaf production began in the late 1970s. Since the early 1980s production capacity expanded approximately 500,000 to about 1,000,000 seedlings per year. Through 1996 the estimated total production about 30,000,000 seedlings. Most of the containerized longleaf seedling production is in Georgia, where some 15 different nurseries are producing seedlings in a variety of containers. But production also occurs in North Carolina, South Carolina, Florida, Alabama, Mississippi, and Louisiana. Production activities from site selection through packaging for shipment are discussed.

INTRODUCTION

Containerized longleaf seedling production dates probably to the mid 1970's in Pineville, Louisiana. Dr. James Barnett, USDA Forest Service Chief Silviculturist began growing longleaf in containers as an alternative to planting bareroot seedlings in silvicultural research outplantings. Successful bareroot seedling establishment of longleaf is difficult. It is a widely know fact among foresters that s substantial risk is taken to transport, handle, and plant bareroot longleaf seedlings. It is very common to obtain less than 50 percent survival from planting bareroot longleaf seedlings. To evade the failure, more bareroot seedlings were planted. Resulting stands remained difficult to manage. They were either greatly overstocked or poorly distributed. Frequent success was limited to plantations established close to the nursery. survival decreased for those seedlings required to be stored and transported for long distances away from the nursery. Because of these problems with bareroot seedlings, Dr. Barnett was researching new methods to establish longleaf pine seedlings.

The Florida Division of Forestry is probably the first organization that began a significant production of containerized longleaf seedlings. They began in 1982 growing containerized seedlings in Styroblocks in Punta Gorda, Florida. Also, during that time period, Speedling Nurseries Inc. in Tampa, Florida began growing containerized seedlings. Several pulp & paper company personnel in South Georgia recognized the need as well to find a way to plant longleaf pine seedlings and obtain acceptable survival. Frank Vandelinde with Brunswick Pulp and Land Company, began some research in cooperation of Howard Waters in Jesup, Georgia. Their objectives were to solve the seed germination problems associated with longleaf and establish the minimum standards to grow containerized longleaf seedlings.

International Forest Seed company began growing containerized longleaf in 1983 and has increased it's production every year, reaching the current annual production capacity of 9,000,000 seedlings. Other nurseries starting large operations of containerized longleaf during the 1980's include: Southern Seed Company Dublin, Georgia, South Carolina Forestry Commission Wedgefield, South Carolina, U.S. Forest Service Brooklyn, Mississippi and Weyerhaeuser Company Aiken, South Carolina. Howard Waters owner of Waters Plant House Jesup, Georgia, produced several million seedlings and has encouraged other growers in the area to grow seedlings as well.

The success of plantations established with containerized seedlings has become widely known over the last few years. The results of containerized longleaf technology has developed firm confidence in successful longleaf regeneration.

PRODUCTION CONSIDERATIONS: Nursery Location

Selecting a site to grow containerized longleaf seedlings requires thoughtful consideration. The first consideration must be the water quality. It is of course the water that will eventually lead to your success or failure over time when growing tree seedlings, whether containerized or bareroot. The source of water is very critical and usually determines whether or not you would like to grow on a particular site. The pH of the water is probably the most important factor. A range of 5.5 to 6.5 is ideal. Also, consider the amount of other minerals and elements in the water. The recommendations of Dr. Charles B. Davey of Zobel Forestry Associates. Inc. is an excellent source to use in establishing water quality thresholds.

When choosing a site, consider the climate in which you plan to grow. Seasonal changes are preferred to help produce quality seedlings. The cool weather in the fall is needed to help push seedlings into dormancy and the cold weather in the winter is needed to maintain dormancy. of course, a cool spring (temperatures below 85 F) facilities excellent germination. Longleaf thrive in full sunlight. The summer months throughout the longleaf range are going to be hot regardless of where you establish your nursery. Establish the nursery within the natural range of longleaf, but chose an area where the plants can be exposed to seasonal changes.

Containerized seedling production is a laboring process. The third most important factor when considering your location is to make sure that you have the infrastructure to support the nursery production. Obtaining labor to grow the crops is an important consideration. in this modern of times having "just in time" suppliers a responsive distribution system is usually not a problem anywhere throughout the South. However, remember it is the biological deadlines of growing a crop that must steer your budgeting and planning.

PRODUCTION CONSIDERATIONS: Product & Service Objectives

The container in which you grow is without a doubt the most important decision to be made. The demands of customer requirements and the biological needs to establish a successful plantation drive this decision. A variety of cavity sizes and multipots are available. Experience has shown that a 5.7 cubic inch cavity with a 3.5 inch depth works well. Multipots tend to cost less per cavity and are easier and less costly to manage when growing large quantities of seedlings. Removable cells provide extra flexibility if sorting is necessary but, in general add to production, packaging, and shipping costs. The seedling quality (the product) and customer service is directly effected by the container used.

PRODUCTION CONSIDERATIONS: SEED

Longleaf seed germination still appears to be an enigma to just about all nurseryman. It is the most variable in regards to germination and vigor when considering all the Southern pines. It's large size and soft seed coat make it extremely difficult to condition in the seed plant. Methods are in place, however coxtlym to consistently produce clean seed with germination's of 85% and better. Once again., experience as shown that any improvements to the seed quality that can be made, should be made, considering the additional costs involved in seedling production.

Choose seed with good vigor. That is, seed which germinates fully and quickly. Purities should be higher than 98% since debris slows sowing operations. Stratify the seed 7 to 10 days at 33 F to enhance total germination and vigor. It is also advisable to sterilize the seed coat before sowing, to remove or kill any pathogens that can inhibit germination.

The sowing strategy involves seed use management and how you plan to manage the crop. Total estimated germination usually drives the decision as to the number of seeds to sow in each cavity. Considering labor costs to sow seed and to thin unneeded germinates from the cavity, the minimum germination for single sowing (one seed per cavity) is 90%. Less than 90%, usually involves sowing more seed per cavity. Germination's less than 60% are rarely cost effective.

PRODUCTION CONSIDERATIONS: MEDIA

Don't use dirt! Use a soilless media. Commonly equal proportions of peatmoss, coarse vermiculite and perlite are used as a growing media. They must be will blended, but care needs to be taken to avoid destroying the material structure. Equal pore space of air: water: media is desirable for proper drainage. The target cation exchange rate should be 25 - 35 MEQ/L.

Often, a few to several amendments are incorporated into the media during blending. Controlled release fertilizers and micronutrients are usually incorporated by most growers. The intent is to optimize growth throughout the seedling life cycle, even into the first few months after outplanting. Considerable investigation is recommended before deciding upon products and rates.

Wetting agents added to the media greatly improve the water distribution in the cavity. This affects drainage, which in turn greatly influences root and shoot growth. In general, any management activity that can optimize the drainage properties of the growing media will result in more plantable seedlings.

Mycorrhizae, usually *Pisolithus tinctorius* ("PT"), is added to the media to improve seedling health. When "PT" is incorporated in the media, more fibrous roots develop aiding in water and nutrient absorption. It stands to reason that a healthier tree will have a better change at survival in the nursery as well as on the planting site. At the same time, granular fungicides are amended to the media to control soil borne pathogens. Choose chemicals however that do not inhibit mycorrhizae development.

PRODUCTION ACTIVITIES: Media filling and Germination management

Filling the containers properly after the media is thoroughly blended is a critical operation that should not be taken lightly. First, the containers must be cleaned well enough to prevent weed seeds and/or diseases from significantly affecting seedling growth and development. During filling, careful tamping of the media is extremely important, as subsequent drainage and root growth are greatly influenced by this operation. Tamp each cavity precisely and uniformly. Do not destroy the media structure with "over tamping". Leave a depression on the top in which to place the seed. Mulch the seed lightly with grit, vermiculite, perlite, or peatmoss. Mulching helps maintain seedcoat moisture through the germination phase of seedling growth.

Once the filled containers are placed in the production area, immediate action is necessary to protect your investment from any environmental damage. Cover the crop with shade clothe. This will protect the seed and germinating seedling from predators, heavy rains, hail storms and wind damage. The clothe should stay in place during the first 4 to 5 weeks after sowing or until about 90% of the seeds have germinated.

Irrigation should be frequent enough during the entire germination phase to maintain seed coat moisture levels that prompt germination, but minimizes pathogen development. Over watering as well as under watering can cause severe variation in filled cavity percentages. It is at this point in time of the operation that has the greatest influence on the success or failure of the crop. Be sure to have plant development goals in place before your operation begins, against which you can measure your progress.

To prevent disease development during the germination phase, regular fungicides applications as are recommended. The "preventive" applications are used to manage against aggressive and undetected pathogens that can very quickly destroy a crop.

PRODUCTION ACTIVITIES: Water management

Water management is the single most important activity the nursery manager must command. Earlier mention of pH and media drainage alluded to the fact that these factors are the two critical elements of water management. The pH of the irrigation water and the leachate should be between 5.5 and 6.5. The various fertilizers and chemicals applied throughout the growing season function best in this range. The drainage characteristics of the media also greatly influence water management decisions. Plant/water relations are continually monitored by the nursery manager. By maintaining a consistently drained media, accurate water schedules are easier to establish. A well drain media also aides in fertility and pest management.

PRODUCTION ACTIVITIES: Fertility management

The goal which a nursery manager should aim for is to produce a seedling with a good rootball first and good top second. It takes relatively little effort to produce a nice looking top, however, more effort is required to get a good rootball with abundant secondary and tertiary roots.

Resist the temptation for apply high levels of nitrogen early in the season. Instead, emphasize the phosphorus and potassium.

If you could roughly breakdown the season in thirds, apply low levels of nitrogen, and high levels of phosphorus and potassium during the first third of the season. During the second third of the season, apply high nitrogen in the approximate ratio of 20 - 10 - 20 or even a balanced fertilizer. As shipping season

approaches during the last third of the growing season, back off the nitrogen once again by applying a low nitrogen fertilizer with medium levels of phosphorus and potassium.

PRODUCTION ACTIVITIES: Pest Management

The key to successful control of all pest, is daily observation, monitoring and action. Every nursery manager should live by the saying "Don't expect what you don't inspect". All pests, whether they be disease, insect or weeds have the potential to explosively develop in the nursery environment. It is only through frequent inspection that problems can be diverted.

Just as daily inspection of the nursery crop is imperative, knowledge for all nursery workers of what a healthy tree looks like is just as important. A person can never identify the abnormal until they are familiar with what is normal. Bank tellers are trained to identify counterfeit money not by learning what the abnormal looks like but rather by having a thorough knowledge of the genuine.

PRODUCTION ACTIVITIES: Weed control:

Weeds are the perpetual nemesis of all nursery managers. The question we must answer each year is not "if we have a weed problem" but rather "when the weeds start developing." Although out "bareroot" nursery counterparts may not agree, weeds are more difficult to control in a container nursery than in a bareroot nursery.

The small cavities used to grow container trees necessitates that any herbicides used must be very target specific. a container nursery manager cannot afford to use a herbicide that may potentially cause any root inhibition to the container seedling. Such a chemical may control the weed, but may reduce the growth of the seedling due to root damage.

The nursery manager must consider the use of pre-emergent herbicides as the first choice in controlling the weed problem. To rely exclusively on post emergent control can be potentially damaging to the tree crop. First, a nursery manager may not find a post-emergent herbicide that ill control the weed pest without doing damage to the trees. Of course, while the nursery manager is looking and experimenting with other post-emergent herbicides, the seeds are lushly growing at the direct benefit of tree that shares the cavity.

Unfortunately, many container nursery managers have relied too heavily upon hand weeding. Every manager knows that this labor intensive activity is a "budget killer". It is costly due to the amount of time required to "climb" in and around the container sets to hand weed. It is also costly due to the time it takes to separate a weed from the tree growing in an individual container cavity.

We as nursery managers owe it to our customers to be continually looking for not only new chemicals but experimenting with different rates of current herbicides to achieve an economic level of control. We can reduce the cost of container seedlings once we find a method of better controlling weeds in the nursery.

PRODUCTION ACTIVITIES: Insect control*:*

Until recently, insect control has not been an activity in which nursery managers have spent a great deal of their time. their main focus has been on diseases, weeds or an occasional raccoon of opossum that decides to run across the top of the container sets. For years, International Forest Seed Company have applied relatively few insecticides during the growth of the tree crop.

Nursery managers need to pay closer attention to the control of insects that directly attack trees and those that have a role in the spread of plant pathogens as insect vectors. Again, the key t successful insect management is monitoring and inspection.

Most container grown trees are grown in a soil-less, high organic media. Under wet conditions this high organic media can support and propagate incredibly large populations of fungus gnats. Their exact role, as to whether they can directly attack and kill young trees or only act as a vector of other plant pathogens is still being defined. All nursery managers should view this particular insect a potentially serious problem. Control of the moisture in and around the container sets is essential to controlling fungal gnats.

Other more “traditional” insect problems can be controlled fairly easily only if they are detected early. Again, daily inspection and monitoring is the key to successful pest management.

PRODUCTION ACTIVITIES: Disease Control:

Water management is the primary factor in control of plant diseases in container nurseries. All nursery managers have noted that in dry years much less fungicides are used than in wetter years. Tied to water management is control of the water pH.

Container design also plays an important role in controlling plant diseases. Some containers used today can potentially harbor plant pathogens by allowing them to “overwinter” either inside the walls of the container of on the wall surface in organic matter left over after the trees were extracted. Each nursery manager must address the problem of set sanitation before the container sets are reused.

All containers used in the industry today have water drainage holes in the bottom of the container. The size and location of these holes or hole can play a part in control of plant pathogens that cause root problems. In general a well designed container set will allow free water to rapidly drain out of the cavity.

Allowing the tree foliage to dry down as rapidly as possible each morning after an evening rain or due is extremely important in controlling foliar pathogens. Most foliar plant pathogens require free moisture to develop. Limiting the amount of time the foliage stays wet following irrigation, rainfall or dew can significantly reduce losses due to plant pathogens.

A review of approved chemicals for containerized trees indicated a broad choice of available options. However, an informal survey of the most frequently used chemicals indicates a much smaller list. The most popular chemicals of choice are Banrot (or it’s components used individually), Captan, Clearly 3336. Most nursery managers sincerely regret that we have lost the use of Benlate.

The chemicals list above are not a “recommended list”. Each manager must make their own choice dependent upon the results in their own nursery and the species of trees grown.

Use of chemicals should be rotated in order to prevent any resistance buildup in the pathogen population. Be sure that the chemical rotation includes chemicals which are not in the same group or similar chemical structure.

Regardless of the chemicals chosen, control of the water pH is imperative. All chemicals have an optimum pH range at which the chemical remains active in the water. This information is not readily available for chemical labels. However if you are using water with a pH much outside the recommended range around 6.0, you should check with the manufacturer to determine if the chemical remains active for as long as you require at your pH.

PRODUCTION ACTIVITIES: Shipping:

Shipping season is not necessarily the end of the headaches, for many managers, it is only the beginning. decisions as to how to ship the seedlings, how to store them and weather concerns permeate the shipping season.

Perhaps the most common way to ship seedlings is to extract them from the container and ship in a box to the customer. Extraction of all the seedlings allows for better quality control than shipping the seedlings to the customer in the container sets. Culls are easily removed before they are shipped to the customer.

Weather conditions are an important consideration during the extraction of seedlings. A wet rootball is more difficult to extract than a rootball that is dry. A seedling that is difficult to extract or has a marginally good rootball that is dry. A seedling that is difficult to extract or has a marginally good rootball may end up as a cull if it must be extracted when very wet.

Container trees are also shipped in the container sets. This is not a preferred method for the nursery manager for several reasons. First, good seedlings and culls that could have been detected by extraction are shipped together. The tree planters seldom remove any culls unless well trained. Second, container sets sent to the customer are frequently not returned or returned damaged. A deposit can

required, however, it significantly increases the amount of administrative bookkeeping to track them. Thirdly, shipping the trees in the sets is more costly than extracted. More extracted trees can be shipped it the same cubic foot area than can trees shipped in the sets.

Although shipping tree in the containers has many disadvantages for the nursery manager, many customers prefer this method. Difficulty in lining up planting crews is not as much of a problem since the customer can easily water and maintain their trees in the container.

Container trees do not need to be shipped in refrigerated vans unless they are traveling to a much hotter location. A tree with a rootball of about 80% moisture would have not problem being shipped in non-refrigerated vans.

We feel that one of the greatest advantages to container seedlings is that it can be planted anytime of the year as long as adequate soil moisture exists. Nursery managers need to encourage customers to accept shipment as early as possible in the fall. We have had customer plant container trees in late July when good summer rains occur.

The other advantage to early planting is the ability to avoid freezing temperatures that are common after mid December in the Southeastern United States. We at International Forest Seed Company are very strong proponents of fall or late summer planting of container trees.

Longleaf Pine - Wiregrass Ecosystem Responses to Flooding

William K. Michener (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Stephen W. Golladay (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Paula F. Houhoulis (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Robert J. Mitchell (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
Brian J. Palik (Forestry Sciences Lab, USDA Forest Service, Grand Rapids, MN)

ABSTRACT - High precipitation throughout southwestern Georgia associated with Tropical Storm Alberto (July 1994) resulted in extensive flooding within the Flint River watershed. Flooding varied in extent, intensity, and duration along stream and river valley segments. Effects of the disturbance were evident at scales ranging from populations (e.g., plant and animal mortality) to the landscape (e.g., water quality, remotely sensed spectral changes in vegetation condition and biomass, etc.).

INTRODUCTION

Hurricanes and tropical storms, like other large natural disturbances, play an important role in regulating ecosystem structure and function, as well as affecting diverse plant and animal populations and communities (Michener *et al.,* in press). Longleaf pine-wiregrass ecosystem structure and function are regulated by the complex interaction of disturbances and gradients in resource availability. At the xeric end of the gradient, for example, droughts are thought to be an important factor causing mortality of young trees and herbaceous vegetation. Excess water, such as infrequent flooding associated with tropical weather systems, may also be important. Wahlenberg (1946) suggested that grass stage longleaf pine (*Pinus palustris*) seedlings are sensitive to inundation if the apical meristem is submerged. Similarly, wiregrass (*Aristida stricta)* may be sensitive to flooding when the aerial portion is inundated (Parrot, 1967). Beyond these observations, little information is available regarding the susceptibility of longleaf pine and wiregrass to flooding.

In the southeastern Coastal Plain, floods and wind storms may result in substantial wood inputs to streams. Coarse wood debris (CWD) is an important structural and functional component of streams draining forested areas. CWD generally accumulates on flood plains or as snags on the lateral edges of stream channels and is often the most productive habitat for aquatic invertebrates (e.g., Benke *et al*., 1985). The rate of wood input is influenced by age structure of riparian forests, tree mortality, riparian geomorphology, and the timing of disturbances (floods, wind storms, debris avalanches).

Tropical Storm Alberto presented an opportunity to assess the role of flooding as a disturbance in affecting longleaf pine-wiregrass ecosystem structure and function. In this paper, we summarize observations related to (1) landscape patterns and processes; (2) longleaf pine and wiregrass mortality; and (3) coarse wood debris input and retention in flooded stream reaches.

Study Area

Ichauway is a 115 km^2 ecological reserve located in southwest Georgia along the Flint River at it's confluence with Ichawaynochaway Creek. The site includes over 22 km of the Ichawaynochaway Creek and over 19 km of the Flint River. Undisturbed terrestrial habitats in the study area are dominated by longleaf pine and wiregrass, the dominant ground cover species.

