Proceedings of the Fourth Longleaf Alliance Regional Conference

Longleaf Alliance Report No. 6
July 2003

Longleaf Pine: A Southern Legacy Rising From the Ashes

November 17 - 20, 2002
Pine Needles & Mid Pines Resort
Southern Pines, North Carolina

www.longleafalliance.org
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This conference would not be possible without the financial support of the following organizations:

Auburn University School of Forestry & Wildlife Sciences
DuPont
Joseph W. Jones Ecological Research Center
North Carolina Division of Forest Resources
US Fish & Wildlife Service
USDA Forest Service

The Longleaf Alliance appreciates the generous support of these organizations.

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FOREWARD

Dean Gjerstad, Co-Director, The Longleaf Alliance

The theme of the Fourth Regional Longleaf Alliance Regional Conference was *Longleaf Pine: A Southern Legacy Rising from the Ashes*. This premise acknowledges the growing interest in fire as related to longleaf and its associated ecosystems by private landowners, conservation groups and organizations and many state and federal agencies. This proceeding contains a compilation of papers and posters presented at the conference addressing specific subject matter topics involving the restoration and management of longleaf pine ecosystems to include silvicultural, ecological, social, political and economic challenges.

The Fourth Longleaf Alliance Regional Conference held at Pine Needles & Mid Pines Resort in Southern Pines, North Carolina continued the superlative standard set by previous conferences. Southern Pines is located in the sandhills of North Carolina and the surrounding longleaf forests represent what is now the extreme northeasterly range of the ecosystem. Longleaf remains prominent in this area for reasons that vary with ownership. The US Army’s Fort Bragg prefers longleaf because it can tolerate frequent fires and the open forests are preferred for troop training exercises. The numerous golf resorts in the area retained natural longleaf stands along and between their fairways. State lands like the Sandhills Gamelands are refugia for fauna and flora once common to this region. And the private sector prefers longleaf for its quality products including a burgeoning pine straw industry. Some 291 attendees were treated to 3 days of interactions with experts on all aspects of longleaf plus exemplary food and entertainment. Fourteen invited papers were presented on topics related to silviculture, ecology, fire, social, political and economic issues. The poster session was the largest and best ever (67 posters) covering a multiplicity of longleaf issues. Numerous positive comments were received on the outstanding quality of the posters. On a beautiful sunny day, a field day was held at two sites representing public and non-industrial landowner management and recovery objectives. Topics on the field trip included timber management, understory plants, fire, pine straw management and harvesting, wildlife, restoration and management, T&E species, vegetative management, container seedlings and tree planting.

The regional conferences would not be possible without the dedicated work of many individuals. I estimate that more than two dozen individuals played a significant role in making the conference a success. Although I will likely overlook individuals that provided important contributions, the following were of particular note. A special thank you goes to Susan Moore, Director of Educational Outreach in the Department of Forestry at North Carolina State University, and her able assistant Becky Bowers, our most capable conference coordinators, who spent countless hours to ensure the success of the conference. Thanks also go to many individuals with North Carolina Division Forest Service with leadership provided by Bill Pickens and Mac McDougald who work tirelessly on the field trip arrangements. Of particular note are Terry Sharpe and Bill Parsons at Sandhills Gamelands who hosted the public portion of the field trip and Jim Gray who made our visit to the Blue Farm possible. In addition, we appreciate the assistance of Nell Allen, Warren Boyette, Bruce Cunningham, Rick Hamilton, Mary Scott Harrison, Mike Kelly, Chris Moorman, Rick Studenmund and our own staff including Stephen Hudson, Sandy Harris, and Vickie Stallings. Special thanks go to John Kush who has been a noteworthy contributor to all of our conferences. John organized the Poster Session, helped with audio-visual setup and coordinated publication of the Program and Abstracts for the conference as well as these proceedings.

We extend a very special thank you to Mrs. Sandra Wallace and her son Charlie Wallace for generously permitting the conference to use Wallace Lodge for lunch and dinner on the field day. Wallace Lodge was a perfect locale for our conference as it is located in a forested setting in rural Scotland County. The evening festivities included a social with samplings of Yeungling beer, various wines, and a North Carolina Pig Pickin’. A trio of musicians lead by Marvin Gaster, a renowned old time banjo player, entertained us with a repertoire of eastern North Carolina music.
Highlights of the Longleaf Alliance

- The Longleaf Alliance was established in October 1995
- Staff: Rhett Johnson & Dean Gjerstad, Co-Directors; Mark Hainds, Research Coordinator; John McGuire, Outreach Coordinator; Part-Time staff: Vickie Stallings and Alison Mason
- Mission: Promote the ecological and economic values of longleaf forests
- Board of Directors: Wayne Bell, Lindsay Boring, Frank Cole, Keville Larson, Ronnie Haynes, Greg Luce, Charles McMahon, Julie Moore and Charley Tarver
- Grassroots partnership of people and organizations throughout the longleaf range
- Primarily an outreach and applied research organization
- Approximately 730 individuals and organizations are members of the Alliance
- The entire operating budget is generated from membership fees, workshops and grants
- Current Initiatives: K-12 education on longleaf; plantation growth & yield; artificial regeneration; fuel management; landowner assistance programs; longleaf nurseries; organize and conduct numerous workshops and conferences

For more information on the Longleaf Alliance as well as information on longleaf and its ecosystems, visit our web page at: http://www.longleafalliance.org/
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Fourth Longleaf Alliance Regional Conference

Schedule of Events/Agenda

Pine Needles/Mid-Pines Resort in Southern Pines, North Carolina

Sunday, November 17

Longleaf Alliance Field Tour for Landowners: A field tour of the Blue Farm in Hoke Country, North Carolina was provided for landowners interested in management of longleaf pines. Participants met at Weymouth Woods Sandhills Nature Preserve in Southern Pines.

5:30 – 7:00 Ice Breaker/Poster Session at the Reception Center, Pine Needles

Monday, November 18 (All sessions will be at the Reception Center, Pine Needles)

7:30 – 9:00 Registration

8:30 Welcome – Dean Gjerstad, Mike Thompson, Dick Brinker

9:00 Keynote Speaker – “Cultural History of the Longleaf Forest in the Carolinas – Past and Present” – Larry S. Earley

9:45 Break

10:15 “Carolina Sandhills and Carolina Bays – Unique Features in the Longleaf Forest” – Bruce A. Sorrie

11:00 “State of the Longleaf Alliance” – Dean Gjerstad

11:30 Lunch at Mid-Pines and Pine Needles

Monday Afternoon, November 18 (Reception Center, Pine Needles)

1:00 Plenary Session I – Ecological Facets of the Longleaf Ecosystem

Moderator: Sharon Hermann, Auburn University


➢ “Amphibians and Reptiles Associated with the Longleaf Pine Ecosystem” – Alvin Braswell, Director, Research Laboratory & Curator, Herpetology, NC Museum of Natural Sciences

➢ “Plant Communities Across the Sandhills Ecotype” – Joan Walker, Research Plant Ecologist, US Forest Service, Clemson, SC

➢ “Restoration Practices for Understory Communities” – Kay Kirkman, JW Jones Ecological Research Center

3:00 Break

Monday Afternoon, November 18 (Reception Center, Pine Needles)

3:30 Plenary Session II – Managing Longleaf Pine Forests

Moderator – Bill Pickens, North Carolina Division of Forest Resources

➢ “Old Field Regeneration Techniques” – Mark Hainds, The Longleaf Alliance
“Mid-Rotation Stand Management on Public Lands” – John McGuire, The Longleaf Alliance

“Mid-Rotation Stand Management on Private Lands” – L. Keville Larson, Larson & McGowin, Inc.

“Pine Straw Management 101” – Rick Hamilton, North Carolina State University

5:30 Adjourn

6:00-7:30 Social/Poster Session, Reception Center, Pine Needles

Tuesday, November 19

8:00 Depart by bus for Field Trip from Reception Center, Pine Needles
Note: One-half day will be spent at each field site with lunch provided at Wallace Lodge.

Sandhills Gamelands (Public Land)

Station 1 — Prescribed Fire, Bill Parsons & Norman Lantz
Station 2 — Wildlife Management, Lincoln Sadler & Alan Schultz
Station 3 — Plant Ecology in Sandhills, Bruce Sorrie & Janet Gray
Station 4 — Local History of NC Sandhills, Joe McDonald & Terry Sharpe
Station 5 — RCW and Songbird Ecology and Management, Brady Beck & Jeff Marcus
Station 6 — Posters and Management Tools Display (near buses)

Blue Farm (Private Land)

Station 1 — Blue Farm History, Naval Stores, Timber Cruise, Jim Gray
Station 2 — RCW Management and regulatory guidelines, safe harbor program, cost-share programs, Pete Campbell & John Ann Shearer
Station 3 — Intermediate stand management, stocking guidelines, competition control w/ herbicides and prescribed burning, Bill Pickens & Jim Smith
Station 4 — Pine straw raking, hand baler and rakes, mechanical baler and rakes, herbicides and fertilizers, Mark Megalos
Station 5 — Natural regeneration of longleaf pine, wiregrass seed collection, fire impacts, Rick Studenmund, Terry Severson & Rick Hamilton
Station 6 — Longleaf planting equipment and techniques, Mark Hainds & Jim Schlenker

5:00 PM Social and Pig Pickin’ Dinner at Wallace Lodge

8:00 PM Return to Mid Pines

Wednesday, November 20 (Reception Center, Pine Needles)

8:00 Plenary Session III – The Economic Argument for Longleaf Pine
Moderator – Terry Sharpe, NC Wildlife Resources-Sandhills Game Land

➢ “Cost Benefit Analysis of Prescribed Fire” – Frank Cole & Sue Grace
➢ “Longleaf as an Investment: An Institutional Investor’s Viewpoint” – Jon Caulfield, TimberVest, LLC.
➢ “Longleaf as an Investment: A Private Landowner’s Viewpoint” – Charley Tarver, Forest Investments Associates

10:00 Break

10:30 Plenary Session IV – Partnerships in Action
Moderator – Rhett Johnson, The Longleaf Alliance
“Sandhills Conservation Group” – Rick Studenmund, The Nature Conservancy
“LLA/GFC/USFWS/FLO” – Rick Hatten, Georgia Forestry Commission
“Sandhills Primary School” – Bruce Cunningham, Cunningham, Dedmond, Peterson & Smith, L.L.P. & Mary Scott Harrison, Principal, Southern Pines Primary School

11:45  Conference Wrap-up & Adjourn Conference – Rhett Johnson

1:00  Post-meeting tour at Southern Pines Primary School. All are invited to participate in a 30-minute tour led by school children of a most unique school playground that has the longleaf ecosystem plus other ecological aspect incorporated into it. Directions will be provided at the registration desk.

Special Additional Symposium

1:30  Grassland/Longleaf Ecosystem Bird Workshop – Pine Needles Reception Center, Wednesday, November 20

Moderator: Todd Engstrom, Greenwood Plantation, Thomasville, GA, TNC

- “Priority Birds and Ecological Issues in Longleaf Ecosystems” – Chuck Hunter, USF&WS
- “Relationships between Bachman’s and Henslow’s Sparrows and Prescribed Fire in Longleaf Grasslands” – James Tucker, Auburn University
- “Wet Savannahs, Fire, Grassland Birds and Sandhill Cranes” – Tracy Grazia, USF&WS – Mississippi Sandhill Crane Refuge
- “Bobwhite Quail and Fire in Longleaf Ecosystems” – Adam Hammond, GA DNR
- “Understory Restoration and Songbird Communities in a Longleaf Forest” – Brandon Rutledge, J.W. Jones Ecological Research Center

“North Carolina’s Cooperative Upland Habitat Restoration Enhancement Program” – Jeff Marcus, North Carolina Wildlife Resources Commission
SHORT TERM EFFECT OF PRESCRIBED BURNING ON SOIL CARBON EFFLUX

Peter H. Anderson (USDA, US Forest Service, Research Triangle Park, NC 27709)
Susan Cohen (USDA, US Forest Service, Research Triangle Park, NC 27709)

ABSTRACT: The use of prescribed burning as a management tool is well established in pine forests of the southern United States. Changes in species composition, soil organic matter, and microbial populations due to fire may result in changes in carbon dioxide flux rates. The purpose of this study was to look at the effect of burning on soil CO$_2$ efflux in longleaf pine (*Pinus palustris* Mill.) stands and at environmental conditions that may control soil CO$_2$ efflux. Study sites are located on the Croatan National Forest, Carteret County, NC and stand age ranged from 70 to 100 years. For the past 20 years, these sites have been winter burned every 2-4 years. Two treatments were established where trees of similar diameter (n=15) were selected on plots that were burned in February 2002 and were not burned (control). Measurements were taken on 5 days from October 24, 2001 and May 10, 2002. Soil carbon efflux was measured at 30 cm and 1 m from the base of each tree. In addition, we collected soil temperature, CO$_2$ concentration, and soil moisture at 15 cm below the surface. Prescribed burning had no significant effect on soil CO$_2$ efflux. Soil CO$_2$ concentrations were higher on burned plots 3 days after burning but were similar to controls thereafter. Soil temperature and soil CO$_2$ concentration at 15 cm were positively correlated with soil efflux ($r^2 = 0.63$ and $0.54$ respectively). This suggests that prescribed burning may increase soil CO$_2$ concentrations but have little effect on diffusion to the atmosphere over a short time period. Longer term results of prescribed burning effects on soil CO$_2$ efflux such as changes in population density, distribution of above ground species and changes in soil properties are currently being studied.
TEMPERATURE EFFECT ON LONGLEAF PINE SEED GERMINATION IN NURSERY

Jill R. Barbour (USDA Forest Service, National Tree Seed Laboratory)
Kathy Holston (USDA Forest Service, National Tree Seed Laboratory)
Rose Eckhart (USDA Forest Service, National Tree Seed Laboratory)

ABSTRACT: Longleaf Pine seeds were planted weekly over a ten-week period from March 22 to May 31, 2001 in a container nursery in middle Georgia. The original laboratory germination was 97%. Ambient air temperatures were recorded every 30 minutes by a Hobo temperature monitor at the planting site. When longleaf pine seeds were planted late March and early April the germination was in the 90 percentile and average air temperatures were below 69°F. Planting the latter half of April decreased germination from 90+% to 75% when average temperatures exceeded 69°F for a period of one or more weeks. Delaying seed planting until May resulted in the germination dropping to 47%; average air temperatures were in the 70’s. It is imperative that longleaf pine seeds be planted as early as possible in the spring. Cool temperatures will not harm the seed; warm temperatures will decrease germination drastically. Delayed planting puts your investment at risk. An example: if costs are: $110/M x 5M seedlings/lb = $550.50/lb of seed. However, you only get 47% germination: $110/M x 5M x 0.47 germ = $258.50/lb of seed; this results in a loss of $292.00. By planting longleaf pine seed early, the seedlot has a better chance of reaching the seed’s germination potential, which was 97%, as measured by the laboratory germination test.

INTRODUCTION

Germination problems with longleaf pine seed can affect the container nursery manager’s ability to make a profit and remain in business; therefore, it is crucial that the optimum sowing date be established. It is possible that many of the germination failures with longleaf pine seed could be due to a late sowing date. The optimum laboratory germination temperature is 68°Fahrenheit (20°Celsius).

This study was designed to investigate the optimum field temperature for sowing longleaf pine seed in a container nursery and indirectly compare it with laboratory temperature.

MATERIALS AND METHODS

Longleaf pine seeds were planted weekly over an 8-week period from March 22 to May 10, 2001 in a container nursery in middle Georgia. The irrigation pipes were frozen until the third week of March which precluded sowing earlier. The original laboratory germination was 97%. The seed was soaked for 10 minutes in Benlate® solution (19 grams per gallon) before planting. Ten plastic containers containing 45 cells each were planted each week with 1 seed per cell. Colored tags attached to the containers were utilized to distinguish the weeks. Trees were subjected to normal nursery procedures relative to soil media, irrigation and fertilization. Rainfall was not recorded. Germination counts were taken weekly until May 31, 2001.

A portable Hobo temperature monitor was placed on a pole next to the containers to record ambient air temperatures every 30 minutes. Daily ambient air temperature was determined by averaging the maximum temperature and minimum temperature each day. Daily averages were added to calculate a weekly average. Temperatures were not recorded between March 28 to April 12 by the Hobo monitor so Macon airport maximum and minimum temperatures were regressed with nursery maximum and minimum temperatures to fill in the data. The R square was 0.70.

The experiment was laid out as a completely randomized design. Each tray was a replication with 45 holes each. Ten trays per week were sown for a total of 450 seeds. Excel regression and SAS® software was used for statistical analysis (Table 2). Repeated measures analysis was performed on weekly data with the Wilks’ Lambda F statistic used to determine significance. The germination curves were best explained by a logarithmic equation which when used in nonlinear regression created 8 sigmoidal curves.
Percent germination = b1 / [1 + b2 x exp(b3 x week)]

Several container longleaf nurseries were queried concerning costs and an approximate cost of $110 per thousand seedlings was determined. All calculations and charts are based on that figure.

RESULTS

Maximum field germination was 94% and the lowest final germination was 47%. Laboratory germination was 97%. Maximum field germination was achieved in 5 weeks (Table 1). There was a rapid rise in germination the third week after sowing then the germination increased slowly until it leveled off (Figure 1).

When longleaf pine seeds were planted late March and early April the germination was in the 90 percentile and average air temperatures were below 69°F. Early planting created a prechilling effect. There was a spike in temperature between April 5th and April 12th that resulted in an increase in germination from 0% to 91% (Table 1). Planting the latter half of April decreased germination from 90+% to 75% when average temperatures exceeded 69°F for a period of one or more weeks. Delaying seed planting until May resulted in the germination dropping to 47%; average air temperatures were in the 70’s F (Figure 3).

An inverse relationship exists between germination and temperature (Figure 1): as temperature increases germination decreases. Warmer temperatures increase rate of germination but reduce total germination (Figure 3). The root mean square error increased as the temperature rose and the R^2 decreased showing that there was more variation around the mean maximum germination (Table 2).

Delayed planting puts your investment at risk. A one-week delay could be the difference between profit and loss. As the total germination decreases the costs rise.

A total cost figure of $110 per thousand seedlings was used to figure the costs by planting date (Figure 2). The March sowing date costs were $118 per thousand seedlings compared to the last sowing date, May 10th when costs soared to $234 per thousand. If the retail price for seedlings was $150 per thousand, then costs would exceed price when the sowing date was delayed until the 4th week of April. A lower price such as $125 per thousand would require a sowing date no later than the 2nd week of April to breakeven. A lower selling price requires an earlier sowing date to make a profit.

DISCUSSION

Ambient air temperature can be controlled by planting earlier in the sowing season in containerized nurseries. The best time to plant is when minimum temperatures are above freezing and average temperatures are close to 70°F. The exact sowing dates need to be determined by the owner at each nursery location. The farther south the nursery’s location the earlier should be the sowing date to achieve the desired temperature.

By planting longleaf pine seed early, the seedlot has a better chance of reaching the seed’s germination potential as measured by a laboratory germination test. Longleaf pine seed cannot tolerate high temperatures during germination and should be planted earlier than loblolly pine and slash pine seed.

The optimum laboratory germination of 68°F appears to be close to the optimum in the nursery. Longleaf pine seeds have a soft seedlot which makes them very susceptible to fungi. High temperatures promote the growth of fungi on the seed and hinder germination in the laboratory and at the nursery.
Table 1.

<table>
<thead>
<tr>
<th>COLOR</th>
<th>P1= date planted</th>
<th>WEEKNLY TEMPERATURES</th>
<th>(\text{AVERAGE})</th>
<th>(\text{MAXIMUM})</th>
<th>(\text{MINIMUM})</th>
</tr>
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<tbody>
<tr>
<td>Yellow P1</td>
<td>3/22 0 0 91 92 93 94 93 93 93 93</td>
<td>54 59 62 69 72 73 76 76 75</td>
<td>68 70 92 90 87 91 90 93 89 89</td>
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</tr>
<tr>
<td>White P</td>
<td>3/28 0 58 76 87 94 93 94 94 93</td>
<td>54 59 62 69 72 73 76 76 75</td>
<td>68 70 92 90 87 91 90 93 89 89</td>
<td>41 47 62 49 52 53 57 59 63 62</td>
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<tr>
<td>Pink P</td>
<td>4/5  P 0  3 44 72 79 81 82 82</td>
<td>54 59 62 69 72 73 76 76 75</td>
<td>68 70 92 90 87 91 90 93 89 89</td>
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<tr>
<td>Green P</td>
<td>4/12 P 0  29 77 84 88 89 89</td>
<td>54 59 62 69 72 73 76 76 75</td>
<td>68 70 92 90 87 91 90 93 89 89</td>
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<tr>
<td>Red P</td>
<td>4/19 P 0  5 63 72 76 76</td>
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<td>Orange P</td>
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<tr>
<td>Blue P</td>
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<td>54 59 62 69 72 73 76 76 75</td>
<td>68 70 92 90 87 91 90 93 89 89</td>
<td>41 47 62 49 52 53 57 59 63 62</td>
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</tr>
<tr>
<td>Yel/White P</td>
<td>5/10 P 0  31 47</td>
<td>54 59 62 69 72 73 76 76 75</td>
<td>68 70 92 90 87 91 90 93 89 89</td>
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Table 2.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Average Max. Germination</th>
<th>Root mean square error</th>
<th>(R^2)</th>
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<td>7.34</td>
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<td>88</td>
<td>6.52</td>
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<td>April 19, 2001</td>
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<td>8.58</td>
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<tr>
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<td>May 10, 2001</td>
<td>49</td>
<td>10.02</td>
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Figure 1.

**2001 Longleaf Pine Seed Nursery Temperature Study**

**Final Germination by Week Planted**

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<th>Week Planted</th>
<th>Final Germination</th>
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<td>4/4</td>
<td>82</td>
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<td>4/11</td>
<td>89</td>
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<td>4/18</td>
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<td>5/2</td>
<td>76</td>
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<tr>
<td>5/9</td>
<td>76</td>
<td></td>
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</tbody>
</table>

- Final Germination (Y1)
- Average Temperature (Y2)

Figure 2.

**Seedling Costs Associated with Sowing Date**

Based on seedling cost - $110 per thousand

<table>
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<tr>
<th>Sowing Date</th>
<th>Costs per thousand trees</th>
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<td>$110</td>
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<tr>
<td>5/2</td>
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<tr>
<td>5/9</td>
<td>$250</td>
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ABSTRACT: The demand for container longleaf pine (*Pinus palustris* Mill.) planting stock continues to increase. A problem facing both producers and users of container seedlings is the lack of target seedling specifications. Outplanting and evaluating performance of seedlings with a range of physiological and morphological characteristics, over a number of years, and on a wide range of sites is needed to have sufficient data to develop optimum seedling criteria. Since resources have been unavailable to conduct this needed research, we have canvassed the producers and users of longleaf container stock for their recommendations on what they consider “preferred” and “not acceptable” planting stock. The compilation of this information has been widely reviewed and all suggested revisions considered. These standards are proposed as guidance until research provides sufficient data to modify and upgrade the specifications.
EXAMINING THE CAVITY-NESTING BIRD COMMUNITY OF THE LONGLEAF PINE ECOSYSTEM: The Role of the Red-Cockaded Woodpecker

Lori A. Blanc (Department of Biology, Virginia Tech University, Blacksburg, VA 24061, USA; lbanc@vt.edu)
Jeffrey R. Walters (Department of Biology, Virginia Tech University, Blacksburg, VA 24061, USA; jrwalt@vt.edu)

ABSTRACT: A 4-year study on cavity-nesting birds and their relation to red-cockaded woodpecker (RCW) cavities is being conducted in the longleaf pine forests of Eglin Air Force Base, Florida. Twenty-seven vertebrate species are known to use RCW cavities. The prevalent use of these cavities by other species suggests that the RCW plays a vital role as the only excavator of cavities in living pines within the longleaf pine ecosystem. The goals of this study are to 1) determine if the abundance of cavity-nesting birds increases with increasing number of RCWs and 2) to evaluate the possible impacts of RCW management on other members of the cavity-nesting community. During the first two years of this study, I will measure the abundance of members of the cavity-nesting community in areas with and without RCWs, and relate abundance to numbers of RCWs, RCW cavities, and snags present. The resulting data will be used to examine potential direct and indirect interactions of the RCW with other members of the cavity-nesting community. During the last two years of the study, experimental manipulation using cavity provisioning and cavity restrictor plates will be used to evaluate the possible impacts of RCW management on other members of the cavity-nesting community. Preliminary results from the first year of this study, conducted from April through July 2002, will be presented in the poster.
A PIEDMONT TRANSITIONAL LONGLEAF LEGACY: Restorating with Residuals

Gary B. Blank (Box 8002 NC State University, Department of Forestry, Raleigh, NC 27695-8002; gary_blank@ncsu.edu; 919-515-7566 fax: 919-515-8149)

ABSTRACT: Across the historic range of Pinus palustris, along the eastern Piedmont in North Carolina, the species' current significant rarity resulted from clearing for cultivation and pasturage during the 18th and 19th centuries. Therefore, in this transitional zone today, few example longleaf sites remain, so discovery in 1987 of a tract where longleaf pines persisted within closed canopy forest prompted attention. The historical ecology project that emerged aimed to characterize the Piedmont transitional longleaf community, as it once existed and then to determine potential for a plant community restoration effort.

Botanical inventory revealed convergence of herbaceous species associated with either the Piedmont or Coastal Plain provinces, underscoring the site's transitional nature. Interpreting existing spatial vegetation patterns focused attention on areas of the tract where plant community conservation effort should be directed. So in the year 2000, a release harvest on 55 hectares exposed residual longleaf pines ranging from 50 to 100 years old. Subsequently introducing prescribed burning intends to foster longleaf regeneration and favor herbaceous species likely to have inhabited the site prior to original disturbance events and the later cessation of intermittent fires. Nearby a 19-hectare longleaf plantation in its third growing season demonstrates viability of the species on such sites under relatively intensive management. Altogether, the Harris Research Tract offers a chance to reaffirm the important complex of community interactions occurring within the realm of longleaf pine ecosystems.
VULNERABLE AMPHIBIANS AND REPTILES ASSOCIATED WITH THE LONGLEAF PINE ECOSYSTEM -- WITH COMMENTS ON MANAGEMENT STRATEGIES

Alvin Braswell (N.C. State Museum of Natural Sciences, 11 West Jones St., Raleigh, NC 27601)

When an ecosystem is endangered, many of the plants and animals that depend on that ecosystem become endangered. Ten amphibian and reptile species associated with the Longleaf Pine ecosystem in NC are listed as Endangered, Threatened, or of Special Concern by the State of North Carolina. Ten amphibian species that depend on ephemeral ponds (another much reduced habitat) in addition to the Longleaf Pine ecosystem fall into a double jeopardy trap. Knowledge of species' biological requirements can help guide management strategies designed to assist declining populations.

SUMMARY OF PRESENTATION

The Longleaf Pine ecosystem is an assemblage of communities, the characteristics of which are dependent on the history of a specific site and the various biotic and abiotic factors in play. More detailed information on the composition and location of Longleaf Pine communities in North Carolina can be found in Schafale (1994). Much change has occurred within the Longleaf Pine ecosystem since European colonization (Frost 1993). A healthy Longleaf Pine community can be tremendously diverse in both plant and animal species (Dodd 1995).

Many species of reptiles and amphibians are dependent on the Longleaf Pine ecosystem, and those with a strict dependence on this system have a status that mirrors the status of the ecosystem. Ten species of reptiles and amphibians associated with the Longleaf Pine ecosystem are listed by North Carolina as Endangered, Threatened, or of Special Concern (Table 1). Ten amphibians dependent on the system also fall into the double jeopardy category of also being dependent on ephemeral ponds -- a greatly reduced habitat. Distribution maps and help with identification of species can be found in Conant and Collins (1998) and Palmer and Braswell (1995).