The riparian zone for both Ichawaynochaway Creek and the Flint River consists of seasonally flooded hardwood hammocks (unconstrained reaches) and longleaf pine-dominated upland terraces (constrained reaches) (Goebel *et al*., in press). Flood tolerant species are confined to hammocks or steep banks adjacent to terraces. Generally, flow in Ichawaynochaway Creek and the Flint River is low and stable from early summer through autumn. Winter and early spring storms often result in bankfull discharges and inundation of riparian areas.

Materials and Methods

Tropical Storm Alberto remained relatively stationary over southwestern Georgia for an extended period (July 2-7, 1994), and resulted in extremely high precipitation throughout the Ichawaynochaway Creek (2,600 km^2) and Flint River (21,000 km^2) watersheds (over 53 cm of rain were recorded in some portions of the Flint River watershed). Flood discharges in tributaries and mainstems of the Flint River exceeded 100-year flood discharges along most stream reaches (Stamey, 1995). Flood waters inundated riparian habitats, as well as agricultural fields, pine plantations, and upland habitats adjacent to streams and rivers.

Remote sensing, field surveys during and after flooding (including Global Positioning System surveys; GPS), and Geographic Information Systems (GIS)-based analyses were utilized to characterize the relative impact of flooding within the study area. SPOT-XS (multispectral) images for October 5, 1990 (pre-flood) and September 28, 1994 (post-flood) were utilized to assess vegetation responses to flooding. Procedures used for image rectification, normalization, and accuracy assessment, as well as GIS data used in analyses have been described elsewhere (Houhoulis and Michener, 1996; Michener and Houhoulis, in press). Differences in Normalized Difference Vegetation Index values (NDVI; a measure correlated with vegetation biomass and condition) observed prior to and following the flood (image differencing) were used in an unsupervised classification (NDVI-ID). In the resulting image data set, values that are negative or close to zero indicate areas where NDVI increased in 1994 or remained relatively unchanged, whereas positive values represent areas exhibiting a decrease in NDVI in 1994. A +1 SD (>9 DN) was selected as the 'change' threshold value.

Maximum water levels, surveyed at >350 locations along Ichawaynochaway Creek and the Flint River, were used to derive a flood boundary map and create 1.52 m contour intervals above bankfull conditions to characterize the magnitude of flooding. One hundred and thirty-nine sites (approximately 650 m^2 per site) containing wiregrass and longleaf pine seedlings and saplings were surveyed throughout the flooded area to quantify vegetation damage. Height of living, recovering, and top-killed trees, valley floor landform, and elevation of all plots with respect to the high water mark during the flood were determined (Michener *et al*., 1995; B. Palik, unpublished manuscript). Each site contained three randomly chosen plots where ground cover mortality was assessed using a 1 m^2 quadrat divided into a 10 X 10 grid (10 cm intervals). Presence of bare ground, detritus, and wiregrass condition (top-kill, live, or recovering) were recorded at all points and data from the three plots were averaged and converted into percentages.

Following the recession of flood waters, riparian areas of Ichawaynochaway Creek were surveyed for tree mortality (i.e. those trees uprooted or downed by floodwaters). Replicate (3) reaches (400-900 m in length) in seasonally flooded hardwood hammocks and longleaf pine dominated upland bluffs were surveyed.

RESULTS and DISCUSSION

Approximately 21 km^2 of upland communities were flooded at Ichauway. Flooding varied in extent, intensity (depth, current velocity), and duration along stream and river channels. Based on soil characteristics, xeric communities were disproportionately affected by the flooding. For example, Bigbee, Kershaw, and Lakeland soils experienced four times more flooding than would be expected if these xeric soils were randomly distributed throughout the study area. Flooded xeric soils were dominated by longleaf pine-wiregrass and shrub-scrub communities.

Relatively sparse overstory canopy coupled with a dense ground cover community primarily dominated by a single species (wiregrass) characterized the study area and facilitated change detection analyses. NDVI-ID proved to be an effective technique for discriminating vegetation responses to flooding. NDVI values in the non-flooded area approximated those observed in 1990, whereas those in the flooded area exhibited a 10 DN decrease. These findings indicate that ground cover vegetation exhibits marked spectral and ecological (mortality, stress, etc.) responses to flooding which can be detected as a decrease in NDVI.

Topkill for both longleaf pine and wiregrass generally occurred where flooding was most intense (both in duration and depth). Flood impacts, however, varied significantly among valley floor landforms. Seedlings and saplings with apical meristems above high water generally survived. Small grass-stage longleaf pine seedlings appeared to have a greater probability of resprouting after initial top kill, than submerged seedlings that had initiated height growth (Michener *et al*., 1995; B. Palik, unpublished data).

Significant tree mortality occurred in riparian areas adjacent to Ichawaynochaway Creek. Mortality was higher in upland bluff riparian habitats than hardwood hammocks. Higher mortality may be due to constrained stream channel morphology in bluff riparian zones, which results in higher current velocities during floods. Mortality during flooding reflected the abundance of tree species in riparian habitats. Bluff zones are generally dominated by oaks (*Quercus* spp.) and cedar (*Juniperus virginiana*), and those species comprised a majority of trees downed by flooding. Mortality in hammocks was more variable, although oaks and cedars were the most commonly downed species.

CONCLUSIONS

Although catastrophic flooding is infrequent in the Coastal Plain, the long-term dynamics of longleaf pine populations may be influenced by floods, given the 300-400 yr potential life span of the species. Flooding induces mortality of wiregrass and longleaf pine seedlings and saplings if the entire aerial portion of the plant is submerged for a critical period. Because of the large area affected and the relatively sparse canopy, vegetation effects were discernible at the landscape scale based on change detection analysis of SPOT XS data.

Results of this study coupled with ongoing fire, fossorial herbivore, and related studies will likely force us to reassess the "disturbance paradigm" in longleaf pine ecosystems. Effective ecosystem restoration and management efforts will ultimately require a better understanding of the role of climatic and hydrological events, fossorial herbivores, fire, and the interactions among the various disturbances in regulating soil, nutrient, and vegetation patterns and processes. Floods, for example, may promote recruitment of propagules into unvegetated areas; enhance primary productivity, nutrient input, and regeneration; and support the development of ecotones in flood-affected areas. Floods may also, however, have a disproportionately negative impact on biodiversity and certain species, populations, and communities. Ideally, the potential for catastrophic flooding and other extreme events should be explicitly incorporated into reserve and riparian corridor planning and design.

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Gaps in Longleaf Pine Forests: A Tool for Ecosystem Management

R.J. Mitchell (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
B.J. Palik (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
L.K. Kirkman (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
C.W. Hedman (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
S.D. Pecot (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
J.P. McGuire (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
D.H. Gjerstad (Auburn University, School of Forestry, Auburn University, AL)

ABSTRACT - Ecosystem management has been a topic of debate primarily due to a lack of consensus on a definition. Here we define ecosystem management as silvicultural practices that reduce the functional and structural disparities between managed and natural forests. Ecosystem management uses natural disturbances as models from which managed disturbances are molded; therefore, knowledge of community responses to disturbance regimes is requisite for implementation. Recognizing the legacies of past management effects on ecosystems is also integral for converting or maintaining stands. Unfortunately, little is known of community response to disturbance and important ecological functions in longleaf pine forests.

Longleaf pine forests are becoming an important part of ecosystem management within this region due to their historical dominance, ecological importance, and economic potential. There is increased interest on private forest lands, with respect to profitable management of longleaf woodlands that maintain enhanced ecological attributes. Ecosystem management is rapidly becoming the dominant paradigm on public forests. Developing silvicultural tools for ecosystem management becomes even more critical as natural longleaf stands continue to diminish in extant, but is constrained, in part, by our rudimentary understanding of fundamental ecosystem processes, including the functional role of gaps in these open canopy forests.

The longleaf pine forests observed by the first European settlers were characterized by even-aged regeneration cohorts nested within large gaps of uneven-aged, open canopied stands. Gaps were formed by overstory disturbance factors such as lightning, windthrow, bark beetles, and fire. These disturbances usually resulted in killing a small number of trees (i.e., 1-5) though occasionally a larger number of trees would die from a single event. It is not well understood how large the gap has to be to foster regeneration. Furthermore, the extent to which competition is important among adults and juveniles, the resources that control competitive interactions, and the extent that fire and other higher order community interactions regulate regeneration dynamics of gaps have received little attention.

We began to study competitive relationships between overstory and understory by separating the effects of overstory longleaf on resource availability in spatially explicit locations within gaps and measuring the rates of growth of seedlings to various quantities of resources. This work has spawned other studies that will address issues of seed availability, seed predation, and seedling growth and mortality and understory composition as they relate to gap size and fire management. In addition, studies that investigate silvicultural methods to re-establish longleaf pine on sites now dominated by other southern pines, e.g., slash pine, have been proposed. Future research will address the work that has been completed, as well as introduce the ideas that we are addressing, or plan to address in ongoing and future studies. Specifically, our goal is to increase the functional understanding of gap formation and regeneration dynamics such that management activities promote profit and biodiversity.

Complex Ecological Gradients in Longleaf Pine Wiregrass Savannas: Patterns and Controls on Productivity and Plant Species Richness

R.J. Mitchell (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
S.D. Pecot (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
L.K. Kirkman (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
J.J. Hendricks (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
L.R. Boring (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
C.A. Wilson (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
M.B. Drew (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)
G.A. Houseal (Joseph W. Jones Ecological Research Center, Ichauway, Newton, GA)

ABSTRACT - Longleaf pine wiregrass savannas occupy a wide ecological gradient. It is thought that the diversity of sites that are dominated by this ecosystem, in part, explains the great biodiversity characteristic of these ecosystems. Also, gradients have been invoked in explaining differences in productivity that might relate to differential fire behavior across the landscape. Yet no data has been published in the literature that describes how edaphic variation across the landscape influences resource availability. Furthermore, productivity differences among sites, particularly as they are regulated by sites' ability to supply resources, have not been adequately studied. Lastly, longleaf pine is thought to be less productive than slash or loblolly pine on all but the driest sites in the Coastal Plain. However, data from Eugene Shoulders casts some doubt on conventional thought. Dynamic simulation modeling has proven to be a valuable tool in exploring the mechanisms by which productivity of slash and loblolly pine is regulated. Before such models can be constructed for longleaf, basic research is needed that quantifies resource availability and patterns in productivity throughout representative landscape units.

In March of 1995, we initiated such a study at the Jones Ecological Research Center at Ichauway. The study encompasses three site types: 1) xeric sand ridges, 2) wet-mesic savannas (that border depressional wetlands, and 3) sites intermediate to the previously mentioned extremes. Overstory and understory productivity and species richness of understory communities have been quantified. In addition, soil resources (moisture, N and P) have been measured through time.

A number of surprising patterns have emerged. Xeric sites tend to have the greatest N-mineralization, extractable P levels in the soil, and standing crop of fine roots, while exhibiting the least soil moisture and above ground productivity of the three sites. Productivity of longleaf pine and wiregrass were much more strongly influenced across the gradient than was total above ground productivity, due to the fact that oak productivity was significant only for xeric sites. Patterns suggest that disturbance and resource availability may be the most important factors regulating productivity. Similarly, species richness patterns of the understory flora indicate that disturbance and resources are factors that maintain high species diversity. The data presented in the poster represents a preliminary analysis of an ongoing study; however, we believe that data sets like this may be used to guide restoration efforts by providing information of structural and functional characteristics of the ecosystem by which restored communities can be evaluated. Also, understanding the controls on productivity may allow for expansion of longleaf management from the most dry sandy sites to others, if growth potential meets landowner objectives. This can only be evaluated if we can more precisely predict productivity by understanding regulatory controls.

Ongoing Tall Timbers Longleaf Research in Florida and Georgia

Dr. W. Keith Moser (Tall Timbers Research Station, Tallahassee, FL)
Chui Kwan Yu (Tall Timbers Research Station, Tallahassee, FL)
Stephen T. Lindeman (Tall Timbers Research Station, Tallahassee, FL)
Chuck Martin (Tall Timbers Research Station, Tallahassee, FL)
Dr. R. Todd Engstrom (Tall Timbers Research Station, Tallahassee, FL)
Dr. Robert M. Farrar (Tall Timbers Research Station, Tallahassee, FL)

ABSTRACT - On Tall Timbers Research Station in northern Florida and on adjacent properties in southern Georgia, research is currently being conducted on management systems that efficiently restore longleaf pine (*Pinus palustris*) ecosystems and that serve to mimic the natural processes of undisturbed longleaf forests.

Selection management of longleaf pine with cyclic burning on Pebble Hill Plantation, Georgia. The selection system, or uneven-aged management, of pine stands has been used with localized good success for about 50 years in loblolly-shortleaf pine types in the southern United States. While previous work has focused on single-tree selection this study will examine (1) the applicability of modified group selection to natural longleaf stands in south Georgia in terms of stand and stock development and production combined with (2) the effect of two seasons of triennial burning on longleaf reproduction and unwanted vegetation.

Uneven-aged management of longleaf pine and the impact upon the red cockaded woodpecker populations. A joint project with the Apalachicola National Forest, is examining the impact of single-tree selection harvesting upon populations of red cockaded woodpecker (*Picoides borealis*) in longleaf and slash (*Pinus elliottii*) pine stands. The current research has already established baseline, pre-harvest data on RCW feeding and nesting patterns and the population distribution within the study area. Pre-harvest measurements have also recorded individual allometric and stand data to compare with post-harvest and control growth measurements. Future RCW population dynamics will be correlated with the stand treatments.

Longleaf pine management and quail populations. The Forestry Research Program is detailing aspects of stand structure that impact northern bobwhite quail populations and by examining regeneration success that would provide adequate future forest cover. Certain landholdings in the Red Hills region are being studied by comparing stand basal area, % canopy cover and volume of utilizable timber of selected hunting courses and pairing these data with quail yields over the years. A subset of this study will also examine the presence of regeneration and the potential for maintaining the open longleaf cover into the future. Particular management practices, such as “ring-arounds”, will be studied as sources of successful longleaf regeneration.

Longleaf pine restoration. The amount of longleaf pine in the Southeast has been diminished by the past agricultural uses dating to the beginning of this century, which if recovered to forest, usually seeded to loblolly pine (*P. taeda*) and shortleaf pine (*P. echinata*). This project will research the efficacy of differing methods of artificial longleaf pine restoration under four cover types: closed old-field pine canopy, open (senescing) pine canopy, and open fields surrounded by hardwood and pine overstories. Successful longleaf pine regeneration efforts and the expectations for future forest cover and yields, both commodity and non-commodity, will be analyzed.

Okefenokee longleaf pine stand dynamics. The Okefenokee National Wildlife Refuge wants to change even-aged stands to a more natural, uneven-aged state and needs to know more about the impact such a change would have upon the current structure and the understory vegetation. Forestry Research is surveying the current stands and the disturbances that influenced them, and will suggest how the Refuge can create similar stands. Ms. Chui Kwan Yu, a recent Ms. Sc. F. student at Purdue, is working in the Refuge taking data on overstory dynamics and associated groundcover data. She is working with Dr., Bob Peet, UNC, regarding appropriate methodology for ground cover measurements.

Northern Longleaf - The Blackwater Ecologic Preserve

Lytton J. Musselman (Blackwater Ecologic Preserve, Department of Biological Sciences, Old Dominion University, Norfolk, VA)

ABSTRACT - The original extent of longleaf pine included approximately 200,000 acres in southeastern Virginia. Development of the maritime industry in Norfolk required naval stores and masts from longleaf. This along with cutting, suppression of fire and the introduction of hogs who ate the grass stage, caused longleaf to rapidly decline. Today, the northernmost longleaf pine community is along the Blackwater River in Isle of Wight County, Virginia near the village of Zuni – the Zuni Pine Barrens. Because of its many rare and disjunct species, the barrens attracted the attention of Harvard University botanists in the 1930s. They published numerous papers on the ecology and flora, providing unique documentation for a restoration program. In 1985, Union Camp Corporation gave the Zuni Pine Barrens to Old Dominion University to establish the Blackwater Ecologic Preserve.. The preserve is managed by a committee with representatives from the university, The Nature Conservancy, Virginia Division of Forestry, Virginia Natural Heritage, and Union Camp Corporation. Objectives are: maintenance and restoration of longleaf pine and communities; foster research in this unique area; and educational uses emphasizing the naval stores industry. A series of controlled burns has resulted in natural regeneration of longleaf. Also as a result of fire, several species unseen for almost 65 years have reappeared. In 1995, more that 400 acres of land contiguous with the preserve known as Antioch Pines was purchased by the state of Virginia. This area and the preserve are dedicated state natural areas and will be managed jointly especially for longleaf.

The original extent of longleaf pine included approximately 200, 000 acres in southeastern Virginia. Development of the maritime industry in Norfolk required naval stores and masts from longleaf. This along with cutting, suppression of fire and the introduction of hogs who ate the grass stage, caused longleaf to rapidly decline. Today, the northernmost longleaf pine community is along the Blackwater River in Isle of Wight County, Virginia near the village of Zuni—the Zuni Pine Barrens. Because of its many rare and disjunct species, the barrens attracted the attention of Harvard University botanists in the 1930's. They published numerous papers on the ecology and flora, providing unique documentation for a restoration program. In 1985, Union Camp Corporation gave the Zuni Pine Barrens to Old Dominion University to establish the Blackwater Ecologic Preserve.

On May 11, 1985, a 319-acre tract of land was donated to Old Dominion University by Union Camp Corporation through The Nature Conservancy. Included on this property are unique plant communities and some of the rarest species in the state of Virginia. Most important are those communities with longleaf pine (*Pinus palustris*), the tree that built Tidewater. What is also unique is the documented exploration of the area by botanists from Harvard University led by Merritt Lyndon Fernald. The preserve, then, is a cultural and botanical link with our natural heritage. Few natural areas were studied sixty years ago with the intensity of the Harvard group of scientists headed by Merritt Lyndon Fernald.

Fernald's exploration of southeastern Virginia was exhaustive. It commenced in 1933 and covered 14 field seasons, spanning the years of his life from around age 60 to 73. He published more than 1,200 pages of botanical literature on Virginia, mostly centered on the area south of the James River, from the coast inland to Brunswick County. His exploration led him to the heart of the Zuni Pine Barrens. In all, Fernald recorded dozens of rare species from what is now the Blackwater Ecologic Preserve and the surrounding area. These rare plants are part of a guild associated with longleaf pine. As longleaf stands were destroyed, so were the habitats of these organisms.

According to Cecil Frost (Frost and Musselman, 1987), the disappearance of longleaf pine from Virginia can be summarized as the consequence of the cumulative effects following activities over three and a half centuries of European civilization:

1. Introduction of feral hogs. Starting from the time of Smith's arrival in 1607, until they reached a saturation population in the woods some time prior to 1800, hogs consumed pine mast and, more importantly, the grass stage seedlings, thereby eliminating reproduction.
2. Small-scale removal of mature trees for lumber, all through the colonial period.
3. Destruction of mature trees by boxing for turpentine, beginning in the mid-eighteenth century and continuing, with increasing intensity, until exhaustion of the pine orchards of the state in the 1840's

(Because of its high resin content, longleaf was the only species of pine regularly used for naval stores).

4. Removal of most of the remaining trees for saw timber in the mid nineteenth century.
5. Elimination of habitat, as a consequence of modern fire suppression, beginning in the first three decades of the twentieth century.
6. Removal of the stands established in the brief period between the end of open range in the late 1800's, and establishment of efficient fire suppression around 1920. The last such stand in the state was cut in Nansemond County (now city of Suffolk) around 1979.

Perhaps because it was overshadowed by production of tobacco and other products; perhaps because the industry ran its course here before extensive records were kept, the extent of naval stores production (tar, pitch, turpentine and rosin) in Virginia is not generally appreciated. Enough glimpses of the past can be gleaned, though widely scattered through the historical literature, to understand the utilization and eventual near extirpation of the species from the state.

John Smith's settlement in Virginia was largely intended as a commercial venture, and experimental "... tryalls of Pitch, Tarre...." etc. were made the first season, with the first export of several dozen barrels shipped to England in 1608. Production of these essential commodities primarily by burning tar kilns of collected, dead longleaf pine "lightwood," was carried out, on a small scale, virtually from this time until around 1850. Customs records still on file in the British Public Records Office from ports around the Chesapeake Bay (Norfolk, Hampton, Yorktown) list barrels of naval stores as one of the most common exports from the colony from the late 1600's until the Revolution. In a report to the Lords of Trade, William Gooch, Governor of Virginia from 1727 to 1749, listed an annual export of 10,000 barrels of pitch and tar. Despite its importance in colonial Virginia, little effort has been made to preserve longleaf habitat.

In addition to the longleaf communities, the preserve has an amazing diversity of other plant communities in its 319 acre confines including pocosins, river bluff, cypress swamp, old field, and riverine.

The preserve is managed by a committee with representatives from Old dominion University, The Virginia chapter of The Nature Conservancy, Virginia Division of Forestry, Virginia Natural Heritage, and Union Camp Corporation. Objectives are: maintenance and restoration of longleaf pine and communities; foster research in this unique area; and educational uses. Because of the importance of maritime commerce, we are emphasizing the naval stores industry. A series of controlled burns has resulted in natural regeneration of longleaf. Also as a result of fire, several species unseen for almost 65 years have reappeared. In 1995, more than 400 acres of land contiguous with the preserve known as Antioch Pines was purchased by the state of Virginia. This area and the preserve are dedicated state natural areas and will be managed jointly for longleaf pine and related communities.

Like many natural areas, the Blackwater Ecologic Preserve is understaffed (0 personnel) and under funded (0 dollars). Without the cooperation and hard work of the cooperating agencies, no restoration work would be possible. Current research projects include the role of termites in relation to fire, phenology and germination of longleaf, and allozyme analysis of northern longleaf. No formal education programs are in place although many individuals, groups, and schools utilize the preserve.

The Longleaf Pine Forest: Trends and Current Conditions

Kenneth W. Outcalt (USDA Forest Service, Southern Research Station, Athens, GA)

ABSTRACT - The area occupied by longleaf pine, once the dominant tree species of the Southern Coastal Plains, has been drastically reduced over the last 200 years. In all states except Florida, the private sector owns the majority of the remaining longleaf pine. The private sector is also where most of the losses in longleaf acreage have occurred from 1986 to 1995. The potential for future losses is high because much of the longleaf controlled by the private non-industrial owner is, or soon will reach, sawtimber size. Harvest levels are likely to increase due to rising prices for this product. If we wish to reverse the loss of longleaf it will be necessary to provide information and incentives to the private sector to encourage them to grow longleaf pine. Although acreage in public ownership is relatively stable there are other conditions that need attention. Fortunately, most of the remaining longleaf pine originated from natural regeneration and much of the understory remains on these sites. More normal fire regimes are needed, however, to improve the condition of the understory. Public lands will also have to provide most of the old-growth longleaf areas and the large contiguous blocks of longleaf type that are necessary for some species and landscape scale process.

INTRODUCTION

Longleaf pine (*Pinus palustris* Mill.) is the key tree species in a complex of fire-dependent ecosystems long native to the Southeastern United States. It once occupied perhaps as much as 60 million acres in the Southeastern United States, stretching from southeastern Virginia south to central Florida and west into eastern Texas (Stout and Marion 1993). These fire-dependent ecosystems covered a wide range of site conditions, from low, wet flatwoods along the coast to dry mountain slopes and ridges in Alabama and northwest Georgia. We have been intensively exploiting longleaf forests since colonial times, with little regard for regeneration. Intensive logging of the old-growth forest reached a peak shortly after the turn of the century (Ware and others 1993) until by 1935, only about 20 million acres of longleaf pine forest remained. The amount declined to 12 million acres by 1955 and to 3.8 million acres in 1985 (Kelly and Bechtold 1990).

METHODS

This report is based on information gathered by the Forest Inventory and Analysis units of the Southern Research Station, USDA Forest Service. Inventory crews collected data from permanent sample plots that are systematically distributed across States to obtain a proportionate sample of all major forest types, sites, and ownership classes in the region. Each sample plot represented a specific number of equivalent acres of timberland from the entire population. This number, termed the expansion factor, had an average value of 3,500 acres for sample plots located in longleaf pine forest type. Data for 1995 if from surveys which were actually completed as follows: North Carolina 1990, South Carolina 1993, Georgia 1989, Florida 1995, Alabama 1990, Mississippi 1995, Louisiana 1991, and Texas 1992. Data used in this report for 1985 is adapted from Kelly and Bechtold (1990).

RESULTS

The amount of longleaf pine has declined, from 3.77 million acres in 1985 (Kelly and Bechtold 1990) to 2.95 million acres in 1995. The distribution of the remaining longleaf stands across the South is similar to the original longleaf range except for the near elimination from northeastern North Carolina and Southeastern Virginia. The largest concentration of longleaf is in Okaloosa and Santa Rosa counties in the Florida panhandle and adjacent Escambia county, Alabama. The amount of longleaf pine on public lands has remained relatively stable from 1985 to 1995, with only North Carolina and Florida showing a small decline. The area of longleaf on forest industry lands in North Carolina, Georgia, Florida and Mississippi declined by about 50 percent over the last decade. Overall, forest industry has lost 225,000 acres, which is 27 percent of the total decline in longleaf pine since 1985. The greatest losses in longleaf, however, occurred on private non-industrial lands. All states except Mississippi show a decline in the amount of longleaf pine on private lands. Georgia, Florida, and Alabama lost over 100,000 acres of longleaf pine from private lands since 1985. The total acreage on private lands declined by 591,200 acres, which is 72 percent of the total decrease in area occupied by longleaf pine.

Florida has the largest amount of longleaf pine remaining, with nearly three quarters of a million acres or 25 percent of the total. Georgia and Alabama both contain 18 percent of the remaining longleaf acreage. Eighty-five percent of the remaining longleaf was established by natural regeneration, 15 percent by planting. Nearly all planted stands are less than 40 years of age while natural longleaf stands are predominantly 41 years of age and older. Forest industry owns 16 percent of the longleaf acreage. Public agencies control 33 percent of the longleaf acreage while other private landowners consisting of individuals, farmers, and other corporations own 51 percent. Florida is unique because it is the only state where the public sector owns the largest amount of longleaf. In Georgia we find the reverse situation, with very little longleaf on public lands.

From 25 to 35 percent of the longleaf remaining in Florida, Georgia, South Carolina and North Carolina occurs in stands of 20 acres or less. Stands of less than 50 acres comprise from 45 to 60 percent of all natural longleaf in these states. In Florida, most small stands of longleaf are in private ownership while most stands over 100 acres are on public lands. Public ownership is also skewed toward the larger stand sizes in North Carolina. Trees in the sawtimber size class dominate over 60 percent of all longleaf stands.

CONCLUSIONS

The area occupied by longleaf pine, once the dominant tree species of the Southern Coastal Plains, has been drastically reduced over the last 200 years. In all states except Florida, the private sector owns the majority of the remaining longleaf pine. The private sector is also where most of the losses in longleaf acreage have occurred from 1985 to 1995. The potential for future losses is high because much of the longleaf controlled by the private non-industrial owner is, or soon will reach, sawtimber size. Harvest levels are likely to increase due to rising prices for this product. If we wish to reverse the loss of longleaf it will be necessary to provide information and incentives to the private sector to encourage them to grow longleaf pine.

Although acreage in public ownership is relatively stable there are other conditions that need attention. Fortunately, most of the remaining longleaf pine originated from natural regeneration and much of the understory remains on these sites. The forests need more normal fire regimes, however, to improve the condition of the understory. Public lands will also have to provide most of the old-growth longleaf areas and the large contiguous blocks of longleaf type that are necessary for some species and landscape scale process.

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Ecosystem Management Ideas for the Longleaf Pine Ecosystem

Neil Pederson (Joseph W. Jones Ecological Research Center, Newton, GA)
W. Leon Neel (Thomasville, GA)
John Kush (Auburn University, School of Forestry, Auburn University, AL)

ABSTRACT - Ecosystem management is a buzzword swirling through the natural resources community. Great controversy has been created by the lack of a concrete definition. At the same time few authors give specific guidelines on how this practice could be carried out. In this presentation we will provide a simple definition and one model of how it might be achieved this year in the Gulf Coast tri-state area (southwest Georgia, southeast Alabama, and the panhandle of Florida). The proposed model will be used as the first step in the construction of a more complete management prescription for ecosystem management of longleaf pine. Ecosystem management is best reflected by the early writings of the nation's first group of foresters and is called stewardship. Careful observation of a year's cone crop and recent stand history can guide sustainable management of a longleaf pine forest. The drought of 1996 experienced throughout much of the region in combination with the apparent above average seed crop make this an ideal year to use a late summer burn to control hardwoods and prepare a seedbed for germination during the winter months. A summer burn would create the window needed for longleaf pine regeneration. Working within recent climate and forest stand conditions can reduce management costs and guarantee productivity of the future forest.

INTRODUCTION

Management of natural resources has again become an important topic of discussion nationwide with logging of old-growth forests in the pacific northwest and subsequent decline of the spotted owl. One outgrowth of the discussion has moved people to survey their backyards closely for old-growth, native ecosystems, and/or endangered species.

As a result in the southeastern United States, interest has escalated in the recovery and management of the longleaf pine-wiregrass ecosystem. This ecosystem has been called the most diverse system in North America. It is the diversity that drives the conflict between extractive management and maintenance of system integrity.

A second, and perhaps more important, consequence of the debate has triggered the proposal of a new resource management philosophy termed ecosystem management. Most parties agree that ecosystem management will solve the desires of society by procuring timber from the natural environment without taking habitat from resident wildlife. However, very few specific procedures have been described to meet the complicated goals of ecosystem management.

HISTORICAL PERSPECTIVE

We believe many of the definitions of ecosystem management were eloquently stated by the first generation of foresters in these United States. Many of these foresters had a stewardship mentality or a land ethic. Witness the 1899 objective of forestry by Henry Graves, the Superintendent of Working Plans for the USDA Division of Forestry:

> "The object of forestry is to remove the timber from a given tract in such a way that repeated crops can be obtained for an indefinite period of time without decreasing the productive power of the forest. In order to do this it is necessary to know what trees must be left standing to form a basis for future growth and to seed the ground to valuable species. It is necessary to know what the rate of growth of the trees left in the forest will be after the first cutting in order to determine how the second crop can be obtained, and also to know what new growth will come in to take the place of the trees which have been removed. The purpose of making a working plan is to study questions of the growth, reproduction, and general character of important trees, and to devise a system of cutting which will enable the owner to make a profit from the land and at the same time to secure the permanence of the forest."

In the 100 years since Graves' quote, we have learned about the interconnectedness in the natural environment between species, nutrient cycles, disturbance regimes, and ecosystem integrity; hence the need for ecosystem management. This was reflected in a 1996 paper by Richard Knight arguing that

ecosystem management is an adaptation of Aldo Leopold's idea that "we are facing the oldest task in human history: to live on a piece of land without spoiling it."

ECOSYSTEM MANAGEMENT DEFINITION AND PHILOSOPHY

Our definition of ecosystem management combines wisdom from the past and the reality of today in the southeast. Our goal in ecosystem management of the longleaf pine-wiregrass ecosystem on private lands is to maintain, restore, and perpetuate the total forest while emphasizing specific structures and functions necessary to satisfy the current owner. This is a complex philosophy of management. However, it can be accomplished successfully if the land is committed to this goal for an extended time period and the management is competent and knowledgeable about the components, patterns, and processes in the longleaf forest.

Furthermore, management following this philosophy will become more successful over time. It precludes the short rotation, even-aged commercial crop method of forestry that emphasizes the fastest economic return of trees to the exclusion of all other components of the forest.

To accomplish these goals, we have outlined certain ecological rules and procedures determined to help in the most practical way. While the entire process is forever ongoing and the perfect condition in which management is no longer necessary, the procedures in our model for 1996 are some of the most basic.

COMPETENT MANAGEMENT AND NATURAL OBSERVATION

An integral part of competent management lies in having a naturalist perspective of the forest. This includes seeing more than one species, factor, value, or frame in the long movie of the forest. William Boyer noted that large crops of female and male flowers do not necessarily coincide (Boyer, 1989). Therefore, a cone crop might be limited by female flower production.

Male and female flowers are set during the growing season before the flowers appear, male in July and female in August. Development of both flowers is weather dependent. Male flowers typically occur in the lower crown while females are often located in the upper crown (Boyer, 1989). By observing female flower development, cone crop abundance could be anticipated a year in advance.

Furthermore, there seems to be a relationship between a significant cone crop and late summer rainfall amount three years previous. The record rainfall of the summer of 1994 might played a major role in this year's bountiful seed production. An observant manager will be able to plan for regeneration well in advance of a substantial cone crop. This would extend the window of opportunity for timber and fire management plans to enhance longleaf pine regeneration.

A competent manager also should know the characteristics and limits of the land being managed. Within the range of the longleaf pine-wiregrass ecosystem there are many ecotypes and site conditions. Management plans for a dry site would differ from a wet site. Dry site regeneration tends to be more patchy than wet site regeneration because of heterogeneity in stand structure, disturbance patterns, and herbaceous layer cover. The mosaic of the herb layer influences fire regime and stand structure and composition (personal observation). We assert that a manager needs to possess an innate knowledge of the land to attain the goals of ecosystem management.

Finally, a competent manager needs to know the population and distribution of forest species habitats across the land. Timber harvesting could proceed without reducing wildlife populations. Certain sites identified as habitats of birds, gopher tortoises, pine reproduction, and rare plants should be marked and buffered from logging damage. In addition, individual trees suitable for red-cockaded woodpeckers, hawks, owls, eagles, and fox squirrels must be recognized and saved if possible. These flora and fauna are components of diversity and are vital to ecosystem integrity of the forest.

1996 ECOSYSTEM MANAGEMENT MODEL

<u>Drought and Seed Crop Interaction</u>

The drought and large seed cone crop of 1996 provides an opportunity to conduct ecosystem management in the longleaf pine system. In southeast Alabama and dry sites of southwest Georgia, the early summer drought caused overstory pines to shed second year needles and trigger dieback in oak species. A fire in these stands would burn hotter with the heavier than normal needle load.

The intense fire would accomplish two tasks. First, the hotter fire would burn off the litter and herbaceous layers, providing a seed bed of mineral soil required for successful germination and establishment of longleaf pine. Secondly, the fire could induce premature senescence of the already drought stressed oaks. Increased mortality in the Red Hills has occurred in similar situations (personal observation). A reduction in competition would increase regeneration success of longleaf pine. If the fire does not provide adequate mortality of competing oaks, we would advise mechanical removal (chemical treatment if necessary) before seedfall in mid-October to reduce losses by logging damage.

Enhancement of Regeneration Opportunities

If timber removal is one of the goals of the land being managed, we stress all harvesting activities must occur before seedfall. Timber removal in these stands after seedfall would severely reduce regeneration stocking. Additionally, opening the forest canopy would increase opportunities for longleaf pine establishment.

We suggest the longleaf pine forest should be managed to obtain a full stocking of trees, according to the communities involved, though cutting amount would be governed by goals for the land. It will result in a stand of uneven aged trees varying in density from low to high. We warn against depleting the overstory of dominant trees. Fire is absolutely essential to the longleaf pine-wiregrass ecosystem. To guarantee frequent and adequate fires, the overstory must always be stocked to guarantee fuel loads and reduce operating costs.

Selective cutting is not the only means of ecosystem friendly timber removal in our forest management philosophy. However, too large a patch cut will reduce chances of adequate seedfall from neighboring or edge trees. A recent study by Brian Palik and others (in press) has implicated a threshold size for regeneration and growth of longleaf pine seedlings occurring in gaps around 1200 m^2 in area. Competition from edge trees in gaps smaller than this significantly reduce growth. However, seedlings can survive overstory competition for periods of five years or longer (Smith 1955, personal observation). Although longleaf pine is considered an intolerant species, we submit that seedlings can persist in denser than expected overstories. During this time of suppression, whether the canopy in thinned naturally or by design, the seedlings are already established as needed for future forest productivity.

Regeneration Establishment and Post-Germination Guidelines

Once a seedbed is prepared, management of the longleaf stand becomes relatively easy. Seedfall begins in mid-October and continues through the winter. Activities in the forest should stop to prevent losses by physical damage.

Although, fire is essential in a longleaf pine forest, seedlings less than a year old are extremely susceptible to fire. We believe fire is not necessary until at least 1998. In stands with good wiregrass groundcover, fire might not be necessary until 1999. In forests with old-field groundcover, a very cool winter burn would be advisable if competition on seedlings is too intense. It is important that this fire be used wisely. After 1999, normal management plans can resume. The period of susceptability for most of the individual seedlings will have passed.

CONDITIONS, RANDOM AFTERTHOUGHTS, ETCETERA

We find that seed crops of some degree are made quite frequently across the landscape. They should be utilized whenever a suitable window of opportunity occurs. A manager should not worry about the density of a stand or having many over-topped trees. Longleaf pine has the ability to respond vigorously to release from suppression at nearly any age.

Disturbance by man on the longleaf pine forest should be kept to a minimum allowable by the management plan. Even when heavy equipment is necessary, the timing should be favorable to avoid

unnecessary damage. When a selective cut is allowable, the selection of trees for removal is perhaps the single most important step in the success of management goals. It is because of the diversity of age in stocking that a longleaf forest can be perpetuated whilst occasionally allowing the harvesting of some timber.

Ecosystem management and, realistically, any form of management is complex. To make a selection that protects the various components of the forest and yet allows an economic return, a thorough knowledge of the forest is required including stand conditions, climatic patterns, and year-to-year events is a must for successful forest management. Many decisions need to be made in the selection of trees for removal. We can maintain a forest of trees, but not a forest that maintains the total diversity that once occurred in the longleaf forest.

Winifred Kessler and others (1992) point out "many scientists remain skeptical, arguing that experiment at the watershed scale, for example, will not only be prohibitively costly but impossible to replicate. And where will suitable controls be found?" To take this a step farther, each harvest should be viewed as an experiment, a work of art, or fingerprint. That is, no two are the same. Continuing in the thought of Douglas Sprugel (1991), what is constant and natural in a changing environment? Managers need to be flexible and manage according to existing and constantly changing physical and biological conditions.