Isolated, ephemeral wetlands can be quite important to the biological community (Moler and Franz 1987, LaClaire and Franz 1990). Two types of wetlands, sinks and depressions associated with underlying limestone along the coast and clay-based Carolina Bays on the inner Coastal Plain, provided most of the natural habitat for ephemeral pond breeding amphibians in southeastern North Carolina. Loss of this habitat type is hard to quantify because many sites fall below regulatory thresholds and accounting of destroyed or altered sites has not been done. Loss of natural-functioning, clay-based Carolina Bays may be greater than 90%. Protections for isolated wetlands also suffered from a recent Federal court ruling.

One example of a species associated with the Longleaf Pine ecosystem, and with ephemeral wetland habitats within that ecosystem, is the Carolina Gopher Frog, a Threatened species in North Carolina (Braswell 1993). This frog lives in woodlands and migrates to ephemeral pond breeding sites from February to April. It is a fish intolerant species, and requires ponds to retain water for about 4 to 5 months until tadpoles can complete metamorphosis. The strongest populations occur in areas having substantial acreages of the Longleaf Pine ecosystem and multiple ephemeral ponds within or immediately adjacent to woodland habitat. Separation of woodland habitat from breeding habitat increases the chance for mortality and local extinction, and decreases possibilities for recolonization.

Upland sites near breeding ponds not currently in Longleaf Pine stands, but that retain other components of that ecosystem are also important. The refuge and food that diverse herbaceous plant communities provide should be more important than the presence of a certain species of pine tree. One would therefore expect that habitat could remain suitable for the Gopher Frog if canopy openness, herbaceous diversity, and underground refugia are maintained at a high level when the Longleaf Pine is removed and replaced by another pine species.

Issues of diseases and declining amphibian populations continue to be the focus of considerable research. Daszak et al. (1999) provided an overview of this epidemic and make it clear that much still needs to be
learned. When trying to protect a given site, resource managers should bear in mind that the biologist is not
the only source of possible disease transfer. Any person, vehicle, piece of field equipment, various wildlife
species, and even wind, can carry contaminants. Some caution and preventative measures are clearly
needed, but maintaining low stress ecosystems with healthy animals may be what really is needed.
Protocols for preventing spread of diseases by biologists are available at:
http://www.jcu.edu.au/school/phmt/PHTM/frogs/prevent.htm and

Invasive species are another source of concern. Plant species like Phragmites and Giant Salvinia can
overwhelm pond habitats and alter them to a less suitable or undesirable condition. The effect of herbicides
on plant and animal communities is not well documented. Invasive animal species such as fire ants are
becoming an increasing source of concern with reptile and amphibian populations in the southeastern
United States and may be a significant cause of declines in some areas. Recently metamorphosed juvenile
amphibians likely are more vulnerable to the attack of fire ants than adults of most species. Fish invasions
of ephemeral wetlands may occur naturally, but ditching and fire line cutting frequently increase the
chances of connecting isolated wetlands to permanent streams.

As with other vertebrate species, habitat fragmentation poses a considerable threat to the Gopher Frog.
Disjunct habitats often expose animals to additional dangers of mortality. Because the Gopher Frog
migrates between terrestrial and breeding habitat, features such as roads and cleared fields greatly increase
risk. Habitat lost due to fragmentation reduces potential breeding sites and increases migration distances.
Fewer alternative breeding sites increase chances for local extinction. Because hydrology of ephemeral
ponds varies from year to year, and suitability of a particular pond for breeding may be good one year and
poor the next, areas with alternative breeding sites support the best remaining populations of the Gopher
Frog. In such sites the likelihood of at least one pond being suitable for breeding in most years is higher
than in places where only one breeding pond remains. While greater migration distances expose adults to
more hazards, they probably also decrease chances that recently metamorphosed juveniles will find suitable
terrestrial habitat in which to grow and mature.

Activities that reduce plant and insect diversity in an area probably are detrimental to the Gopher Frog's
food supply. Activities that disrupt the burrows these frogs live in, or change soil moisture, may be
detrimental. Maintenance of a relatively natural community structure near breeding ponds seems to be a
critical factor for Gopher Frog populations to persist.

Destruction of aquatic breeding sites also does not have to take the form of ditching and draining or filling
and paving. Lowering of the water table by well water withdrawal, or by ditching in the area of ponds, can
have the effect of sufficiently altering the hydrology of a breeding site to the point of destroying it
functionally. Any human activities that reduce water available to a breeding site tend to increase the
impact of natural droughts and promote succession of dry-land plants. Also, reduction of the influence of
groundwater as a buffering agent and increasing the influence of our typically more acidic rainwater may
be a critical factor in naturally acidic ponds that are near the tolerance limits of the Gopher Frog.

Activities that allow predatory fish access to normally isolated wetlands can destroy a breeding site for
fish-intolerant-species like the Gopher Frog. Also, introduction of fish by uninformed persons, however
innocent the intent, can be devastating. Temporary and semi-permanent ponds suitable for the Gopher Frog
typically dry out or dry down, respectively, some time during late summer or fall. This allows oxygenation
of the substrate that promotes decomposition of dead vegetation, and it greatly reduces or eliminates many
of the aquatic invertebrate predators that prey heavily on amphibian larvae. The end result of the drying
dout phase is a very productive pond with few predators when winter rains refill the site.

Acidic water is a problem in many ponds. Acid rain may be a factor; average pH of rainfall in the eastern
United States has dropped from about 5.6 to less than 4.7 (Mayer 1985). However, natural sources such as
acid soils and acid producing plants also contribute to pond acidification. The Gopher Frog's eggs and
 tadpoles seem to do best at a pH of 4.3 or above (Smith and Braswell 1994). These figures agree with
information from Florida (Richard Franz personal communication). A pH of 4.5 is generally considered a
cutoff below which most amphibians have trouble and above which most amphibians can tolerate. The 4.5 pH figure may be more accurate than 4.3 for low stress development of Gopher Frog eggs and tadpoles, but more research is needed to confirm that. Readings below 4.5 have been recorded in several ponds currently considered active breeding sites or that have supported Gopher Frog breeding in the past, and egg mortality possibly caused by acid water has been observed at a pH of 4.2 (Smith and Braswell 1994). Research has demonstrated that amphibian growth and/or survivorship can be inhibited by a variety of factors caused by acid conditions at sublethal levels (Haines 1981, Freda 1986). To this date no acid water related LC-50 value has been determined for Gopher Frog eggs.

Knowledge of the Gopher Frog’s biology and the ecosystems on which it depends is necessary to develop management strategies to halt the species' decline and promote its recovery, and to better use the species as a biological indicator of general environmental health. Management strategies for ephemeral pond breeding amphibians have been recommended (e.g., Semlitsch 1998, 2000a, and 2000b). Federal, state, and private agencies are encouraged to expand existing programs designed to protect, enhance, and recover highly diverse Longleaf Pine habitats and to include the ephemeral wetlands associated with them.

**MANAGEMENT RECOMMENDATIONS:**

1. Continue and increase survey efforts to locate and document high diversity areas.
2. Protect and add to habitat blocks that contain listed species and important ephemeral pond breeding sites.
3. Promote use of fire at appropriate intervals to enhance diversity.
4. Purchase inholdings or secure management agreements with their owners that will allow good management practices for the Longleaf Pine ecosystem.
5. Discourage pine straw harvest.
7. Allow fire to burn through ephemeral ponds when the opportunity occurs.
8. Pursue measures to guard against fish invasions and to eliminate fish from ephemeral ponds when invasions occur.
9. Establish strict buffer zones of at least 30 meters (100 feet) from the water/upland ecotone around aquatic and ephemeral pond habitats that restrict potentially detrimental activities like off-road vehicle use, pesticide and herbicide applications, use of fertilizer, military training activities that require earth movement, and clearcutting. Establish less stringent buffer zones of 500 to 1000 meters around breeding sites to protect the terrestrial home ranges of aquatic breeding species. Richter et al. (2001) recommended 1000-meter buffer zones around potential breeding sites for the Endangered Dark Gopher Frog.
10. Guard against groundwater draw down that impacts on ephemeral pond breeding sites.
11. Identify and restore degraded terrestrial and aquatic habitats that can be used by the Longleaf Pine ecosystem herpetofauna.
12. Avoid and eliminate migration barriers to breeding sites.
13. Promote research on fire ant impacts on herpetofauna.
14. Promote creation of ephemeral ponds in suitable habitats.
15. Establish protocols where feasible to discourage the spread of disease and invasive species.
16. Protect large, unbroken tracts, and develop corridors between such tracts for species' dispersal.

**LITERATURE CITED**


"wysiwyg://67/http://www.cdc.gov/ncidod/EID/vol5no6/daszak.htm"


Table 1. Amphibians and reptiles largely dependent on the Longleaf Pine ecosystem in North Carolina. State listed species are indicated by [E] = Endangered, [T] = Threatened, and [SC] = Special Concern. Additionally, species considered Vulnerable [V] due to range reductions and population declines are indicated.

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<th>Reptilia</th>
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ABSTRACT: A major challenge for ecosystem restoration implementation is determining which natural communities should be re-established and where they naturally occurred. Often a property is so degraded from years of human influence that little or no trace of the historic conditions remains. Rarely do restorationists have more than coarse anecdotal information on the distribution of these historic natural communities. Therefore, restoration efforts must often rely on an ecological classification system based largely on current vegetation, soil characteristics, and hydrology, which may yield a range of different community types, depending on unknown variables such as natural disturbances.

Restoration of the recently acquired Chickasawhatchee Wildlife Management Area (WMA) represents a rare opportunity to combine detailed ecological classification with a systematic survey of species information on boundary trees from the early 19th century. The Georgia Department of Natural Resources (DNR) and the Joseph W. Jones Ecological Research Center (Jones Center) are developing a 50-year management plan for the WMA. This process has yielded a generalized site classification as well as insight into the specific fire regimes that maintained not only the longleaf pine savanna, but also several unusual hardwood communities that resulted from historic fire exclusion. This information will serve as a foundation for developing the plan and will help identify and prioritize restoration targets.

Chickasawhatchee Wildlife Management Area

The WMA is a 19,700-acre property located approximately 12 miles southwest of Albany, Georgia and spans parts of Dougherty, Baker, and Calhoun counties. The WMA is managed by the DNR and is approximately 50% wetlands. The juxtaposition of contiguous forested wetlands, open seasonally-ponded depressional wetlands, and upland pine forests provide potential habitat for numerous endangered and threatened birds, freshwater fish, freshwater mussels, amphibians, and plant species and significantly contributes to the conservation of regional biotic diversity. Management goals include enhancing wildlife habitat (including rare plant and animal species), providing outdoor recreational opportunities, and protecting wetland functions.

Most of the uplands have been converted to loblolly and slash pine plantations. Intensive site preparation has degraded the natural plant and animal communities. A large scale and long term effort will be required to restore these upland communities as well as wetland-upland ecotonal areas. In order to develop a comprehensive restoration plan, landforms, soil types, and potential plant communities are being examined to identify and prioritize ecological restoration. In addition, biologists are researching wetland hydrology and inventorizing rare species.

Soil and Vegetation Mapping Process

The vegetative communities and soil types are being mapped by the Jones Center to develop a current vegetation map and a 50-year vegetation map which projects desired future conditions on the WMA.

First, soil surveys from Dougherty, Calhoun, and Baker Counties were digitized in ArcView GIS to create a preliminary WMA soil map. Over 30 different soil types were delineated. This map was scrutinized and field-tested by a University of Georgia soil scientist. A final soil map was created by consolidating soil types of the preliminary map into 11 soil groups. Consolidation was based on the Bt horizon texture and...
color, thickness of A and E horizon, and depth to seasonal saturation. Site indices were also reviewed in conjunction with field surveys to reveal sites appropriate for longleaf pine.

A vegetation map was created using a timber stand map and USGS 1999 color infrared digital orthographic quarter quadrangles aerial photography. The unplanted areas are mainly isolated wetlands and bottomlands. Over 75 field locations were visited during ground verification. Photographs were taken and georeferenced for mapping. Five vegetation types were identified: planted pine, grass-sedge marshes, gum/cypress forest, oak-gum forest, and regenerating bottomlands.

**Hydrologic Studies**

These soil mapping efforts have also contributed to a better understanding of the hydrology of Chickasawhatchee Swamp WMA. Because the swamp is situated over an important water source known as the Upper Floridan aquifer, understanding the hydrology can provide scientists with a forecast of the water resources available. This information will also be important in helping plan restoration activities.

The expansive palustrine wetland complex provides a major recharge zone for the Upper Floridan aquifer and protection of this is critical to ensure both water quality and quantity in the Flint River watershed. The wetland complex within the WMA functions both as a recharge and discharge area of the aquifer, one of the most heavily used groundwater reservoirs in the southeastern United States.

Inventory-level soil mapping indicates that beneath many of the wetlands and low-gradient streams, the shallow aquifer is overlain by poorly drained, low permeability, swamp-alluvial soils. Where erosion has removed the overburden, the carbonate rocks that comprise the aquifer are exposed. The degree of interaction between the aquifer and the wetlands and streams is controlled by the hydraulic conductivity of the material of the boundary layer that separates them and the hydraulic head relation between them. It is hypothesized that the geology and hydrology of this region may have a significant influence on the landscape position and hydroperiod of many of the wetlands.

Hydrologic research has been ongoing for almost a year. Thirteen monitoring wells are in place and provide hourly readings of groundwater levels. These wells are also sampled monthly along with two wetland sites and two stream sites to provide valuable information on water quality and chemistry in the WMA. There are four surface-water drainages into the Chickasawhatchee Swamp and only one outflow. Flow patterns and streamflow variability are being tracked in these streams. This information will be helpful in understanding the relationship between the surface waters and the aquifer and in determining suitable habitat for a number of rare aquatic species. Effects of the drought, which has been ongoing since 1998, are also being studied.

**Historic Data**

Understanding how humans have changed an area is key to its restoration. Humans have long used the land in and around Chickasawhatchee WMA. This area was a center of activity for the Creek Nation as evidenced by numerous mounds located in the vicinity. The wilderness of Chickasawhatchee was one of the last strongholds of the Creek Nation, with an estimated population of 300-400 remaining in the area well into the 1840s, long after most other Native Americans had been forced into exile. While it is unknown how Native Americans shaped the vegetation in and around Chickasawhatchee, we do have an idea of how early European settlers and their descendants may have affected this landscape. Nearly two centuries of human use, including subsistence farming, cotton and pecan farming, livestock, and intensive silviculture have eliminated much of the native flora and fauna, particularly in the uplands. The big question facing restoration ecologists is what native communities once thrived here?

Fortunately, land survey maps carefully stored at the Georgia Archives in Atlanta provide insight into this question and are proving to be a key resource in restoration efforts. Four separate district maps that provide excellent descriptions of the extent and composition of the forest in the 1800s cover the Chickasawhatchee
WMA. For every 250-acre lot, 12 "witness trees" were identified, often to the species level (Figure 1). The data from these land lot surveys dating from 1819-1820 suggest that settlers encountered a primal forest vastly different from what is found there today. Numerous sites, which today exhibit similar soil and hydrological characteristics, appeared to have supported vastly different forest types in 1820.

Interesting patterns emerge when these survey maps are generalized to basic forest types and are overlain with a map of wetlands (Figure 2). These historic documents provide clues as to how landscape context most likely affected forest composition, particularly in terms of fire frequency. Natural firebreaks, such as creeks and wetlands appear to have influenced the development of a unique fire-tolerant hardwood or mixed pine/hardwood community in 1820. Other upland areas completely isolated by wetlands supported a fire-intolerant hardwood forest composed of species such as beech, ash, and maple, even though soil types would have been appropriate for longleaf pine. Those sites dominated by pines in the 1800s were the most connected to the surrounding landscape and the most likely to have carried the landscape-level fires necessary for supporting a longleaf pine ecosystem.

In addition, parallels can be drawn between this map and the soil groups map. Soils that are characterized as most suitable for longleaf pine were indeed largely dominated by pine in the early 1800s.

The Future

Utilizing this wide spectrum of information, the Jones Center is creating a 50-year vegetation map which projects what habitat types are desirable goals on the WMA. Figure 3 shows a draft of this map.

The planning effort for the restoration of the Chickasawhatchee WMA, particularly the development of the 50-year vegetation map, represents a rare opportunity to combine detailed scientific information collected with modern technology with coarse survey information from the early 19th century to define future desired conditions. This process has yielded a site classification for the property and a better understanding of soils and hydrology as well as insight into the fire regimes that maintained the unique natural communities once supported in the region. This information will serve as a foundation for developing the plan and will help identify and prioritize restoration.
Figure 1. Photocopy of survey map dating back to 1820 depicting forest composition and distribution. Each square depicts a 250-acre landlot with 12 “witness trees.”
Figure 2. A rough depiction of historic forest type distribution based upon land lottery survey maps of 1819-1820.
Figure 3. Draft map of projected 50-year habitat types.
ABSTRACT: The vascular flora of the Southern Loam Hills of south Alabama was inventoried during a study to identify landscape scale land units. Eight land units with unique species assemblages were identified. The study identified 269 species in 80 families and 173 genera. These numbers do not adequately express the plant diversity of the Southern Loam Hills because riparian or depressional wetlands were included in the study. However, the inventory does represent the diversity of flora found in upland and flatwoods longleaf pine ecosystems. A number of the species were found in specific land units and are considered diagnostic for those land units. This included six species considered rare in the state of Alabama including Pinguicula pumila and Pityopsis oliganthes.

INTRODUCTION

Beneath the overstory of longleaf pine (P. palustris) ecosystems of the southeastern United States is an open forest with an understory dominated by grasses and forbs (Boyter and Peterson 1983). The ecosystems are floristically similar to mid-western prairies (Komarek 1968, Vogl 1972) and occur on a wide range of soil types, excluded only from areas that are very poorly drained (Shoulders 1990). The purpose of this study was to identify ecological land units in the Southern Loam Hills portion of the longleaf pine belt and describe the soils and vegetation of each land unit (Carter 1999). Although the purpose was not to produce an extensive vascular flora of the Southern Loam Hills, there were some important vegetational trends revealed.

METHODS AND ANALYSIS

The study area is the Conecuh National Forest and Auburn University’s Solon Dixon Forestry Education Center. They are located in the Southern Loam Hills of the Middle Coastal Plain Province (Hodgkins et al. 1976) in Escambia and Covington Counties, Alabama. Vegetation, soils, and landform variables were sampled in 200 plots installed in mature and recently regenerated forest stands in the summer of 1995 and spring and summer of 1996. Only stands that were burned within the past three years were sampled so understory vegetation was under similar successional conditions. The only exception was stands near the Conecuh River.

A circular 0.04 ha plot was located in each stand. Strata sampled included trees, sapling and tall shrub stratum, seedlings, low shrubs, herbaceous species, and rhizomatous shrubs. Nomenclature follows Clewell (1985) and Godfrey (1988) with the exception of Aristida beyrichiana, which follows Peet (1993). Soil and landform variables sampled included slope gradient in percent, aspect, landform index, terrain shape index (McNab 1990), A and B horizon depths, depth to mottling, depth to the water table, and drainage class. Texture analysis and chemical analysis for total N and C (%), and P, K, Ca, and Mg (ppm) were also performed.

Vegetation in each stratum was summarized by species for each plot. The vegetation data was then classified into land units with ordination (CCA, DCA, and CA) (ter Braak 1987) and cluster analysis (TWINSPAN) (Hill 1979).

RESULTS

Eight landscape scale land units were identified and described. The purpose of this study was not to classify sites near the Conecuh River (Conecuh River Bluffs); however, species descriptions for the Conecuh River Bluffs are included.
Three land units were identified along a moisture gradient from intermediate to xeric in areas classified as the Pine Hills. The intermediate land unit had a species assemblage consisting of Pinus palustris, Rhus copallina, Vaccinium myrsinites, Gaylussacia dumosa, Pityopsis graminifolia, Rhezia alifanus, Carpephorus odoratissimus, Pteridium aquilinum, Eupatorium rotundifolium, Lechea minor, and Smilax glauca. The species assemblage for the subxeric land unit consisted of Pinus palustris, Quercus stellata, Q. hemisphaerica, Q. falcata, Q. incana, Rhus copallina, Cornus florida, Vaccinium myrsinites, V. corymbosum, V. arboreum, Gaylussacia dumosa, Licania michauxii, Smilax glauca, Pteridium aquilinum, Pityopsis graminifolia, and Stylisma humistrata. The xeric land unit vegetation assemblage included Pinus palustris, Quercus incana, Q. falcata, Q. laevis, Q. hemisphaerica, Cornus florida, Vaccinium arboreum, Gaylussacia dumosa, Ipomoea sp., Stylosanthes biflora, Smilax glauca, Pityopsis graminifolia, Eriogonum tomentosum, Pteridium aquilinum, Carpephorus odoratissimus, Rhynchosia reniformis, and Cnidoscolus stimulosus.

Two land units identified in the Dougherty Plain along a moisture gradient from intermediate to xeric. Vegetation of the intermediate land unit consisted of Pinus palustris, Quercus falcata, Q. margaretta, Q. incana, Q. laevis, Vaccinium corymbosum, V. arboreum, Diospyros virginiana, Gaylussacia dumosa, Cornus florida, Lechea minor, Crotolaria purshii, Oxalis corniculata, Croton argyranthemus, Danthonia sericea, Smilax glauca, Silphium compositum, Elephantopus tomentosus, Berlandiera pumila, Aristida beyrichiana, Eleaphantopus tomentosus, Commelina erecta, and Eriogonum tomentosum. The species assemblage for the xeric land unit included Pinus palustris, Quercus incana, Q. geminata, Q. falcata, Diospyros virginiana, Rhus copallina, Vaccinium corymbosum, V. arboreum, Cornus florida, Gaylussacia dumosa, Elephantopus tomentosus, Gelsemium sempervirens, Vitis rotundifolia, Helianthemum carolinianum, Croton argyranthemus, Silphium compositum, Stylosanthes biflora, Aristida beyrichiana, and Hibiscus aculeatus.

In the area identified as the Wet Pine Flatwoods, two land units were identified along a moisture gradient from mesic to xeric. The vegetation of the mesic was characterized by Pinus palustris, P. elliottii, Gaylussacia mosieri, Aristida beyrichiana, Ctenium aromaticum, Chaptalia tomentosa, Rhezia alifanus, Xyris elliottii, Smilax glauca, Eriocaulon texense, Drosera brevifolia, Eupatorium rotundifolium, Sarracenia flava, and S. leucophylla. In the xeric land unit, the vegetation assemblage included Pinus palustris, P. elliottii, Symlocos tinctoria, Rhus copallina, Clethra alnifolia, Rhus copallina, Quercus falcata, Diospyros virginiana, Hibiscus aculeatus, Smilax glauca, Eupatorium album, Aristida beyrichiana, Eupatorium album, and Ctenium aromaticum.

The species assemblage of the Conecuh Rivers Bluffs included Quercus alba, Fagus grandifolia, Acer barbatum, Magnolia grandiflora, M. pyramidata, Ostrya virginiana, Carpinus caroliniana, Ilex opaca, I. vomitoria, Callicarpa americana, Michella repens, Smilax pumila, S. smallii, Vitis rotundifolia, and Parthenocissus quinquefolia.

**DISCUSSION**

A total of 269 species in 173 genera and 80 families were identified in the Southern Loam Hills. Species in the Gramineae and Cyperaceae are poorly represented due to the sampling methods and season. Sampling was predominantly in the summer between flowering and fruiting of many species in the Gramineae and Cyperaceae. Families represented by the largest number of species were Compositae (31 species), Leguminosae (28 species), and Fagaceae (15 species). Vascular floras of Conecuh County, Alabama (Diamond and Freeman 1993) and Baker County, Georgia (Drew et al. 1998) also found that Compositae and Leguminosae represented a large number of species. Genera represented by the most number of species were Quercus (13 species), Eupatorium (8 species), and Lespedeza (5 species).

There were several species found in the Southern Loam Hills not represented in the floras by Diamond and Freeman (1993) and Drew et al. (1998). Those species include Euphorbia floridana, Gaylussacia mosieri, Hedyotis nigricans, Hypericum fasciculatum, Iris tridenta, I. verna, Lophiola americana, Melanthium...
The Pine Hills contained the greatest number of species in the Leguminosae. The Pine Hills Xeric, Subxeric, and Intermediate contained 22, 21, and 20 leguminous species respectively. The Dougherty Plain Xeric and Wet Pine Flatwoods Xeric and Mesic land units contained 18 leguminous species while the Dougherty Plain Intermediate only contained 14. The dry conditions in the Pine Hills are more conducive to fire, which favors legumes. *Rhynchosia cytisoides* was restricted to the Pine Hills Xeric and Subxeric land units, while *Crotolaria angulata* and *Tephrosia virginiana* were restricted to the Dougherty Plain Intermediate land unit. The largest number of Compositae species was found in the Wet Pine Flatwoods Xeric and Mesic (22 in each).

Species in the Southern Loam Hills considered rare in Alabama include *Castanea pumila*, *Erigeron strigosus*, *Eriocaulon texense*, *Pinguicula pumila*, *Pityopsis oligantha*, and *Sarracenia leucophylla* (Oberholster 1996). Geographic specific studies such as this are needed to identify threatened land units that contain rare and endangered species.

ACKNOWLEDGEMENTS

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LITERATURE CITED


THE BERRY COLLEGE LONGLEAF MANAGEMENT PLAN: Status of Mountain Longleaf Pine (*Pinus palustris*) on Campus and Current Management Plans

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ABSTRACT: *Pinus palustris* populations upland from the coastal plain ("Mountain Longleaf") are particularly rare. One such population, including a number of trees >200 years old, is found at Berry College in northwest Georgia. To establish baseline data for the development of a management plan at this site, we mapped trees within five 1-hectare stands, classifying individuals into grass, juvenile, non-reproductive adult, and reproductive adult stages, and measuring the CBH of adults. Censuses began in 1999 and take place every two years. In 2001, we recorded a total of 215 grass, 151 juvenile, 123 non-reproductive adult, and 481 reproductive adult individuals, indicating a deficit in recent recruitment. We found grass stages in only two stands, and documented considerable litter build-up, hardwood encroachment, and closed canopy conditions, all due to fire suppression. A wild-fire was associated with the death of a number of adults between 1999 and 2001, pointing to the risk of implementing fire management without attention to current heavy litter buildup. A matrix demographic analysis suggested that the population is declining rapidly in absence of management. In 2001, volunteers began planting seedlings in areas cleared of Loblolly and Shortleaf Pine for Southern Pine Beetle control. About 63% of planted seedlings survived the first full year after planting. While remaining seedlings were healthy, the relatively low survivorship was attributed to poor planting technique, coupled with drought conditions. We present current management plans with respect to our study results.

PROJECT SUMMARY: Studies on the 28,000 acre Berry College campus show an urgent need for restoration of a fire-suppressed mountain longleaf pine habitat, and a need for further study of this rare ecosystem. A plan for restoration and study has been developed, the primary goal of which is to restore a 130-acre area to a healthy fire-maintained ecosystem. We will also involve students in research, management, and public education, foster research on mountain longleaf, and engage in public education and outreach. The management of fire-suppressed mountain areas is still in infancy, and Berry’s students, faculty, and staff have an opportunity to contribute to this research.

Our goals follow Berry’s tri-fold mission -- to educate the “head, heart, and hands”. By providing learning experiences, we address the “head”. By responding to an ethical need (conservation) via volunteerism, we address the “heart”. By involving participants in a variety of physical tasks, we address the “hands”.

Of particular concern to southern landowners is a recent epidemic of Southern Pine Beetle (SPB), which primarily attacks pines other than longleaf. When faced with tree losses, landowners might consider planting mountain longleaf coupled with fire management. As such, part of our research focuses on this option.