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The Regional Longleaf Pine Growth Study

Jyoti N. Rayamajhi (Auburn University, School of Forestry, Auburn University, AL)
Ralph S. Meldahl (Auburn University, School of Forestry, Auburn University, AL)
John S. Kush (Auburn University, School of Forestry, Auburn University, AL)
Charles K. McMahon (USDA Forest Service, Southern Research Station, Auburn University, AL)

ABSTRACT - From 1964 to 1967, the US Forest Service established the Regional Longleaf Pine Growth Study (RLGS) in the Gulf States. The original objective was to obtain a database for the development of growth and yield predictions for naturally regenerated, even-aged longleaf pine stands. Study plots were installed to cover a range of ages, densities, and site qualities. Plots are remeasured on roughly a 5-year cycle. A total of 309 plots are now in the study. They are located in central and southern Alabama, southern Mississippi, southwest Georgia, and northern Florida. In an effort to expand the study beyond the Gulf States, plots have been established in the sandhills of North Carolina. The original study has been expanded to include the development of taper equations, site index curves, pole prediction models, pine straw production models, and the impacts of climate on longleaf pine productivity. Efforts relating to longleaf pine productivity include timing and amount of litter fall; specific leaf area and leaf area index; standing biomass and net primary productivity; and integration of climate variables into growth models. Mention of published products from the RLGS will be made. Information relevant to private property owners (eg., growth rates, pine straw production, and utility pole prediction) will be emphasized.

INTRODUCTION

In 1964, the U.S. Forest Service established the Regional Longleaf Pine Growth Study (RLGS) in the Gulf States. The original objective of the study was to obtain a database for the development of growth and yield predictions for naturally regenerated, even-aged longleaf pine stands. Plots were installed to cover a range of ages, densities, and site qualities. The study accounts for possible growth change over time by adding a new set of plots in the youngest age class every 10 years. The project is in its sixth measurement period (30-year measurement). Research utilizing this existing longleaf pine database has been expanded to include utility pole and pine litter production.

METHODS

The study consists of 305 permanent 1/10- and 1/5-acre measurement plots located in central and southern Alabama, southern Mississippi, southwest Georgia, northern Florida, and the sandhills of North Carolina. Plot selection was based upon a rectangular distribution of cells formed by four stand age classes ranging from 20 to 80 years, five site-index classes ranging from 50 to 90 feet at 50 years, and five density classes ranging from 30 to 150 square feet per acre. The oldest plots will be in the 120 year age class with the completion of the current 30-year remeasurement.

Within this distribution are four time replications of the youngest age class. All four replications are located on the Escambia Experimental Forest in Brewton, AL. As a part of the RLGS, plots in the youngest age class were first established in 1964 and new sets of plots have been added in this age-class every 10 years. Plots are located to achieve similar initial site qualities and ages, and are thinned to their target basal areas.

At the time of establishment, plots are assigned a target basal area class of 30, 60, 90, 120, or 150 square feet/acre. They are left unthinned to grow into that class if they are initially below the target basal area. In subsequent remeasurements, if the plot basal area has grown 7.5 square feet/acre or more beyond the target basal area, the plot is thinned back to the previously assigned target. The thinnings are generally of low intensity and from below.

Net (measurement) plots are circular and 1/5-acre (14 net plots are 1/10-acre) in size surrounded by a similar and like-treated ½-chain wide isolation strip with both surrounded by a ½-chain wide protective buffer strip that receives extensive management . Plots are inventoried, and treated as needed, every 5 years. The measurements are made during the dormant season (October through March) and it takes three years to complete a full remeasurement of all plots. Cooperators are asked to use cool, winter burns on a 3-year cycle to control hardwood competition.

Each tree on the net plot with a DBH (diameter breast height) > 0.5 inches is numbered by progressive azimuth from magnetic north and has its azimuth and distance from plot center recorded. At every remeasurement, each tree has its DBH recorded to the nearest 0.1 inch, and crown class and utility pole class and length determined. A systematic sub-sample of trees from each one-inch DBH class has been permanently selected and measured for height to the live-crown base, total height, and, if the tree is dominant or co-dominant, for age from seed.

In addition to maintaining the RLGS plots, several topics directly associated with the RLGS are being studied. These include:

- Soil samples which have been taken on the RLGS plots to provide baseline data and to improve estimates of site productivity.
- The pole utility information is being used to develop relationships between stand characteristics, thinning activities, and pole production.
- Efforts are being completed to improve estimates of longleaf pine taper equations by including crown ratio as an independent variable.
- Data are being examined in an effort to improve the estimates of site index for naturally regenerated longleaf pine stands.
- Basal area and mortality models are being developed to improve the predictions of stand dynamics.
- Old-growth stands are being identified and measured to improve estimates of growth and mortality for longer rotations and to assess the stability of old-growth stands.

The RLGS represents a stable long-term data base and field plots for natural, even-aged, longleaf pine stands. The value of this project increases as additional measurements are obtained. The plots are also available for cooperative studies that would not harm the plots or interfere with future activities.

An example of such a cooperative study is our U.S. Forest Service Southern Global Change Program project (which is nearing completion). This study was undertaken to examine the productivity of natural stands of longleaf pine in relation to competition and climatic factors.

Using the existing RLGS plots and database, the project is investigating the relationship between productivity (biomass) of natural stands of longleaf pine in relation to stand age, site quality, stand density (competition), and the climatic factors, precipitation and atmospheric temperature.

UTILITY POLE PRODUCTION

As part of the 25-year remeasurement, pole class and length determinations were made on all trees in the RLGS. Factors important in predicting pole production (expressed as the percent of the merchantable basal area in poles(PMBAP)) include basal area (BA), site index (SI), age, average stand DBH, previous thinning activity, slope, and numerous interaction terms. The relationships between important individual variables and PMBAP (ignoring all other variables) show the following: 1. The relationship with stand age is hump shaped increasing rapidly from age 30 to 60, reaching a maximum between ages 60 to 80 (PMBAP of 60-68%), and decreasing thereafter; 2. The relationship with average stand DBH is also hump shaped with a maximum PMBAP of 60-75% between DBH's of 10-16"; 3. The relationship with site index increases rapidly from 50 to 65, levels off at about 62% between SI's of 70 to 80, and decreases slightly after 80; 4. The relationship with merchantable BA is quite linear decreasing from about 65% at 30 ft^2 to about 40% at 150 ft^2. When thinking about the relationships/values presented, one must remember that they reflect the distribution of plots by age, BA, SI, etc., of the RLGS, that past thinning activity is very important, and that our plots receive frequent light thinnings from below. It must also be noted that the history of our plots prior to their establishment is not known. These unknown conditions could have had a significant effect on pole production. In general, the relationship between pole production and stand characteristics is highly variable and our best models are only able to explain about 55% of the observed variability. Table 1 presents preliminary values for predicted pole production as a function of age and basal area class.

Table 1. Predicted Percent of Merchantable Basal Area in Poles.

Age	Merchantable Basal Area Class						
Class	40	60	80	100	120	140	160
30	0.63	0.49	0.35	0.20	0.06	--	--
40	0.86	0.74	0.62	0.51	0.39	0.27	0.16
50	0.95	0.86	0.77	0.68	0.58	0.49	0.40
60	0.94	0.87	0.80	0.73	0.67	0.60	0.53
70	0.84	0.80	0.76	0.71	0.67	0.63	0.58
80	0.70	0.68	0.66	0.64	0.62	0.61	--
90	0.53	0.53	0.54	0.55	0.55	0.56	--
100	0.36	0.39	0.43	0.46	0.49	0.52	--
110	--	--	0.35	0.40	0.46	--	--

PINE LITTER PRODUCTION

A major component of the SGCP project was to examine longleaf pine litter (pine straw) production. Needle fall has been monitored monthly since August, 1992 via litter traps on a representative sub-sample of plots across the range of site, age, and density combinations. Efforts are underway to model annual litter production (tons/acre, dry weight) as a function of stand variables. Factors affecting litter production include basal area, age, site index, fire history, weather, and several interactions. An examination of the relationships between important individual variables and pine straw production (ignoring all other variables) show the following: 1. Pine straw production is a linear function of age decreasing slowly from about 1.58 tons/acre at age 20 to about 1.52 tons/acre at age 110; 2. Pine straw production increases fairly rapidly with site index from about 1.25 tons/acre at SI 50 to 1.65 ton/acre at SI 75 and levels off thereafter at about 1.7 tons/acre; 3. The relation with BA is almost linear increasing from about 1.9 tons/acre at 20 ft^2 to about 2.3 tons/acre at 140 ft^2. As noted above, these values/relationship reflect the distribution and history of the plots in the RLGS. Table 2 presents preliminary estimates of predicted annual litter production by age and basal area class (using a site index of 70).

STAND BASAL AREA GROWTH

Basal area growth is influenced by factors such as stand age, basal area, site index, fire history, and weather (plus their interactions). The average basal area growth across the entire RLGS data set has been about 2.5 square feet/acre/year. Young high density stands grow about 6-8 square feet/acre/year and more mature stands grow at about 1-2 square feet/acre/year.

Over the course of the RLGS, several stand and individual tree level models have been developed to provide data to evaluate management alternatives. Individuals interested in predicting stand growth and mortality are directed to the works of Farrar (1979 and 1985), Somers and Farrar (1991), Farrar and Matney (1994), and Quicke et al. (1994 and In Press). Work will continue to incorporate new data and refine growth relationships as new models are developed.

Table 2. Predicted Annual Pine Litter Production (tons/acre).

Age	Merchantable Basal Area Class						
Class	20	40	60	80	100	120	140
20	1.18	1.55	1.87	--	--	--	--
30	0.98	1.35	1.67	1.95	2.19	2.39	--
40	0.82	1.18	1.50	1.79	2.03	2.22	2.38
50	--	1.05	1.37	1.65	1.90	2.09	2.25
60	--	0.95	1.28	1.56	1.80	2.00	2.16
70	--	0.89	1.22	1.50	1.74	1.94	2.10
80	--	0.87	1.19	1.47	1.71	1.91	2.07
90	--	0.88	1.20	1.48	1.72	1.92	2.08
100	--	0.92	1.24	1.52	1.77	1.96	2.12
110	--	--	--	1.60	1.84	2.04	--

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Geographic Variation in Allozymes of Natural and Select Longleaf Pine (*Pinus palustris* Mill.)

R.C. Schmidtling (USDA Forest Service, Southern Research Station, Saucier, MS)
V. Hipkins (USDA Forest Service, National Forest Genetics Electrophoresis Laboratory, Placerville, CA)
E. Carroll (USDA Forest Service, National Forest Genetics Electrophoresis Laboratory, Placerville, CA)

ABSTRACT - Seed were collected from 17 geographic sources of longleaf pine, 15 of which were located in provenance test plantings of the Southwide Southern Pine Seed Source Study. Seed was also collected from four seed orchard sources. A total of 500 individual trees were genotyped at 24 isozyme loci (PGM-1, PGM-2, LAP-1, LAP-2, ACO-1, ME7, FEST-1, PGI-2, ADH, GOT-2, GOT-3, 6PGD-1, G6PD-1, G6PD-2, GLYDH, TPI-2, MDH-1, MDH-2, MDH-3, MDH-4, 6PGD-2, IDH-1, AK-1, and AK-2) using three buffer systems. The mean number of alleles per locus ranged from 1.3 to 2.1 (mean of 1.8), the percentage of polymorphic loci ranged from 33.3 to 75.0 (mean of 56), and mean heterozygosity ranged from 0.066 to 0.131 (mean of 0.092). these values are all lower than diversity indices found in a similar loblolly pine study. The one source with th3e lowest values for all three indices, from southeast Louisiana, had been identified by Wells and Wakeley (For. Sci. 16:28-42, 1970) as performing below expectations, and possibly inbred. The allozyme data lends some credence to that hypothesis. Diversity indices for the seed orchard sources were similar to those in the provenance test sources. Principle components were used to relate allozyme variation with climatic and geographic variables.

Restoration of the longleaf pine ecosystem will necessarily require a great deal of planting (or perhaps direct seeding) of longleaf pine. Choosing the proper seed source will be essential to ensure long-term success of restoration plantings. It is necessary to define geographic variation in longleaf pine precisely to identify suitable seed sources for restoration planting. Establishing base-line information on genetic diversity and geographic variation in longleaf pine is important in determining seed sources for restoration plantings. Because vast acreage's of old-growth longleaf pine were clear-cut, many existing natural second-growth stands may have originated from only a few residual parent trees. Many of these stands would be genetically degenerate (Wells and Wakeley 1970) and should not be used in restoration efforts.

In this study we use genetic variation in iso-enzymes (allozymes) from longleaf seed to measure genetic diversity within natural longleaf stands and examine geographic patterns across the natural range of the species.

MATERIALS AND METHODS

Seed were collected from 17 geographic sources of longleaf pine, 15 of which were located in provenance test plantings of the range-wide Southwide Southern Pine Seed Source Study (SSPSSS). Seed was also collected from three seed orchards. A total of 500 individual trees were genotyped at 24 isozyme loci using three buffer systems.

Allozyme data were transformed using the methods of Smouse and Williams (1982). Canonical discriminant analysis was used to discriminate among seed sources.

Height and plot volumes from the 25-year measurements of the longleaf SSPSSS are available from 30 plantings for comparison to diversity indices (Schmidtling and White 1990). Height and volume data are fitted to a polynomial regression using average yearly minimum temperature and its square as the independent variables (Schmidtling 1994). The model is used to compute the mean deviation of the source from growth that would be expected at a planting site based on its origin.

RESULTS AND DISCUSSION

The mean number of alleles per locus ranged from 1.33 to 2.17 the percentage of polymorphic loci ranged from 33.3 to 75.0, and mean heterozygosity ranged from 0.066 to 0.132 (Table 1). These values average slightly lower than diversity indices found in a similar loblolly pine study. Diversity indices of the seed orchard sources were similar to those in the provenance test sources. F statistics indicate very little inbreeding overall (mean F_{IS} = 0.005) and low differentiation among populations (mean F_{ST} = 0.037).

Volume per acre and height data, expressed as per cent deviation from the expected, are compared to diversity indices in Table 1. One source with low values for all three indices, from southeast Louisiana, had been identified by Wells and Wakeley (1970) as performing below expectations, and possibly having limited genetic variation. The poor performance is verified in the growth/climate model of Figure 2. The low

diversity values from the allozyme data lends some credence to the inbreeding hypothesis. There is a positive relationship between volume and all three diversity indices (r = 0.51, 0.51, and 0.19 for alleles per locus, percent loci polymorphic and heterozygosity, respectively).

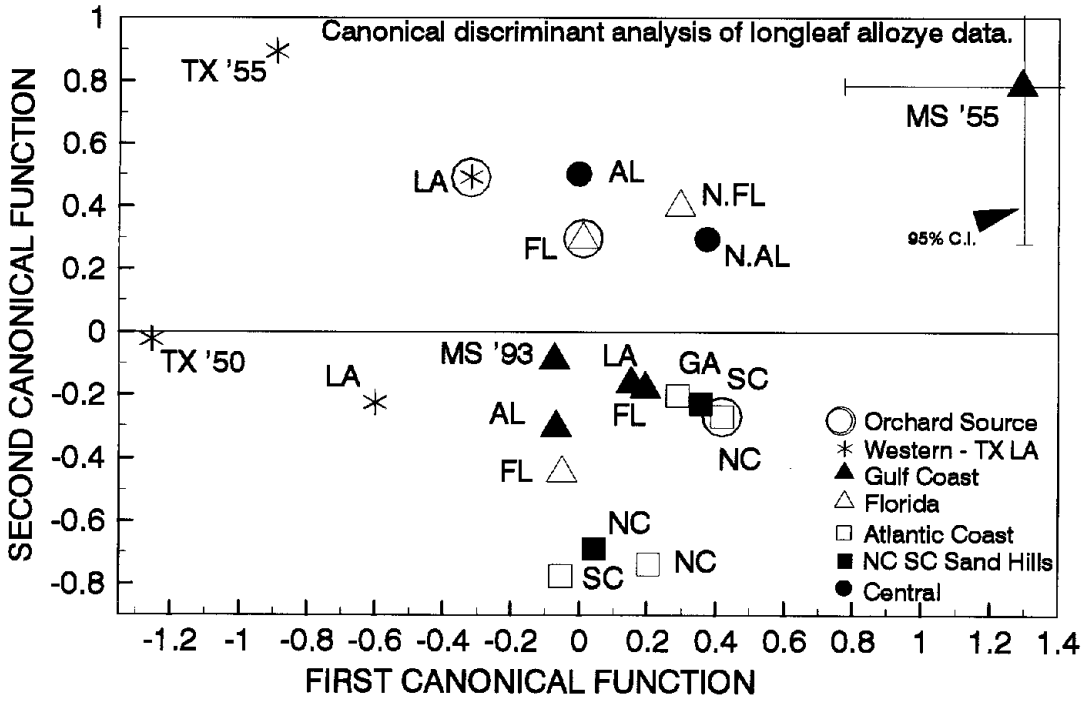
Table 1 - Seed sources, Diversity indices and growth.

Seed Source	Trees No.	Alleles /locus	% Loci Polymorphic	Heterozyg. %	Ht-dev %	Vol-dev %
N AL (119)	31	2.00	75.0	9.14	1.05	-1.74
SE LA (123)	30	1.67	45.8	7.50	-3.53	-13.38
E TX (127)	30	2.00	70.8	12.36	-1.60	9.67
SE NC (153)	14	1.58	45.8	8.04	-2.32	-8.47
S NC (155)	17	1.63	45.8	6.86	2.40	-0.74
NE SC (157)	27	1.71	50.0	6.64	-2.96	-1.32
N SC (161)	29	1.96	62.5	8.48	1.08	11.27
SE GA (163)	30	1.83	58.3	7.78	4.05	3.29
S FL (167)	7	1.33	33.3	8.93	-1.00	-24.77
NW FL (169)	20	1.75	54.2	10.28	0.43	18.04
C AL (175)	31	1.96	54.2	9.54	4.80	11.01
S MS (177)	28	1.88	58.3	9.23	4.22	47.82
S LA (181)	31	2.17	62.5	12.63	-1.26	-2.15
E TX (183)	30	1.96	58.3	13.19	-1.60	7.26
S MS (MS)	30	2.00	66.7	8.75		
N FL (FL)	15	1.46	37.5	9.17		
Mean		1.82	55.9	9.30		
ORCHARDS						
Florida	9	1.42	33.3	10.65		
N. Carolina	31	1.96	54.2	8.47		
Louisiana	28	1.92	62.5	11.16		

In the multivariate analysis, the first two canonical functions arrayed the data points more or less according to geographic origin (see Figure). Sources from west of the Mississippi were positioned in the upper left, those from the Atlantic Coast in the lower right and Gulf Coast and central sources in between.

One of the sources, the Harrison County, Mississippi source from the SSPSSS (#177), collected in 1955, is well separated from all others, especially in the first canonical function. The source from the same location, collected in 1993 (MS), falls well within the other Gulf Coast sources. The only qualitative difference of this source from the others is the presence of a sixth allele at the PGM-2 locus, but the frequency of this allele is only 0.06 in the source. This source also deviates greatly in growth from the other sources, having nearly 50% greater than expected volume (Table 1). Diversity indices for the source are about average. Hybridization is proposed as a reason for the differences.

The other anomaly in the canonical analysis is the separation of the two Texas sources. The difference between the two is that the 1955 collection was made only in Polk County (#183), on the western edge of the natural distribution, whereas the 1950 collection was made in Polk County plus two adjoining counties to the east (#127). Both the first and second canonical functions appear to be related to moisture availability at the source.



CONCLUSIONS

Longleaf pine appears to have less allozyme variability than loblolly pine, but there is a geographic pattern to the variability which may be useful in defining seed zones. Allozymes also appear to be useful in determining whether or not certain populations are inbred, and therefore less likely to form healthy, vigorous stands.

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Longleaf Pine Restoration - An Ecosystem Approach

Steve Seiber (Eglin Air Force Base, Natural Resources Division, Niceville, FL)
Neil Hoskins (Eglin Air Force Base, Natural Resources Division, Niceville, FL)

ABSTRACT - Eglin Air Force Base is the largest air base in the Western Hemisphere, covering 463,448 acres of Northwest Florida. At 724 square miles, Eglin includes many different ecosystems, the largest of which is the rolling longleaf pine sandhills. This is the largest remaining old-growth longleaf pine ecosystem in the world. Eglin managers have taken an ecosystem approach to restoring the longleaf pine sandhills. The goal is to be good stewards of Eglin's ecosystems in support of the military mission and for public benefit. One focus of ecosystem management at Eglin is to restore the longleaf pine forest, which covers 80% of the base and is home to many endangered or threatened plants and animals. Eglin is using a variety of tools in this restoration effort:

1. Removing Sand pine that has invaded onto historically longleaf pine sites. Managers are removing 5,000 acres of sand pine from longleaf sites each year. These removals are planned to maximize the benefits to endangered species and limit the initial impacts to the ecosystem.
2. Managers are planting 1.5 to 2.2 million containerized longleaf pine seedlings each year. Eglin managers are protecting native grasses and mimicking natures patterns in planting activities. Seedlings are no longer planted in straight rows and spacing and numbers per acre are varied from area to area.
3. Reintroducing growing season fire into the longleaf pine sandhills. Managers are using prescribed fire to restore the balance of native plants and trees. Between 40 and 50 thousand acres are prescribe burned each year. These burns are designed to meet restoration and maintenance goals using aerial or ground ignition.

Genetic Improvement for Early Height Growth and Brown-spot Resistance of Longleaf Pine

Michael Stine (School of Forestry, Wildlife, and Fisheries, Louisiana State University Agricultural Center, Baton Rouge, LA)
Changren Weng (School of Forestry, Wildlife, and Fisheries, Louisiana State University Agricultural Center, Baton Rouge, LA)
Thomas L. Kubisiak (USDA Forest Service, Southern Research Station, Southern Institute of Forest Genetics, Saucier, MS)
C. Dana Nelson (International Paper, Bainbridge, GA)

ABSTRACT - The delay of early height growth (EHG) known as the "grass stage" and the susceptibility to brown-spot disease have been two important factors that limit artificial regeneration of longleaf pine. We are cooperating on a research program to breed for EHG and brown-spot resistant longleaf pine. This research program is designed to introgress genes for EHG and brown-spot resistance from slash pine into longleaf pine by recurrent backcrossing of the quantitative trait loci, backcrossing assisted by marker-aided selection could be an efficient approach. Therefore, identifying these loci and mapping markers linked to them are important parts of the research. So far, the interspecific crosses between longleaf pine and slash pine and backcrosses have been made Low to medium density linkage maps with 132 and 101 random amplified polymorphic DNA markers have been constructed for longleaf pine and slash pine, respectively. Loci for EHG and brown-spot resistance will be mapped using backcross populations in the coming years. In addition to breeding of EHG and brown-spot resistant longleaf pine, successful completion of this research should result in a better understanding of EHG in longleaf pine, establishment of a breeding population, and identification of hundreds of genetic markers for population genetics research.

Longleaf pine (*Pinus palustris* Mill.), in addition to having been a dominant component of southeastern forests, has many desirable qualities such as good form, moderate wood specific gravity, resistance to fusiform rust, resistance to southern pine bark beetles, and a high navel-stores content (Wahlenberg 1946). The use of longleaf pine in intensively-managed forests has been limited by the grass stage, an extended period of juvenile development, and by the species susceptibility to brown-spot needle blight (caused by *Scirrhia acicola* Dearn.), which makes artificial regeneration more unreliable than for other southern pines (Schmidtling and White 1989). Previous breeding work has demonstrated that the grass stage is controlled by five (C. D. Nelson, unpublished data) to ten loci (Brown 1964), and brown-spot resistance can be increased.

Recurrent backcross breeding is a common plant breeding tool used to introgress genes from one species into another species. Following the initial hybridization (e.g. longleaf pine crossed to either slash pine or loblolly pine), the hybrid plants are backcrossed to the recurrent species (longleaf pine in this example), while selecting for the trait of interest (early height growth) and the characteristics of the recurrent parent. After 5 to 10 generations, a largely pure longleaf pine would be obtained. The number of generations required and the long breeding cycle, precludes the timely completion of such a program for most trees.

The addition of marker assisted selection (MAS) offers the opportunity to reduce the number of backcross generations to only two to four (Hillel et al. 1990), a more reasonable number. For MAS to work, a large number of markers must be identified. Some markers must be mapped to the loci that control the trait of interest, others must allow selection for the recurrent species genotype or selection against the genotype of the species donating the trait. Molecular markers can also be used to estimate the number of loci regulating early height growth and to design mating schemes to combine specific alleles. In addition, the amount of genetic variation for early height growth can be estimated in both species, and this information can be used to select parental lines to be included in breeding programs.

The most commonly used marker for molecular genetic studies has been allozymes, which are relatively inexpensive and utilize a well-proven technology. The main problem with allozymes is their limited number (only approximately 20-40 loci are available in most species). Newly developed DNA based techniques (e.g. RAPDs, RFLPs, microsatillites, and AFLPs) have largely eliminated the problem of limited marker numbers. The method that we have used in these studies is the random amplified polymorphic DNAs (RAPDs) technique, which uses the polymerase chain reaction to identify genetic markers (Williams et al. 1990). The main advantage of the RAPD technique is its ability to quickly identify many markers. Currently, several thousand of the primers used to detect RAPD loci are commercially available. RAPDs do

have several limitations, the primary being that most RAPD loci are scored as dominant markers, some loci are unreliably scored, and the technique is more expensive than allozymes.

In order to study the genetics of early height growth in longleaf pine we have backcrossed F_1-hybrids to longleaf pine and slash pine, and started producing genomic maps for both species. A low-to-medium density linkage map of RAPDs was produced in a single longleaf pine (Nelson et al. 1994) that was selected for good growth rate and disease resistance. This study utilized segregating haploid tissue from the megagametophyte of seeds to map 133 loci into 16 linkage groups of three or more markers. The advantage in using the megagametophyte is that no controlled pollinations are required and seedlings do not need to be grown, but it is limited to mapping only the seed parent, and the trait of interest was not scored.

Two additional RAPD linkage maps have also been produced using the F_1-hybrid progeny of a controlled cross between same longleaf pine as used for the haploid map, and a slash pine parent selected for disease resistance and good growth (Kubisiak et al. 1995). The resulting longleaf pine map placed 129 markers into 18 linkage groups of three or more markers, with three additional marker pairs. For slash pine, 91 markers were placed into 13 linkage groups of three or more markers, with six additional pairs of markers. We estimate that the markers cover approximately 58% of the longleaf pine genome, and 41% of the slash pine. Additional mapping experiments should reduce the number of linkage groups to equal the number of chromosomes, which is 12.

In order to map loci for early height growth, we need to backcross the F_1-progeny onto one of the parent species in order for the trait of interest to segregate. By backcrossing the F_1-progeny onto both longleaf pine and to slash pine we hope to be able to map alleles conferring a positive effect on early height growth from slash pine parent, and negative effect alleles from longleaf pine. Additionally, by planting the progeny on a variety of sites, we hope to explore the effect of environment on the expression of this trait.

In addition to breeding applications, markers like RAPDs and other PCR based markers, can be used for many population genetics studies. They have been successfully used to fingerprint progeny for paternity analysis, to calculate genetic distances among genotypes, and to estimate gene flow among populations. DNA marker based technologies are advancing very rapidly, and it is very likely that the cost per marker will continue to fall while the number of markers increases.

CONCLUSIONS

The recent advancements in molecular marker technology makes a virtually unlimited number of markers available for both applied breeding programs and basic genetics research. No longer should the type of questions studied be limited by the availability of markers; now it is only a matter of the number of markers needed to definitively answer the question. The coupling of molecular markers to backcross breeding programs should result in the more rapid recovery of longleaf pines with better brown-spot needle blight resistance and a regulated grass stage, while retaining the desirable characteristics of the species.

Successful completion of this research should result in a better understanding of early height growth in longleaf pine, establishment of a breeding population, and identification of hundreds of genetic markers useful in other research.

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Seeing the Forest for the Trees: Why Site Preparation is Important

Jonathan P. Streich (The Nature Conservancy of Georgia, Atlanta, GA)

ABSTRACT - One of the principal considerations regarding the high biological diversity of longleaf pine communities is the rich groundcover found in our southern pinelands. For this reason, natural regeneration methods should be promoted as the preferred Southern pine reforestation method. Traditional intensive mechanical site preparation techniques, usually necessary for artificial regeneration, tend to diminish the diversity in the groundcover. Many of the original native flora are replaced by “weedier” ones: for example, wiregrass is replaced by broom straw. This change in the understory may be related to the disturbance of the soil profile, or the physical removal of the species (and their allelopathic influences). Nevertheless, every day, many site preparation techniques are leading to the diminishment of the rich biological diversity of the longleaf pine community. New techniques of site preparation which leave the understory intact should be investigated. Site preparation techniques that allow for good pine regeneration while retaining the wealth of biodiversity in the understory are critical to the future of truly sustainable longleaf forests.

Effects of Fire Frequency and Season on Longleaf Pine Groundcover Vegetation: Results of Three Studies

Donna R. Streng (Tall Timbers Research Station, Tallahassee, FL)
Jeff S. Glitzenstein (Tall Timbers Research Station, Tallahassee, FL)
William J. Platt (Department of Plant Biology, Louisiana State University, Baton Rouge, LA)
Dale D. Wade (USDA Forest Service, Southern Research Station, Juliette, GA)

ABSTRACT - Fire frequency and fire season are two components of the fire regime that can be relatively easily manipulated by fire managers. Variation in these two factors may have important influences on forest structure and species composition. We report here results of three studies designed, in part, to examine effects of fire regimes on vegetation in longleaf pine forests. We will focus on fire effects on groundcover vegetation, the most species-rich component of these forests. The three studies include: 1) The Tiger Corner Study, Francis Marion National Forest, SC, ongoing since 1959; examines effects of fire frequency (i.e., annual, biennial, triennial, and quadrennial burns). Burning is usually conducted in late winter. 2) The St. Marks Study, ongoing since 1980 at the St. Marks National Wildlife Refuge, FL; examines effects of habitat, and fire season (8 different seasonal burn treatments). 3) Longleaf Pine Fire Study (LPFS), Francis Marion National Forest, begun in 1992; examines effects of habitat, fire season (dormant vs. growing), fire frequency (biennial vs. quadrennial), and regularity of fire (regular vs. random) on vegetation. The 35-yr Tiger Corner Study demonstrates striking effects of fire frequency. Annual and biennial-burn plots are dominated by a diversity of grasses and forbs, while less frequently burned plots are less diverse with a greater abundance of woody plants. In contrast to these effects of fire frequency, effects of season of burn on groundcover vegetation are less pronounced. Few significant changes have occurred in the groundcover vegetation at the St. marks plots, even after 14 years of seasonal burning. Consistent with the long-term study at the Santee Experimental Forest (Francis Marion National Forest), early results from the LPFS suggest that growing season fires may be more effective than dormant season fires in reducing woody stem density. Certain grasses (e.g., *Aristida virgata*) and bracken (*Pteridium aquilinum*) also declined significantly after growing season burning. We conclude that longleaf pine forests require annual or biennial burning in order to maintain a high diversity of species in the groundcover. Burning season appears to be of secondary importance, except, perhaps in annually burned plots (e.g., see results of the Santee Study). However, significant effects may occur in some years depending in part on interactions with climate and fire behavior.

INTRODUCTION

Fire frequency and fire season are two components of the fire regime that can be relatively easily manipulated by fire managers. Variation in these two factors may have important influences on forest structure and species composition.

We report here results of three studies designed, in part, to examine effects of fire regimes on vegetation in longleaf pine forests. We will focus on fire effects on the groundcover vegetation, the most species-rich component of these forests. The three studies include: 1) the Tiger Corner Study, Francis Marion National Forest, SC, ongoing since 1958, examines effects of fire frequency; 2) the St. Marks Study, St. Marks National Wildlife Refuge, FL, ongoing since 1980, examines effects of habitat, and fire season; 3) Longleaf Pine Fire Study (LPFS), Francis Marion National Forest, SC, begun in 1992, examines effects of habitat, fire season, fire frequency, and regularity of fire on vegetation.

STUDY DESIGN

The Tiger Corner Study was designed as a randomized block experiment with four replicates (blocks) of five frequencies of burn: annual, biennial, triennial, quadrennial, and no burn. Burns are usually conducted in late winter. Burn plot size is .8 ha (2 acres).

The St. Marks Study was designed as a randomized block experiment with 2 factors: 1) habitat (the blocking factor, with one block in sandhill habitat and one in flatwoods), and 2) season of burn (8 different seasons: early January, late February, early April, late May, early July, late August, early October, late November). There are 2 replicates of each season-of-burn treatment within each habitat, for a total of 32 burn treatment plots. All plots are burned biennially during their assigned season. Burn plot size varies from 2-5 ha (5-12 acres).

The LPFS was designed as a randomized block experiment with 7 burning treatments replicated 3 times within each of three habitats (the blocking factor). There are a total of 63 burn treatment plots, each 1 ha (2.5 acres) in size. The 7 treatments include burns: 1) every 2 yrs in the dormant season, 2) every 4 yrs in the dormant season, 3) every 2 yrs in the growing season, 4) every 4 yrs in the growing season, 5) in the growing season with a mean of every 2 yrs, but with random variation around the mean, 6) in the growing season with a mean of every 4 yrs, but with random variation around the mean, and 7) unburned. The three habitats in the study were chosen to span the range of site moisture and fertility for longleaf pine in the Francis Marion National Forest.

DATA COLLECTION METHODS

Tiger Corner Study. Groundcover biomass was collected from eight .25 m^2 subplots per burn treatment plot, sorted by species, oven-dried, and weighed. Two important factors were controlled for when collecting these data. 1) Topographic variation (i.e., from higher, drier microsites through wet depressions) was controlled for by randomly sampling biomass only from the narrow range of elevations (.2 m) that was common to all burn treatment plots. 2) Time since last fire was controlled for by collecting biomass 1 yr after each plot was burned.

St. Marks Study. Three sets of data have been collected to examine effects of the season-of-burn treatments on groundcover vegetation.

1) Long-term biomass collections. In each burn plot there are eight permanently located 3 m^2 subplots, from which .25 m^2 biomass samples are collected prior to the treatment fires.
2) During 1988-1989 we carried out an extensive survey of the groundcover vegetation in each treatment plot. In each plot we randomly located 100 .25 m^2 subplots, and recorded all plant species occurring in those subplots.
3) In 1992 we collected additional data on groundcover species composition in the sandhill habitat as "pretreatment data" for a study on small-scale disturbances within the larger burn treatment plots. Twenty 1m^2 subplots were randomly located in each of the main treatment plots. Each subplot was subdivided, using a plot frame, into 100 10 cm X 10 cm cells, and all plant species occurring in each cell were recorded.

LPFS. In each burn plot, effects of the fire treatments on groundcover vegetation are monitored in six, randomly chosen, permanently located, 1.5 m X 2.0 m subplots. Each subplot is subdivided, using a plot frame, into 48 25 cm X 25 cm cells. Each time a subplot is censused the following data are recorded: 1) occurrence of all plant species in each of the 48 cells, 2) number of woody stems in each of three size classes, 3) cover of each species, 4) height of the tallest seedling or sapling of each tree species. For this poster, we present results from a set of 18 burn plots that received their first treatment burns in 1993. Groundcover vegetation was censused prior to the treatment fires in 1993 (i.e., pre-treatment data), and then recensused in 1995 (i.e., post-treatment data).

RESULTS

The 38-yr Tiger Corner Study demonstrates striking effects of fire frequency. Annual- and biennial-burn plots are dominated by a diversity of grasses and, especially, forbs, while less frequently burned plots are less diverse with a greater abundance of woody plants.

In contrast, few significant changes have occurred in the groundcover vegetation in the St. Marks plots, even after 14 yrs of seasonal burning.

Early results from the LPFS suggest that growing season fires may be more effective than dormant season fires in reducing groundcover woody stem density. Certain grasses (e.g., *Aristida virgata*) and bracken (*Pteridium aquilinum*) also declined significantly after growing season burning.

DISCUSSION

Frequency of burn exerts a powerful influence on the diversity and composition of longleaf pine groundcover vegetation.

Season of burn is also expected to influence groundcover composition. Growing season burning, in particular, is thought to favor grasses and forbs over woody plants. However, we have not yet observed this effect in the St. Marks study. We conclude that almost all plants that occur in the groundcover of longleaf pine-dominated communities are extremely tolerant of burning, regardless of the season.

However, initial results from the LPFS appear to contradict this conclusion. In this study, woody stem density declined following growing season burns. One possible reason for this effect is that the growing season fires in the Francis Marion were carried out during somewhat droughty conditions (i.e., summer of 1993), and thus fires may have been more intense than usual. Perhaps fire intensity, rather than fire season *per se* was responsible for declines in abundance of some species in the LPFS.

Our initial results from the LPFS do, however, agree, in general, with results from the long-term Santee Fire Plot Study (also carried out in the Francis Marion National Forest, see Waldrop, et al. 1992, *Forest Ecology and Management* 47:195-210). In that study, annual growing season burns essentially eliminated woody stems from the groundcover, but woody stems persisted in plots burned annually in the dormant season, as well as, in plots burned periodically (i.e., every 3-7 yrs) in the growing season. Since our growing season burns are biennial and quadrennial, it is not certain whether woody stem number will continue to decline with future growing season fires.

CONCLUSIONS

Fire frequency has a strong effect on longleaf pine groundcover vegetation. Annual or biennial burning is required to maintain a high diversity of species. With less frequent burning, woody plants dominate the groundcover. Season-of-burn effects seem to be weaker, except perhaps in annually burned areas, as demonstrated by the Santee Fire Plot Study. However, significant seasonal effects may occur in some years depending, in part, on interactions with climate and fire behavior.

ACKNOWLEDGEMENTS

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Role of Root System Development in Defining Longleaf Pine Seedling Quality

Mary Anne Sword (USDA Forest Service, Southern Research Station, Pineville, LA)

ABSTRACT - The root system morphology of planted longleaf pine is a major determinant of establishment success. Longleaf pine planting guidelines recommend that planted seedlings possess a minimum quantity of primary and fibrous lateral roots. Lateral root formation is controlled by genetic and environmental stimuli that influence the growth regulator and carbohydrate relations of developing root systems. Furthermore, the unique morphology of the longleaf pine root system suggests that distinct patterns of carbon partitioning within the root system are possible. Preliminary research is underway to understand how genetic and environmental variables influence the partitioning of carbon between the taproot and lateral roots of longleaf pine seedlings. This information will improve our understanding of how longleaf pine root system development can be manipulated to improve seedling quality.