JUSTIFICATION AND GENERAL APPROACH: The Berry Mountain Longleaf Ecosystem is one of the few remaining in mountain areas (most are in the coastal plain). Surveys in the early 1990’s established that many trees pre-date European colonization, thus qualify as “old growth.” Data collected since then show the effects of fire suppression, including litter buildup, hardwood encroachment, minimal regeneration, closed conditions, reduced understory, and high risk from wildfires. Berry’s undergraduate Plant Ecology class has put together a plan to address these problems. The full plan, reference list, and participant list can be found in Vaughn, et al. (2002).

Our primary approach will be a stepwise implementation of hardwood control and prescribed burns within small experimental study plots, with an eventual expansion to a 130-acre area designated as the Berry Longleaf Management Area. The second approach will be to plant mountain longleaf in mountainous areas that have been logged for SPB control, and to subsequently fire-manage those areas. Both approaches involve pre- and post-management surveys of trees, and of other flora and fauna. Students, faculty, and
public volunteers will be involved in various aspects of the project, and educational workshops will be offered for local land managers. We will develop our website and other public education materials, and will conduct educational tours of the management areas.

The significance of Berry’s plan has been summed up by Mr. John McGuire, of The Longleaf Alliance: 1) Berry’s longleaf forests represent an ecologically significant landscape type with a paucity of knowledge about it. 2) Berry’s campus has many very old trees, some in excess of 200 years old. These trees are significant ecologically, historically, and socially. 3) The hillsides at Berry have not been plowed and thus have the potential of benchmark groundcover species found on fire maintained mountain longleaf sites. 4) By establishing a model management plan that includes controlled burning, the project has important implications for fire re-introduction programs in other mountain sites. 5) The project has high potential to serve as an outdoor classroom and as a demonstration site.

SITE DESCRIPTIONS AND MANAGEMENT PLANS (All sites lie on the southern slopes of Lavender Mountain):

**Stand A:** This 1 hectare site contains only adult longleaf, and is dominated by hardwoods. Stand A will initially be the most intensely managed because it has the fewest longleaf, so fewer will be at risk. It is very accessible, allowing the restoration effort to be showcased. In 2002-2003, adult hardwoods will be cut, litter will be removed from the base of each longleaf, and cool season fires will be repeated on an annual basis. When analysis of fuel loads indicates that it is safe to conduct growing season burns, they will take place every 3-5 years.

**Stand B:** In 1999, a wildfire killed a number of adult longleaf in this 1 hectare site. The site is dominated by hardwoods, and contains some seedlings that emerged following the fire. As this stand has already been affected by a wildfire, it will be treated identically to site A, but the first burn will not take place until after the early results from Stand A are assessed.

**Stand C:** This 1 hectare site is dominated by longleaf, but no seedlings or juveniles are present. Some adults were killed in the 1999 wildfire. This site has a thick herbaceous community, probably due to the wildfire. In 2003-2004, we will initiate cool season burns after litter has been blown away from the base of each longleaf. Methods will follow that of site A and B, except that mechanical hardwood removal will not be performed.

**Stand D:** This 1.25 hectare site contains the highest density of seedlings and juveniles of all stands. Areas containing seedlings have low litter build-up and a relatively open canopy. Based upon burns conducted in other sites, a specific burn plan will be developed for this site to take place in 2004-2005.

**Stand E:** This 1 hectare site contains some of our oldest longleaf, but very few seedlings or juveniles, has extensive hardwood encroachment, and a thick litter layer. As for stand D, this site will not be burned until early results of burns in other stands have been interpreted. In the latter two sites (D and E) some hardwood removal will be undertaken in 2002-2003 to open up canopy gaps so as to meet the light requirements of seedlings/juveniles.

**SAVE 2001 Areas:** In 2000, these two sites were subjected to pine tree removal for SPB control, leaving an open canopy of primarily Chestnut Oak. They were planted in 2001 with 2000 mountain longleaf seedlings. A permanent firebreak will be pulled around the one of the areas prior to a cool season burn in 2003-2004. Growing season burning will thereafter be undertaken every 3-5 years. The second area will be left untreated as a reference stand. This comparison will be replicated in newly logged areas.

**Stands Salvage-Cut for SPB Control in 2001-2002:** In 2001-02, a number of 1-6+ acre sites have been logged to contain SPB outbreaks. When clear-cut, all timber was removed; when selective-cut, all pines were removed, but oaks and hickories were left. Their size and accessibility make the sites ideal for controlled studies, and for providing educational tours. 1) **Clear-cut areas:** A large clear-cut area will be divided into eight plots of equal size. Following a fall 2002 site preparation burn, containerized mountain
longleaf will be planted in four of the plots (2 longleaf timber and 2 longleaf biodiversity plots) and bare-root loblolly seedlings will be planted in the other plots (2 loblolly timber and 2 loblolly biodiversity plots). Timber plots will have management regimes that follow those normally used for loblolly timber production. Biodiversity plots will be managed with a combination of thinning and more intense fire management that fosters an open-canopy, mixed pine-hardwood forest. 2) Selective-cut Areas: Within two selective-cut areas, we will compare the fate of mountain longleaf planted in areas with and without total timber removal. After planting of containerized mountain longleaf seedlings, fire management and data collection will be identical to the longleaf biodiversity plots in the clear-cut area study (above).

THE GREATER LONGLEAF PINE MANAGEMENT AREA AND LONG-TERM PLANS: We would like to eventually re-establish mountain longleaf habitat throughout the 130-acre area. Expanding from the nucleus of study stands, and using methods developed from our experimental fires, we will begin to conduct cool-season burns. Once fuel has been reduced, growing season burns will begin at a frequency of every 3-5 years. The gradual replacement of deep litter with herbaceous groundcover will ameliorate erosion problems.

USE OF BERRY MOUNTAIN LONGLEAF SEED STOCK: Current plans for planting use mountain longleaf from distant sources. Ideally, planting should be done with Berry College seedlings. Creekside Consulting Corp. (AL) wants to obtain mountain longleaf seed, and will help collect and process seed. Seeds will then be used to produce seedlings at our own greenhouse facilities.

RESEARCH OPPORTUNITIES: Countless opportunities exist for the development of research projects commensurate with our overall goals. For example, many aspects of the ecosystem can be studied for the effects of differing management practices, and the project will thus be a natural laboratory for studying the effects of the restoration methods. Several long-term research projects have already been initiated, and will continue after management efforts begin. 1) Demographic study of longleaf will continue to be performed every two years by the Plant Ecology class. 2) Plant community analysis will be repeated biennially by the Longleaf Team. 3) Litter and understory sampling will be repeated biennially by introductory Biology classes. 4) Studies of various taxa will be conducted by students in various classes (e.g., Directed Studies, Biological Diversity, Conservation Biology, General Botany, Ecology, Advanced Ecology). These projects will focus not only on plant diversity, but also on diversity other taxa (e.g., mammals, birds, insects, reptiles, etc.). 5) Planted seedlings will be monitored annually by The Longleaf Team. 6) Specific additional studies/new management ideas will be generated by a graduate or post-doctoral research assistant, and a research technician will be hired to assist with data collection, entry, and management, including the development of a GIS database.

FACULTY/STAFF LEVEL PERSONNEL: The Project Coordinator will oversee the project; other personnel may change depending on the nature of new projects that are developed, and as students graduate. The forest management crew will be supervised by Dean Wilson (Land Resources). Scott Layfield (US Forest Service) will provide fire-management training. Faculty (most with PhDs in Biology) will develop specific research projects (Directed Studies, class projects, independent faculty/student research). We are also interested in supporting graduate research by students from regional universities. Oversight of research will be facilitated by the involvement of a graduate research assistant and a research technician.

EMPLOYEES AND VOLUNTEER GROUPS: The “Longleaf Team” includes students supervised by the Project Coordinator. Some (majors in the natural sciences) will focus on research and management, and will share information during tours and conferences. Others (Communications, Art, and Computer Science majors) will work on publicity, public education, and website development. A “Student Burn Crew” will be trained to respond when needed for prescribed burns or wildfires. Student clubs and other volunteer groups will participate in management activities, most notably the planting of seedlings. For short-term labor-intensive tasks, student workers and volunteers will form temporary work crews.

THE BERRY LONGLEAF NETWORK AND INTERAGENCY BURN TEAM: The Berry Longleaf Network (a group of regional experts; see web page) critiques all aspects of our plan. An Interagency Burn
Team (J. Rickard, U.S. F & W Service; N. Edmundson, GA Forestry Comm.; J. McGuire, Longleaf Alliance) will help plan and carry out burns.

EXPECTED SHORT-TERM RESULTS: Expected results must be interpreted in the context of our long-term objectives. In the first 3 years, we will begin management practices according to the methods discussed below. Our longleaf ecosystem is in decline, based upon recent field data. Through our efforts, we expect that: 1) future data will show a self-sustaining population. 2) the plant community will approach that of healthy mountain longleaf stands at Ft. McClelland, AL, and will contain many species reported on Berry’s mountains early in the 20th century. 3) basic field data will be generated about the poorly understood mountain longleaf ecosystem. 4) We will be able to provide information to local and regional land managers concerning the usefulness of mountain longleaf and fire management in their own plans. 5) Participants will gain academically, professionally, and personally from their experiences.

http://fsweb.berry.edu/Academic/MANS/mcipollini/index.html
ABSTRACT: The once-dominant longleaf pine-grassland ecosystem of the southeastern Coastal Plain, associated with extremely diverse ground cover, is critically endangered due primarily to agricultural practices and fire suppression. Wiregrass (Aristida beyrichiana), a dominant native bunchgrass in eastern longleaf pine forests, is considered a functionally important species in this ecosystem. It exhibits structural ground cover dominance and facilitates fuel accumulation and fire, making it an important target species for restoration in a fire-maintained ecosystem. Due to limited seed availability and unique life history traits of wiregrass, progress in re-establishment has been limited. Recently, interest in wiregrass restoration has increased among private landowners who have either former agricultural fields planted with longleaf pine within the Conservation Reserve Program (CRP) or existing stands of longleaf pine with degraded understories. Many of these landowners recognize the important role native ground cover plays in fire management and its value to wildlife, and have joined new partnerships integrating research and development of basic restoration techniques. In 2002, partnership members harvested wiregrass seed in native longleaf pine stands in southwestern Georgia and sowed seed into plots established in previously cultivated fields. We compare wiregrass seedling establishment from the following treatments: 1) different seeding rates, 2) effect of herbicide application on competition, as well as wiregrass seedlings, and 3) use of cover crops. Preliminary results indicate no difference between the two highest planting rates; however, the lowest seeding rate produced significantly fewer wiregrass seedlings. Herbicide application has had no effect on seedling establishment, regardless of planting density.
REGENERATING LONGLEAF PINE ON HYDRIC SOILS: Short- and Long-Term Effects on Native Ground-Layer Vegetation

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ABSTRACT: Large land areas, once dominated or co-dominated by longleaf pine, now support different forest types, especially on wetter, more productive sites. This is the result of historical land uses, especially fire suppression and silvicultural preferences for other species. Most existing longleaf pine stands occur on drier sites and traditional approaches to restoring longleaf pine to wetter sites on the coastal plain require intensive practices that compromise the integrity of the ground layer vegetation. A project is being established at Marine Corps Base Camp Lejeune, Onslow County, NC to evaluate a range of site preparation methods that could potentially be used to restore longleaf pine stands on sites that no longer have a natural seed source. It will determine the impact of these methods on the extraordinarily diverse ground layers that occur on moist, poorly drained sites. Immediate and short-term effects of management treatments on ground layer vegetation, and on longleaf pine establishment and early growth will be evaluated with a controlled field experiment. Long-term effects will be investigated by quantifying vegetation composition and structure in mature plantations, and relating current conditions to known treatment histories and to the vegetation in high quality natural areas. Thus, this project employs a unique blend of operational forestry techniques, ecological sampling and analysis, historical and land-use research, and multivariate analysis and modeling. The results of this work will provide a scientific foundation for assessing management choices for longleaf pine and associated species on the landscape, as well as supplying land managers with better information about the efficacies of alternative site preparation practices to support longleaf pine seedling establishment without degrading the ground layer.

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**ABSTRACT:** Longleaf pine (*Pinus palustris* Mill.) seedlings were grown in a model regenerating ecosystem in open-topped chambers under two CO₂ regimes: ambient, 365 µl l⁻¹ and elevated, 720 µl l⁻¹. Several feeding experiments were conducted using red-headed pine sawfly larvae (*Neodiprion lecontei* Fitch; Diprionidae: Hymenoptera) to assess the effects of CO₂-enriched diets on larval growth and development. Needle chemistry (macro- and micronutrients, total phenolics, condensed tannins) did not significantly differ between CO₂ treatments. In general, most measures of larval performance (growth rates, consumption rates, length of time to pupation) were unaffected by CO₂-enriched diets. Initial larval survival, however, was greatly reduced for larvae that were exposed to CO₂-enriched foliage from nascence. Nevertheless, subsequent larval development of surviving larvae was not affected by elevated CO₂. We predict that pine sawfly populations will not be significantly impacted as atmospheric CO₂ continues to rise towards predicted levels.
THE NORTHERN BOBWHITE CONSERVATION INITIATIVE: A Report on the Status of the
Northern Bobwhite and a Plan for Recovery of the Species

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ABSTRACT: From 1980 to 1999, the autumn bobwhite population declined 65.8% while declines in
bobwhite breeding numbers averaged 3.8% per year from 1982 to 1999. The Northern Bobwhite
Conservation Initiative (NBCI) delineates population and habitat objectives for 15 Bird Conservation
Regions to facilitate coordination and cooperation with other bird management plans. The NBCI includes
chapters detailing management practices for agricultural land, grasslands, and forests, and one chapter-outlining implement of the plan.

Restoring northern bobwhites to their desired density will require the addition of 2.8 million coveys to the
current population. To achieve this population increase, it will be necessary to impact the habitat on 81.1
million acres. The recommended land management practices would change the primary land use on only
6.2% of this acreage. Implementation of the NBCI will require the continuing cooperation of federal, state,
and private wildlife organizations and of individual landowners and managers. Much of the needed
funding can be derived from existing federal and state programs. If immediate action is taken the
bobwhite's decline may be arrested in five years, and the restoration may be effected in 20-25 years.
FIRE MANAGEMENT IN THE URBAN-WILDLAND INTERFACE ON SOUTH CAROLINA’S HERITAGE PRESERVES

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ABSTRACT: The South Carolina Department of Natural Resources Heritage Trust Program (HTP) protects and manages unique natural and cultural sites dedicated as heritage preserves. Many of these preserves are centered on longleaf pine ecosystems. Two of these, Lewis Ocean Bay and Victoria Bluff heritage preserves, are located in the urban-wildland interface, respectively adjacent to Myrtle Beach and Hilton Head Island, 2 of the fastest-growing cities on the east coast. As population growth and concomitant urbanization metastasize into and around these and similar wildland areas in the southern United States, prescribed burning of longleaf pine and other pyrophytic ecosystems is becoming extremely difficult and hazardous. These ecosystems are increasingly becoming isolated islands of natural habitat in a matrix of residential and commercial so-called “development”.

As the urban-wildland interface increases, so does the chance for wildfires and their associated risks. A major wildfire adjacent to urban areas can threaten human lives, damage property, impact local economies, and erode public support for forested natural areas. Wildfires can also imbue in the public a negative image of fire on the landscape, thereby potentially hindering support for prescribed fire programs.

In order to manage wildfire risks, the HTP has developed wildfire management plans for Lewis Ocean Bay Heritage Preserve and Victoria Bluff Heritage Preserve. These plans aim at assisting personnel from the HTP, South Carolina Forestry Commission, and other public safety agencies in assessing suppression and public safety options for wildfires on or near preserves, and to provide information to the public about wildfire safety. These documents do not provide detailed plans for suppression activities, but rather, they serve as informational tools and to catalyze discussions among relevant parties. As resources become available, the HTP will expand these plans to include more human dimensions efforts, and will allot more time and money for implementation.

INTRODUCTION

Across the southeastern United States, managers of the longleaf pine forests are confronted with the problem of people building homes adjacent to fire adapted habitats. This urban-wildland interface is defined as the line, area or zone where structures and other human development meet or intermingle with undeveloped woodlands or vegetation (Davis 1987). Often the individuals moving into these areas come from regions where the habitat is not fire maintained and past wildfire tragedies such as the Wisconsin Peshtigo Fire that killed 1500 people and the Hinkley Fire in Minnesota where 418 people died (Davis 1959) are still discussed. People moving into this potentially dangerous interface may give little thought to the potential wildfire risks and expect the government to protect them from natural hazards. The issue that local entities must take responsibility and action to address hazardous situations at the wildland-urban interface was underscored by Plevel (1987). Often, new residents are also vocal opponents of prescribed fire and do not realize fire is a natural part of many ecosystems and prescribed fire is an invaluable tool in natural resource management (Davis 1987).

Prescribed fire is often the best alternative for reducing the risk of wildfires. A prescribed fire is a fire applied in a skillful manner in a definite place for a specific purpose under certain weather conditions to achieve specific management objectives (Mobley and Balmer 1981). Benefits of prescribed fire include restoration and maintenance of ecosystem integrity, low cost, quickness, and reduction of fuel loads.

Build-up of highly flammable vegetation due to fire suppression and lack of control burning creates a dangerous situation. Fire suppression policies in fire-adapted ecosystems lead to unnatural fuel build-up,
which in turn sets the stage for catastrophic wildfire (Greater Yellowstone Coordinating Committee 1989). This was demonstrated in Florida in 1998 when 58,000 acres and 47 homes were burned in a massive wildfire (Crawford 1998). Nearly all of these homes were in the urban-wildland interface. In many pyrophytic ecosystems it is not the case of if but when an area will burn (Crawford 1998). By the skillful application of prescribed fire under specific weather parameters, managers can reduce the risk of catastrophic fires by reducing the fuel load.

The South Carolina Prescribed Fire Act defines a prescribed fire as "a controlled fire applied to forest, brush, or grassland vegetative fuels under specified environmental conditions and precautions which cause the fire to be contained to a predetermined area and allow accomplishment of the planned land management objectives." S.C. Code Ann. 48-34-20 (Supp. 1995). The Act - pursuant to its restrictions - also makes prescribed burning a "property right of the landowner," and helps protect the landowner from liability arising from damages caused by prescribed fire. S.C. Code Ann. 48-34-50 (Supp. 1995). Prescribed fire on heritage preserves is conducted by Certified Prescribed Fire Managers of the SCFC or the DNR. The main objectives of prescribed fire are to restore and maintain the fire-dependent ecotypes and reduce fuel loads.

LEWIS OCEAN BAY HERITAGE PRESERVE

Lewis Ocean Bay Heritage Preserve is located in Horry County, the second fastest growing county in South Carolina and one of the top 50 in the United States (US Census Bureau 2001). The city of Myrtle Beach (population 27,000) is adjacent to the preserve. The preserve is fast being surrounded by the classic urban sprawl. Upscale, planned communities are being constructed at an alarming rate in the urban-wildland interface. Lots in many of these developments average $150,000 and are marketed primarily to out of state retirees (Prudential Reality, personal communication). Recent road construction has resulted in two major highways being built near the preserve. The Conway Bypass is less than a mile from the preserve and the Carolina Bays Parkway bounds most of the preserve's southeastern boundary. The South Carolina Department of Transportation estimates that 75,000 vehicles per day will utilize each of these roads by the year 2015. The population increase, new highway construction, and associated development around LOBHP has made prescribed and wildfire management increasingly difficult.

Historically, wildfires were common on LOBHP and surrounding areas. The site is infamous with many South Carolina wildland fire-fighting personnel. In just the past 50 years, numerous historic blazes have occurred. On June 27, 1954 the Bombing Range fire was most likely started by a cigarette. The fire took nine days to control and burned 10,162 acres. The weather during the fire was very dry and stayed above 100 degrees for a week. On April 18, 1967 the Buist Tract fire began and burned over 6,000 acres in 3 days. Burning embers produced spot fires nearly a mile from the main body of the fire. What became the largest wildfire in recent history started from an unattended campfire on April 10, 1976 just east of LOBHP? More than 120 firefighters worked for a week to control the fire. It eventually burned more than 30,000 acres and became so intense that burning embers were thrown several miles from the flaming front. Some idea of the magnitude of this fire is evident in the fact that an average of about 30,000 acres are burned by wildfire statewide in South Carolina annually (SCFC 1999). Since 1985, approximately 1000 acres per year have burned on or around the preserve in wildfires.

Most of the unique ecosystems on the preserves are pyrophytic and require regular prescribed burning. Lewis Ocean Bay Heritage Preserve contains one of the most significant group of Carolina bays in South Carolina. Carolina bays are elliptical depressions, oriented northwest/southeast along their axes. They are found in the Coastal Plain of the southern Atlantic states and range in size from a few acres to several square miles (Bennet and Nelson 1991). Bay complexes such as those at LOBHP consist of numerous bays, many which overlap other bays.

Carolina bays typically are isolated, temporary freshwater wetlands. Most bays in South Carolina are not associated with a flowing water system and are fed only by rainfall. The bays on LOBHP are peat-based. Peat, which is not decomposed or partially decomposed organic matter from plants, fills the depression
The preserve's Carolina bays are covered with dense, almost-impenetrable thickets of pocosin vegetation that consists of evergreen and semi-evergreen shrub and vine species often associated with peat soils. Dominant pocosin species include fetterbush (*Lyonia lucida*), gallberry (*Ilex glabra* and *I. coriacea*), bamboo-vine (*Smilax laurifolia*), red bay (*Persea borbonia*), and sweetbay (*Magnolia virginiana*). The shrub thickets are often topped by a sparse canopy of pond pine (*Pinus serotina*) and loblolly bay (*Gordonia lasianthus*).

Carolina bays present a difficult challenge to wildfire control. The dense, evergreen vegetation burns severely, spreads rapidly and results in crown fires. The peat soils are soft and not easily plowed with heavy equipment. Bulldozers and fire engines can easily become stuck in the moist peat. During dry periods, the peat can ignite and cause ground fires. Once ignited, it is difficult to extinguish and produces large amounts of smoke and air-borne particulate matter (McDonald et al. 1983).

The preserve has significant acreage of upland longleaf pine forests such as sand ridges and flatwoods. The xeric sand ridges on LOBHP are associated with the sand rims of the Carolina bays. Canopy species are longleaf pine with subcanopies of turkey oak (*Quercus laevis*), sand live oak (*Q. virginiana var. geminata*), and persimmon (*Diospyros virginiana*). Common understory plants include wiregrass (*Arstida spp.*), dropseed (*Sporobolus spp.*), meadow beauty (*Rhexia spp.*), and prickly-pear (*Opuntia compressa*).

Pine flatwoods occur on generally sandy soil where the water table is near the surface. Longleaf and loblolly pine are the common canopy species with sweetgum (*Liquidambar styaciflua*), red maple (*Acer rubrum*), gallberry, and blackjack oak (*Quercus marilandica*) dominating the midstory. The ground cover is diverse, and includes wiregrass, dropseed, orchids, blueberry (*Vaccinium spp.*), and huckleberry (*Gaylussacia spp.*).

Prescribed burns have been conducted at LOBHP since 1997. The Department of Natural Resources and Forestry Commission cooperated to burn 224 acres in 1997, 500 acres in 1998, 1200 acres in 1999, 1271 acres in 2000, and 1193 acres in 2001. The continued assistance of the SCFC has been instrumental in the success of burning on the preserve. Burning over 1,000 acres a year in an essentially urban situation is a major accomplishment.

**VICTORIA BLUFF HERITAGE PRESERVE**

The 1,111 acre Victoria Bluff Heritage Preserve is located in Beaufort County, the fastest growing county in South Carolina and one of the top 50 in the United States (US Census Bureau 2001), near the town of Hilton Head Island. Highway 278 runs adjacent to the preserve and is a heavily traveled four lane with an estimated daily traffic load of 65,000 vehicles. Upscale developments with bucolic names such as Sawgrass Point, Victoria Bluff and Colleton River Plantation have surrounded the preserve. These properties are marketed with slogans such as "...where nature is invited to stay".

The preserve was established to protect an outstanding example of a Florida type pine flatwoods community dominated by a longleaf (*Pinus palustris*), pond pine (*P. Serotina*) and slash pine (*P. elliotii*) overstory with a dense evergreen shrub understory composed of saw palmetto (*Serenoa repens*) and gallberry (*Ilex spp.*). Although common in Georgia and Florida, pine-saw palmetto flatwoods are rare in South Carolina. Waxy-leaved plants that burn severely when ignited dominate the shrub understory.

Prescribed burns have been conducted at VBHP since 1980. The HTP and SCFC cooperated to burn a total of 3447 acres between 1980 and 1991. The amount burned each year ranged from 115-932 acres. An average of 300 acres per year was burned during this time period. Prescribed burns of 125 acres and 400 acres were conducted in 1997 and 1998. No prescribed burns have been conducted since 1998 due to the construction of a new subdivision adjacent to the preserve. The subdivision is located in one of the only remaining smoke corridors and therefore limits what units can be burned without significantly impacting homes with smoke.
WILDFIRE PLANS

In order to manage wildfire risks on these two preserves, the HTP has developed wildfire management plans. Detailed wildfire plans are a staple of many communities in the western United States, but uncommon in the southern United States. These plans aim at assisting personnel from the HTP, SCFC, and other public safety agencies in assessing suppression and public safety options for wildfires on or near preserves, and to provide information to the public about wildfire safety. The plans formally state that fire is a natural, essential, and inescapable part of the ecosystems of the southeastern United States, but uncontrolled fire can have devastating consequences. They also state that public safety is the top priority when considering control alternatives but if conditions allow a less aggressive plan of attack, that alternative should be used to reduce the impact on cultural resources, rare species and habitats which support them.

The documents do not provide detailed plans for suppression activities, but rather, they serve as informational tools to catalyze discussions among relevant parties and provide useful information to the Incident Commander. Groups not normally involved with wildfire planning such as volunteer fire departments, SC Highway Patrol, county sheriffs department, local emergency preparedness offices and neighbors will be invited to meet on the preserves to discuss the plans, and to see firsthand the fuels, roads, homes and other elements that will be involved in suppressing a wildfire. As resources become available, the HTP will expand these plans to include more human dimensions efforts, and will allot more time and money for implementation. Hopefully, this will lead to greater cooperation with suppression activities, prescribed burning and the education of the local community.

LITERATURE CITED

HERPETOLOGICAL POPULATIONS IN MIXED LOBLOLLY-LONGLEAF PINE STANDS

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ABSTRACT: Amphibians and reptiles can be dominant taxa in many ecosystems and their unique physiology makes them sensitive to changes in their environment. Their primary role is as regulators of the invertebrate populations responsible for the breakdown of forest litter; and as a result, amphibians may be indicators of site productivity or ecosystem deterioration. In anticipation of long-leaf restoration efforts on the Croatan National Forest a herpetological survey is being conducted on some proposed restoration sites. Eight plots are being surveyed prior to conversion using 24” x 24” cover boards. Four of the plots are in areas that will be converted and four plots will remain in the unconverted forest type. Site descriptions, current management regime, and herpetological survey data will be presented.
FROM COWPENS TO FAIRWAYS: A CULTURAL HISTORY OF LONGLEAF PINE IN THE CAROLINAS

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Chapter One: Git Along Little Dogies

Let me give you a sound picture: imagine the sound of hundreds of lowing cows, cowboys on horseback whistling and shouting, whips cracking, as they drive their cattle herds to market. No, this is not a John Ford movie, and we’re not in Texas or Oklahoma. We’re in South Carolina sometime in the 1600s, and we’re traveling through a longleaf pine forest, not the western plains.

Surprised? We shouldn’t be. Historian Terry Jordan believes there’s a direct link between the 17th century cattle herding traditions that developed mainly in South Carolina, and the more familiar cattle ranching customs found on the western plains. Jordan says that many of the cattle ranching traditions of North America actually began in the longleaf pine country of the Atlantic Coastal Plain, and made their way to the western prairies by way of the extensive longleaf forests in the Gulf States. The interminable Piney Woods were so open, it was said on numerous occasions, you could drive a carriage or ride a horse for 20 or 30 miles in any direction. And there were many open places within the woods they called “savannas” or “prairies.”