INTRODUCTION

Vast portions of the mature longleaf pine (Pinus palustris Mill.) forests that dominated much of the South were cleared or logged by the mid-1900's (5). The unique character of young longleaf pine and its ecology hindered efforts to regenerate this species (5). Improvements in longleaf pine regeneration methods, and concern over the loss of longleaf pine-wiregrass (Aristida stricta Michx.) and -bluestem (Andropogon spp.) communities have renewed interest in its establishment.

Southern pine establishment success is closely related to planting stock root system morphology (1, 4). Longleaf pine planting guidelines recommend a minimum quantity of primary lateral and fibrous roots (4). Manipulation of genotype and environment are valuable tools used to customize tree seedling root system morphology.

Plant scientists have also recognized that interactions between genotype and environment influence root system morphology (7). For example, Zobel (7) planted rows of three cultivars of tomato in soil that graded from coarse to fine texture. Each of two tomato cultivars produced either a large or small amount of fibrous roots throughout the soil texture gradient. The third cultivar exhibited an increase in the amount of fibrous roots produced as the soil texture became more fine. Similar plastic responses may be characteristic of longleaf pine seed sources.

We are initiating research to improve our understanding of longleaf pine seedling root system development and phenotypic plasticity. The purpose of this presentation is to describe our research direction and some of the experimental observations that we have made in support of this direction.

Longleaf Pine Root System Development

Root system morphologies of young southern pine species do not differ dramatically. However, as longleaf pine seedling development progresses, it appears as though photosynthate translocated to the root system is preferentially partitioned for taproot, rather than lateral root metabolism. Research will be conducted to evaluate lateral root primordia formation and elongation, and the pattern of carbon partitioning between the taproot and lateral roots of longleaf pine throughout seedling development.

Data from a preliminary greenhouse trial indicated that an increase in root-zone temperature from 13 to 23°C did not affect the number of primary lateral roots per length of the upper 5 cm of the taproot of 7-week-old longleaf pine seedlings, but did increase the number of primary lateral roots per length of the taproot below 5 cm. Research will be proposed to identify environmental conditions that are conducive to the formation of persistent primary lateral roots throughout the length of the taproot. Research will also be proposed to evaluate seedling developmental stages in which primary lateral roots formation is most strongly influenced by environment.

Carbon Partitioning Within the Longleaf Pine Seedling Root System

Carbon partitioning within plants is controlled by "source-sink" relationships between different plant parts (3). Genotype and environment influence "source-sink" relationships and thus, the pattern of carbon partitioning within tree seedlings (2). A similar relationship may be characteristic of carbon partitioning within the longleaf pine seedling root system. We previously investigated the growth of 6-month-old container-grown longleaf pine 28 days after planting in response to each of three seed sources, soil temperatures and water availability's (6). We found that the Mississippi seed source had a larger stem diameter, but less new root growth when compared to the Alabama seed source; and the Alabama seed source had a smaller stem

diameter, but more new root growth than the Mississippi seed source. If the assumption that stem diameter and taproot size are positively related is valid, then a negative relationship may have existed between taproot size and new root growth. Significant correlation's between stem diameter and new root growth were not found either within or among seed sources. However, our results warrant additional experimentation to determine whether carbon is inversely partitioned to the taproot and fibrous roots of longleaf pine seed sources during seedling development.

In this study, a significant seed source X temperature interaction was observed indicating that at 18°C, new root growth was not affected by seed source; but at 23°C, the new root growth of the Alabama seed source was significantly greater than that of the Florida and Mississippi seed sources (6). Furthermore, as soil temperature increased from 18 to 23°C, the response range of the Alabama seed source became wider than that of the Florida and Mississippi seed sources. These results may be related to the adaptation of seed sources to different planting zones. However, this information also illustrates possible phenotypic plasticity of longleaf pine seedling root growth in response to soil temperature. Further research is needed to determine how manipulation of genotype and environment could be used to improve seedling root system morphology before planting, and new root growth after planting.

CONCLUSIONS

A better understanding of how the longleaf pine seedling root system responds to genotype, environment and an interaction between these effects is needed. Our observations have prompted testing of the following hypotheses: (1) longleaf pine seedling root system morphology is affected by early root system development, (2) early development of the longleaf pine seedling root system is affected by environment, (3) carbon partitioning between the taproot and lateral roots of longleaf pine seedlings is affected by seed source, (4) root system morphology and growth of longleaf pine seed sources are phenotypically plastic in response to soil environment.

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Longleaf Restoration in Northeast Alabama: Shoal Creek Ranger District, Talladega National Forest

Dagmar Thurmond (Shoal Creek Ranger District, Talladega National Forest, Heflin, AL)
Suzanne Oberholster (National Forests in Alabama, Montgomery, AL)

ABSTRACT - The Shoal Creek District of the Talladega National Forest represents the interior limit of longleaf pine's natural range, as it extends into Alabama's Ridge and Valley physiographic province. Among Alabama's highest points, 200-year old longleaf pines eke out a living in shallow, rocky soils. These stands are the last bastion of the endangered red-cockaded woodpecker (RCW) in north Alabama. The ecosystem management initiative has charged the Forest Service with insuring the continued existence of the mountain longleaf pine ecosystem. Advanced hardwood midstory must be removed to allow natural longleaf regeneration. Unnaturally high fuel levels must be reduced through winter burning, to lessen the intensities of future summer prescribed burns. Once midstory hardwoods are removed, their rootstocks must be repeatedly treated with fire or herbicides until they no longer pose an inordinate threat to longleaf dominance. These management practices are poorly understood by the public, who see longleaf pine restoration as another assault on hardwood forests. Not all aspects of longleaf restoration on the Forest are problematic. Containerized longleaf seedlings earn their cost by providing phenomenal survival rates. Alternative methods of prescribed burning have lowered its cost. Timber sales clear longleaf stands of the advanced hardwood midstory that threatens to succeed them. Research on the mountain longleaf pine ecosystem is scarce. The effects of some management practices presently cannot be predicted. The herbaceous understory accompanying mountain longleaf pine is poorly known. The Longleaf Alliance can help bridge the gaps in our knowledge, increase public awareness, and forge research cooperatives to overcome these difficulties.

The Shoal Creek District of the Talladega National Forest represents the interior extent of longleaf pine's natural range, as it reaches Alabama's Ridge and Valley physiographic province. On Alabama's highest points, 200- year old longleaf pines eke out a living among the shallow, rocky soils. These longleaf, and mixed longleaf-shortleaf pine stands are the last bastion of the endangered Red-cockaded woodpecker (RCW) in north Alabama. Interior RCW populations, though small, are important due to their relative safety from hurricanes.

Historical accounts by Charles Mohr and Roland Harper document the significance of longleaf in this region at the turn of the century, and provide clues to its eventual decline. Mohr (1901) wrote the " ...most prominent and characteristic feature in the vegetation of this subdivision of the mountain region is the xerophile forests of the longleaf pine which cover the rocky ridges to an elevation of 2,000 ft." He goes on to describe these forests as open with little undergrowth. Harper (1913) noted that longleaf was a common tree below 1,900 ft. especially on south-facing slopes in the Blue Ridge area of Alabama (which includes Cheaha Mt.).

Little information exists documenting the understory of the mountain longleaf pine woodlands. In the Coastal Plain, wiregrass and longleaf occur together. There is no herbaceous equivalent to wiregrass in the mountain longleaf ecosystem. Grasses occur in the understory of mountain longleaf pine woodlands, but none forms a continuous fuel mat as wiregrass does in the Coastal Plain. Mohr (1901) mentioned three grasses that sparingly covered the steep slopes of the region; namely big bluestem, little bluestem and plumegrass. While little bluestem and plumegrass are still encountered today, big bluestem has become rare. Perhaps more frequent, or growing season burns will reclaim these prairie-like components of the Alabama longleaf woodlands.

Mohr (1901) also documented rich legume diversity in these woodlands. In a trip to the area in September he recorded 7 beggar tick species (Desmodium ssp.), 5 native Lespedeza ssp., goat's rue (Tephrosia virginiana), false indigo (Amorpha fruticosa), and partridge pea (Cassia fasciculata). Today, many of these species are confined to roadsides, and are rarely seen in forests choked with midstory. Lespedeza ssp. (L. hirta and L. capitata) have returned to an area that received a growing season burn this year.

There are no known threatened or endangered plants associated with the mountain longleaf pine woodlands, but recently turkey beard (Xerophyllum asphodeloides) was discovered on a burned and mid-storied longleaf ridge. The basal tuft of leaves of this rare and unusual plant resembles the grass stage

longleaf, but is readily identifiable when it is in flower. This is the first documented record of this species in Alabama.

Even as Mohr and Harper were gathering information about this ecosystem, it was being destroyed. Both men noted that as the local iron industry grew, extensive areas of longleaf were denuded for charcoal and lumber production. Other, less desirable timbers were left intact. The decline of the mountain longleaf pine ecosystem was multifactorial. 1) Longleaf pine was cut without subsequent regeneration, while hardwoods were left intact; 2) fire suppression beginning in the 1920's repressed longleaf regeneration where adequate seed sources remained; and 3) free ranging hogs fed heavily on longleaf seedlings.

The Agency's own successful fire suppression policy contributed to the problems now facing the Shoal Creek District in restoring longleaf pine. Under the ecosystem management initiative, the Forest Service has embraced management tools little used in the mountains, to insure the continued existence of the mountain longleaf ecosystem. Advanced hardwood midstory must be removed to allow for natural longleaf regeneration. Unnaturally high fuel levels must be reduced through winter burning to lessen the intensities of future summer prescribed burns. Once midstory hardwoods are removed, their rootstocks must be repeatedly treated with fire or herbicide until they no longer represent an unnatural threat to longleaf dominance.

These management practices are poorly understood by the public, who see longleaf restoration as another assault on hardwood forests. While hardwood forests are not limited on today's landscape, mountain longleaf woodlands were recently identified as a rare ecological group in the Southern Appalachian Assessment (SAA 1996). Hardwoods are replacing the longleaf forests in northeast Alabama's mountains, and fire suppression is cited by the SAA as the primary reason for the decline of mountain longleaf pine woodlands. Public awareness of the plight of the mountain longleaf ecosystem must be increased among environmental groups if the Forest Service hopes to be successful in its restoration efforts.

CONCLUSIONS

Not all aspects of longleaf restoration on the forest are problematic. Containerized longleaf seedlings merit their additional cost by providing phenomenal survival rates. Alternative methods of prescribed burning have lowered its cost. Profitable timber sales have been used to clear longleaf stands of advanced hardwood midstory that threatens to succeed them. Still, many of the outcomes of management efforts cannot be predicted. Research dealing specifically with mountain longleaf ecosystems and responses to treatments are scarce. The herbaceous understory accompanying mountain longleaf is poorly known. Northeast Alabama, North Carolina and Georgia are the only remaining areas of this habitat that can be studied. The extent to which their herbaceous understories have been altered by fire exclusion cannot be measured. The Longleaf Alliance can help to bridge the gaps in our knowledge, increase public awareness, and forge research cooperatives to overcome these difficulties.

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The Alabama Forestry Commission Encourages Longleaf in Northeast Alabama

Jeff Thurmond (Alabama Forestry Commission, Heflin, AL)

ABSTRACT - In the Piedmont/Ridge and Valley physiographic regions, longleaf survives in isolated pockets of scattered individuals among upland hardwoods, loblolly, shortleaf, and Virginia pines. They are, on rare occasions, found in pure stands. Much of the non-industrial private lands in northeast Alabama are not being regenerated properly. These lands are left to regenerate from hardwood stump sprouts, residual pine seed and scattered unmerchantable pines. Fire is excluded which prevents the few longleaf that may have been there from regenerating effectively. The Alabama Forestry Commission provides technical land management assistance to landowners, including advice on harvesting and regeneration alternatives. In conjunction with the Farm Services Agency and the Natural Resources Conservation Service, the Alabama Forestry Commission provides monetary assistance, or cost-share, for proper regeneration of forestland. This includes site preparation, seedlings, and planting. Ordinarily, the cost-share programs do not cover the extra cost of containerized seedlings. County Soil and Water Conservation Boards have the authority to include containerized seedlings under the state cost-share program. A few, including Cleburne County, have approved this change to keep longleaf regeneration costs reasonable to the average landowner. The Alabama Forestry Commission encourages landowners to plant longleaf within its range when it is within their land management goals. In counties with high wildfire numbers, such as Cleburne and Talladega, the AFC strongly encourages landowners to plant longleaf on high wildfire occurrence sites. Longleaf seedlings are resistant to fire and have a smaller window of vulnerability to wildfires compared to loblolly. In some areas, loblolly plantations may burn and need replanting two or three times before a stand is established. Longleaf could reduce regeneration costs significantly in these areas.

In the Piedmont and Ridge and Valley physiographic regions of northeast Alabama, longleaf survives in isolated pockets of scattered individuals among upland hardwoods, loblolly, shortleaf, and Virginia pines. They are on rare occasions, found in pure stands. The majority of these stands are on the steepest, most inaccessible slopes and ridges.

Much of the non-industrial private lands in northeast Alabama are not being regenerated adequately. The land is left to regenerate from hardwood stump sprouts, residual pine seed and scattered unmerchantable pines. In these areas longleaf regeneration fails. Acceptable natural seeding from longleaf has many inherent problems. Wahlenberg (1946) wrote, “Good crops often occur every 5 to 7 years and [total] failures about every 1 year out of 5, but exceptions are so common that no specific interval can be relied upon.” Fire exclusion is also a problem for adequate regeneration. Wahlenberg (1946) also states, “Burning off the ground cover is... essential, and during seed years this should occur late in the calendar year, prior to seed fall and before logging.” Consequently, the chances for unplanned longleaf regeneration are slight.

The Alabama Forestry Commission provides technical land management assistance to landowners, including advice on harvesting and regeneration alternatives. In conjunction with the Farm Services Agency and the Natural Resources Conservation Service, the Alabama Forestry Commission provides monetary assistance, or cost-share, for proper regeneration of forestland. This includes site preparation, seedlings, and planting.

In recent years, vast improvements have been made in longleaf seedling survival and initial growth through the development of containerized seedlings. Croker (1987) reports, “Early results indicate that both growth and survival for the containerized seedlings will be superior to that for nursery [bareroot] stock. Use of them promises to be the wave of the future...” Ordinarily, cost-share programs do not cover the extra cost of containerized seedlings. County Soil and Water Conservation Boards have the authority to include containerized seedlings under the state cost-share program. A few, including Cleburne County, have approved this change to keep longleaf regeneration costs reasonable to the average landowner.

The Alabama Forestry Commission encourages landowners to plant longleaf within its range when it achieves their land management goals. In counties with high wildfire numbers, such as Cleburne and Talladega, the AFC strongly encourages landowners to plant longleaf on high risk sites. Wahlenberg (1946) states, “An element of the rural population in the South has burned the woods at will from time immemorial.” This characterizes many of northeast Alabama’s rural counties. Longleaf seedlings are resistant to fire and

have a smaller window of vulnerability to wildfires compared to loblolly. “Losses due to ordinary fires on protected and unprotected lands have been relatively low because of the intrinsic resistance of the species.”, writes Wahlenberg (1946). “In one test, tissue paper placed around the buds of seedlings 1 to 3 feet high were not even scorched though needles were scarred to within 3 inches of the bud” (Chapman 1936.) In some areas, loblolly plantations may burn and need replanting two or three times before a stand is established. Longleaf could reduce regeneration costs significantly in these areas.

The Alabama Forestry Commission has offices in every county in Alabama. Landowner assistance is available in every aspect of forest management. AFC personnel are available during normal working hours for all forest management assistance and 24 hours a day for wildfire control.

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A FRAMEWORK FOR ECOREGIONAL CONSERVATION: THE NATURE CONSERVANCY/HERITAGE PROGRAM SOUTHEAST COASTAL PLAIN CONSERVATION INITIATIVE

Kimberly Wheaton (The Nature Conservancy, Chapel Hill, NC)

ABSTRACT - The Southeast Coastal Plain, which extends across a nine state area from southeast Virginia south through Florida and west to eastern Texas, is an area of high conservation priority because it is one of the most biologically rich ecoregions outside the tropics and also one of the most threatened. Nature Conservancy field offices, regional offices, and Heritage programs from Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas, and Virginia are participating in an ecoregional initiative to conserve multiple examples of high quality natural communities and vulnerable species at sites that collectively encompass the ecological variability of the Southeast Coastal Plain. The longleaf pine ecosystem, which once dominated the Southeast Coastal plain, will be the initial focus of this initiative because of the vulnerable status and continued decline of many of its associated communities and species. The Nature Conservancy/Heritage Program Southeast Coastal Plain Conservation Initiative is built upon a framework of conservation actions that occur simultaneously at several scales, including site, state, subregional, and ecoregional levels. Site and state-based conservation actions are the building blocks of this initiative and include the following: filling data gaps and strengthening our understanding of Coastal Plain ecosystems, conducting research projects, acquiring new preserves and other land management agreements, restoring and maintaining our own preserves, and working with public and private partners on restoration and management projects on their lands. Subregional and ecoregional actions include identifying and prioritizing the highest quality species, communities, and sites in need of conservation, and increasing outreach and communication with public agencies, industry, private landowners, universities, and other organizations in support of ongoing conservation efforts.

BACKGROUND

The Nature Conservancy/Heritage Program Southeast Coastal Plain Conservation Initiative (SECPCI) focuses on a nine state area that extends from southeast Virginia south through Florida and west to eastern Texas. The Southeast Coastal Plain (SECP) is an area of high conservation priority because it is one of the most biologically rich ecoregions outside the tropics and also one of the most threatened. In fact, the Southeast Coastal Plain is a center of biodiversity and has some of the greatest species richness and endemism in continental North America for vascular plants, fish, reptiles, amphibians, and tiger beetles (Noss and Cooperrider 1994).

Nature Conservancy (TNC) field offices, regional offices, and Heritage programs from Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas, and Virginia are participating in this initiative to ensure the long-term survival of high quality natural communities and vulnerable species in the Southeast Coastal Plain. The longleaf pine ecosystem, which once dominated the Southeast Coastal Plain, is the initial focus of this initiative because of the vulnerable status and continued decline of many of its associated communities and species.

Because of the size and linear nature of the Southeast Coastal Plain, the ecoregion has been divided into five “ecoregional planning units” for planning, protection, and management purposes:

- Mid-Atlantic Coastal Plain (NC, SC, VA);
- South Atlantic Coastal Plain (FL, GA, SC);
- Florida Peninsula (FL);
- East Gulf Coastal Plain (AL, FL, GA, LA, MS); and
- West Gulf Coastal Plain (LA, TX).

VISION

The vision of the Southeast Coastal Plain Conservation Initiative is that Nature Conservancy and Heritage Programs will work together and with public and private partners to ensure the long-term survival of high quality natural communities and vulnerable species at sites that collectively encompass the full ecological variability of the Southeast Coastal Plain Ecoregion.

GOALS AND ACTIONS

To achieve the above vision for the Initiative, Nature Conservancy and Heritage partners identified eight long-term goals that provide a framework for and give cohesion to conservation actions occurring simultaneously at several scales, including site, state, planning unit, and ecoregional levels. Listed below are examples of conservation actions for each Initiative goal:

GOAL 1. Build a cooperative, information-sharing coalition of Heritage programs, TNC field offices, and TNC regional offices in support of an ecoregional conservation initiative.

- Each planning unit in the SECP has an interdisciplinary team of Heritage and TNC Science, Stewardship, Protection, and Development staff who:
  - share data and coordinate activities across state lines;
  - determine which species and communities will be targeted for conservation action;
  - select priority sites for protection; and
  - make recommendations for state-level conservation actions.

- In addition to interdisciplinary teams, several Heritage programs and TNC field offices are working on joint initiatives that support information sharing and cooperation across state lines.

GOAL 2. Strengthen Heritage program and Nature Conservancy knowledge bases and fill data gaps for Southeast Coastal Plain ecosystems.

- Heritage programs in all states in the Southeast Coastal Plain are conducting ongoing inventory work to fill data gaps for longleaf pine species and communities and for other Coastal Plain ecosystems.
- The Louisiana Natural Heritage Program is conducting several research projects at the 800 acre Lake Ramsey Savannah tract as part of long-term conservation and restoration efforts at the site.

GOAL 3. Identify and prioritize significant, viable sites containing high quality natural communities and vulnerable species for conservation actions.

- For each planning unit, the interdisciplinary Heritage/TNC teams are systematically identifying the highest priority naturally occurring communities and vulnerable species (including rare, threatened, endemic, and declining species) for conservation actions.
- Expected products from the initial process may include:
  - given current data, an iterative list of sites and their respective communities and species across each planning unit;
  - identification of data gaps for future inventory and research work;
  - GIS and other data layers that will be shared between state programs;
  - an assessment of the level of protection of natural communities and species on currently managed areas (TNC, state, and federal lands); and
  - a summary of the status of biodiversity and conservation in each planning area and across the Southeast Coastal Plain.

GOAL 4. Develop site conservation plans for all priority sites.

- Site conservation planning in The Nature Conservancy is a scale-independent process that defines the landscape within which targets of conservation can persist, identifies the human context of the site and surrounding area, identifies threats, and outlines strategies to protect conservation targets and their functional landscape.
- Examples of existing site conservation plans in the Southeast Coastal Plain include the North Landing River Natural Area Preserve in southeast VA, and the Grand Bay Savanna Bioreserve in southeast MS and southwest AL.

GOAL 5. Implement protection of natural, high quality communities and associated species on priority sites through acquisition and related strategies.

- TNC's Alabama field office has a management agreement with Champion Timber Company on a virgin longleaf pine forest. Other partners in this project include Auburn University and the U.S. Forest Service.
- A conservation easement of 2,806 acres surrounding Sandylands Preserve in east Texas was established in 1994 with Temple-Inland Forestry, Inc.
- The Georgia field office has several preserves with substantial longleaf pine acreage, including the Charles Harrold Preserve, the Ohoopee Dunes Preserve, the Broxton Rocks Preserve, and the R.G. Daniell Conservation Easement.

GOAL 6. Ensure appropriate management and restoration of natural communities and associated species at selected sites on: 1) TNC preserves and easements, and 2) public and other lands.

- TNC's North Carolina chapter, in partnership with the Georgia Pacific Corporation, is beginning a restoration project in the 900 acre Myers/Clemmons tract of the Green Swamp Preserve.
- A Memorandum of Understanding (MOU) was signed between several partners in the Eglin Air Force Base area of the Florida Panhandle and southern Alabama for the protection of longleaf pine communities and associated species.

GOAL 7. Develop education and outreach programs and improve communication with public agencies, industry, private landowners, universities, and other conservation organizations in support of ongoing conservation efforts.

- TNC is a supporting member of the Longleaf Alliance.
- TNC and Duke University's School of the Environment have a joint program in applied conservation biology (Dr. Laura Snook, Program Director, is heading a longleaf pine sustainable forestry research project).
- TNC field offices work with military installations in several states across the Southeast on inventory, restoration, and adaptive management (including monitoring) projects.

GOAL 8. Increase funding for conservation activities in the Southeast Coastal Plain.

- States in the Southeast Region of The Nature Conservancy have allocated regional funds to support planning and conservation actions as part of the Coastal Plain Initiative.
- States and regional offices are pursuing a mix of grants to support the Southeast Coastal Plain Conservation Initiative.

LITERATURE CITED

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LEAFS - A Demonstration Project

John Winn (LEAFS Trustee, Waldo, Florida 32694)

ABSTRACT - The Longleaf Ecology and Forestry Society (LEAFS) is a non-profit organization founded to promote the use of longleaf pines in reforestation and to demonstrate to small landowners the use of low impact, low cost, ecologically beneficial methods of timber management. To acquaint smaller landowners with the potential of longleaf pines, LEAFS has established a demonstration project on 90 acres in northeastern Alachua County, Florida, designed to show how longleaf pines can be profitably grown and sold as timber while maintaining a viable ecosystem. The pine flatwoods site of the project was once occupied by virgin longleaf pines, but is now much altered. Most of the longleaf pines were cut many years ago. Through the use of prescribed burning, selective harvesting, and replanting with desired species, LEAFS is restoring the tract to a more natural condition that will show how—once re-established—the longleaf pine ecosystem can be maintained and utilized for the sustainable production of forestry products on a commercial basis.

The tract is open to the general public and an interpretive trail is maintained to show the management practices utilized in the LEAFS demonstration project. Although to the casual visitor the tract might n many ways resemble a park or nature preserve, the interpretative materials make it clear that a fundamental objective of LEAFS is production of timber, in addition to preservation of a longleaf pine ecosystem.

INTRODUCTION

The Longleaf Ecology and Forestry Society (LEAFS) is a non - profit tax-exempt organization founded in 1993 by a handful of forestry professionals and lay persons to promote the use of longleaf pines in reforestation and to demonstrate to small landowners the use of low impact, low cost, ecologically beneficial methods of timber management.

The objective in acquainting smaller land owner with the potential of longleaf pines, LEAFS has established a demonstration project on 90 acres in northeastern Alachua County, Florida, designed to show how longleaf pines can be profitably grown and sold as timber while maintaining a viable ecosystem.

The pine flatwoods site of the project was chosen because the organization's founders (who also serve as volunteer workers!) live nearby. Once the site was occupied by virgin longleaf pines, but having been used for a variety of purposes in the past 100 years, it is now much altered. Most of the longleaf pines were cut many years ago. Through the use of prescribed burning, selective harvesting, and replanting with desired species, LEAFS is restoring the tract to a more natural condition that will show how—once re-established—the longleaf pine ecosystem can be maintained and utilized for the sustainable production of forestry products on a commercial basis.

The interpretive trail

The tract is open to the general public for non-consumptive recreational uses and an interpretive trail is maintained to show the management practices utilized in the LEAFS demonstration project. This self-guiding trail is the primary educational tool used by LEAFS.

To the casual visitor, the tract might in many ways resemble a park or nature preserve, and although preservation of a functioning longleaf pine ecosystem is important, the interpretive materials make it clear that a fundamental objective of LEAFS is production of timber. This is reflected in the first words in the trail guide:

This is <u>not</u> a nature preserve where all plants are protected. The LEAFS tract is a **working forest**, the objective of which is to produce timber and other forest products, so from time to time, some trees are harvested.

The trail begins with signs giving information on the site, longleaf pines, and prescribed burning. the signs also serve as dispensers for two brochures. "About Leafs," which contains general information about longleaf pines and the organization, and the LEAFS trail guide. The trail guide has a map and entries for 13 correspondingly numbered stops along the trail. Using the guide, visitors to the LEAFS tract may stop at designated locations along the half-mile loop trail to read about the demonstration project.

The LEAFS message is directed towards small private landowners considering planting longleaf, who might visit on their own, or as clients of consulting foresters. These individuals were selected as the

targeted audience because it is assumed that for the most part today, large landowners—particularly of timberlands—are corporations with astute corporate mangers who are already aware of the benefits—such as higher quality timber products or even just good public relations—which they can gain from growing longleaf; there is little that LEAFS could tell them that they don't already know. On the other hand, small landowners—without extensive corporate resources—may be less aware of planting and growing longleaf as an option.

Since private landowners cannot be expected to managed their property in the same manner as parks and nature preserves and must have a financial return from the land (or at least the prospect of some return in the future), the Leafs project emphasizes low - cost, low-impact, do-it-yourself management methods. Once this initial phase nears completion, the project will also demonstrate harvest procedures with increasing emphasis on natural regeneration techniques.

Location

The LEAFS tract comprises about 90 acres in northeastern Alachua County, Florida, on County Toad 1471. It is located between Starke and Gainesville, about 2 ½ miles southeast of Waldo and one half of a mile northeast of U.S. Highway 301. The trail has been open to the public since early 1995. You are welcome to visit any time.

Funding for the project

The land for the project was acquired by donation from individuals. A grant of $15,000 for initial operational costs was secured from a private foundation; of that, nearly two-thirds has been spent on fireline construction and maintenance, prescribed burning, and seedlings. The balance was utilized for trail construction and interpretive materials, as well as miscellaneous administrative costs. It is anticipated that most additional costs of the project in the next five years will be met with proceeds from timber sales or small grants. No public donations are sought at present.

Future projects

In the near future, LEAFS will acquire by donation a small 10 acre contiguous addition and a separate 60 acre site. The smaller addition contains a modest home site which could be used by an employee or for rental income. The larger site—also in Alachua County, Florida—is adjacent to a county park, so the interpretive trail planned for it may be more accessible and readily used than the present trail. We are enthusiastic about these projects and hope they will lead to other undertakings. We would like to develop other sites, either on our own or in cooperation with other groups, both close to our home base and further afield in the heart of the longleaf range if circumstances will allow.

Attendees of the 1996 Longleaf Alliance Conference

Achtemeier, Gary
USDA FS Southern Res Station
Route 2, Box 240
Juliette, GA 31046
(912) 986-4605

Alexander, Brad
Alexander & Associates
P.O. Box 447
Wiggins, MS 39577
(601) 928-3671

Alexander, Gene
Alexander & Associates
P.O. Box 447
Wiggins, MS 39577
(601) 928-3671

Allen, Wendy
The Nature Conservancy of AL
2821-C 2nd Avenue South
Birmingham, AL 35233
(205) 251-1155

Andreu, Michael
Larson & McGowin, Inc.
P.O. Box 2143
Mobile, AL 36652
(334) 438-4581

Atkinson, Jimmy
Jones Ecological Res Ctr
Route 2, Box 2324
Newton, GA 31770
(912) 734-4706

Bagwell, David
Armbrecht, Jackson, DeMouy
63 S. Royal St., #1300
Mobile, AL 36602
(334) 405-1300

Bagwell, Julie
Armbrecht, Jackson, Demouy
63 S. Royal St., #1300
Mobile, AL 36602
(334) 405-1300

Bailey, Mark
AL Natural Heritage Program
64 N. Union Street
Montgomery, AL 36130

Baker, Wilson
Tall Timbers Reserach Station
Route 1, Box 678
Tallahassee, FL 32312
(904) 668-7781

Ballard, Louis
Eglin AFB Natural Resources
501 DeLeon Street
Eglin AFB, FL 32542-5133
(904) 882-4164

Barbour, Jill
USDA FS Natl. Tree Seed Lab
Route 1, Box 182 B
Dry Branch, GA 31020-9696
(912) 751-3553

Barnhill, Haven
GA Wildlife Resources Div.
142 Bob Kirk Road
Thomson, GA 30824
(706) 595-4222

Barrett, Bettigrey
10499 McMillian Road
Stockton, AL 36579
(334) 937-7320

Beam, Lynda
312 Vernonburg Road
Savannah, GA 31419
(912) 232-3129

Beaudrot, Lew
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 844-1062

Becker, Danny
DOD, AC/S EMD/Forestry
PSC Box 20004
Camp Lejeune, NC 28542-0004
(910) 451-2195

Bein, Jeff
USDA Forest Service
Route 1, Box 1
Meadville, MS 39653
(601) 384-5876

Belser, Harvey
SC Forestry Commission
6810 Headquarters Road
Wedgefield, SC 29168
(803) 494-8196

Bethancourt, Don
USDA Forest Service
325 John Knox Rd., # F100
Tallahassee, FL 32308
(904) 942-9355

Bishop, Larry
USDA Forest Service
1720 Peachtree Rd. NW #811N
Atlanta, GA 30309
(404) 347-2067

Blackwell, David
Stone Container Corporation
P.O. Box 625
Ozark, AL 36360
(334) 744-1595

Boddie, Eddy
USDA Forest Service
2500 Shreveport Highway
Pineville, LA 71360
(318) 473-7191

Boldog, Sandor
Conecuh National Forest
801 Waterford Drive
Andalusia, AL 36420
(334) 222-7707

Boring, Lindsay
Jones Ecological Res. Ctr.
Route 2, Box 2324
Newton, GA 31770
(912) 734-4706

Boyce, Tim
AL Forestry Commission
513 Madison Avenue
Montgomery, AL 36130

Boyer, Bill
USDA FS Southern Res. Sta.
DeVall Drive
Auburn University, AL 36849
(334) 826-8700

Boyette, Warren
NC Div. of Forest Resources
P.O. Box 29581
Raleigh, NC 27626-0581
(919) 733-2162

Bradley, Tom
Gulf Lumber Company, Inc.
P.O. Box 1663
Mobile, AL 36633-1663
(334) 457-6872

Bramlett, David
USDA FS Southern Res. Sta.
Route 2, Box 240
Juliette, GA 31046
(912) 986-4605

Braswell, Allen
US Army - Ft. Gordon
4655 Cutter Mill Road
Martinez, GA 30907
(706) 791-2327

Brock, Dale
Jones Ecological Res. Ctr.
Route 2, Box 2324
Newton, GA 31770
(912) 734-4706

Brock, Jean
Jones Ecological Res. Ctr.
Route 2, Box 2324
Newton, GA 31770
(912) 734-4706

Brown, Bruce
Brown Properties
P.O. Box 100
Longville, LA 70652
(318) 725-3298

Brown, Steve
NW FL Water Mgt. Dist.
Route 1, Box 3100
Havana, FL 32333
(904) 539-5999

Burke, Gib
AL Forestry Commission
32760 State Hwy. 59
Loxley, AL 36551

Burnes, Suzanne
US Army/Southern Reg Env Off
77 Forsyth St., SW, Suite 362
Atlanta, GA 30335-6801

Busby, Rod
USFS SOFES/RMT-10210, PSB
701 Loyola Avenue
New Orleans, LA 70113
(504) 589-6652

Cantrell, Mark
US Fish & Wildlife Service
225 N. Bennett Street
Southern Pines, NC 28387

Carter, Robert
AU - School of Forestry
P.O. Box 926
Auburn, AL 36831
(334) 844-1026

Cassell, Greg
University of Mobile
5735 College Pkwy.
Mobile, AL 36678
(334) 675-5990

Causey, Vince
LA Div. of Forestry
P.O. Box 1628
Baton Rouge, LA 70821
(504) 925-4500

Clark, Stan
SC Forestry Commission
P.O. Box 21707
Columbia, SC 29221
(803) 896-8823

Clason, Terry
Louisiana State University
Route 1, Box 10
Homer, LA 71040
(318) 927-2578

Cleckley, William
NW FL Water Mgt. Dist.
Route 1, Box 3100
Havana, FL 32333
(904) 539-5999

Clewell, Andy
A.F. Clewell, Inc.
Route 7, Box 1195
Quincy, FL 32351
(904) 875-3868

Clough, Ken
The Nature Conservancy
809 N. President Street
Jackson, MS 39215
(601) 355-5357

Cole, Frank
US Fish & Wildlife Service
Route 1, Box 678
Tallahassee, FL 32312-9712
(904) 893-4153

Cole, Gary
AL Forestry Commission
P.O. Box 538
Monroeville, AL 36460

Cole, June
US Fish & Wildlife Service
Route 1, Box 678
Tallahassee, FL 32312-9712
(904) 893-4153

Compton, Vernon
FL Div. of Forestry
11650 Munson Highway
Milton, FL 32570
(904) 957-4201

Condon, Michael
University of South Alabama
7380 Smithfield Road
Mobile, AL 36695

Costa, Ralph
Clemson Univ. - Forest Resources
Lehotsky Hall
Clemson, SC 29634
(864) 656-2432

Crosby, J.D.
P.O. Box 1331
Bay Minette, AL 36507
(334) 937-7413

Crosby, J.R.
P.O. Box 304
Stockton, AL 36579

Crosby, Neil
Crosby Lumber Company
P.O. Box 1178
Bay Minette, AL 36507
(334) 937-5545

Davis, James
James E. Davis Forest Resources
P.O. Box 180514
Mobile, AL 36618
(334) 476-4221

Davis, M.C.
151 Regions Way, Suite 2-C
Destin, FL 32541
(904) 837-1253

Dear, Clarence
DRS Enterprises, Inc.
147 W. Plum Street
Jesup, GA 31545
(912) 427-8911

Dear, Richard
DRS Enterprises, Inc.
147 W. Plum Street
Jesup, GA 31545
(912) 427-8911

Dennington, Roger
1840 Lipscomb Road
Social Circle, GA 30279

Dismukes, Robert
AL Forestry Commission
P.O. Box 178
Brewton, AL 36427

Douglas, John
Douglas Properties
701 Evergreen Avenue
Brewton, AL 36426
(334) 867-7100

Duryea, Mary
University of Florida
P.O. Box 110410
Gainesville, FL 32611-0410
(352) 846-0896

Dwinell, David
USDA Forest Service
320 Green Street
Athens, GA 30602
(706) 546-2455

Earley, Larry
NC Wildlife Commission
512 N. Salisbury Street
Raleigh, NC 27604-1188
(919) 834-4533

Edwards, Mike
Branco, Inc.
701 Evergreen Avenue
Brewton, AL 36426
(334) 867-7100

Engstrom, Todd
Tall Timbers Research Station
Route 1, Box 678
Tallahassee, FL 32312

Evans, Turner
Temple-Inland
P.O. Box 966
Silsbee, TX 77656
(409) 385-5296

Farnsworth, David
USDA FS/Apalachicola RD
P.O. Box 579
Bristol, FL 32321
(904) 643-2282

Fincher, Chad
James R. Fincher Timber Co., Inc.
11760 Tanner Williams Road
Mobile, AL 36608
(334) 649-7005

Fincher, Eileen
James R. Fincher Timber Co., Inc.
450 Stateline Road
Wilmer, AL 36587
(601) 641-3930

Fincher, James
James R. Fincher Timber Co., Inc.
450 Stateline Road
Wilmer, AL 36587
(601) 641-3930

Foley, Deborah
Conecuh National Forest
Route 5, Box 157
Andalusia, AL 36420
(334) 222-2555

Ford, Larry
Gulf States Paper Corporation
P.O. Box 48999
Tuscaloosa, AL 35401-8999
(205) 669-3141

Fore, Chuck
GA Forestry Commission
Route 1, Box 67
Helena, GA 31037

Franklin, Robert
Clemson Univ/Coop. Ext. Serv.
219 S. Lemincks Street
Walterboro, SC 29488
(803) 549-2595

Frazer, Eley
F & W Forestry
P.O. Box 3610
Albany, GA 31706-3610
(912) 883-0505

Frederick, David
AL Forestry Commission
P.O. Box 302550
Montgomery, AL 36130
(334) 240-9335