For the early settlers of South Carolina, this landscape mosaic of open pine woodlands, savannas, swamps, canebrakes and the like provided an excellent range for cattle. In spring and summer, cattle would browse on the greening grasses and shrubs of the savannas and grassy pine woods, while in fall and winter they moved into the wet areas—the swamps and canebrakes—to feed on the young leaves and tender shoots of cane. The cows might have been scrawny, but they basically took care of themselves.

Huge cattle ranches began to develop in North and South Carolina. As the Carolinas became crowded with new settlers, cattle herders found it easy enough to migrate all the way to Texas by way of the longleaf pine forests.

Chapter Two: Turpentine Maniacs

A more familiar chapter in the cultural history of the longleaf pine forests in the Carolinas is the story of naval stores—tar, pitch, turpentine and rosin. When the first settlers arrived in Jamestown, Virginia, in 1607, they discovered a vast forest of longleaf that stretched far to the South. The growing season was long and the trees yielded incredibly rich amounts of the resin that produced tar and turpentine. It didn’t take the Virginians, and the Carolinians after them, long to exploit these riches. If naval stores were the petrochemicals of their day, by the 19th century the longleaf pine forests of the Carolinas were Saudi Arabia.

Tar was used on the farm for many purposes and was carried on board sailing ships. Sailors frequently had to tar down the standing rigging, and they might also have to make pitch from tar in order to patch leaky seams while on long ocean voyages.

The other naval stores, turpentine and rosin, came from the gummy resin contained in the living trees. In ante-bellum days, slaves cut streaks in the pines so that the resin would run into cavities called "boxes" axed into the bottoms of the trees. The sticky flow was collected several times a growing season and brought to a distillery where it made two products—a clear liquid called spirits of turpentine and a darker solid called rosin.

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It's hard for us to imagine today how bewitching the word "turpentine" once was. During the century, cotton and gold drove many people to distraction, but "getting turpentine" was also a mania, driving thousands of whites and blacks into the pine woodlands of the Carolinas.

In 1840, North Carolina had a near monopoly on the production of turpentine and rosin in the United States—its ports produced nearly 96 percent of the U.S. total. North Carolina’s dominance was due partly to a century-long incubation process in its forests by which standard methods of making turpentine were developed. Producers in Alabama or Georgia might find investors if they were turpentining “according to the procedure in Carolina.” Tar Heel turpentine workers—both slaves and eventually free men—became valuable commodities and operators from other states traveled to North Carolina each winter to recruit them.

Turpentine distilleries were built mainly at landings along rivers and streams at first, so that the products could be floated easily to market. But after the introduction of steam-powered railroads, turpentiners were able to expand their operations into the forest interior which had been as yet untapped. The development of a rail system also enabled North Carolina’s turpentiners to migrate to fresh forests to the south.

Once North Carolina’s industrial model of turpentining took hold, few operators worked trees much longer than a couple of years. The reason is that the most valuable spirits of turpentine and rosin were made from what was called “virgin dip,” or the gum produced in its first year. In subsequent years, the gum made an increasingly darker rosin and turpentine whose market value was much less. The longer an operator worked the same piece of forest, the less he made. The key to profitability, then, lay in abandoning forests after a few years of working them, and finding new forests with trees that hadn’t been tapped.

If there was any profitability, that is. A secondary result of the turpentine mania was ruinous overproduction and volatile prices.

Chapter Three: It's All Heart

Longleaf pine was also among the most valuable timber trees in the country. Heartpine lumber was rot resistant and it had a beautiful finish. Heart pine planks made sturdy and durable floors for mills and factories as well as homes, and they took a fine polish producing a beautiful effect. Giant squared dimensional timbers from heart pine logs were desirable all over the world in the construction of mills, warehouses, bridges, trestles and pilings—anyplace where great strength and durability were demanded.

In the late nineteenth century, the population of the United States nearly doubled, from 50 million to 96 million. Immigrants and other pioneering Americans flocked to the western territories and their treeless prairies, and they clamored for wood to build houses and factories. As New England and the Lake States were stripped of their white pine forests, southern yellow pine came into its own. With the advent of steam technology, woods work was totally revolutionized. Steam-powered railroads could penetrate even the remotest forest, steam-powered skidders could lay waste to acres of forest in a day; and steam-powered sawmills churned out hundreds of thousands of board feet a day.

Timber cutters in the Sandhills began to exploit the longleaf pine in the 1880s. By that time, most of the forests near the rivers had been cut. In 1882, Allison Francis Page, Sr. built the first lumber mill and several miles of tramways in North Carolina's Moore County to haul timber from the uncut forests to the mill. At first mules were used to haul the loaded cars along crude wooden rails, and then steel rails of standard gauge were laid down. At the peak of timber cutting in the 1890s and the first decade of the new century, dozens of tramways twisted through the forests hauling out millions of board feet of timber. In just a couple of decades, the forests were stripped of their trees and the tramways abandoned.

Chapter Four: Breathing That Good Ol' Piney Air

By the end of the 19th century, the piney woods of the Carolinas were attracting a different type of user—consumptives. Consumption, or tuberculosis, was once the most dreaded disease in the world. In the nineteenth century it was tuberculosis that people feared the most.

The medical profession, such as it was, was helpless to confront this disease. Up until 1888, physicians thought that tuberculosis might be hereditary. The best remedy for tuberculosis and just about any fever or lingering disease was thought to be a change of scene—especially to a warmer and drier climate.

Nineteenth-century consumptives and other invalids, most of them from the North, set out by boat, steamer, railway or carriage to such far-flung locations as the French Riviera, the Adirondacks of New York, the rustic outdoor camps of Colorado, Arizona and California. They also flocked to the Piney Woods of the South. The fragrance of the longleaf pines themselves was thought to be highly curative. In the 1880s and 1890s, Southern Pines and Pinehurst sprang up as health resorts in North Carolina with a season running from October to May. Aiken, South Carolina, was already a fashionable resort for the well-heeled invalid and Thomasville, Georgia, was another area that was exploiting its location in the Piney Woods for its economic advantage.

Physicians of the day were enthusiastic about the healing power of pines. “The dry air of the interior in conjunction with the aroma of the pine forests is peculiarly congenial to delicate lungs,” one wrote.

It was a good business for a while. In Thomasville, Georgia, they even had a way of referring to the new business: "A Yankee is worth two bales of cotton and is twice as easy to pick."

But once it was discovered that tuberculosis was actually contagious, the consumptives were discouraged from coming back. When James W. Tufts issued a promotional brochure about his new Sandhills town of Pinehurst, North Carolina, and mailed it to northern physicians, he stated bluntly: "It is not intended to be a sanitarium."

The Sandhills of North Carolina, of course, went on to develop a gilded national reputation as a golf resort. Aiken turned to horses, and Thomasville’s wealthy Yankees found a better use for their money—assembling immense plantations of pines for the hunting of bobwhite quail.

Chapter Five: Putting Out the Fires

By the turn of the 20th century, the longleaf pine forests in the Carolinas were in desperate shape. The destructive methods of turpentiners had destroyed many trees and left countless others vulnerable to storms and fires. The cut-and-run tactics of loggers left few trees behind but mounds of flammable debris that frequently fueled catastrophic fires. Lumbermen were clearcutting the forest as quickly as they could before their investment was destroyed by fire.

Even worse, however, was the realization that the forest was not regenerating.

Longleaf's problems with regeneration had been observed in North Carolina ever since the early 19th century. "It is a curious fact, and one much to be lamented," one traveler wrote in 1840, "that there is scarcely any reproduction of the long leaf pine throughout the vast region . . . . [W]hen the trees now living shall have died, there will be almost a total extinction of this beautiful and valuable tree." He blamed it on the numerous hogs, introduced to the Southeast by Hernando de Soto in 1539, that roamed the forests in enormous numbers. This enormous and ever-growing population of hogs fattened on longleaf seeds, and they rooted up the seedlings and young saplings to get at their roots.

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4 Frank Ryan. 1992. The Forgotten Plague: How the Battle Against Tuberculosis Was Won—And Lost (Boston: Little, brown and Co.).
Others blamed the lack of regeneration on the use of fire by the cattlemen and turpentiners. Indeed, many foresters believed that if they could eliminate hogs and fire from the longleaf pine woodlands, longleaf would respond and the forest could be restored.

For the better part of a century, war was declared on forest fires. Fires were suppressed whenever and wherever they occurred. Without fire, the scrub oaks, originally shrub-sized in longleaf forests, grew into dense and tall thickets, ensuring that the pines wouldn’t regenerate. Without fire, the diverse ground cover was smothered beneath a thick carpet of pine needles and oak leaves.

Chapter Six: Brown Gold and Southern Heritage

Let’s fast-forward to the 1980s and 1990s when many landowners in the Carolinas, especially here in the Sandhills area, were possessed by what can only be described as a mania for growing longleaf pine.

The furor was excited by the market for pine straw, longleaf’s foot-long needles that thickly carpet a forest floor. Pine straw was rediscovered as a mulch for gardeners and landscapers, and the new market has recast this humble product of the longleaf pine into "brown gold." Longleaf pine straw is longer, has a more attractive color than loblolly pine straw, and can be baled like hay. Pine-straw raking can be a year-round enterprise. In the Sandhills an acre of longleaf pine can produce from 65 to 100 bales of pine straw each year, netting a dollar a bale for the landowner (or the thief! Pine straw poaching is a cottage industry in the Sandhills).

As a result, pine straw is a $50 to $55 million dollar-a-year industry in North Carolina. The booming pine straw market has given landowners a powerful incentive for planting new forests of longleaf and for managing the forests they already have. Even newly planted longleaf pine trees yield straw relatively quickly and raking can occur every year, or even several times a year.

That’s where problems arise. Ecologists view too frequent raking to be little more than a form of mining, especially when it’s done by tractor-mounted rakes. Mats of needles play an important natural role in the sandy soils of the Sandhills forests by holding moisture at the surface where the shallow root systems of the pines can get at it; by providing sources of nutrients for the trees and other plants; and by providing the fuel for periodic fires that ensure a healthy and reproducing forest. Too frequent pine straw raking may well be impoverishing one of the most diverse ecosystems on earth.

But financial gain is not the only reason why landowners are giving longleaf a second look. Longleaf restoration is also being driven by a nostalgic vision of what the original landscape looked like—and how different it was from today’s. In North Carolina’s Sandhills, landowners are excited about their ability to restore oak-overgrown longleaf land to its "presettlement" condition by reinstating growing-season fires.

One landowner recalled sitting in his house one evening with a friend talking about an old tract of pine land the friend didn't know what to do with. "I mentioned 'pre-settlement times' to him and I could see him just light up," he said. "Once you get that concept in your mind, that's kind of a driving force."

Conclusion

The cultural history of longleaf pine, like that of so many other natural resources, has been one of exploitation, well-intentioned mismanagement and lost opportunities. Yet changes are in the making.

We know how to grow longleaf today and landowners are making money-growing longleaf. The U.S. Fish and Wildlife Service’s Safe Harbor program is helping landowners protect their forest investments. And the Longleaf Alliance has provided the strong direction and educational leadership that longleaf restoration has needed for decades.

Though longleaf pine restoration is still an uphill battle today, its future in the Carolinas, as well as throughout the Southeast, is brighter today than it has been in a long, long time.

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BIRDS OF THE LONGLEAF PINE ECOSYSTEM

R. Todd Engstrom (Greenwood Project, The Nature Conservancy, 4340 Highway 84 West, Thomasville, Georgia 31792)

ABSTRACT: The longleaf pine ecosystem varies naturally in plant species composition across its broad geographic distribution along gradients of soil and hydrological characteristics from mesic to xeric conditions. It is no surprise that avian community characteristics of longleaf pine woodlands also vary substantially. Rarefaction analysis of Breeding Bird Censuses in longleaf pine communities in South Carolina, Georgia, Florida, and Mississippi, resulted in estimates of 38 to 219 breeding pairs and 6 to 22 bird species on plot sizes standardized to 8.1-ha. Variation in structure of longleaf woodlands caused by historical factors, including timber management, adds another layer of variation to avian community composition. Fire is the overriding factor that influences all levels of variation in longleaf plant and animal communities.

Old-growth longleaf pine woodlands have several structural characteristics that may contribute to relatively high avian species richness compared to younger managed forests. First, the large, old trees provide critical foraging substrate and cavity trees for the endangered red-cockaded woodpecker (Picoides borealis). Red-cockaded woodpecker cavities are important roost and nest sites for at least 25 other animal species, including many birds. Canopy branches in these old trees also can support large nests of raptors, such as bald eagles (Haliaeetus leucocephalus), swallow-tailed kites (Elanoides forficatus), red-tailed hawks (Buteo jamaicensis), and great horned owls (Bubo virginianus). Second, snags of old trees may persist longer than snags from younger trees, because of the presence of greater quantities of heartwood, although this needs to be tested. Longleaf pine woodlands have many bird species that use snags, including woodpeckers and nuthatches. Third, old-growth forests tend to develop vertical and horizontal heterogeneity (i.e., regeneration in gaps) as a result of lightning and minor wind events. Gaps in the canopy and wide-spacing of trees are particularly important for species that sally for insects, such as eastern kingbird (Tyrannus tyrannus) and red-headed woodpecker (Melanerpes erythrocephalus). A fourth characteristic of longleaf pine woodlands that contributes to bird species richness is ground cover quality. Although this is not exclusively a feature of old-growth, modern intensive forest management frequently results in reduction or elimination of many ground cover plant species that are found on unplowed sites to enhance growth of planted pines. Disruption of ground cover by plowing and invasion of weedier species may affect long-term ecosystem stability, although this needs further study. Approximately half of the bird species of longleaf pine woodlands nest or forage on the ground or in low shrubs. Eastern meadowlark (Sturnella magna) may be one species that is negatively affected by transition from undisturbed ground cover to old-field composition. Retention of these four structural during forest management can greatly enhance the avian community of longleaf pine woodlands.
ABSTRACT: Years of low fire intensity along field edges and hedgerows due to fuel conditions and fire "shadowing" have led to hardwood encroachment and the loss of native grasses and legumes in these areas, making them extremely difficult to burn and allowing further hardwood encroachment. Typically, mechanical treatments are used to restore such areas, but continued mechanical treatment is necessary for several years before fire can be successfully reintroduced. The objective of this study was to determine if herbicides can speed up the return of grasses and forbs in the groundcover vegetation following such mechanical treatments.

One field edge and two hedgerows along cultivated agricultural fields were selected for a pilot project to examine the effects of these treatments. In the fall of 2000, the entire field edge and hedgerows were mechanically treated with a feller-buncher to remove large hardwoods and the understory was mowed or drum chopped. In July of 2001, half of the field edge and one hedgerow were treated with herbicide (Garlon + Escort) in a broadcast spray. Vegetation composition was monitored prior to herbicide application (spring 2001) and following herbicide application (fall 2001, spring and fall 2002) using a 1.6 ft² quadrat at points along transects through the treatments. The herbicide treatment completely changed the composition of the understory from woody plant to grass dominance (mainly *Andropogon* spp.) within the first year, and virtually eliminated hardwood stems from the understory. This change in composition will greatly improve the ability to quickly reintroduce fire in these areas.

INTRODUCTION

Historically, in the southeastern United States, frequent, low-intensity fires have maintained the open-canopy structure and the diverse understory of longleaf pine-wiregrass ecosystems (Heyward, 1939; Rebertus et al., 1989; Brockway and Lewis, 1997; Harrington and Edwards, 1999; Brockway and Outcalt, 2000; Provencher et al., 2001). These fires prevent large accumulations of fuel (Heyward, 1939; Lemon, 1949; Brockway and Lewis, 1997), create a bare mineral soil seedbed for longleaf pine regeneration (Lemon, 1949; Hodgkins, 1958; Rebertus et al., 1989; Brockway and Lewis, 1997; Brockway and Outcalt, 2000; Provencher et al., 2001), impede hardwood encroachment (Heyward, 1939; Lemon, 1949; Rebertus et al., 1989; Brockway and Lewis, 1997), promote flowering of certain species (such as wiregrass (*Aristida beyrichiana* Trin. & Rupr.); Mulligan et al., 2002), provide habitat for wildlife (Brockway and Lewis, 1997; Brockway and Outcalt, 2000) and control brown spot needle blight infection (Lemon, 1949; Rebertus et al. 1989; Brockway and Lewis, 1997; Brockway and Outcalt, 2000). Since European settlement, however, certain management practices (such as fire suppression and farming) have led to the degradation of much of the remaining longleaf pine forest (Rebertus et al., 1989; Brockway and Lewis, 1997; Harrington and Edwards, 1999) and have resulted in changes in the composition of understory vegetation (Lemon, 1949; Hodgkins, 1958; Brockway and Lewis, 1997; Brockway and Outcalt, 2000).

Fire suppression results in a reduction in the cover of grasses and herbs (especially legumes) and an increase in hardwoods (Lemon, 1949). Over time, the hardwoods grow into the mid- and overstories, further degrading the sites (Heyward, 1939; Rebertus et al., 1989) by reducing the amount of flammable litter. In addition, large diameter hardwoods are generally difficult to top-kill using prescribed fire (Heyward, 1939; Rebertus et al., 1989; Provencher et al., 2001), therefore, alternative methods may be required for restoration in these degraded areas (Heyward, 1939; Brockway and Outcalt, 2000; Provencher et al. 2001).

Mechanical means can be used to remove large stems from the overstory; however, mechanical treatments alone can result in excessive hardwood sprouting (Provencher et al., 2001). The use of herbicides has been suggested as a means of effectively removing hardwoods, reducing competition and increasing light
availability at the forest floor, thereby promoting the growth of grasses and herbaceous vegetation (Brockway and Outcalt, 2000; Ramsey et al., In press). Herbicides have been successfully used to restore degraded sandhill sites (Harrington and Edwards, 1999; Brockway and Outcalt, 2000; Provencher et al. 2001).

On Ichauway, a more mesic site, there are numerous cultivated agricultural fields with hedgerows and edges in need of restoration. These areas tend to have cooler, spottier fires than larger areas with more contiguous fuels (fire-shadow effect). The hedgerows have since developed a heavy cover of old-field vegetation, including large hardwoods, and do not burn regularly or well. The field edges have been burned historically, but because of the fire shadow effect hardwoods have been able to encroach into the mid- and overstories. Prescribed fire alone is not sufficient to restore these areas. It was the intention of this study to see if restoration through a combination of mechanical and chemical means is feasible. If so, the resulting grassland will be managed aggressively with fire to keep hardwoods in the understory while maintaining a high diversity of grasses and herbs.

METHODS

Study site
The study was conducted at the Joseph W. Jones Ecological Research Center, at Ichauway, located in southwestern Georgia, USA, in the lower Gulf Coastal Plain. The 11,600 ha property contains approximately 7,500 ha of fire-maintained second-growth longleaf pine. The climate for this area is classified as humid subtropical with an average annual precipitation of 131 cm, distributed evenly throughout the year. Mean daily temperatures range from 21 to 34°C in summer and 5 to 17°C in the winter. The study sites were located along the edge of a cultivated field and along two hedgerows in a cultivated field. Dominant species are listed in Table 1. Soils consisted of well-drained to excessively well-drained Kandiudults.

<table>
<thead>
<tr>
<th>Table 1. List of dominant species by growth habit.</th>
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<tbody>
<tr>
<td>Species</td>
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<tr>
<td><strong>Overstory</strong></td>
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<tr>
<td><em>Quercus virginiana</em> Mill.</td>
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<tr>
<td><em>Quercus falcata</em> Michx.*</td>
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<tr>
<td><em>Quercus nigra</em> L.*</td>
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<tr>
<td><em>Prunus</em> spp. L.*</td>
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<tr>
<td><em>Cornus florida</em> L.</td>
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<tr>
<td><em>Pinus palustris</em> Mill.</td>
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<tr>
<td><em>Pinus taeda</em> L.</td>
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<tr>
<td><em>Acer rubrum</em> L.</td>
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<tr>
<td><strong>Woody shrubs</strong></td>
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<tr>
<td><em>Diospyros virginiana</em> L.</td>
</tr>
<tr>
<td><em>Sassafras albidium</em> (Nutt.) Nees</td>
</tr>
<tr>
<td><em>Rubus</em> spp. L.</td>
</tr>
<tr>
<td><em>Asimina longifolia</em> Kral</td>
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<tr>
<td><strong>Nonwoody shrubs</strong></td>
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<tr>
<td><em>Callicarpa americana</em> L.</td>
</tr>
<tr>
<td><em>Rhus copallinum</em> L.</td>
</tr>
<tr>
<td><strong>Grasses</strong></td>
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<tr>
<td><em>Andropogon</em> spp. L.</td>
</tr>
<tr>
<td><strong>Herbaceous vegetation</strong></td>
</tr>
<tr>
<td><em>Ambrosia artemisifolia</em> L.</td>
</tr>
<tr>
<td><em>Toxicodendron toxicarium</em> Gillis</td>
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<tr>
<td><strong>Vines</strong></td>
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<tr>
<td><em>Smilax</em> spp. L.</td>
</tr>
<tr>
<td><em>Parthenocissus quinquefolia</em> L.</td>
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</table>

*These species also occurred in the woody shrub category.
FIELD WORK AND DATA ANALYSIS

In September 2000, a feller-buncher was used to remove overstory hardwoods (with basal diameters less than 61 cm) from around the entire field edge and along both hedgerows. Removal of larger stems was not possible with the available equipment. The understory vegetation was either mowed or drum chopped. In May, 2001, a liquid herbicide mixture was broadcast applied to half of the field edge, and to one of the two hedgerows. The specific herbicide mixture was: 9.4 liters ha\(^{-1}\) Garlon 4 (triclopyr), 0.02 liters ha\(^{-1}\) Tordon K (picloram), and 0.11 liters ha\(^{-1}\) Escort (metsulfuron). The spray volume was 422 liters ha\(^{-1}\) sprayed in a 12 meter swath. This mixture was selected to minimize the impact on desirable herbaceous and grass species, while effectively controlling undesirable hardwood and shrub species.

An initial vegetation survey was conducted to determine pre-treatment conditions. Transects were established around the field edge and along each of the two hedgerows. A 0.5 m\(^2\) quadrat was used to estimate percent groundcover in temporary plots located every 20 m along the transects (n=124). Vegetation was classified into one of the following categories: wiregrass, other grasses, forbs, vines, live oaks, other oaks, other woody vegetation, debris, bareground, non-woody shrubs and ferns. Sampling was repeated in the fall of 2001 and in the spring and fall of 2002. Groundcover data were analyzed using analysis of variance procedures. Significance was determined at \(\alpha = 0.05\).

RESULTS AND DISCUSSION

In mature longleaf pine forests, frequent burning is required for development and maintenance of a diverse understory (Hodgkins, 1958). An important fuel in mesic longleaf pine ecosystems is wiregrass (Mulligan et al., 2002). Wiregrass not only burns quickly and provides a continuous fuel source, but also elevates pine needle litter, decreasing moisture content and increasing the pyrogenecity of the needles (Glitzenstein et al., 1995; Mulligan et al., 2002). As expected, however, wiregrass was not identified in any of the plots in this study, either before or after treatment. Wiregrass does not generally recover from intense soil disturbances, such as plowing and compaction (Outcalt 1992, Mulligan et al. 2002), which occurred around the field edges and hedgerows in this study.
However, other native grasses also provide good fuels. The results of this pilot study indicate that the combination of removing hardwoods from the overstory (increasing the amount of light reaching the soil) and the herbicide application (reducing competing understory vegetation – particularly woody stems) resulted in a significant increase in grass cover (3% control versus 4% treated, spring, 2001; 10% control versus 22% treated, fall, 2001; 2% control versus 16% treated, spring, 2002; and 13% control versus 26% treated, fall, 2002; Figure 1). A similar response to herbicide application has been demonstrated in xeric longleaf pine forests (Brockway and Outcalt, 2000).

Herbaceous vegetation is also an important component of the understory in longleaf pine forests. In this study, we saw an initial decline in the amount of herbaceous groundcover in the treated plots (27% control versus 8% treated, fall, 2001; p < 0.001). However, this difference subsided over time, and by fall, 2002, was not longer significant (31% control versus 27% treated; p = 0.46). Similar short-term reductions in herbaceous vegetation following herbicide application have been identified on xeric sites (Harrington and Edwards, 1999; Brockway and Outcalt, 2000). Herbaceous vegetation responds differently to herbicide than to fire; after fire the number and diversity of herbaceous plants usually increases (Hodgkins, 1958; Brockway and Outcalt, 2000). However, in the absence of fire, herbaceous plant cover declines sharply (Harrington and Edwards, 1999), so a temporary decline from herbicide application, which should eventually result in a restored site, is acceptable. Alternative methods of herbicide application (i.e., directed spot application), may provide better protection for some herbaceous species (Harrington and Edwards, 1999; Brockway and Outcalt, 2000) although this method may not be as economical as broadcast application for large-scale operations.

Hardwood tolerance to fire depends on diameter, species, season of fire and fuel loads (Rebertus et al., 1989). Harrington and Edwards (1999) found that herbicides accelerated the removal of non-pine woody vegetation on xeric sites, although several treatment applications were required. In the current study, live
oak sprouts decreased significantly after treatment in fall, 2001 and fall, 2002 (p < 0.05). Other oak species showed an initially significant decline in cover in fall, 2001 (3% control versus 1% treated); however, this difference dissipated by spring, 2002 (3% control versus 2% treated). In contrast, cover of other woody vegetation, including persimmon and cherry, was significantly and consistently lowered by the herbicide treatment (15% control versus 1% treated, fall, 2001; 9% control versus 3% treated, fall, 2002; p<0.001). Brockway and Outcalt (2000) found similar results on xeric sites. These results are for understory hardwoods only; overstory hardwood survival was not monitored in this pilot study.

Debris increased significantly in the treated plots following herbicide application and almost doubled by fall, 2001 (31% control vs. 66% treated; p < 0.001); this difference slowly dissipated over the next year as grasses began to fill in the openings left by woody vegetation, and by the fall of 2002, was no longer significant (29% control vs. 37% treated; p=0.09)

FUTURE WORK

Based on the results of this pilot study, we believe that using a combination of mechanical and chemical techniques is an effective way to restore degraded mesic longleaf pine forests. We have implemented another adaptive management study which will allow us to further improve our management recommendations. This new study will look at the efficacy of three different types of herbicide: Garlon, Arsenal and Velpar. The initial phase of this study has already been completed, with Arsenal and Garlon applied this fall; Velpar will be applied in the spring.

ACKNOWLEDGEMENTS

We wish to thank the Joseph W. Jones Ecological Research Center for providing the funding for this adaptive management project. We also thank conservation personnel for operating the feller-buncher, Mark Atwater for applying the herbicide treatment and Dee Davis for assisting with data collection.

LITERATURE CITED

ABSTRACT: Longleaf pine is a masting species, producing heavy seed crops infrequently. In 1987, land managers on Ichauway, a 29,000 acre preserve in southwest Georgia, anticipated a heavy seedfall and burned ~7600 acres in July and August to prepare the seedbed. To quantify the role of prescribed fires in longleaf pine regeneration, 100 monitoring plots (0.07 acre circular plots) were established across the property. Plots were located in the center of canopy openings in mature longleaf pine stands on sites with little advanced regeneration. Fifty of the plots were in areas that were burned that summer, and 50 were in areas not burned. In subsequent years all 100 plots were burned on a two-year interval.

In 2002, eighty of the plots were revisited and all seedlings were counted and recorded by size class as follows: germinant - trees lacking a well-developed bud and secondary needles; grass stage - trees not in active height growth, but with a well-developed bud and secondary needles; "rocket" stage - trees in active height growth but < 6.5 ft tall; and sapling (≥ 6.5 ft tall). Because 1987 was the last mast year at Ichauway, all regeneration except germinants was assumed to be 15 years old (germinants were assumed to be from later seed crops). In 2002, the number of germinants was not significantly different between the two treatments, but the average total number of grass, rocket and sapling stage trees was significantly higher in the plots burned in 1987 (559 versus 40; P = 0.01).

INTRODUCTION

Longleaf pine is a masting species, producing infrequent heavy seed crops (Wahlenberg, 1946; Croker, 1975; Dennington and Farrar, 1983; Boyer and White, 1989; Boyer, 1996). Generally, heavy seed crops occur once every 5-7 years (Wahlenberg, 1946) and can vary from region to region in any given year (Boyer, 1996). Between 1,800 and 2,500 cones per hectare are needed to provide adequate regeneration (Boyer, 1996). Seed production is thought to be affected primarily by weather conditions during the year of flower formation (Boyer and White, 1989), although other factors, such as site quality, stand density, tree size, and genetics can also influence seed production (Wahlenberg, 1946; Boyer and White, 1989). A wet spring and early summer followed by a dry late summer promotes production of female flowers; in contrast, a consistently wet growing season promotes production of male flowers (Boyer and White, 1989). These requirements result in infrequent occurrences of high numbers of both male and female flowers. In any given year, trees on higher quality sites produce more seed than trees on lower quality sites (Wahlenberg, 1946). Additionally, a basal area of 7 m²ha⁻¹ maximizes seed production; higher or lower densities decrease seed production (Croker and Boyer, 1976; Boyer and White, 1989). The best seed producing trees are at least 30 years old (Croker and Boyer, 1976), have diameters of at least 25 cm (Wahlenberg, 1946; Croker and Boyer, 1976; Boyer and White, 1989), and have long, vigorous crowns (Wahlenberg, 1946).

Heavy seed crops alone do not ensure regeneration success. Regeneration attempts can fail, even in a masting year, if the other ecological requirements of longleaf pine are not met (Boyer, 1979). First, longleaf pine seeds are large, winged, and wind-dispersed (Croker and Boyer, 1976; Boyer and White, 1989) with an effective seeding distance of 46 m (Wahlenberg, 1946). The majority of seeds (71%) fall within 20 m of the parent tree (Boyer and White, 1989). For natural regeneration efforts to be successful, areas to be regenerated must be no more than 46 m from several suitable seed trees. Second, understory conditions must be favorable for germination. Heavy groundcover prevents the large seeds from making contact with the soil (Wahlenberg, 1946). Burning in the 12 months prior to seedfall will prepare a receptive seedbed. Spring counts of male and female flowers can be used to predict a masting year 18 months in advance, allowing land managers to time their burns to coincide with the seedfall (Croker and
Boyer, 1976; Boyer, 1979; Boyer, 1996). Third, once the seedlings are established, the canopy must be open enough to allow sufficient light to reach the seedlings and to minimize below-ground competition for nutrients and water (Wahlenberg, 1946). Higher resource availability should result in more vigorous seedlings, which are more likely to survive (Grace and Platt, 1995). Fourth, competing understory and midstory vegetation must be controlled (Wahlenberg, 1946). Finally, areas with longleaf pine germinants should not be burned for at least one year after seedfall (Wahlenberg, 1946). The first year of growth is critical to longleaf pine development. During this time, seedlings develop an extensive root system and thick fire-resistant needles which protect the tree from fire. While in this stage, however, fire can kill the germinants. If the above requirements are met during a masting year, longleaf pine regeneration efforts should be successful.

On Ichauway, a private reserve in southwest Georgia, flower counts in the spring of 1986 revealed that a heavy seed crop would occur in the fall of 1987. At that time, annual burning for quail management had left very little longleaf pine regeneration on the property. In an effort to increase the amount of natural regeneration, land managers took advantage of this masting year to increase seedling numbers and to begin development of a multi-aged forest. The objectives of this study were to establish long-term monitoring plots to follow the germination and survival of longleaf pine seedlings in canopy openings and to evaluate the importance of seedbed preparation prior to seedfall.

METHODS

Study Site
The study was conducted at the Joseph W. Jones Ecological Research Center at Ichauway, located in southwestern Georgia, USA, in the lower Gulf Coastal Plain. The 11,600 ha property contains approximately 7,500 ha of fire-maintained second-growth longleaf pine. The climate for this area is classified as humid subtropical with an average annual precipitation of 131 cm, distributed evenly throughout the year. Mean daily temperatures range from 21 to 34°C in summer and 5 to 17°C in the winter.

The study sites were located across the property in canopy openings which had a minimum of three longleaf pine seed trees within 46 m of the plot center. Plots were located on sites with either intact understory vegetation (wiregrass; Aristida beyrichiana Trin. and Rupr.) or disturbed understory vegetation (old-field sites with bluestem grasses Andropogon spp. L.) as the dominant cover). Very little, if any, advanced regeneration was noted in any of the plots.

One hundred 0.03-ha circular plots were established in areas with understory vegetation heavy enough that a bare mineral soil seedbed was not present. Fifty of these plots were burned between July and August 1987. The other fifty were not. Plot centers were marked with metal poles. Advanced regeneration and groundcover were noted and plots were photographed. In the winter of 2001-2002, eighty of the plots were revisited. Plot centers were permanently documented using GPS. All seedlings within the plots were counted and classified as one of the following growth classes: geminant – seedlings without a well-developed bud and no secondary needles; grass stage – seedlings with a well-developed bud and secondary needles, but not in active height growth (< 1 m tall); rocket stage – seedlings in active height growth, less than 2 m tall; and saplings – trees greater than 2 m tall with diameters at breast height less than 10 cm. Notes were also taken on ground cover vegetation, condition of the surrounding overstory trees and the presence of large oaks near the edge of the gaps. There was little advanced regeneration prior to 1987 and no masting years since (there was a moderately good bumper crop in 1996), so we assumed that all regeneration except for germinants was from 1987. The variation in seedling size within an age class is fairly typical for longleaf pine, as the grass stage can last from 1-20 years, depending on site conditions and genotype (Wahlenberg, 1946).

Data were analyzed using analysis of variance techniques. Total number of seedlings and number of seedlings by growth stage were compared between the burned and unburned plots. Significance was determined at $\alpha = 0.05$.

RESULTS AND DISCUSSION
Seedbed preparation, using prescribed fire to expose bare mineral soil, effectively increased longleaf pine seedling establishment in a masting year. There were significant differences in the number of seedlings in each of the growth classes except for the germinant class (Figure 1). The mean number of seedlings per hectare in the grass stage was significantly higher in the burned plots (1,893 burned (range 0-8,242) versus 631 unburned (range 0-10,803). A similar pattern was found for rocket stage seedlings (1,225 burned (range 0-11,880) versus 260 unburned (range 0-4,344)) and saplings (594 burned (range 0-4,307) versus 111 unburned (range 0-1,040). Croker (1975) found comparable differences in seedling establishment six years after seedfall in southern Alabama. The mean number of germinants per hectare was not significantly different between the treatments (334 burned (range 0-2,599) versus 446 unburned (range 0-11,435; p=0.7)). This result was expected because we assumed germinants came from more recent seed crops.

Numerous seedlings were present in 3 of the unburned plots. Historical photos suggest that these may have been areas with sparse groundcover, which would allow seeds to reach the bare mineral soil even in the absence of prescribed fire. In addition, there were 7 burned plots with little or no regeneration. Historical photos suggest that these may have been areas with heavy woody vegetation and/or areas that did not burn well, leaving a heavy understory cover even after prescribed fire. Woody vegetation not only is a poor fuel but also is a strong competitor which can impede longleaf pine seedling survival (Provencher et al., 2001). However, because groundcover vegetation was never quantified, these speculations are based solely on visual inspection of historical photos.

CONCLUSIONS

In masting years, preparing a receptive seedbed two months prior to seedfall can improve longleaf pine seed germination and result in long-term differences in regeneration success. Fire alone, however, may not create an adequate seedbed in areas with heavy woody vegetation.
Figure 1. Mean number of longleaf pine trees per hectare by size class in 2002.

ACKNOWLEDGEMENTS

We wish to thank the Joseph W. Jones Ecological Research Center for providing the funding for this project. We also extend thanks to J. Scott Sanders, J. Larry Landers, W. Leon Neel, and Bill Adkins for initiating this study, collecting baseline data, and for conducting the prescribed burns in 1987. Chris Ward assisted with data collection in 2002.

LITERATURE CITED


VEGETATION COMPOSITION OF EARLY SUCCESSIONAL LONGLEAF PINE CONSERVATION PRIORITY AREA FIELDS IN SOUTH GEORGIA, USA

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ABSTRACT: Amendments to the Farm Bill in 1998 established a National Longleaf Pine (Pinus palustris) Conservation Area (CPA) within the Conservation Reserve Program with a goal of restoring the longleaf pine ecosystem. Longleaf pine is planted on private, former agricultural fields. Traditionally, the understory of the longleaf pine ecosystem is comprised of a variety of fire resistant native grasses and forbs. However, invasive and often exotic, agricultural pests including Bermuda grass (Cynodon dactyla) and coffee weed (Senna obtusifolia) could dominate old-field longleaf pine stands making them less valuable for wildlife. We monitored vegetation during May to July 2001 in 41 recently established (6 months to 3 years) longleaf pine stands in South Georgia to assess ground vegetation. We measured: vegetation density and composition, percent coverage of grasses, forbs, shrubs/saplings, bare ground, and debris, and average sapling height. Target species including Bermuda grass, broom sedge (Andropogon virginicus), Bahia grass (Paspalum notatum), crab grass (Digitaria spp.) and coffee weed were identified and quantified. Preliminary results suggest that the majority of the vegetative understory was composed of forbs (31.7%). Coffee weed was the predominant forb occurring in over 23% of all plots surveyed. Grass composed 21.8% of the field’s understory, with Bermuda grass being the most abundant occurring in 18% of the plots surveyed. Bahia and crab grass occurred in 4.7% and 5.3% of the plots surveyed respectively. Broom sedge occurred in 1.6% of the plots surveyed. These data suggest ground vegetation management needs to be undertaken to increase the value of these fields.
HABITAT PREFERENCES, DIET, AND SCAT DEGRADATION ON A MANAGED NORTHERN BOBWHITE PLANTATION IN SOUTHWEST GEORGIA

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ABSTRACT: Bobcat habitat quality is often defined by the ability of habitats to support prey. I looked at the habitat preference of bobcats within a managed quail plantation in a longleaf pine/wiregrass ecosystem during 2001-2002. Through compositional analysis, I found that bobcats tend to prefer agriculture fields/food plots and mature pine within their home range, and hardwoods and mature pine throughout the site.

Bobcats are opportunistic predators. Southeastern studies show that bobcats prey most heavily on small mammals such as rabbits and cotton rats. Diet can vary seasonally, however, depending on the availability of prey. Food habits of bobcats in a longleaf pine/wiregrass ecosystem are unknown. In this study, I looked at the food habits of bobcats from summer of 2001 through spring 2002. I found that rodents were the most common prey item throughout the year.

Carnivore food habits are primarily studied through the collection and sorting of scat. Many studies have even looked at the digestibility of prey in carnivores. No studies have looked at the persistence of prey items in scat or the persistence of the scat in the environment. I fed 3 different diets to captive bobcats and collected the scat. I then put the scat in the environment, during the spring, and compared starting weight to ending weight over 6 weeks. I found that scat containing deer degraded faster than scat containing mice/rats or rabbit, and that the length of time that the scat spent in the environment influenced degradation of the scat.

INTRODUCTION

Because quail managers consider bobcats (Lynx rufus) to be major predators of Northern bobwhite (Colinus virginianus), hereafter quail, it is important to understand the effects of quail management on bobcat ecology. Creation of agriculture fields and food plots, supplemental feeding, and prescribed burning are prominent quail management practices that also affect bobcat ecology (Landers and Mueller 1986, Boutin 1990, Cummings and Vessey 1994).

Bobcat habitat quality is often defined by the ability of habitats to support prey (Fendley and Buie 1982, Boyle and Fendley 1987). Many quail management practices are beneficial to bobcat prey, and may make habitats more attractive to bobcats. Prey, such as cotton rats (Sigmodon hispidus) and other small rodents, are most dense in areas with dense herbaceous ground cover (Golley et al. 1965). Quail management practices such as prescribed burning can increase the abundance of herbaceous ground cover (Landers and Mueller 1986). Small mammals are known to be attracted to field edges (Cummings and Vessey 1994). Supplemental feeding increases breeding, decreases home range size, and increases density of potential prey, which may benefit bobcats (Boutin 1990).

Bobcats are opportunistic predators (Latham 1991). In the southeast, bobcats prey most heavily on small mammals (e.g. rabbits (Sylvilagus spp.), cotton rats) (Beasom and Moore 1977, Miller and Speake 1978). Only one other study has been done on land that was managed for quail and they found that bobcats most commonly preyed on rodents, the second most common prey item was bird, but quail remains were rare (0.9% occurrence) (Miller and Speake 1978).

STUDY SITE AND METHODS

The study took place on Ichauway, the outdoor laboratory facility of the Joseph W. Jones Ecological Research Center, located in Baker County, Georgia. This 11,700-ha facility was found in the Southern Coastal Plain. Longleaf pine (Pinus palustris) woodlands dominated the landscape. Slash pine (P. elliottii)
flatwoods, natural loblolly pine (\textit{P. taeda}) stands, mixed pine hardwoods, creek swamps, and agricultural fields were distributed throughout the area. Old field grasses (e.g., \textit{Andropogon} spp.) and wiregrass dominated the understory (Goebel et al. 1997). However, more than 1,000 vascular plant species were documented on the property (Drew et al. 1998).

To keep areas productive for quail, fields at Ichauway were disked to increase food and cover. Disking removed thicker vegetation and allowed establishment of plants such as ragweed (\textit{Ambrosia artemisiifolia}) and partridge pea (\textit{Chamaecrista fasciculata}) (Landers and Mueller 1986). Widely scattered agriculture and wildlife food plots consisting of grain sorghum (\textit{Sorghum vulgare}), Egyptian wheat (\textit{Sorghum} spp.), brown top millet (\textit{Brachiaria ramose}), cowpea (\textit{Vigna} spp.), corn (\textit{Zea mays}), and winter wheat (\textit{Triticum aestivum}) made up about one-fifth of the property. To supplement quail food, grain consisting of corn, milo (\textit{Sorghum vulgare}), soybean (\textit{Glycine max}) and sunflower (\textit{Helianthus} sp.) seed was spread in areas heavily managed for quail from November–May in 2-week intervals. Supplemental food was spread in thickets and along field edges and in food plots. Prescribed burning occurred throughout the site. Ichauway employed dormant and growing season burns in a 2-year rotation on approximately 4,000-6,000 ha annually.

We studied habitat selection of bobcats and the effect of supplemental feeding and prescribed burning on bobcat habitat selection on land managed for quail during 2001-2002. Bobcats (\(n=27\)) were captured beginning in January 2001 using foothold traps. Following sedation, they were fitted with a radio-transmitter collar and released. Bobcats were then located by triangulation of radio signals from known reference locations. These locations were used in a compositional analysis to determine habitat selection.

We studied bobcat diet on quail-managed land in a longleaf pine/wiregrass (\textit{Aristida beyrichiana}) ecosystem during 2001-2002. We searched 30 1 km sections of road each month for scat as well as collecting any scat we came across opportunistically. We placed the scat in a paper bag which was labeled with the date and location and then was frozen. Prior to analysis we dried the scat and sorted the remains in the scat to species when possible.

**RESULTS**

Within their home range, we found that bobcats preferred agriculture fields and food plots during fall (\(P = 0.0588\)), winter (\(P = 0.0008\)), and spring (\(P = 0.0027\)). In the summer (\(P = 0.0003\)) they preferred hardwood areas. Since rodents and other bobcat prey are also attracted to field edges, bobcats could be attracted to this prey source. In the summer, bobcats may be less interested in hunting and more likely to look for cool, shady areas. Bobcats did not select for habitat for their home range throughout the site except during the spring (\(P = 0.0016\)) and summer (\(P = 0.0085\)) when they preferred mixed pine/hardwood areas.

We determined if bobcats were attracted to supplemental food by comparing bobcat locations to random locations and found that bobcats were found closer to supplemental food than expected (\(P < 0.0001\)). We determined if bobcats were attracted to areas that were burned by comparing the locations found in areas 30 days before a burn versus 30 days after the burn. We found that there was no significant difference in the number of locations found in the areas before or after the burn.

We found that bobcats most commonly preyed upon rodents, with cotton rats being the most common rodent consumed. Birds were the second most common prey item. This is not surprising because quail management practices such as creation of fields, prescribed burning, and supplemental feeding all benefit birds (e.g. quail) as well as other bobcat prey (e.g. cotton rats).

**DISCUSSION**

We believe that bobcats may benefit from many quail management practices. Although we did not evaluate quail populations in our study area, we suggest that bobcats may be more beneficial than detrimental to quail populations. For example, we found that bobcat consumption of known quail nest
predators (i.e. opossums (*Didelphis virginiana*), armadillos (*Dasypus novemcinctus*), raccoons (*Procyon lotor*), and snakes) was greater than their consumption of quail. Moreover, quail management practices, such as creation of field edges, prescribed burning, and supplemental feeding, benefit many rodent species (e.g. cotton rats), that both compete with quail for food and destroy quail nests. Finally, increases in rodent populations may attract many other predators that are more detrimental to quail (e.g. snakes, birds of prey).

**LITERATURE CITED**


USING THE PAST TO PREDICT THE FUTURE: A Model for Growth and Development of Longleaf Pine Plantations

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ABSTRACT: To restore longleaf pine to sites within its natural range, many young plantations have been established by land managers. Sound management of longleaf pine plantations requires prediction of stand growth and development. This is needed to determine timber yield as well as stand characteristics that are reflected in the productivity of understory communities and the suitability of stands for wildlife. A growth and yield model for longleaf pine plantations within the Gulf Coast States is currently being developed.

The Forest Service’s laboratory at Pineville, LA has been conducting research on the growth and development of longleaf pine plantations for over 50 years. We have seven long-term studies, including over 250 permanent plots, scattered within the Gulf Coastal Plain. The plots represent ranges of site, age, initial spacing, and thinning regimes. These plots have all been measured for twenty years or more, and include plantations currently over 65 years old.

This data set is being used to create a growth and yield model that will predict stand characteristics for longleaf pine plantations. In this poster, we will describe characteristics of diameter distributions of longleaf pine, which obligate use of a nonparametric diameter distribution structure. The novel model structure is transparent to the user who perceives a stand and stock table similar to other diameter distribution models. We will describe the structure of the model, including methodology to project initial and future diameter distributions. We will provide preliminary site index curves for longleaf pine plantations, and will outline some special considerations of growth and yield modeling in an ecosystem restoration context.

Sound management of longleaf pine plantations requires prediction of stand growth and development. This is needed to determine timber yield as well as stand characteristics that are reflected in the productivity of understory communities and the suitability of stands for wildlife. The only growth and yield model for planted longleaf pine considers only unthinned stands of no greater than 40 years old (Lohrey and Bailey 1977). Goelz and Leduc (2001) provide an empirical yield table for longleaf pine plantations. This paper summarizes a growth and yield model for longleaf pine plantations within the Gulf Coast States that is currently being developed that will be applicable to thinned and unthinned plantations up to at least 65 years old.

The Forest Service’s laboratory at Pineville, LA has been conducting research on the growth and development of longleaf pine plantations for over 50 years. We have seven long-term studies, including over 250 permanent plots, scattered within the Gulf Coastal Plain. The plots represent ranges of site, age, initial spacing, and thinning regimes. These plots have all been measured for twenty years or more, and include plantations currently over 65 years old. This data set is being used to create a growth and yield model that will predict stand characteristics for longleaf pine plantations.

Longleaf pine often has irregular diameter distributions (Figure 1, Goelz and Leduc 2002). There are several causes for these irregular diameter distributions. Length of time in the grass stage varies among individuals in a stand; effectively, multiple cohorts comprise a stand. This may create diameter distributions that are multi-modal; if unimodal, the diameter distribution may be strongly skewed. Longleaf pine can persist in inferior crown positions for many years. These small trees create a diameter distribution with a long left-hand tail; such diameter distributions are not well-represented by most parametric diameter distributions. Regular prescribed fire can cause mortality that affects diameter distributions. These characteristics obviate the use of classical diameter distribution modeling methodology.
Our model for longleaf pine is structured differently from standard diameter distribution models used for southern pines, but the output is still a stand and stock table similar to existing diameter distribution models. Thus, our novel model structure is transparent to the user.

The starting conditions for the model may be from inventory data collected from a specific stand, or the starting conditions may be from “bare ground” by specifying site index, planting stock (container or bare-root, or alternatively, the length of time in the grass stage), and initial planting density (or number surviving to a given age). In the case of the inventory data, the empirical diameter distribution is used. In the case of starting from “bare ground”, a neural net (Leduc et al. 2001) will produce a non-parametric diameter distribution by assigning trees to one inch diameter classes.

Rather than a simple histogram, the diameter distribution within each class will be defined by a simple quadratic polynomial. A histogram assumes a uniform (flat) distribution within each class; this differs by having a curved (quadratic) distribution within each class. This is an important distinction as the uniform distribution produces a bias in standard stand table projection procedures (Goelz 2002). The diameter distribution is segmented. The distribution will thus be continuous within each class, but discontinuous at the boundary of each class.

Mortality is calculated using an individual tree survival function. After adjusting for mortality, the limits of each diameter class will be projected into the future by using an individual tree diameter growth equation (Figure 2, Goelz and Leduc 2002). At this point, each diameter class is potentially of varying width, but will possess the same number of trees per acre. The diameter distribution will be adjusted to be consistent with predictions of a whole-stand basal area growth equation. By constraining the model to be consistent with the basal area equation we can condition the model to behave appropriately. Then, by using appropriate limits of integration, we will reconstitute fixed one-inch diameter classes (Goelz and Leduc 2002). Although this might seem somewhat involved, it is completely transparent to the user who will perceive a familiar stand and stock table as output.
Figure 1. Longleaf pine plantations have curious irregular diameter distributions that are not well represented by parametric functions (Goelz and Leduc 2002).
Figure 2. Projecting a diameter class. The initial within-class distribution is a quadratic polynomial (solid line). After projection (dotted line), the limits of the diameter class have changed, but the area under the curve is identical and thus the number of trees per acre is conserved (Goelz and Leduc 2002)

Site index is a critical component of the model, as site quality is one of the main driving variables for forest growth and yield. We present preliminary site index curves in Figure 3 (Goelz [in prep]). The equation is a modification of McDill and Amateis (1992). The curves happen to be very similar to the site curves presented in the classical miscellaneous publication No. 50 (USDA 1929). Like miscellaneous publication 50, these curves are based on a grass stage of 5 years and a base age of 50 years. Although the curves seem to be diverging across the range of age from 15 to 70 years, the asymptote is a constant plus site index; thus at extreme ages, the curves will be parallel and equidistant.
Our data, although extensive, is not ideal. We have several studies that include repeated measurements to age 65, however none of these older studies have measurements before age 16, and all of them are based on bare root seedlings. This dataset provides good information on long-term growth, but provides no information on length of the grass stage. In our modeling, we can estimate grass stage length as a parameter, but it is poorly estimated with this data. We chose 5 years as a compromise estimate for grass stage length when using bare root seedlings. We have one newer study established with container stock that has measurements between 4 and 22 years age, however we cannot estimate site index as measurements are not near base age. For plantations established with container stock, the length of the grass stage is specified as 2 years. In application, a user can specify the expected grass stage from one to seven years, or accept the default of five years for bare root plantations and two years for plantations established from container stock.

Figure 3. Height curves for site indices of 50, 60, 70, 80 and 90 feet at base age of 50 years. The duration of the grass stage is set at 5 years.

As longleaf pine is typically planted in an ecosystem restoration context, an appropriate model should consider more than simply timber growth (Goelz 2001). Thus we will consider elements that are not typically incorporated into standard growth and yield models. Critical issues include (1) extrapolability to ages that exceed the data; (2) estimation of non-timber variables; (3) incorporation of (prescribed) fire effects. Extrapolability will be considered in model formulation (Goelz 2001). Independently-derived
non-timber and fire components will be incorporated into the implementation of the model. These supplemental components are not measured in our database. However, we intend to incorporate results of other experiments that describe the relationship between stand structure and fire regime on understory community characteristics and pine straw as well as the effects of fire on longleaf pine mortality and growth (for example, Haywood et al 2001, Haywood and Grelen 2000, Boyer 1987, Bower and Fahnestock 1966). The user of the model can decide to switch on these supplemental effects or not, depending on their interest.

**LITERATURE CITED**


CONTAINER-GROWN LONGLEAF PINE SEEDLING QUALITY

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James P. Barnett (USDA Forest Service, Southern Research Station, 2500 Shreveport Highway, Pineville, LA 71360)

ABSTRACT: This study was initiated to determine the feasibility of increasing longleaf pine planting success by visually sorting through given lots of container-grown longleaf pine seedlings and removing non-target seedlings. Most container longleaf seedlings are grown in small ribbed containers averaging 5-7 cubic inches in volume and 3-6” in depth (Longleaf Nursery List). Typical seedling are sown in the spring and form a well-rooted “plug” by late fall or early winter. Herein, these seedlings are referred to as “target” seedlings. Target seedlings met the seedling quality standards as defined by the “Interim Standards for Longleaf Pine Container Seedlings Stock” (Barnett, et. al.). Some nurseries double-seed containers to insure an optimum percentage of cells are filled with viable seed, often resulting in two live seedlings per plug. These seedlings are herein referred to as “doubles”. Other seedlings are suppressed in the container by surrounding seedlings that exhibit faster growth. Suppressed seedlings usually do not develop sufficient root collars or fine root systems to form a good plug, and are typically referred to as “culls” or in this study as “floppies”. Seedlings that did not meet the Interim Standards because of inadequate plugs were selected as floppies for this study. A final category of seedlings is hybrids between longleaf and loblolly. These hybrids are historically referred to as “sondereggers” (Walker & Wiant 1966). Sonderegger seedlings typically exhibit height growth while still in the container. Longleaf seedlings are usually sold on a per thousand basis and an average lot of 1000 seedlings will contain target, double, floppy, and sonderegger seedlings. This study examines the relative survival rates of these four seedling types in the first growing season.

METHODS

Study sites were installed on the “Samson Site” in Southeast Alabama in Geneva County and the “Monroe Site” in southwest Alabama in Monroe County. A randomized complete block study design was utilized on both sites. Four replications of each block were planted with 20 seedlings per treatment. Seedlings were grown in 6” styroblock containers by two nurseries in South Georgia. Seedlings were separated into classes to examine survival and growth for different container-grown seedlings classifications. Seedlings classes were:

- Good Quality: Seedlings with firm plugs and no visible diseases on the foliage.
- Floppies (Culls): Seedlings whose plugs were not firm or solid enough to remain straight when held in a horizontal position. When held horizontally by the terminal bud, the seedling “flopped” over.
- Doubles: Two seedlings per plug.
- Sondereggers: Potentially hybrid seedlings that exhibited some stem elongation in the plug.

All 4 seedling types were utilized at the Samson Site. “Doubles” were not included at the Monroe Site.

Prior to planting, both sites were scalped. Scalping was done with a three-point hitch fire plow and the scalped area was approximately 30” in width and 4” deep.

Seedlings were assessed for percent surviving and overall appearance. Health was assessed based upon the aboveground foliage. Scores were assessed on a scale of 0 to 6. A perfect seedling scored a zero, while a dead seedling scored a six. Average scores are given for surviving seedlings only: the lower the average score, the healthier the appearance of seedlings in a given treatment.

Samson Site: The study site had been unsuccessfully planted to bareroot longleaf seedlings two years prior to the study installation. The landowner and county forester attributed the previous planting failure to a spring drought following planting. Prior to this planting, the site had been in cotton and peanut production.
Seedlings were provided by Meek’s Farms of Kite, Georgia. Seedlings were shipped to The Longleaf Alliance and planted within a few days of extraction and shipping. Seedlings were hand planted on December 14th, 2001. Seedlings were band-sprayed with 2 oz of Oust in April.