Gables, Tim
C.V. Forestry Services, Inc.
P.O. Box 307
Clayton, AL 36016
(334) 775-8345

Garland, Bill
Fort McClellan
ATZN-EM, Directorate of Environ.
Ft. McClellan, AL 36205-5000
(205) 848-3758

Gilley, Ed
E.L. Gilley Timberlands
P.O. Box 8767
Mobile, AL 36689
(334) 344-1520

Gjerstad, Dean
AU - School of Forestry
111 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 844-1020

Glitzenstein, Jeff
Tall Timbers Research Station
Route 1, Box 678
Tallahassee, FL 32312
(803) 881-9921

Goldman, Larry
US Fish & Wildlife Service
P.O. Drawer 1190
Daphne, AL 36526
(334) 441-5181

Gothard, Tim
AL Forestry Commission
513 Madison Avenue
Montgomery, AL 36130

Grable, Larry
AL Forestry Commission
42161 State Hwy. 225
Bay Minette, AL 36507

Graham, Michael
Land Visions, Inc.
304 N. Craft Hwy.
Chickasaw, AL 36611
(334) 456-1161

Gramling, Charles
USDA Forest Service
P.O. Box 248
Wiggins, MS 39577
(601) 584-8488

Guy, Steve
AL Farmers Federation
2108 E. South Blvd.
Montgomery, AL 36116
(334) 613-4305

Hainds, Mark
Solon Dixon Forestry Ed. Ctr.
Route 7, Box 131
Andalusia, AL 36420
(334) 222-7779

Hall, Doug
F & W Forestry Services, Inc.
1310 W. Oakridge Drive
Albany, GA 31707
(912) 883-0505

Hamilton, Jim
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 887-3990

Hancock, Mathew
LA Div. of Forestry
P.O. Box 1628
Baton Rouge, LA 70821
(504) 925-4500

Hanula, Jim
USDA Forest Service
320 Green Street
Athens, GA 30602
(706) 546-2455

Hardesty, Jeff
The Nature Conservancy
P.O. Box 118526
Gainesville, FL 32619
(352) 392-7006

Hassell, Scott
Eglin AFB Natural Resources
501 DeLeon Street
Eglin AFB, FL 32542-5133
(904) 882-4161

Haupt, Ray
USDA FS Apalachicola RD
P.O. Box 579
Bristol, FL 32321
(904) 643-2282

Haywood, James
USDA FS Southern Res Sta
2500 Shreveport Hwy
Pineville, LA 71360

Henderson, John
Kimberly-Clark Corporation
P.O. Box 899
Saraland, AL 36571
(334) 330-4241

Hermann, Sharon
Tall Timbers Res. Sta.
Route 1, Box 678
Tallahassee, FL 32312
(904) 893-4153

Hooks, Susan
USDA Forest Service
1720 Peachtree Rd. NW, #816
Atlanta, GA 30367
(404) 347-4083

Hoskins, Neil
Eglin AFB Natural Resources
501 DeLeon Street
Eglin AFB, FL 32542-5133
(904) 678-5479

Hubbard, Bill
Cooperative Extension Service
220 Austin Drive
Athens, GA 30606

Huff, Gary
D.W. McMillan Trust
P.O. Box 867
Brewton, AL 36427
(334) 867-4881

Huff, Jeanette
D.W. McMillan Trust
P.O. Box 867
Brewton, AL 36427
(334) 867-4881

Hughes, Glenn
MS Cooperative Ext. Service
P.O. Box 16689
Hattiesburg, MS 39404-6689
(601) 264-3903

Huntley, Jimmy
USDA Forest Service
2946 Chestnut Street
Montgomery, AL 36107
(334) 832-4470

Inge, George
1555 Dauphin Street
Mobile, AL 36604
(334) 476-6143

Jeffers, Richard
USDA Forest Service
1720 Peachtree Rd. NW, #816-N
Atlanta, GA 30367
(404) 347-4753

Johnson, Rhett
Solon Dixon Forestry Ed. Ctr.
Route 7, Box 131
Andalusia, AL 36420
(334) 222-7779

Johnston, Hamilton
USDA Forest Service
209 Kay Street
Prattville, AL 36066
(334) 241-8168

Jones, Lance
Stephen F. Austin State Univ.
P.O. Box 6109, SFA Station
Nacogdoches, TX 75962

Jones, R.H.
Cedar Creek Land & Timber, Inc.
P.O. Box 1765
Brewton, AL 36426
(334) 867-6165

Kelly, Harriet
Big Tree Farm
P.O. Box 987
Semmes, AL 36575
(334) 649-9585

King, Sharon
US Dept Int/Southern Sci Ctr
700 Cajundome Blvd.
Lafayette, LA 70506

Kluson, Robert
Univ. South FL - Biology Dept.
4202 E. Fowler Avenue
Tampa, FL 33620-5150
(813) 974-3226

Knowles, Robert
AL Forestry Commission
P.O. Box 178
Brewton, AL 36427

Kush, John
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 844-1065

LaClaire, Linda
US Fish & Wildlife Service
6578 Dogwood View Pkwy, #A
Jackson, MS 39213
(601) 965-4900

Ladnier, Rebecca
USDA Forest Service
P.O. Box 248
Wiggins, MS 39577
(601) 928-4422

Lambert, John
P.O. Drawer 328
Sumrall, MS 39482
(601) 758-4970

Lane, Dennis
US Army - Ft. Stewart
DPW-ENRD Forestry
Ft. Stewart, GA 31314-5000

Lang, Tom
AL Forestry Commission
7575 Alabama Hwy. 22
Selma, AL 36701

Larimore, Robert
US Army - Ft. Benning
ATZB-PWN-R
Ft. Benning, GA 31905
(706) 544-7319

Larson, Jessica
Larson & McGowin, Inc.
P.O. Box 2143
Mobile, AL 36652
(334) 438-4581

Larson, Keville
Larson & McGowin, Inc.
P.O. Box 2143
Mobile, AL 36652
(334) 438-4581

Laterza, Ken
Stephen F. Austin State Univ.
P.O. Box 6109, SFA Station
Nacogdoches, TX 75962

Ledbetter, Wendy
The Nature Conservancy of TX
P.O. Box 909
Silsbee, TX 77656
(409) 385-0445

Lewis, Dave
Southern Forestry Consultants, Inc.
105 W. Anderson Street
Monticello, FL 32344
(904) 997-6254

Lewis, Lisa
USDA Forest Service
P.O. Box 248
Wiggins, MS 39577
(601) 928-4422

Lindauer, Charles
University of South Alabama
307 University Blvd.
Mobile, AL 36688-0002
(334) 460-6356

Lindeman, Stephen
Tall Timbers Research, Inc.
Route 1, Box 678
Tallahassee, FL 32312
(904) 893-4153

Lint, John
Conecuh National Forest
Route 5, Box 157
Andalusia, AL 36420
(334) 222-2555

Lippincott, Carol
University of FL - Botany Dept.
209 NE Blvd., #8
Gainesville, FL 32601-3424
(352) 373-2309

Luce, Dwain
Luce Packaging Company
P.O. Box 1157
Mobile, AL 36633
(334) 343-3311

Luce, Greg
Luce Packaging Company
P.O. Box 1157
Mobile, AL 36633
(334) 343-3311

Lyda, Steve
AL Forestry Commission
1070 Schillinger Road
Mobile, AL 36608

Maceina, Nellie
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 844-1005

Mahler, Larry
USDA Forest Service
P.O. Box 426
Laurel, MS 39441
(601) 428-0594

Maitland, John
US Army - Ft. Jackson

Matthews, Amelia
P.O. Box 1
Nashville, GA 31639
(912) 686-2113

Matthews, Joe
P.O. Box 1
Nashville, GA 31639
(912) 686-2113

Maxime, David
Mobile County School System
504 Government Street
Mobile, AL 36602
(334) 690-8090

May, Allen
The Nature Conservancy of LA
340 St. Joesph
Baton Rouge, LA 70802
(504) 338-1040

McCoy, Robin
Georgia-Pacific Corporation
Hwy. 15 North
Richton, MS 39476
(601) 788-6383

McDonald, Lynn
USDA Forest Service
P.O. Box 227
Hemphill, TX 75948
(409) 787-3870

McIlwain, James
USDA Forest Service
1001 North Street
Talladega, AL 35160
(205) 362-2909

McInnis, Nelwyn
The Nature Conservancy
P.O. Box 4125
Baton Rouge, LA 70821
(504) 338-1040

McKee, H. Leon
Molpus Forest Products
584 Main Street
Philadelphia, MS 39350
(601) 656-1291

McMahon, Charles
USDA Forest Service
DeVall Drive
Auburn University, AL 36849
(334) 826-8700

McNeel, Joe
Gulf Lumber Company
300 Cameron Court
Daphne, AL 36526
(334) 621-8267

McWhorter, Ike
The Nature Conservancy of TX
P.O. Box 909
Silsbee, TX 77656
(409) 385-0445

Mead, Chris
AL Forestry Commission
P.O. Box 687
Geneva, AL 36340
(334) 684-2876

Means, Bruce
Florida State University
Dept. of Bio. Science
Tallahassee, FL 32303

Megalos, Mark
NC State University
Box 8003 - NCSU
Raleigh, NC 27695
(919) 515-5518

Megginson, Brett
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 844-1020

Meldahl, Ralph
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 884-1060

Mitchell, Bob
Jones Ecological Res. Ctr
Route 2, Box 2324
Newton, GA 31770
(912) 734-4706

Moore, Julie
MS Natural Heritage Program
DDW-E Camp Shelby, Bldg. 6
Camp Shelby, MS 39407
(601) 558-2894

Morris, Robert
26159 Wolf Bay Circle
Orange Beach, AL 36561
(334) 981-4961

Moser, W. Keith
Tall Timbers Research Station
Route 1, Box 678
Tallahassee, FL 32312
(904) 893-4153

Musselman, Lytton
Blackwater Ecological Preserve
Old Dominion Univ - Bio. Sci.
Norfolk, VA 23529-0266
(757) 683-3595

Myers, Ronnie
MS Forestry Commission
301 N. Lamar Steet
Jackson, MS 39201
(601) 359-1386

Neal, Don
USDA Forest Service
P.O. Box 248
Wiggins, MS 39577
(601) 928-4422

Nelson, Larry
Clemson University
272 E. Lehotsky Hall
Clemson, SC 29634
(864) 656-4866

Nevels, Don
MS Forestry Commission
301 N. Lamar Street
Jackson, MS 39201
(601) 359-1386

O'Meara, John
FL Div. of Forestry
3125 Conner Blvd.
Tallahassee, FL 32399-1650
(904) 488-8180

Omans, Jim
US Marine Corps
Headquarters, 2 Navy Annex
Washington, DC 20380-1775
(703) 696-0865

Outcalt, Kenneth
USDA FS Southern Res. Sta.
320 Green Street
Athens, GA 30602
(706) 546-2441

Ozier, Jim
Georgia DNR
116 Rum Creek Drive
Forsyth, GA 30209
(912) 994-1438

Pancake, Dale
Solon Dixon Forestry Ed. Ctr.
Route 7, Box 131
Andalusia, AL 36420
(334) 222-7779

Pecot, Stephen
Jones Ecological Res. Center
Route 2, Box 2324
Newton, GA 31770
(912) 734-4706

Pershke, Lee
DuPont
Route 6, Box 215A
Killen, AL 35645

Petrick, Carl
Eglin AFB Natural Resources
501 DeLeon Street
Eglin AFB, FL 32542-5133
(904) 552-4164

Phernetton, Ronald
US Fish & Wildlife Service
Route 2, Box 3330
Folkston, GA 31537
(912) 496-7366

Pohl, Russ
GA Forestry Commission
5645 Riggins Mill Road
Dry Branch, GA 31020

Pouncey, Rich
Longleaf Foresters, Inc.
192 Deer Ridge Trail
Tallahassee, FL 32312
(904) 893-3293

Powell, Allen
Georgia-Pacific Corporation
P.O. Box 555
Taylorsville, MS 39168
(601) 785-4721

Pritchett, George
HC 34, Box 137
Evergreen, AL 36401
(334) 578-2303

Pritchett, Lisa
HC 34, Box 137
Evergreen, AL 36401
(334) 578-2303

Pryor, W.L.
Stormy Branch Nursery
P.O. Box 91
Bellville, GA 30414
(912) 739-4709

Purcell, Jerry
US Army - Ft. Stewart
DPW-ENRD Forestry
Ft. Stewart, GA 31314-5000
(912) 767-2383

Rainwaters, E.L.
c/o James R. Fincher
450 Stateline Road
Wilmer, AL 36587
(601) 641-3930

Ranalet, Peter
International Forest Seed Co.
P.O. Box 7909
Macon, GA 31209
(912) 994-2944

Rayamajhi, Jyoti
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 844-1004

Reinman, Joe
US Fish & Wildlife Service
P.O. Box 68
St. Marks, FL 32355
(904) 925-6121

Rice, Charles
Forest Owners, Inc.
P.O. Box 850
Purvis, MS 39475-0850
(601) 794-2010

Rice, Tim
Fort McClellan
ATZN-EM/Directorate of Environ.
Ft. McClellan, AL 36205

Richardson, Beth
Clemson Univ/Coop Exten Serv
P.O. Drawer 1206
Orangeburg, SC 29116-1206
(803) 534-6280

Roach, Edwin
US Fish & Wildlife Service
P.O. Drawer 1190
Daphne, AL 36526
(334) 441-5181

Roberts, Scott
Mississippi State University
Box 9681
Mississippi State, MS 39762
(601) 325-3044

Robertson, Kenny
SC Forestry Commission
Route 3, Box 13-A
Chesterfield, SC 29709
(803) 623-2188

Robinson, David
Carolina Sandhills Refuge
Route 2, Box 330
McBee, SC 29101
(803) 335-8401

Routhier, Rob
F & W Forestry Services, Inc.
1310 W. Oakridge Drive
Albany, GA 31707
(912) 883-0505

Sabine, John
Sabine & Waters, Inc.
311 N. Magnolia Street
Summerville, SC 29483
(803) 871-5383

Savery, Scott
Florida Park Service
550 Wakulla Park Drive
Wakulla Springs, FL 32305
(904) 922-3633

Schmidtling, Ron
USDA Forest Service
23332 Hwy. 67
Saucier, MS 39560
(601) 832-2747

Schultz, Randy
Kimberly Clark
163 Ridgewood Drive
Daphne, AL 36526
(334) 621-4193

Seiber, Stephen
Eglin AFB Natural Resources
501 DeLeon Street
Eglin AFB, FL 32542-5133
(904) 882-4164

Simmons, Terrell
Simmons Tree Farm
Route 1, Box 56
Denton, GA 31532
(912) 375-7520

Smalley, D.G.
109 Parks Ridge
Dublin, GA 31021
(912) 272-0327

Smalley, Nell
109 Parks Ridge
Dublin, GA 31021
(912) 272-0327

Smiley, Robert
USDA Forest Service
P.O. Box 227
Hemphill, TX 75948
(409) 787-3870

Smith, Latimore
LA Dept. of Wildlife & Fish
P.O. Box 98000
Baton Rouge, LA 70898

Smith, Pete
Texas Forest Service
Texas Forest Service
College Station, TX 77843-2136
(409) 845-2641

Smith, Robert
Jones Ecological Res. Ctr.
Route 2, Box 2324
Newton, GA 31770
(912) 734-4706

Stark, Rod
Superior Forestry Service, Inc.
P.O. Box 25
Tilly, AR 72679
(501) 496-2442

Stine, Mike
Louisiana State University
School of Forestry Wildlife & Fish
Baton Rouge, LA 70803
(504) 388-4137

Streich, Jonathan
The Nature Conservancy
1401 Peachtree St., Suite 236
Atlanta, GA 30309
(404) 873-6946

Streng, Donna
Tall Timbers Research Station
Route 1, Box 678
Tallahassee, FL 32312
(803) 881-9921

Studenmund, Rick
The Nature Conservancy
P.O. Box 393
Bristol, FL 32321
(904) 643-2756

Sullivan, Lynn
AL Forestry Commission
P.O. Box 267
Chatom, AL 35518

Sutton, Matthew
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418

Swift, J.B.
Swift Lumber
Route 4, Box 5
Atmore, AL 36502

Sword, Mary
USDA FS Southern Res Sta
2500 Shreveport Hwy.
Pineville, LA 71360

Taylor, Gary
Conecuh National Forest
Route 5, Box 157
Andalusia, AL 36420

Thompson, Emmett
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 844-1007

Thompson, Larry
GA Forestry Commission
5645 Riggins Road
Dry Branch, GA 31020

Thompson, Lester
P.O. Box 2066
Moultrie, GA 31776
(912) 985-2424

Thompson, Mike
NC Div. of Forest Resources
P.O. Box 29581
Raleigh, NC 27626-0581
(919) 733-2162

Thurmond, Dagmar
USDA FS Shoal Creek RD
450 Highway 46
Heflin, AL 36264
(205) 463-2273

Thurmond, Jeffrey
USDA NRCS
311 Airport Road
Pearl, MS 39208
(601) 965-4559

Tomczak, Donald
USDA Forest Service
1720 Peachtree Rd. NW, #811
Atlanta, GA 30367
(404) 347-3551

Turner, Rick
The Nature Conservancy
P.O. Box 909
Silsbee, TX 77656
(409) 385-0445

Valenta, John
NW FL Water Mgt. Dist.
Route 1, Box 3100
Havana, FL 32333
(904) 539-5999

Wade, Dale
US Forest Service
Route 1, Box 182-A
Dry Branch, GA 31020

Waldrop, Pat
AL Forestry Commission
32760 State Hwy. 59
Loxley, AL 36551

Warren, Sarah
U.S. Forest Service
100 Campbell Hall
Tuskegee University
Tuskegee, AL 36088
(334) 727-8131

Weaver, Earl
Huxford Trust
P.O. Box 901
Brewton, AL 36426
(334) 867-9772

Weekley, Ernest

Wehrle, Brett
US Fish & Wildlife Service
P.O. Drawer 1190
Daphne, AL 36526
(334) 441-5181

Wheaton, Kimberly
The Nature Conservancy-SERO
101 Conner Drive, Suite 302
Chapel Hill, NC 27514
(919) 967-5493

Williams, Roger
Louisiana Tech University
P.O. Box 10138T.S.
Ruston, LA 71272
(318) 257-4020

Willingham, Tracey
Georgia-Pacific Corporation
Hwy. 15 North
Richton, MS 39476
(601) 788-6384

Wilson, Bruce
USDA Forest Service
P.O. Box 248
Wiggins, MS 39577
(601) 928-4422

Wilson, Carlos
Jones Ecological Res. Ctr.
Route 2, Box 2324
Newton, GA 31770
(912) 734-4706

Wilson, Howard
P.O. Box 2245
Daphne, AL 36526
(334) 626-5834

Winn, John
Longleaf Ecology & Forestry Soc.
Route 1, Box 479
Waldo, FL 32694
(352) 468-1669

Wright, William
W.M. Wright & Company
P.O. Box 755
Jackson, AL 36545
(334) 246-9469

Wuichet, John
US Army
430 10th St. NW, Suite S-206
Atlanta, GA 30318
(404) 892-3099

Zhang, Daowei
AU - School of Forestry
108 M. White Smith Hall
Auburn University, AL 36849-5418
(334) 844-1067

INDEX OF AUTHORS

Achtemeier, G.L.: 39
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