**Monroe Site:** This site is part of an Auburn University Agricultural Experiment Station and was in cotton production the year prior to study installation. Seedlings were provided by Simmons Tree Farm of Denton, Georgia. Seedlings were shipped to The Longleaf Alliance and planted approximately 1 week after extraction and shipping. Seedlings were hand planted on 2/21/02 with dibble bars and plug tools. Seedlings were band-sprayed with 2 oz of Oust in April.

**RESULTS**

<table>
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<th>Percent Surviving (6 months post-planting)</th>
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<tr>
<td>Site</td>
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<td>------</td>
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<tr>
<td>Samson</td>
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<td>Monroe</td>
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Overall survival rates varied between the two sites. We attributed this to the earlier planting date on the Samson Site (December) as compared to the Monroe Site (February). Good quality seedlings excavated in April exhibited more developed root systems on the Samson Site, as compared to the Monroe Site.

Across both sites, “floppy” seedlings performed the poorest. Sondereggers, or seedlings that looked like sondereggers had lower survival rates than “target” seedlings. Some seedlings that were originally thought to be sondereggers turned out to be regular longleaf pine seedlings. Doubles did better than expected on the Samson site where 96% of the plugs had at least one surviving seedling.

![Samson Site - Six Month Survival](image1)

![Monroe Site - Six Month Survival](image2)
CONCLUSIONS

- Removing floppies and sonderegger seedlings prior to planting may increase overall survival rates on some sites.
- Floppies/culls may survive better under optimal conditions. Or conversely, poor quality seedlings may experience higher mortality under more adverse conditions.
- Doubles appear to initially survive as well as target/good quality seedlings.
- True sonderegger seedlings may suffer differing mortality rates than reported here since some of the seedlings included in this study turned out to be regular longleaf pine seedlings. Seedlings exhibiting minimal stem elongation (1-2") in the container are often true longleaf seedlings.

ADDITIONAL STUDY

The initial two study sites will be tracked for survival and growth for at least two years. In the winter of 2002/03 additional seedling quality studies were installed in Milledgeville, GA, Lexington SC, Denton, GA, and on the Solon Dixon Forestry Education Center near Andalusia, AL. Treatments installed during the winter of 2002/03 on these subsequent sites include:

#1 Target/Good Quality Seedlings (> 6.0 mm RCD)
#2 J-Rooted Average (> 6.0 mm RCD)
#3 Floppy Small (<4.75 mm RCD)
#4 J-Rooted Floppy (4.75-7.00 mm RCD)
#5 Floppy-Large (4.75-7.00 mm RCD)
#6 Double – Codominant Large (at least 1 seedling > 6.0 mm RCD. No more than 3.0 mm difference between seedlings)
#7 Double – 1 Suppressed (at least 1 seedling > 6.0 mm RCD. No less than 3.0 mm difference between seedlings.)
#8 Extra-Large RCD (>= 9.0 mm RCD)
#9 Hybrids/Sondereggers.

SUMMARY

Visually sorting container-grown longleaf pine seedlings may result in the removal of numerous floppy, hybrid, and double seedlings. Removing floppies and sondereggers will likely result in an increased overall survival rate, especially when adverse environmental factors stress newly planted seedlings.

LITERATURE CITED


DETERMINING THE CORRECT PLANTING DEPTH FOR CONTAINER-GROWN LONGLEAF PINE SEEDLINGS

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ABSTRACT: As early as 1996, approximately 30 million container-grown longleaf pine were planted annually in the Southeastern, US (Hainds, 2002). Approximately 45 million container-grown longleaf pine seedlings will be planted during the 2002/03 planting season (Hainds, unpublished data). Despite these huge investments in the artificial regeneration of longleaf pine, no research was located prior to 1998 that examined methods for planting container-grown longleaf pine seedlings. In December of 1998, The Longleaf Alliance installed the first planting depth study to validate “common knowledge” related by tree planters and foresters who generally had considerable experience planting bareroot loblolly and slash pine. “Common knowledge” stressed that “deeper is better” regardless of the pine species being planted. Planting guidelines developed from these theories typically emphasize a narrow planting window with a major concern being the avoidance of “shallow planting” that will expose the plug. The prevailing theory was that an exposed plug would act as a “wick” (Larson, 2002), drying out the plug and increasing seedling mortality. Furthermore, most guidelines allow for the terminal bud to be covered with soil at the time of planting, assuming that erosion will uncover the bud and allow unrestricted growth. Consequently, these planting guidelines tend to encourage “deep planting”. The Longleaf Alliance installed four planting depth studies from 1998 to 2002 to determine the optimal depth for container-grown longleaf pine seedlings. Results indicate that deep planting significantly reduces seedling survival and growth. Results also indicate that longleaf is very tolerant of “shallow” planting whereby the plug is exposed at the time of planting, thus discrediting the “wick” theory. Planting depth guidelines for most states may be incorrect. Emphasis should be shifted from depth of the plug to height of the terminal bud above the soil surface.

INTRODUCTION

The first planting depth study was installed in 1998 to examine the effects of planting depth on survival and height growth initiation of container-grown longleaf pine seedlings. At the time, The Longleaf Alliance still cautioned tree planters to avoid “shallow” planting that exposed the plug above the soil surface. Supposedly, the plug would act like a “wick”, desiccating the root system and leading to seedling mortality. Based upon this theory, the depth of the plug was more important than the position of the terminal bud. Prior to this 1998 study, no research examining planting depth and container-grown longleaf pine seedling survival could be located in the existing literature.

Initial findings from the first study indicated that “deep planting” where the terminal bud was covered, was severely detrimental to seedling survival and growth. Unexpectedly, “shallow” seedlings exhibited no ill effects as a result of exposing the plug. Suspecting that this finding was an anomaly, three subsequent planting depth studies were installed over the following years.

STUDY SITES & METHODS

Study Designs: All four planting depth studies utilized the randomized complete block design. Each study has 4 or 5 replications of each treatment (depth) and 14 seedlings per plot. Survival rates were assessed at 1-2 years post-planting with the exception of the Monroe Study on saturated soils that was installed in February of 2002.

Planting Methods, Soils, Seedlings: All seedlings were planted by hand using either plug tools or OST planting bars (dibbles). Soils across all sites were sandy loams or loamy sands. The Monroe Study was unique in that soils were exceptionally wet with the seedlings often being under water following rainfall events. Seedlings were 4 ½” plugs on the Orchard Site and 6” plugs with the remaining three studies.

Orchard Site (1998): This study was installed in an old pecan orchard on the Solon Dixon Center in south Alabama. Site preparation consisted of a scalping operation exposing a trench about 4” deep and 30” in width. Immediately after scalping, the site was ripped/sub-soiled to an approximate depth of 16”. Seedlings were hand planted with a plug tool in Dec, 98. Four planting depths were examined: #1) Exposed
plug, 1 cm above soil surface(Exp +1cm), #2) Exposed plug, planted at soil surface(Exp), #3) Plug planted 1 cm below soil surface, plug covered but terminal bud not covered (-1cm), #4) Plug planted 2 cm below soil surface with terminal bud covered (-2cm).

Silvopasture Site(2000): Six-inch plug seedlings were planted with an OST dibble on 12/7/2000 on a cutover site that had a minimal mechanical site preparation. Survival was assessed on 6/10/02. Terminal bud position was used for treatment depths rather than plug position. The 4 treatments were #1) bud 3 CM (1.2” ) beneath soil surface, #2) Terminal bud 1cm (.4”) beneath soil surface, #3) Bud exposed at soil surface, #4)bud 2 CM (.8”) above soil surface.

Godwin Site (2000): Site preparation consisted of a scalping operation exposing a trench about 4” deep and 30” in width. Six-inch plug seedlings were planted w/ an OST bar on 12/1/00 and survival was assessed on 12/03/02. Terminal bud position was used for treatment depths rather than plug position. The 4 treatments were #1) bud 3 CM (1.2” ) beneath soil surface, #2) Terminal bud 1cm (.4”) beneath soil surface, #3) Bud exposed at soil surface, #4)bud 2 CM (.8”) above soil surface.

Monroe Site(2002): Site preparation consisted of a scalping operation exposing a trench about 4” deep and 30” in width. Six-inch plug seedlings were planted w/ an OST bar on 2/21/02 and survival was assessed on 7/30/02. Terminal bud position was used for treatment depths rather than plug position. The 3 treatments were #1) plug exposed, bud 1 CM (.4”) above soil surface, #2) Terminal bud 3 cm (1.4”) above soil surface, #3) Terminal bud 6 cm (2.4”) above soil surface.

RESULTS AND DISCUSSION

Seedling survival and growth were negatively affected by “deep planting.” Mortality increased if the bud was covered at the time of planting or buds were subsequently covered by soil moving onto buds in scalped rows. In scalped furrows, experience has shown that seedlings planted with the bud at/or slightly above the soil surface will end up with the bud covered by soil moving into the scalped furrow. Anticipate up to 1” of soil movement into a 3-4” deep scalped furrow within six months of planting. Deeper scalping furrows will probably have more soil movement into the furrow and over the terminal bud, resulting in increased mortality and decreased growth rates of surviving seedlings.

No significant increases in mortality were detected in seedlings planted with the plug exposed, even at the most shallow depths where approximately 5 cm of the plug was exposed above the soil surface on the Monroe Site.

![Mortality by Planting Depth](Mortality by Planting Depth)
CONCLUSIONS

- “Deep planting” where the terminal bud is covered with soil results in increased seedling mortality and reduced growth.
- The “wick theory” does not appear to be valid. Container-grown longleaf pine seedlings appear tolerant of “shallow planting” where the plug is exposed.

NEW RECOMMENDATIONS FROM THE LONGLEAF ALLIANCE

- Rather than focusing on depth of the plug, focus on the anticipated position/depth of the terminal bud 6 months-to-1 year post planting.
- On flat planted sites, instruct tree planters to leave plug slightly exposed so that the terminal bud is above the soil surface.
- On scalped sites, try to position the terminal bud approximately 2” above soil surface, leaving 1-1 ½” of the plug exposed.
- On extremely wet sites, position terminal bud > 2” above the soil surface, leaving 2-3” of the plug exposed.

ADDITIONAL STUDY

A fifth planting depth study was installed on a cutover site in July, 2002. A sixth study was installed in Milledgeville, Georgia in January 2003. A sixth site was planted February 4th in Lexington, South Carolina. And a seventh site was selected and planted in Denton, Georgia on February 6th, 2003.

Additional studies will be installed with plugs protruding further above the soil surface on cutover sites. Sites with heavier soils should be examined in future replications. Also, different plug lengths and seedling root collar diameters should be examined for tolerance of shallow planting.

SUMMARY

Seedlings planted with the plug protruding above the soil surface survived and grew at the best rates regardless of the site, environmental conditions, or plug length. Position of the terminal bud is more important than position of the plug. Seedlings planted with the terminal bud beneath the soil surface suffer increased mortality compared to seedlings with the terminal bud above the soil surface. Benefits of shallow planting appear to be more pronounced in areas where soil will move onto the seedling (i.e. scalped fields). Seedlings planted with the plug exposed did not suffer increased mortality as presupposed with the “wick” theory.

LITERATURE CITED


Hainds, M.J. Unpublished data collected while updating the Longleaf Nursery List for the 2003-04 planting season.

ESTABLISHING LONGLEAF PINE SEEDLINGS ON AGRICULTURAL FIELDS AND PASTURES

Mark J. Hainds (Research Coordinator, The Longleaf Alliance, 12130 Dixon Center Road, Andalusia, AL 36420)

The Longleaf Alliance was formed in 1995. At approximately the same time, tens-of-thousands of agricultural acres were enrolled in the Conservation Reserve Program (CRP). The Longleaf Alliance played a crucial role in educating and informing CRP participants as to the many benefits and challenges unique to longleaf pine (*Pinus palustris* Mill). Unfortunately, the best available information was often inadequate and success rates varied considerably. With the benefits of hindsight and much experience, we believe that most planting failures were avoidable. Furthermore, many planting failures were attributed to factors that may not have played a role in seedling mortality on a given site.

A new CRP enrollment has been authorized for 2003. In all likelihood, tens-of-thousands of additional acres will be enrolled in the CRP in the near future. If we have not learned our lessons from plantings in the late 90’s, we are doomed to repeat many mistakes that were made during the initial CRP longleaf plantings - at considerable expense to landowners, state agencies, and the federal government.

The Longleaf Alliance has a unique advantage in that it is a regional organization with members from every state in longleaf pine’s natural range. The Alliance works directly with State Forestry Commissions, the USDA Forest Service, the Natural Resource Conservation Service, the Farm Service Agency, forestry consultants, herbicide applicators, tree planters, and landowners from across the Southeastern, US. Alliance personnel have witnessed almost every possible combination of site preparation, seedling stock, and herbaceous release on a variety of soil types from North Carolina to Texas. This wide-ranging experience has allowed us to work with others to identify many of the leading factors in longleaf seedling mortality.

SITE SELECTION

Before planting an agricultural field or pasture, it is important to determine if the site is appropriate for longleaf pine. Some sites are inappropriate and repeated planting failures are foreordained for those attempting to plant longleaf pine on sites that have: high pH/basic soils (>7.0 pH), excessive soil nutrients, or excessively wet soils.

**High pH/basic soils**
The majority or soils across the Southeastern, US are acidic in nature and acceptable for longleaf pine seedling establishment. However, many agricultural sites have had their soil pH artificially raised by repeated applications of lime. The Alliance has received reports of tomato fields in north central Florida with pH readings approaching 8.0. Planting failures are the norm for any southern pine species on these sites. It could take many years for the soil to reach an acceptable pH for longleaf seedling establishment on these sites.

Other soils are naturally basic (>7.0 pH). In particular, many prairie type soils in central Alabama and Mississippi are basic in nature. Experience has shown that it is very difficult to successfully establish longleaf pine on soils that are greater than 7.0 pH.

**Excessive soil nutrients**
Some areas have become so nutrient-loaded that seedlings pick up toxic concentrations of normally beneficial nutrients. The Alliance has visited or received reports concerning sites where large amounts of chicken litter was deposited, or, cattle catch pens were located. On these nutrient-loaded sites longleaf seedling mortality approached 100% during the first growing season.

**Excessively wet sites**
Ponded soil types are typically problematical. Seedling mortality increases dramatically when seedlings are under water for more than a few days. Mortality can be reduced by planting seedlings with most of the plug protruding above the soil surface. However, excessively wet soils (Pelhams & Gradies) are generally ill suited for longleaf pine.
BAREROOT OR CONTAINER
After determining the site is appropriate, selection of seedling stock is the next important step. Longleaf seedlings are grown and planted as both bareroot and container-grown seedlings. Seedling survival varies considerably based upon seedling quality, and to some degree, on seedling type. A 1995 survey (Boyette, 1995) found that foresters, tree planters, and landowners averaged 85% survival using container-grown stock and 65% survival using bareroot stock. While some tree planters are consistently successful planting bareroot seedlings, the trend has been away from bareroot and towards container-grown seedlings. (Table 1) Consequently, this paper will focus on the successful establishment of container-grown seedlings.

Table 1. Annual Longleaf Seedling Production (Millions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Bareroot</th>
<th>Container</th>
<th>% of Total Production (Container)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>30.2</td>
<td>31.1</td>
<td>51%</td>
</tr>
<tr>
<td>1997</td>
<td>27.6</td>
<td>36.3</td>
<td>57%</td>
</tr>
<tr>
<td>1998</td>
<td>25.0</td>
<td>42.6</td>
<td>63%</td>
</tr>
<tr>
<td>1999</td>
<td>26.2</td>
<td>56.4</td>
<td>68%</td>
</tr>
<tr>
<td>2000</td>
<td>32.6</td>
<td>82.3</td>
<td>72%</td>
</tr>
<tr>
<td>2001</td>
<td>23.8</td>
<td>73.2</td>
<td>75%</td>
</tr>
</tbody>
</table>

Inadequate containers were an early problem for a relatively new industry producing longleaf seedlings in containers. The absence of ribs in some containers led to root spiraling, which is extremely detrimental to seedling survival, growth, and form. Also, longleaf seedlings were occasionally grown in containers that were too small to produce a quality seedling.

Another early problem was the absence of seedling standards. Seedlings were often shipped with small root collar diameters (RCD), poor root systems, diseased foliage, and with weeds in the plug. In response to the lack of seedling standards, The Longleaf Alliance cooperated with the USDA Forest Service to produce The Interim Standards for Producing Longleaf Pine Seedlings in Containers (Barnett & others 2002). This publication has recommendations for: ribbed containers, minimum root collar diameters (1/4”), plug attributes, foliage attributes, minimum container volumes and depths, and other characteristics to look for in a quality longleaf seedling.

There are several different types or classes of seedlings in a typical lot of longleaf seedlings. The Longleaf Alliance installed two studies to identify easy diagnostics that would allow an individual to sort out seedlings that would not survive and grow well when compared to seedlings that met preferred criteria in the Interim Guidelines (Barnett & others 2002).

Study sites were installed in or near Monroeville and Samson, AL. Seedlings types utilized in these studies included: hybrids (or seedlings that looked like hybrids), doubles (two seedlings per plug), culls/floppies, and good quality seedlings without weeds in the plug. Survival was assessed approximately 6 months-to-one year post-planting (Table 2). Culls or “floppies” were seedlings in which the plug “drooped” or would not hold itself parallel to the ground when held by the terminal bud.

Table 2. Survival by seedling type

<table>
<thead>
<tr>
<th>Site Type</th>
<th>Good</th>
<th>Double</th>
<th>Floppy/Cull</th>
<th>Hybrid (lob x long)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monroeville Site (age = 1 yr.)</td>
<td>75%</td>
<td>N/A</td>
<td>21%</td>
<td>64%</td>
</tr>
<tr>
<td>Samson Site (age= 6 months)</td>
<td>91%</td>
<td>96%</td>
<td>80%</td>
<td>81%</td>
</tr>
</tbody>
</table>

As expected, good quality seedlings demonstrated some of the best survival rates. Likewise, doubles did very well at the Samson study site but were not included at the Monroeville study site. Hybrid seedlings had lower survival rates than good quality seedlings. Finally, floppies/culls had the lowest survival rates, doing much worse on the Monroeville site, but only slightly worse than good quality seedlings on the Samson Site. These findings are in line with the Interim Standards: “Seedlings that fail to meet the criteria for the preferred category may survive and grow well under favorable site conditions.” The Samson site was planted December 14th, allowing seedlings to establish a better root system than the Monroeville seedlings, which were planted February 21st. It is likely that planting dates were an important factor in the
lower overall survival of seedlings on the Monroeville site, and the abysmal performance of the floppy/cull seedlings in Monroeville.

From these two studies and previous work done by the USDA Forest Service we recommend that landowners or foresters:

#1 Sort through seedlings boxes before delivering to the tree planter.
#2 Establish counts of good quality seedlings per box.
#3 If an excessive number of culls are found, send them back to the nursery.
#4 Request additional seedlings if your seedling count is short.

SITE PREPARATION

Over the past several years the Alliance has witnessed and directly participated in many attempts to establish longleaf pine in pastures or agricultural sites with significant components of perennial pasture grasses including bahia (Paspalum notatum Fluegge), fescue (Festuca arundinacea Schreb.), and Bermuda grass (Cynodon dactylon (L.)Pers). For several years, most pasture plantings ended in failure. It was soon established that grasses had to be removed or controlled through the site preparation prior to planting. Planting seedlings directly into pastures with the intention of controlling grasses through a post-planting herbaceous release was a recipe for failure.

The question was “What is the best site preparation for agricultural sites that have pastures grasses in place?” The Longleaf Alliance attempted to answer this question through a 1998 study: Comparison of Site Preparation Methods and Herbaceous Releases for Longleaf Pine Establishment in an Old Pecan Orchard. The study site was an old pecan orchard in Covington County, AL. Soils were sandy loams with a history of frequent liming and fertilization. The site had a full compliment of old-field broadleaves and grasses including Bermuda, Bahia, and crab grasses (Digitaria spp.), among many other competitive old field weed species. Three site preparations were tested in this study: scalping and sub-soiling, broadcast chemical (glyphosate & imazapyr) plus sub-soiling, and check or sub-soiling only plots. This study utilized a randomized complete block design with four replications. The main plot treatment was the site preparation and subplot treatments were herbaceous releases.

Site preparation was completed in the fall of 1998 and container-grown longleaf were hand planted in January 1999. After planting, seedlings were released in April and May of 1999. Eleven herbaceous release treatments were applied (Table 3):

Table 3. Herbaceous Release Treatment (Subplot Treatments)

<table>
<thead>
<tr>
<th>Product oz/acre</th>
<th>Active Ingredient</th>
<th>Timing of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Velpar DF 10.67/Oust 2</td>
<td>hexazinone/sulfometuron</td>
<td>4/7/99</td>
</tr>
<tr>
<td>Oust 2</td>
<td>Sulfometuron</td>
<td>4/7/99</td>
</tr>
<tr>
<td>Arsenal 4/Oust 2</td>
<td>imazapyr/sulfometuron</td>
<td>4/7/99</td>
</tr>
<tr>
<td>Arsenal 4/Oust 2</td>
<td>imazapyr/sulfometuron</td>
<td>5/12/99</td>
</tr>
<tr>
<td>Atrazine 64</td>
<td>Atrazine</td>
<td>4/7/99</td>
</tr>
<tr>
<td>Atrazine 64/Oust 2</td>
<td>atrazine/sulfometuron</td>
<td>4/7/99</td>
</tr>
<tr>
<td>Oust 2 &amp; Arsenal 4</td>
<td>sulfometuron &amp; imazapyr</td>
<td>4/7/99 &amp; 5/12/99 (2 app.s)</td>
</tr>
<tr>
<td>Fusilade 24</td>
<td>fluazifop-P-butyl</td>
<td>4/7/99 &amp; 5/12/99 (2 app.s)</td>
</tr>
<tr>
<td>Velpar DF 21.34</td>
<td>Hexazinone</td>
<td>5/12/99</td>
</tr>
<tr>
<td>Velpar DF 10.67</td>
<td>Hexazinone</td>
<td>4/7/99</td>
</tr>
</tbody>
</table>

Survival was assessed in the first and second growing seasons (Table 4). Differences were significant and increased with time post-planting. Consistent with work previously conducted in Florida (Barnard 1995), survival and growth was significantly better on scalped plots as compared to check (subsoil only) plots. Survival and growth of longleaf was also significantly better on scalped vs. chemically site prepared plots. Overall, scalping provides a much better return in seedling survival and growth as compared to chemical or site preparation (Table 4).
Table 4. Survival, Growth, and Costs by Site Preparation.

<table>
<thead>
<tr>
<th></th>
<th>Check SP - Subsoil Only</th>
<th>Chemical SP + Subsoil</th>
<th>Sculp SP + Subsoil</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Surviving (Age 1)</td>
<td>64%</td>
<td>72%</td>
<td>88%</td>
</tr>
<tr>
<td>% Surviving (Age 2)</td>
<td>46%</td>
<td>61%</td>
<td>82%</td>
</tr>
<tr>
<td>Starting Height Growth (Age 2)</td>
<td>30%</td>
<td>54%</td>
<td>72%</td>
</tr>
<tr>
<td>Total $$/Acre (Site Prep, Planting, Seedlings, &amp; Release)</td>
<td>$175.00</td>
<td>$245.00</td>
<td>$195.00</td>
</tr>
<tr>
<td>$$ per Surviving Seedling (Age 2)</td>
<td>$0.77</td>
<td>$0.86</td>
<td>$0.48</td>
</tr>
<tr>
<td>$$ per Seedling Initiating Height Growth (Age 2)</td>
<td>$3.48</td>
<td>$2.21</td>
<td>$0.78</td>
</tr>
</tbody>
</table>

HERBACEOUS RELEASE
The Longleaf Alliance has conducted four herbicide screening trials (as of December 2002) with further demonstrations and trials planned in 2003. Results from the eleven herbaceous release treatments tested in the old pecan orchard were consistent with previous and subsequent screening trials. From these screening trials, our most consistently effective release is the “split” treatment. The split treatment is composed of an early pre-emergent application of Oust® at 2 oz in March or April, followed by a post-emergent Arsenal® application of 4-6 oz. Wait for grasses to emerge before applying the 2nd Arsenal® application. On low fertility sandy sites, the first Oust® application is often sufficient by itself. On more fertile sites, problematic grasses or weeds will generally start to appear approximately six weeks following the initial pre-emergent Oust® application. Typically the 2nd post-emergent treatment will go out between mid-May and late-July.

Alternatively, for those who can only afford a single application, an Arsenal® (4-6 oz)/Oust® (2 oz) tank mix has consistently tested as one of the best herbaceous releases. We recommend the Arsenal®/Oust® tank mix be applied after May 1st, as injury and seedling mortality have been associated with earlier pre-emergent applications.

Many people believe their herbaceous release application has led to increased seedling mortality. In many cases, they are probably correct. Reviewing the first four herbicide screening trials conducted by The Longleaf Alliance, we believe trends are emerging with late plantings and/or high pH soils and mortality related to soil active herbicides such as Oust® or Oustar®. In general, seedling mortality will be greater with late plantings, agricultural sites, and high pH soils, regardless of the herbicide applied.

Root growth prior to herbaceous release appears to be the key to avoiding increased seedling mortality or injury following an herbaceous release. If good root systems are established prior to the herbicide application, seedlings appear to be more tolerant of soil active herbicides. If few or no fine roots have exited the plug, expect increased mortality associated with early applications of soil active herbicides. To avoid this conundrum, plant good quality seedlings early in the planting season, and excavate several seedlings prior to any herbicide application. If several roots have exited the plug, soil active herbicides can be applied with less risk. If the root system is still confined to the plug, it is probably better to avoid soil active herbicides that could potentially increase seedling mortality. Dig before you spray!

PLANTING DEPTH
Of all the factors that come into play, planting depth may be the single most critical factor affecting seedling survival and growth. Again, with hindsight, we believe that a large percentage of early unexplained planting failures were a direct result of planting seedlings too deep. Results from the first four planting depth studies installed by The Longleaf Alliance have been extremely consistent (Table 5). When soil covers the terminal bud, seedling mortality increases dramatically while seedling growth is set back with surviving seedlings.

Prior to this research, the “wick” theory was widely promoted across the Southeast. The premise of the wick theory is that seedlings planted with the plug exposed will “wick out” or desiccate and die. The wick theory promotes deep planting and the avoidance of exposing the plug at all costs. Studies conducted by The Longleaf Alliance prove the wick effect is a fallacy. In every study conducted thus far, seedlings planted with the plug exposed have outperformed seedlings planted with the terminal bud beneath the soil.
surface. Subsequent studies installed in 2002 and 2003 in Alabama, South Carolina, and Georgia, are being tracked at this time.

Table 5. Mortality by Planting Depth from Deep to Shallow (height to terminal bud) 1 or 2 Years Post-Planting

<table>
<thead>
<tr>
<th>Study Site</th>
<th>-3 CM</th>
<th>-1 CM</th>
<th>Level</th>
<th>+1 CM</th>
<th>+2 CM</th>
<th>+3 CM</th>
<th>+6 CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silvopasture Site</td>
<td>57%</td>
<td>41%</td>
<td>24%</td>
<td></td>
<td>21%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Godwin Site</td>
<td>79%</td>
<td>71%</td>
<td>39%</td>
<td></td>
<td>36%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orchard Site</td>
<td>56%</td>
<td>19%</td>
<td>17%</td>
<td></td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monroe Site</td>
<td></td>
<td>38%</td>
<td></td>
<td></td>
<td></td>
<td>33%</td>
<td>21%</td>
</tr>
</tbody>
</table>

TIME OF PLANTING

Historically, planting season has been restricted to the winter months with the majority of seedlings planted in December, January, or February. With the advent of container-grown seedlings, a longer planting season was advocated with some people delaying plantings until March. While little research has been conducted on time-of-planting with container grown seedlings, the majority of anecdotal evidence suggests that earlier plantings are much likelier to succeed as compared to later plantings. Given adequate soil moisture, The Longleaf Alliance recommends planting as early as October. In moist soils, longleaf seedlings frequently initiate root growth very quickly. Early planted container longleaf seedlings appear more tolerant of winter droughts than bareroot seedling stock. Seedlings planted early in the planting season have more developed root systems come spring, and thus appear more tolerant of spring droughts and herbaceous competition. Seedlings planted in late February or March appear much less hardy, and are more susceptible to injury or mortality from herbaceous release treatments, herbaceous competition, and spring or summer droughts. From plantings on or around the Solon Dixon Center, one good rain (>1”) soon after planting is sufficient to insure a successful establishment of container-grown longleaf seedlings on most sites.

Many people are unaware that summer planting is a viable option. The Longleaf Alliance has planted longleaf on several sites in May, June, and July of 2001 & 2002. Overall survival rates have averaged approximately 80% at one year post-planting. With this limited experience, we only recommend summer planting in areas where seasonal rainfall is high during the summer months. June and July are typically wet months along much of the lower Coastal Plain. From our experience, summer planting is a good option for filling in mortality on winter plantings, as long as adequate soil moisture is present and competition has been controlled through an herbaceous release treatment.

SUMMARY

#1 Use good seedlings.
#2 Scalp agricultural fields.
#3 Plant as early as possible.
#4 Plant shallow with the terminal bud well above the soil surface.
#5 Release seedlings from herbaceous competition for increased growth.
#6 Examine roots before applying soil active herbicides.
#7 Interplant mortality (May-July) if soil moisture is adequate.

LITERATURE CITED


INFLUENCE OF FORESTRY NURSERY CONTAINERS ON SURVIVAL, ROOT COLLAR DIAMETER GROWTH, AND ROOT DEVELOPMENT ON LONGLEAF PINE SEEDLINGS

Sandy Harris (Auburn University School of Forestry & Wildlife Sciences)

ABSTRACT: Longleaf Pine (*Pinus palustris* Mill.) from a southern Mississippi seed source were grown in six different container types and subjected to outplanting trials to examine if container type affected seedling performance. Bareroot stock, from a different seed source, was also included in these tests. Survival, root collar diameter growth, foliar nutrition, and root development are reported.

Results indicated that stock types with large cavities and low stocking densities performed best. Also, stock types that did not induce lateral root growth while in the nursery had more roots emerging from the upper half of the root plugs. Foliar analyses suggested that for the first growing season, seedlings with roots closer to the soil surface after outplanting did not have enhanced nutrition over other seedling stocks.

Regression analysis did not reveal a strong relationship between soil strength measurements and root development. Two factors may account for this; 1) soil strength measurements were recorded after seedlings were excavated, and 2) soil strength measurements were not high enough at any site to induce root growth problems on conifer seedlings.
ABSTRACT: In the southern United States, the chief influence of burning on landscapes is not how fire influences long-term pine yield but rather how fire influences overall stand structure and species composition. Without the continual use of fire, a forest canopy will develop with a basal area dominated by loblolly pine overstory trees. Beneath this canopy, a well developed midstory and understory of woody plants and vines with draped and laddered fuels will evolve. The resulting deep shade and accumulation of litter will nearly eliminate herbaceous vegetation.

We have become convinced that on most upland sites a series of preharvest treatments are needed to ensure the restoration of longleaf pine plant communities and lessen the hazard of wildfires on these pyric landscapes.

Our objective in this Joint Fire Science Program project is to demonstrate changes in fuel load condition on uplands being restored to longleaf pine in the West Gulf Coastal Plain. First, we are evaluating two conversion treatments: (1) clearcutting and (2) harvesting to a longleaf pine shelterwood. These treatments are being compared to (3) unharvested forest. Treatments 1 and 2 are planted with longleaf pine seedlings. Second, each of the three treatments is subdivided for evaluating vegetation management practices: (a) untreated condition, (b) prescribed burning only, and (c) a combination of mechanical woody plant control and prescribed burning. Over time, this will allow us to evaluate how different combinations of treatments influence the management and development of forest fuels, vegetation, and structure on sites being restored to longleaf pine.

INTRODUCTION

In the southeastern United States, wildland fuels accumulate, and without fire management, understory vegetation can shift from grasses to woody plants with significant numbers of highly flammable shrubs supporting draped fuels (Haywood and Grelen 2000, Haywood et al. 2001). We believe this shift in vegetation increases fire intensity, which makes fire fighting more hazardous and costly and places property and natural resources in greater danger. To avoid this outcome, many forest managers are trying to increase the use of fire in upland forest landscapes and to ultimately restore existing upland loblolly pine-hardwood forests to the native fire-manageable longleaf pine ecosystem. The desired future condition being pure longleaf overstories (80% or more of the basal area is longleaf pine), with few if any midstory hardwoods except in riparian areas, and a rich, diverse ground cover of herbaceous and low woody plants.

As part of this effort, our Joint Fire Science Program project evaluates changing fuel conditions as upland loblolly pine-hardwood forests are restored to longleaf pine in the West Gulf Coastal Plain. At each demonstration site we are comparing two vegetation management treatments—prescribed burning alone or in combination with mechanical woody plant control—to an untreated check.

DEMONSTRATION AREAS

The demonstration areas lie within the humid, temperate, coastal plain and flatwoods province of the West Gulf region of the southeastern United States and are suitable for the restoration of loamy dry-mesic upland longleaf pine forests (Turner et al. 1999). They are located within the boundaries of the Kisatchie National Forest in central Louisiana at an average elevation of 100 to 200 ft above sea level. Slopes vary from 1 to 10%.

The original longleaf pine forests were cutover beginning in the 1920s. Although some small stands of pine remained, a general cover of perennial grasses under scattered pines and hardwoods was maintained by periodic burning for open-range grazing. Hogs were excluded in the 1950s and cattle stocking was regulated. Eventually, natural and plantation stands of pines and hardwoods reforested much of the
landscape; in which we established three demonstration areas that represent stages in the change from loblolly pine to longleaf pine forest—loblolly pine, mixed pine, and seedling and sapling longleaf pine plantation.

**STUDY DESIGN**

Each demonstration area is a block. Each block is about 20 acres and was divided into three parts to which three treatments were randomly assigned: (1) **check**: no treatment; (2) **prescribed burning only**: plots are prescribed burned every two years beginning in May 2001; and (3) **mechanical woody plant control and prescribed burning**: plots were prescribed burned as in treatment 2, and in July 2002, the understory vegetation was cut to within 2 inches of the ground with a machine-mounted horizontal-shaft drum shredder (Woodgator®).

**PLOT LAYOUT AND MEASUREMENT**

A 0.25-acre main plot was established within each check and treated area. In April 2001, woody plants greater than 4-inch dbh were measured and inventoried by species. To measure and inventory trees and shrubs 1 to 4 inches in dbh, four 12-by-12 ft plots were randomly selected and permanently established within each main plot. The overstory and midstory vegetation was again examined in July 2001 after the burns. Understory trees and shrubs < 1-inch dbh, blackberry, woody vines, and herbage were inventoried and percent cover ocularly estimated in July 2001 on a 3.3-by-3.3 ft subplot that was nested within each 12-by-12 ft plot.

To determine changes in available fuels, four 6.6-by-16.5 ft fuel plots were randomly selected and permanently established within each main plot. Each fuel plot was divided into ten 3.3-by-3.3 ft subplots for sampling without replacement. Fuel samples were collected on one subplot per fuel plot a month before the May-2001 prescribed burns. A second subplot was sampled 6 weeks after the burns. Fuel samples were divided into three classes that were considered available for combustion before being oven-dried and weighed: (1) living foliage within 6 ft of the ground; (2) living blackberry canes, woody stems, and vines no more than 0.25 inch in diameter; (3) 1-hour time-lag dead fuels (surface litter and duff to a 0.25 inch depth and small roundwood, and stubble no more than 0.25 inch in diameter.

**RESULTS AND DISCUSSION**

The overstory and midstory vegetation was not affected by prescribed burning. Due to dry soil conditions in May 2001, a burning root breached the fireline on the loblolly pine site and the check plot was accidentally burned. Nevertheless after the burn, understory trees, shrubs, and woody vines still shaded 41% of the ground (Table 1). In the mixed pine stand, burning reduced understory tree, shrub, blackberry, and vine cover by 74 percentage points, but the coverage of forbs and ferns increased after burning. The responses to burning in the mixed pine stand were the normally expected short-term outcome. In the seedling and sapling longleaf pine plantation, grasses dominated the understory vegetation, and burning had little effect on the relative importance of the plant taxa. Burning reduced overall ground cover from 97 to 85% in the longleaf plantation.
Fire greatly affected the living available fuels, oven-dried lb/acre of foliage was reduced by 89, 96, and 63% and oven-dried lb/acre of stems was reduced by 95, 99, and 95%, respectively, in the loblolly pine, mixed pine, and young longleaf pine stands (Table 2). The average pre-burn weight of these two fuel classes was similar on all three sites and averaged 1,382 lb/acre. However, post-burn re-growth occurred and replaced 17, 12, and 58% of the pre-burn living fuels on the three sites, respectively, in 6 weeks. Needle-cast resulting from the burns occurred on all sites, but was most significant on the mixed pine site. The weight of 1-hr time-lag fuels was reduced by 62% across all three sites. Overall, burning reduced total available fuel load from an average of 8,212 lb/acre to 3,682 lb/acre or by 55% across all three sites.

Table 1—Percent cover of the understory vegetation by taxa on the burned and unburned portions of each forest stand 6 weeks after the May-2001 burns

<table>
<thead>
<tr>
<th>Plant taxa</th>
<th>Loblolly pine No burn</th>
<th>Burn</th>
<th>Mixed pine No burn</th>
<th>Burn</th>
<th>Seedling and sapling longleaf pine plantation Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees and shrubs &lt; 1-inch dbh</td>
<td>27</td>
<td>87</td>
<td>25</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Blackberry</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Woody vines</td>
<td>14</td>
<td>14</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Grasses</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>59</td>
<td>50</td>
</tr>
<tr>
<td>Grass-like plants</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
</tr>
<tr>
<td>Forbs</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Legumes</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Ferns</td>
<td>0</td>
<td>&lt;1</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

*No data.

Table 2—Fuels available for burning (lb/acre oven-dried weight) by fuel classes and three forest types before and 6 weeks after the May-2001 burns

<table>
<thead>
<tr>
<th>Fuel classes</th>
<th>Loblolly pine before</th>
<th>after</th>
<th>Mixed pine before</th>
<th>after</th>
<th>Seedling and sapling longleaf pine plantation before</th>
<th>after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live foliage</td>
<td>489</td>
<td>55</td>
<td>760</td>
<td>31</td>
<td>1,096</td>
<td>406</td>
</tr>
<tr>
<td>Live stems ≤ 0.25 inch diameter</td>
<td>876</td>
<td>45</td>
<td>658</td>
<td>4</td>
<td>268</td>
<td>13</td>
</tr>
<tr>
<td>Post burn re-growth</td>
<td>0</td>
<td>226</td>
<td>0</td>
<td>164</td>
<td>0</td>
<td>792</td>
</tr>
<tr>
<td>Post burn needle cast</td>
<td>0</td>
<td>96</td>
<td>0</td>
<td>1,428</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>1-hr time-lag dead fuels</td>
<td>7,643</td>
<td>4,709</td>
<td>9,102</td>
<td>1,869</td>
<td>3,745</td>
<td>1,196</td>
</tr>
</tbody>
</table>

Fire greatly affected the living available fuels, oven-dried lb/acre of foliage was reduced by 89, 96, and 63% and oven-dried lb/acre of stems was reduced by 95, 99, and 95%, respectively, in the loblolly pine, mixed pine, and young longleaf pine stands (Table 2). The average pre-burn weight of these two fuel classes was similar on all three sites and averaged 1,382 lb/acre. However, post-burn re-growth occurred and replaced 17, 12, and 58% of the pre-burn living fuels on the three sites, respectively, in 6 weeks. Needle-cast resulting from the burns occurred on all sites, but was most significant on the mixed pine site. The weight of 1-hr time-lag fuels was reduced by 62% across all three sites. Overall, burning reduced total available fuel load from an average of 8,212 lb/acre to 3,682 lb/acre or by 55% across all three sites.

We concluded that a single burn did not greatly change overall fuel conditions or the composition of the understory vegetation, but single burns rarely do (Haywood and Grelen 2000, and Haywood et al. 2001). We expect that additional burning with and without mechanical woody plant control will have significant effects in the future without greatly altering the overstory vegetation. Changing the composition of the overstory vegetation should require additional treatments, such as thinning or a shelterwood regeneration.
cut. Our long-term goal is to study the effects of these kinds of stand management and regeneration techniques on fuel loads as well.

ACKNOWLEDGEMENT

The Joint Fire Science Program, Boise, Idaho, funds this project.

LITERATURE CITED


ABSTRACT: Frequent growing season burning is considered essential for restoring longleaf pine plant communities, and the maintenance of mature longleaf pine ecosystems requires recurrent burning at a 2- to 4-year interval to create an open park-like landscape with species-rich communities of native herbaceous plants. However, fire can be a destructive force causing reduced productivity and mortality among overstory longleaf pine trees.

On two central Louisiana sites, we determined that severe crown scorch reduced longleaf pine diameter growth by 22 percent during five growing seasons after prescribed burning. Crown scorch also reduced root sucrose and starch concentrations, total, and live fine root mass density, and the initiation of secondary root development.

It is apparent that fire-induced loss of leaf area potentially reduces carbon fixation and allocation to the stem and root system. The magnitude and duration of these effects depend on the amount and season of leaf area loss, as well as interacting site quality and climate factors. Depending on management objectives, however, the need to restore and maintain historic plant communities as habitat for endangered species is worth a moderate reduction in growth among large overstory trees.

INTRODUCTION

Restoring longleaf pine (Pinus palustris Mill.) plant communities is an objective of many in the southern United States as a way to provide desirable habitat for nearly 200 threatened or endangered taxa of vascular plants and several vertebrate species (Brockway and others 1998). Frequent growing season burning is considered essential for the restoration of these plant communities (Haywood and Harris 1999), and the maintenance of mature longleaf pine ecosystems requires recurrent burning at a 2- to 4-year interval to produce open park-like stands of longleaf pine with species rich communities of native herbaceous plants.

Fire can be a destructive force causing mortality and reduced productivity among overstory longleaf pine trees. Decreases in longleaf pine growth on routinely burned sites may be attributed to the intensity and timing of burning relative to the seasonal pattern of carbon fixation and allocation in trees. The importance of foliage as a carbon or food source and the vulnerability of fire-exposed foliage to heat injury could be critical factors affecting stand productivity. The objective of this study was to monitor relationships between crown scorch and foliage dynamics, stem growth, root carbohydrate concentrations, and fine root growth in a mature longleaf pine stand. These research results are being used to design additional experiments to study the carbon dynamics of longleaf pine in response to repeated prescribed fire.

METHODS

The study trees are located in two stands on the Calcasieu Ranger District, Rapides Parish, Louisiana. In September 1996 at site one, a stand of 65-year-old longleaf pine was prescribe burned using a series of strip-headfires. At strip interfaces, the crowns of longleaf pine were nearly defoliated. Along two of these interfaces, 10 defoliated trees were selected, as were 10 adjacent non-scorched longleaf pine trees. Thus, 40 (20 scorched and 20 non-scorched) trees were monitored.

At site two in March 1997, a stand of predominately 45-year-old slash pine (Pinus elliottii Engelm.) was prescribed burned using a helicopter-mounted ignition system. Most of the stand was scorched. However, there were natural longleaf pine in the overstory (these trees were over 45 years old), and 10 of the non-scorched longleaf pine were paired with adjacent scorched longleaf trees in May 1997. In total, 20 longleaf pines were monitored (10 non-scorched and 10 scorched) within this predominately slash pine forest.
Soils at site one were Ruston fine sandy loam on the ridges and Smithdale fine sandy loam on the side slopes. At site two the soil was predominately Beauregard silt loam. At both sites in May 1997 through September 2001, the diameter at breast height (dbh) and total height of each selected pine tree was measured with a diameter tape or height instrument. At site one in May 1997 through May 1998 and in December 1998 one soil core was randomly collected to a 20 cm depth within six feet of each tree (Sword and Haywood 1999). Roots were elutriated from the soil cores. Fine root carbohydrate concentrations and biomass were determined.

For the pine tree measurements, the dominant effect in this study was crown scorch, and we compared dbh and height using a completely randomized model with the May 1997 measurements as covariates (alpha =0.05). At site one, root data were transformed to natural logarithms and evaluated using a randomized complete block design with topography as blocks.

RESULTS

Longleaf pine dbh growth was significantly less for the scorched trees than for the non-scorched trees through five growing seasons after prescribed burning (1997-2001) (Table 1). Total tree height was not significantly affected.

Root sucrose and starch concentrations varied seasonally, but overall, they were significantly reduced in response to crown scorch through February 1998 (Sword and Haywood 1999) (figure 1). One year after burning, total and live pine fine root mass densities were significantly lower in response to crown scorch (figure 2). However, this effect was not evident at earlier sampling dates. Also, one year after burning the percentage of live roots exhibiting secondary growth was significantly reduced in response to crown scorch.

DISCUSSION AND CONCLUSIONS

Severe crown scorch reduced diameter growth by 22 percent, but height growth was not affected through five growing seasons after prescribed burning (Table 1). It is likely that water deficits during the prolonged drought of 1998 through 2000 in Central Louisiana inhibited the growth of both the non-scorched and scorched trees. We hypothesize, therefore, that in the absence of drought, diameter growth reductions in response to crown scorch may have been more pronounced and total height growth differences may have become apparent.

Crown scorch also reduced root sucrose and starch concentrations, total and live fine root mass density, and the initiation of secondary root development. It is apparent that fire-induced loss of leaf area potentially reduces carbon fixation and allocation to the stem and root system. However, the magnitude and duration of these effects depend on the amount and season of leaf area loss, as well as interacting site quality and climate factors. Nevertheless, the need to restore and maintain historic forest types as habitat for endangered species may be worth a moderate reduction in growth among large overstory trees depending on the landowner’s objectives.
Table 1—Comparisons of longleaf pine diameter and total height over a 5-year period between non-scorched and scorched trees and the probabilities of a greater F-value (P-value); the May-1997 data were used as covariates in the analyses.

<table>
<thead>
<tr>
<th>Groupings</th>
<th>Dbh (inches)</th>
<th>Total height (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May 1997</td>
<td>Sept 2001</td>
</tr>
<tr>
<td>Non-scorched</td>
<td>16.1</td>
<td>17.0</td>
</tr>
<tr>
<td>Scorched</td>
<td>15.4</td>
<td>16.1</td>
</tr>
</tbody>
</table>

Figure 1. Longleaf pine fine root sucrose and starch concentrations 8 to 19 months after crown scorch in September 1996.

Figure 2. Longleaf pine fine root mass density (above) and percentage of root mass exhibiting primary and secondary development (below) in September 1997.
FUTURE RESEARCH

As part of a long-term study, we continue to investigate the effects of prescribed fire on longleaf pine root and stem development. Our work is now concentrated in newly established longleaf pine plantations on upland sites being converted from a loblolly pine-hardwood to an historic longleaf pine landscape. Our objectives are to determine how fascicle physiology, leaf area dynamics, growth and carbon allocation of sapling longleaf pine are affected by fuel treatments that result in varied intensities of biennial prescribed fire. At the same time, long-term effects of biennial prescribed fire on soil chemical and physical properties are being evaluated to determine the effects of repeated fire on soil quality.

ACKNOWLEDGEMENT

The Joint Fire Science Program helps fund this project.

LITERATURE CITED


MODELING ECOLOGICAL CONDITION FOR USE IN LANDSCAPE SCALE MONITORING AND RCW MANAGEMENT

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ABSTRACT: Monitoring the status and trends of longleaf pine communities across large landscapes using traditional field sampling techniques is made problematic due to personnel limitations, excessive travel time between sampling points, funding limitations, and statistical requirements for large sample sizes. Eglin AFB has developed a spatially explicit model of ecological condition to provide timely status and trends monitoring of ecological condition across the landscape. Using extensive field data of from the Eglin Air Force Bases Ecological Monitoring Program, the ecological condition model was analyzed for its capacity to determine 4 and 6 classes of ecological condition within longleaf pine sandhill habitat at Eglin. Using discriminant function analysis, the classifications were determined to be 85% and 71% accurate, respectively. This level of accuracy exceeds that obtained through subjective assessments of ecological condition by biologists. These results of ecological condition also correlate well with measures of biodiversity in the understory of Eglin’s longleaf pine sandhills. With an increasing body of literature pointing to the importance of quality groundcover to the Federally endangered red-cockaded woodpecker, this ecological condition model can be used across the Southeast to assess groundcover conditions in red-cockaded woodpecker foraging habitat where monitoring resources are limited. At Eglin Air Force Base, the ecological condition model output has been integrated within an automated red-cockaded woodpecker foraging assessment tool with Eglin’s geographic information system database.
ABSTRACT: Prescribed fire resources are frequently insufficient to manage landscapes for all conservation or resource management objectives, necessitating tradeoffs as to the portion of the landscape that receives fire within any given year. Defining the rules of these tradeoffs when applying limited prescribed fire to large landscapes is made more difficult by the complexity of weighing competing management objectives at the landscape scale. Eglin Air Force Base has used a simple four-step spatial modeling process to help managers prioritize limited prescribed fire resources across its 185,000-ha landscape. First, managers and biologists identify key conservation criteria and landscape management objectives that drive the application of prescribed fire. Second, remote sensing and other spatial data are developed to directly or indirectly represent all of these criteria. Third, using geographic information system software in a facilitated workshop, each criterion is weighted by managers according to its contribution to overall burn prioritization, and values for the criterion are scored as to how they influence the need to burn. Lastly, the model is validated through research and monitoring and is adapted to evolving management objectives. This process was successfully transferred to the 80,000-ha Blackwater River State Forest. The advantages to this simple modeling approach for prioritizing limited prescribed fire resources are its reliance on accessible geographic information system software, the articulation of spatially explicit management objectives, its ease of transferability, and its clearly stated assumptions about management actions that may be tested through monitoring and reviewed through public comment.
WHO’S AFRAID OF THE BIG, BAD TURKEY OAK? Shifting the Paradigm in Sandhills Fire Management

J. Kevin Hiers (Science Applications International Corporation, Eglin AFB Ecological Monitoring Program, 1130 Eglin Parkway, Shalimar, FL 32579)
Morgan Varner (The University of Florida, Department of Botany, Gainesville, FL)
Doria Gordon (The Nature Conservancy of Florida, Gainesville, FL and The University of Florida, Department of Botany, Gainesville, FL)

ABSTRACT: It is a widely held belief among both researchers and managers that the presence of midstory oaks degrades longleaf pine ecosystems. The mechanism for this degradation is assumed to be shade from midstory hardwoods. While appropriate for productive longleaf ecosystems, this hypothesis has not been tested in the xeric sandhills. In sandhills, fire-induced mortality of deciduous oaks is a primary restoration objective for many--if not most--managers. At Eglin Air Force Base, fire management targeting oak stem reduction has compromised other restoration objectives through excessive overstory longleaf pine mortality. We examine data from a large-scale midstory reduction study in sandhills at Eglin AFB. Combined with new information generated by Eglin AFB's monitoring program, we present a contrasting mechanism for degradation within sandhills ecosystems based in fuels management. This proposed mechanism for degradation focuses on shading of understory species through hardwood litter accumulation and self-shading in grasses. From this fuels perspective, restoration success is not dependent upon the short-term reduction of deciduous oak density, but rather frequent consumption of litter and other accumulated fuels. Understanding the mechanism for degradation has direct relevance in prioritizing restoration objectives for long-unburned longleaf pine ecosystems by placing increased emphasis on the dynamics of litter consumption and fire frequency while relegating oak mortality to an ancillary objective of restoration. Based upon these results, the primary objectives of prescribed fire in fire-excluded sandhills should be 1) the frequent, thorough consumption of the litter layer, 2) the retention of overstory pine, 3) and a long-term reduction of oak stem density.
ABSTRACT: The use of young pine plantations by wildlife has been studied intensively. However, few studies have been performed with respect to comparing wildlife habitat within artificially regenerated longleaf and loblolly pine plantations. As a result, a study has been established in the coastal plain of south central Alabama to compare wildlife habitat quality within longleaf and loblolly pine plantations at age 7 and 8 with different stocking levels and artificial regeneration practices. The surrogate of the study will be the bobwhite quail, and “habitat quality” will be referred to as foods and plant cover essential to the species. We will assess the impact of 8 different longleaf and loblolly pine density levels ranging from 300 to 1100 trees per acre (TPA) and 2-year post-plant chemical vegetation control with the use of glyphosate (Roundup®) and/or sulfometuron (Oust®) on leaf area index (LAI), understory plant communities, and light intensity levels reaching understory plant communities. Results from the study should prove useful in complementing longleaf restoration efforts of many private, state, and federal organizations and agencies.
PUTTING THE SAVANNA BACK IN THE SAVANNAH RIVER SITE: An Integrated Ecological Approach

Donald W. Imm (USDA-FS, Savannah River, New Ellenton, SC 29809)
John I. Blake (USDA-FS, Savannah River, New Ellenton, SC 29809)

ABSTRACT: Longleaf savannas once dominated the uplands of the upper Coastal Plain of South Carolina. These open, fire-maintained communities harbored diverse assemblages of herbaceous plants and provided habitat for a wide variety of fauna. Since European settlement much of the habitat at the Savannah River Site (SRS) was lost through agricultural-use and fire protection. During this period, populations of species dependent upon pine savanna habitat were either reduced or fragmented. In the early 1950’s, longleaf pine was planted on abandoned farmland and cutover forests. During the mid 1980’s forest management emphasis shifted to restoring longleaf pine forests for the recovery of the federally endangered red-cockaded woodpecker (2 groups in 1985 to 39 groups 2002). In the early 1990’s an integrated ecological approach for the recovery of native species and community was initiated. The integrated approach included comprehensive management and research efforts. Projects developed a template for restoration including a data-based multivariate analysis of pre-European and potential pine savanna communities based on historic records and landscape characteristics. Site wide surveys for rare plant populations and remnant patches of savanna species were conducted to determine priority areas for restoration and conservation. Other projects focused on management techniques (silvicultural, prescribed burning) and strategies for native plant species reintroduction and enhancement (native plant culture and establishment). Finally, several projects were implemented to determine the effects of RCW habitat and plant restoration on faunal populations and communities (game species, non-game birds, herptofauna, small mammals, and gopher tortoise).
ADAPTIVE MANAGEMENT IN PRACTICE: An Example from Ichauway

S.B. Jack  (J.W. Jones Ecological Research Center, Newton, GA)
J.B. Atkinson (J.W. Jones Ecological Research Center, Newton, GA)
L.R. Boring (J.W. Jones Ecological Research Center, Newton, GA)

ABSTRACT: The Joseph W. Jones Ecological Research Center at Ichauway was established in 1991 to serve as a regional center of excellence in ecology and natural resource management that includes integrated research, education, and conservation goals. In accord with this mission, the Center began over the last three years to formally implement an adaptive management program to better integrate resource management and research interests and concerns.

An informal mode of adaptive management – i.e., trying new techniques or practices and incorporating those that work to achieve the desired results – is frequently used by good land managers. In implementing an adaptive management program at the Jones Center we integrated this mode of operation into a framework of scientific investigation through the use of treatment plots and quantification. At Ichauway, the resource management group defines questions and topics about which there is uncertainty in regard to the best possible management practices. We then work to coordinate the development of applied research projects with the scientific staff to address these questions in a scientifically and statistically defensible manner. While we are still working to refine working relationships and operational logistics, several successful adaptive management projects have been initiated and, in some cases, expanded. Examples include work on invasive hardwood removals for restoration, longleaf planting arrangements in abandoned agricultural fields, restoration of depressional wetlands, and initiatives for wiregrass restoration. Additional projects are continually being developed as ongoing projects are monitored.
ABSTRACT: The National Forests (NF), USDA, and Savannah River Natural Resource Management and Research Institute (SRI), DOE, are making restoration of the longleaf pine ecosystem a high priority issue as their Forest Plans are being revised. The National Forest System’s continuous inventory of stand conditions (CISC) database showed that longleaf pine and mixtures of longleaf and other species existed on 688 thousand acres of NF and SRI lands in 1988. The CISC databases showed that these acres had increased to 803 thousand acres in 1997 (20% increase compared to 1988) and in excess of 840 thousand acres in 2002 (26% increase from 1988). The longleaf pine ecosystem will not be restored to the full range of sites and conditions, which existed prior to pre-European settlement. Longleaf pine ecosystem restoration on the NF and SRI will be a slow and continuing process. However, it will be restored, maintained and enhanced to the fullest extent possible. The target goal, or Desired Future Condition, for the longleaf pine ecosystem on the NF and SRI is 1.245 million acres (86% increase compared to 1988).

Approximately three-quarters of the increase in longleaf pine acres have resulted from a very aggressive planting program on these Forests. During the five-year time period 1997-2001, an average of between 5 and 6 thousand acres were planted annually for a total of nearly 30 thousand acres. Approximately 85 percent of the longleaf acres planted on NF lands were planted with container-grown longleaf pine, while virtually all of the longleaf pine planted on SRI lands was bare root stock. In 2001, survival of container-grown longleaf pine seedlings, three years after planting, averaged 73 percent and 54 percent for bare root stock on the National Forests. In comparison, third-year survival for bare root stock on Savannah River Institute site averaged 85 percent. These high survival rates only occur when good quality planting stock is used; the planting stock is properly handled and planted on good, well-prepared sites; and the plantings receive good quality post-planting treatment.

The NF and SRI are making restoration of the longleaf pine ecosystem a high priority issue as their Forest Land and Resource Management Plans (Forest Plans) are being revised. Forest Plans are required by the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976. Forest Plan revision occurs when forest conditions have changed significantly, or at least every 15 years. A Forest Plan does not direct specific management activities for specific locations. It does, however, significantly influence the design, execution, and monitoring of site-specific forest activities. Environmental documents, which accompany the Forest Plan, provide data disclosing environmental consequences of proposed management alternatives. The Forest Plan also discloses the effects of proposed alternatives and how they respond to public issues and concerns. Current Forest Plans for the NF and SRI call for total of nearly 1.3 million acres of desired future condition acres (DFC) of longleaf pine forest types (Figure 1 and Table 1). This is a 94 percent increase as compared to 1988.

Revised Forest Plans for the NF and SRI in the Southern Region having significant acreages of longleaf pine call for continued increases of longleaf pine and longleaf-other species mixtures, control of competing vegetation in the mid-story, and improved health of the understory plant communities by mechanical and chemical means and through the use of periodic growing season and dormant season prescribed fires (McMahon, Tomczak, and Jeffers 1997).

Longleaf pine ecosystem restoration on the NF and SRI will be a slow and continuing process. Although the longleaf pine ecosystem will not be restored to the full range of sites and conditions, which existed prior to pre-European settlement, it will be restored, maintained and enhanced to the fullest extent possible.

LITERATURE CITED

Figure 1. Longleaf Pine Acres on the National Forests and Savannah River Institute

Table 1. Longleaf Pine Acres on the National Forests and Savannah River Institute*

<table>
<thead>
<tr>
<th>Forest</th>
<th>1988</th>
<th>2002</th>
<th>DFC**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North Carolina</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NF's in North Carolina</td>
<td>12,208</td>
<td>15,075</td>
<td>19,403</td>
</tr>
<tr>
<td><strong>South Carolina</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Francis Marion &amp; Sumter NF's</td>
<td>32,658</td>
<td>48,812</td>
<td>54,555</td>
</tr>
<tr>
<td>Savannah River Institute</td>
<td>33,913</td>
<td>44,035</td>
<td>86,089</td>
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<td><strong>Florida</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NF's in Florida</td>
<td>175,994</td>
<td>215,335</td>
<td>221,121</td>
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<tr>
<td><strong>Alabama</strong></td>
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<td></td>
<td></td>
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<tr>
<td>NF's in Alabama</td>
<td>128,575</td>
<td>154,449</td>
<td>270,619</td>
</tr>
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<td><strong>Mississippi</strong></td>
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<td></td>
<td></td>
</tr>
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<td>182,283</td>
<td>208,978</td>
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</tr>
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<td><strong>Louisiana</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kisatchie NF</td>
<td>81,526</td>
<td>127,670</td>
<td>263,000</td>
</tr>
<tr>
<td><strong>Texas</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NF's in Texas</td>
<td>20,805</td>
<td>28,417</td>
<td>107,225</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>667,962</td>
<td>842,771</td>
<td>1,297,041</td>
</tr>
<tr>
<td>Increase since 1988 (%)</td>
<td>26</td>
<td>94</td>
<td></td>
</tr>
</tbody>
</table>

*Includes longleaf pine and mixtures of longleaf pine and other species.
**Desired Future Condition.
The biodiversity of the longleaf pine ecosystem and effective fire management of this forest type are dependent on the structure and composition of ground cover. The high diversity of ground cover species per unit area makes these ecosystems among the most species-rich plant communities in North America (Walker and Peet 1983, Kirkman et al. 2001). The herbaceous ground cover provides the fine fuels necessary for long-term maintenance of the ecosystem. Of the few remaining tracts of longleaf pine forest in the Southeast, most have degraded native ground cover due to fire suppression or past land use disturbances. An estimated 35 million ha of pre-settlement longleaf pine forests have been reduced to a mere 1.2 million ha with perhaps only 0.5 million ha with intact ground cover (Outcalt 2000).

Functionally, dominant grasses coupled with pine needles provide the fine fuels necessary to carry frequent fire. In particular, pineland 3-awn wiregrass (Aristida beyrichiana and A. stricta) dominates ground cover through a significant portion of the longleaf pine range. Wiregrass is considered extremely important because of its flammability, but also because it suspends pine needles above the soil surface (Noss 1989). Pine needles decompose at a slower rate when elevated (Hendricks et al. 2002), and thus a greater mass of needle litter is retained as a source of fine fuels. Together, wiregrass and pine needles provide more flexibility for implementing prescribed fire across variable weather conditions (Figure 1). Because wiregrass is not known to re-establish dominance on previously cultivated sites, and is less vigorous without periodic fire disturbance, the presence of wiregrass is often used to indicate relatively undisturbed longleaf pine communities (Clewell 1989). Consequently, reintroduction of this species and other fine fuels is thought to be an important first step in restoration and maintenance of ecosystem diversity.

Wiregrass and other native ground cover species provide important cover for nesting bird species, and many other plant species provide important wildlife food for both game and non-game species. Many legume species are native to the longleaf-wiregrass ecosystem (Hainds et al. 1999) and play an important role in nitrogen fixation (Hiers 1999) (Figure 2). Studies of nutrient loss indicate that nearly 90% of total foliar nitrogen is volatilized during fire (Boring et al., unpubl.). Thus, the presence of these species may be critical for re-capturing nitrogen lost with burning and in turn, are essential to maintaining long term site productivity with a frequent fire regime.
Figure 2. Percent foliar nitrogen derived from atmosphere for selected legume species. (From Hiers 1999, Hiers et al. 2003)

Figure 3. Wiregrass seedlings established following direct seeding in 2/2001 and by herbicide (Garlon + Plateau) or no herbicide in 8/2001. Bulk is approximately 75% seed by weight.

Management efforts for native ground cover may range from restoration, to rehabilitation, or enhancement depending on starting conditions and economic and ecological goals. However, an overarching objective for longleaf pine ecosystem management is to return, improve and sustain forest ecosystem health and native biodiversity through the use of frequent fire. In addition to varied goals for restoration, regional differences in native vegetation and variation in soil types provide mixed challenges and dictate different approaches to reintroduction of native ground cover species on disturbed sites. Regardless of the scope of implementation, the development of economically feasible approaches and seed sources for private
landowners remains a critical bottleneck for successful and widespread implementation of ground cover restoration.

Information is slowly emerging regarding successes and failures of wiregrass reintroduction techniques throughout the region through operational practices, adaptive management trials and research efforts. Wiregrass can be successfully established from either seed or seedling plugs grown in greenhouses (Figure 3). However commercial sources of seed are unavailable and planting of wiregrass seedlings appears to be prohibitively expensive at large scales; cost ranges from 18-30 cents per plug. At a planting density of 2 plugs per m$^2$, cost ranges from $3500-$5800 per ha ($1420 - $2360 per acre). Contract seedling planting labor adds an additional cost of $2000 per ha ($800/acre). In addition, species such as wiregrass require specialized equipment for harvesting and seeding, and sources of seed in natural stands are limited.

Many technical questions remain before recommendations for ground cover restoration by direct seeding can be promoted to a wider audience. Conversion of agricultural fields and pastures present particularly difficult challenges for establishment of native ground cover due to weedy and non-native grass competition. Such sites require intensive site preparation and herbicide application prior to or after seeding. In some forested conditions, hardwood removal or plantation thinning must be implemented prior to restoration of native ground cover to facilitate prescribed fire and eliminate competition (Mulligan et al. 2002, Kirkman and Mitchell 2002).

The Native Ground Cover Partners (NGCP) is a collaborative effort to obtain basic information regarding native ground cover species seed harvest, cultivation, commercial potential and restoration in longleaf pine ecosystems. Participating partners include the J. W. Jones Ecological Research Center, the University of Georgia National Environmentally Sound Production Agriculture Laboratory (NESPAL), Private Landowners, and the Georgia Department of Natural Resources. The purpose of this strategic outreach program is to produce wiregrass stands for future seed harvest, to provide research sites and demonstration areas for growing wiregrass as a crop, and to refine direct seeding techniques for restoration planting. For example, research and operational-scale trials for wiregrass propagation are being conducted on public and privately owned lands, and education and outreach programs incorporate research results of ongoing field trials (Figure 4).

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**Figure 4.** Model of adaptive management implemented by Native Ground Cover Partners.
Initial participating landowners are selected based on the availability of wiregrass seed on their property and their willingness to experiment with crop development and restoration techniques. Working with several landowners and their land managers provides replication of trials across a gradient of site conditions. Specialized equipment for seed harvest and planting has been acquired by the NGCP to conduct small plot studies that evaluate cultural practices associated with direct seeding and to address issues of weed control. Additionally, this organization is examining the feasibility of development of landowner incentive programs for ground cover restoration association with ongoing Conservation Reserve Programs that promote planting longleaf pine. Additionally, funding is being pursued to purchase seed collection access in natural stands on private lands and the development of ground cover seed as alternative agricultural crops. A future goal of this organization is to target other functionally important grasses and legumes for similar research and development projects.

LITERATURE CITED


LONGLEAF PINE: The Southern Pine for Increasing Storage of Terrestrial Carbon?

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ABSTRACT: Before the arrival of settlers to the United States, natural communities dominated by longleaf pine (Pinus palustris Mill.) occurred throughout most of the southern Atlantic and Gulf coastal plains. These communities once covered an estimated ninety million acres, or two-thirds of the forested area in the Southeast. Exploitation of longleaf pine led to a steady decline of its acreage. Today, estimates indicate that less than 3 million acres remain. However, private, state, and federal land managers have recently undertaken ecological restoration and reforestation in the longleaf pine forests of the southeastern United States. This trend suggests an opportunity to increase terrestrial carbon storage within an ecological sound, economically viable and socially acceptable framework based on: historical records that show longleaf pine to be a long-lived species with a low mortality rate, tolerating a wide variety of habitats. Longleaf is better able to sustain growth at high densities and older ages, (over 150 years) and is tolerant to fire, insects and disease.

INTRODUCTION

If southern forests are going to play an expanded role in the sequestration and storage of atmospheric carbon then many questions must be addressed such as: What species are optimal for carbon storage? What management practices and rotation options favor long term carbon storage? What are the impacts of a regional carbon storage strategy on biodiversity and soil quality? Will the process be sustainable and socially acceptable? In this paper, we propose a regional carbon sequestration and storage approach utilizing longleaf pine as the preferred commercial southern pine species (the other species being loblolly pine, shortleaf pine, and slash pine to use in the southeastern United States, especially in the Atlantic and Gulf coast coastal plain regions. This approach is based on the convergence of several factors related to: the biology and ecology of longleaf pine, research findings from long-term studies, longleaf pine products and utilization, and recent trends in longleaf pine management.

THE BIOLOGY AND ECOLOGY OF LONGLEAF PINE

Life span

One of the major ways to successfully sequester and store carbon is to tie it up for as long as possible in long-lived trees. Among southern tree species, longleaf pine is a long-lived tree and may outlive any other species except for bald cypress. While the native longleaf pine forest contained stands covering a wide range of ages, a substantial portion of the old-growth timber appeared to be in the 200- to 300-year age range when it was logged. Longleaf pine in excess of 450 years in age has been reported (Platt and others 1988) thus a maximum biological age of over 500 years is not unreasonable. However, due to the constant hazards of lightning and wind, very few are ever likely to reach this biological potential.

West and others (1993) reported on increases in annual increments of all age classes for trees from 100 to nearly 400 years old. This increase, beginning in approximately 1950 and continuing to the present, resulted in an average annual ring increment approximately 40% greater in 1987 than 1950. When compared with expected annual increment, the increase for 100-150-year-old trees is approximately 45%, while the increase for 200- to 400-year-old trees is approximately 35%. They could not explain the increased growth based on disturbance, stand history, or trends in precipitation and temperature.

Site adaptations

Longleaf pine occurs under a variety of environmental conditions. 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. Longleaf pine forests exist up to an elevation of 580 meters above mean sea level, and
down to near sea level along the Atlantic Ocean and Gulf of Mexico coastline. Though most often associated with deep (often > 4.7 meters) sandy soils, or “sandhills”, longleaf pine occurs on all but the most inundated soils in the southeastern USA (Wahlenberg 1946).

**Natural resistance to risks**
Comparatively speaking, longleaf pine has a superior natural resistance to fire, insects, diseases, and windthrow from hurricanes that the other southern pines (Wahlenberg 1946). Across much of the Southeast, southern pine beetles have periodically destroyed vast acreages of loblolly pine stands. Littleleaf disease, a disease caused by a complex of factors including the fungus *Phytophthora cinnamomi* Rands has been a major problem with shortleaf pine. However, where longleaf pine is grown, there are no reports of large acreage losses. Diseases and insects rarely cause mortality of longleaf pine. Longleaf is somewhat resistant to the several species of Coleopteran bark beetle, a severe problem for other southeastern USA pine species (Anderson and Doggett 1993). Longleaf is usually less susceptible to infection from fusiform rusts than other southern pines (Walkinshaw and others 1993). Lightning strikes are the primary inciting agent of mortality in longleaf forests (Platt and others 1988, Palik and Pederson 1996). In a more recent study, McNulty (2002) concluded that longleaf pine maybe the species to grow in the South where hurricanes can have a major impact noting it’s resistant to breakage and uprooting, fire, as well as its natural resistance to insect and disease outbreaks.

**Specific gravity**
There is very little difference in the percent carbon found in various tree species, all have approximately 50% carbon on a dry weight basis. However, there are significant differences among tree species in the specific gravity or density of the wood. This is a very important factor in the context of carbon storage since it is directly related to the quality of wood products, product utilization, and related long-term decay rates. It is also very important when comparing the growth rates of tree species using models which report productivity in volumetric terms (i.e. cubic meters per hectare).

There can be wide variations in the specific gravity of a tree species based on age, and site location. From a large sample of age classes and site locations, the specific gravity (based on green volume and oven dried weight) of longleaf pine averaged 8-12 % higher than the other commercial southern pine species (Koch 1972). The specific gravity of longleaf pine averaged 0.57, with a range of 0.40 to 0.75; slash pine (var. *elliottii*) averaged 0.53, range 0.41 to 0.70; loblolly pine averaged 0.51, range 0.38 to 0.68; and shortleaf pine averaged 0.52, range 0.37 to 0.72. Zobel and others (1972) also reports that when grown on the same site, longleaf pine nearly always produced wood with a higher specific gravity than either slash or loblolly pine.

**RESEARCH FINDINGS FROM LONG-TERM STUDIES**
Several studies indicate that for longer rotations (especially on sites with low to marginal site quality); longleaf pine will outperform the other three major commercial southern pines. In the past, forest managers generally did not seriously consider longleaf pine in their management plans because of poor survival and the slow early growth (during longleaf’s grass-stage period) compared to slash and loblolly pines which do not have a grass-stage. However, as more data from long-term studies emerge, there is more and more convincing evidence that the long-term growth rate of longleaf pine is equal or superior to other southern pines and it produces a higher quality, longer lasting product mix. In this paper, we briefly summarize four long-term studies that support the observation.

Schmidtling (1985). In a side by side comparison with loblolly and slash pine, longleaf pine grew as well as, or better, than loblolly or slash once it had emerged from the grass stage. A reexamination of that study at 39 years (Harris and others 2001) found that longleaf pine had higher survival, total basal area and volume when compared with either slash or loblolly pine. In addition, more than 70 percent of the longleaf pine could be classified as having a quality to make them into utility poles compared to 12 percent for slash pine and 8 percent of the loblolly pine.

Shoulders (1985). The results of 35 site-species trials in Louisiana and Mississippi were re-examined: a) to learn if early emergence of well stocked longleaf plantations from the grass stage would make them competitive in terms of growth and yield with the other major southern pines on a given site and b) because
of concerns in the early 1980’s that yields from slash and loblolly pine plantations would be substantially reduced due to fusiform rust. While there were certain site conditions where the other southern pines had more volume at the end of 20 years, longleaf pine stand basal area equaled or exceeded that of other species from age 15 onward. The conclusion was that longleaf pine was as potentially productive as the other southern pine species under a wide variety of site conditions if the problems of poor planting survival and brownspot needle blight could be overcome.

Outcalt (1993). Sandhills occupy significant acreages of the southeastern United States. They are typified by soils that are infertile and droughty. Many of these sites were planted to sand pine, either Choctawhatchee sand pine or Ocala sand pine. The growth of these two species was compared to longleaf, slash and loblolly pines after 28 years on deep sands in South Carolina and Georgia, USA. If the goal was to maximize yield for pulpwood rotations of 25 to 35 years, then Choctawhatchee sand pine was recommended for planting on these sandhill sites. However, longleaf pine has been growing as fast as Choctawhatchee sand pine since the age of 15 and if longer rotations are desired, then longleaf pine was recommended as the alternative species to plant.

Hoover (2000). As part of the Northern Global Change Program, a project was conducted to estimate current carbon storage on selected Department of Defense installations and to evaluate the future carbon sequestration potential of these lands under different forest management scenarios. Multiple stand growth simulations were run on a 40-hectare stand with a rotation age of 40 years. The parameters tested were site index, initial stocking level and survivorship at 10 years. In nearly all cases, the simulations indicated that longleaf pine would store more carbon then the other 3 major southern pine species, given the same starting conditions. Results from the old-field longleaf pine plantation simulator indicated there would be carbon gains due to increased stocking toward the end of the simulation period, when the trees were putting on volume rapidly and continued to do so beyond the 40-year rotation. Holding stocking levels constant and varying site index, a rotation of longleaf pine on a high quality site stored more carbon than any other species investigated.

LONGLEAF PINE PRODUCTS AND UTILIZATION

As early as the late 1800’s, the wood of longleaf pine was reported as heavier as and stronger than that of any other pine (Mohr 1897). Due to its excellent wood quality for construction, they estimated that nearly one-third of all lumber manufactured in the South at that time was longleaf pine. The wood was unsurpassed for posts, pilings, and joists, especially in bridge, railroad trestle, warehouse, and factory construction. In the early years, the untreated heartwood was widely used for railroad ties due to its natural resistance to termites and rot. If forest management is going to be practiced and trees are cut, then longleaf pine is a favorable tree species for the purpose of long-term carbon storage. This is based on the durable nature of the products produced and how they can be utilized for centuries, as compared to the pulp and fiber products derived from short rotation forest management, which return carbon to the atmosphere over a relatively short period.

One of the many unique characteristics that make longleaf pine superior to the other southern pines for long term storage is its growth form. The natural form is characterized by straight, knot-free boles. Therefore, a stand of longleaf pine produces a greater percentage of high-valued poles than other southern pine species; as much as 75 percent of a longleaf pine stand that has been managed for pole growth according to Williston and Srepetis (1975). The percentage is considerably less for loblolly or slash pine. This has a potential financial advantage for landowners and industry because poles may bring up to twice as much income as saw-timber. In addition, poles (especially when treated) represent a source of long term storage for carbon. In addition to poles, longleaf pine produces high quality products for pilings, posts and housing materials. The inherent strength and structural properties of longleaf pine make it the preferred species for the manufacturing of structural glue-laminated beams and timber bridge components.

Many buildings in the US and certainly most in the South built in the early 1800’s were built of longleaf pine. Today, many of the timbers left from buildings constructed long ago are being recycled for flooring, paneling, molding, and beams. Carbon that was stored in longleaf pine when trees were cut in the early 1800’s is still being stored today in these recycled materials. In addition, old-growth longleaf pine logs cut around 1900 are also being recovered from rivers and waterways and processed into high quality products.
RECENT TRENDS FAVORABLE FOR LONGLEAF PINE MANAGEMENT

Public Land Trends

Restoration of the longleaf pine ecosystem is now a goal on much of the public land in the southeastern United States. The National Forests (NF’s) that lie in the former range of longleaf pine are making restoration of this ecosystem a high priority. Jeffers and Tomczak (2003) report a 26% increase in longleaf pine hectares on lands managed by the NF’s in the period 1988-2002. The restoration on these lands will be a slow and continuing process involving both natural and artificial regeneration, the removal of off site pines, and expanded prescribed burning programs. The target goal, or desired future condition is 504,000 thousand hectares, an 86% increase compared to 1988 targets. Similar restoration activities are also occurring on other large parcels of public lands managed by the Department of Defense, the US Fish and Wildlife Service, and several southeastern States.

Private Land Trends

The incentives for planting longleaf pine on private land in the federally sponsored Conservation Reserve Program (CRP) resulted in approximately 121,000 hectares being planted on mostly agriculture lands in the two years the program was available (1999-2000). About 50 million longleaf seedlings were planted under this program in 2000, nearly half of the total grown and sold (Johnson 2001). By itself, this number may seem insignificant when compared to other commercial pine species such as loblolly pine. However, it represents a sharp reversal of the precipitous decline in longleaf pine hectares that had been occurring on private lands. For example, regional survey results reported by Kelly and Bechtold (1990) and Outcalt and Sheffield (1996), indicate that private lands accounted for approximately 95% of the longleaf hectares lost region wide in the ten year period between the mid 1980’s and the mid 1990’s.

Demand for Southern pine pulpwood derived from short rotation forest management has dropped dramatically in recent years, with a corresponding drop in prices. The drop in demand is a combination of increased use of recycled fiber, increased imports, a shift of production capacity to foreign lands with fewer environmental constraints, and the increased efficiencies of domestic mills (Shorter 2002). These trends have turned some large industrial forestry corporations and associated investment management firms toward a strategy of growing pine trees for lumber rather than for pulpwood. Since fast grown trees do not have the best quality for lumber, managing for mature wood grown over longer rotations is being carefully considered. The new strategy for longer rotations embraces a vision to plan for maximum economic return rather than maximum volume and includes consideration of potential income derived from carbon credits. Large forest product companies, associated timberland investment management institutions, the electric power industry and other “carbon intensive firms” have begun to examine carbon sequestration programs aimed at restoring forestlands and capturing the resulting environmental and economic benefits (Totten 1999).

Emerging Markets for Carbon Credits from Southeastern Forests

Organizations such as the Carbon Fund (http://www.thecarbonfund.org), based in Stoneville, MS are financing and promoting the protection, restoration and enhancement of forests all over the world through carbon sequestration programs. One of the primary purposes of The Carbon Fund is to assist farmers and landowners in pooling and marketing their carbon credits. The current focus is on bottomland hardwood programs but also includes plans for lands in the longleaf range in the coastal plain and flatwood regions of the southeast. The nonprofit UtilTree Carbon Company consists of 40 utilities which sponsor a diverse mix of rural tree planting, forest preservation, forest management, and research efforts at both domestic (Arkansas, Louisiana, Mississippi, and Oregon) and international sites (www.eei.org/issues/enviro/g_climate/utilitree.pdf). The Winrock International Ecosystems Services Group has recently prepared an assessment of the carbon sequestration potential of longleaf pine in Georgia for the Oglethorpe Power Company. They concluded a restoration program would be best aimed at marginal farmlands with low opportunity costs, particularly at sites removed from the path of urbanization (Shoch and others 2002).

LITERATURE CITED


Mohr, C.T. 1897. The timber pines of the southern United States. USDA Division of Forestry Bulletin 13, Washington, DC.


LONGLEAF MANAGEMENT AS MUCH ART AS SCIENCE

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This presentation is a case history and description of experiences and lessons learned from many years of ownership and management of a family property with natural stands of longleaf pine. The management history is known for 100 years and is well documented for 50 years. The property, located along the State line between Alabama and Mississippi, originated as a portion of a larger tract. Ownership has descended to the third generation. The current owners, a forester and his wife, inherited half of the property and acquired half through purchases and family exchanges.

The following is an outline of the property’s past 100 years:

1900 –1925 Hurricanes and cut-out
Hurricane – September 1906
Hurricane – July 1916
Cut-out Brannan Lumber Company
Hurricane – September 1926

1925 –1950 Fire Protection and regrowth
Acquisition ($1/acre) by 1st generation as Ray Sawmill Company – 1926
Grazing and wildfires
Transfer to 2nd generation – 1932
Fire Protection begun 1940’s
Regrowth
Light improvement cut – 1943

1950 –1975 Fire Protection, TSI, timber sales
Division among 2nd generation – 1952
Fire protection
Resolution of land line, encroachment and title problems
Periodic sawlog cutting 5-7 year cycles thinning, creating gaps
Winter prescribed burning begun – 1960
Girdling scrub hardwoods
Planting - 35 acres of Slash Pine – 1962
Grazing ended – 1970
Transfer to 3rd generation – 1967-70
Hurricane Camille – August 1969

1975 –2000 Prescribed burning, timber sales, recreation
Division among 3rd generation – 1978
Winter prescribed burning
Lease hunting begun – 1975
Hurricane Frederic – September 1979
Occasional pole & sawlog cuts to meet silvicultural and owner needs
Enlarging gaps, removing overstory, money cuts
Growing season prescribed burning begun – 1991
Road construction and upgrade - 1992
Timber sale – 1993
Lake construction – 1994
Recreational uses

Protection, burning, harvesting, planning and patience have been the primary management activities. Mistakes were made, lessons were learned, but the underlying motivation was always to meet changing owner objectives through good care of a productive forest.
The activity of protection works two ways, protection from certain things and protection of other things. Early laws prohibiting burning, hunting, grazing cutting timber or trespassing on the property of another are often credited with providing the first encouragement for landowners to grow timber. For this property and most others, enforcing these laws has been one of the first steps to management. Other threats requiring owner vigilance include hurricanes, logging damage, invasive species and unreasonable regulations or taxes, especially the death tax. For a forest owner the risk of loss from the power and whims of nature pales to insignificance in comparison with the risk of loss from the power and whims of government. Preservation of valued assets is the other side of protection. Federal law mandates care for gopher tortoises. Encouraging scattered live oak trees and hardwood patches is an objective for the owners. These special features and favorite picnic or camping areas require protection during logging and prescribed burning. The same need applies to areas of young regeneration. Similarly, roads must be guarded from damage by hunters or loggers. Over the years, the owners of this tract learned boundary line, hunting, or road use disputes can make ownership unpleasant. Good neighbor relations can help protect timberland, but standing up to intimidation is equally important.

For two generations of owners, fire in this forest was a foe not a friend. Nearly 50 years was required for acceptance of the economic and biologic necessity of fire as a tool for managing longleaf pine. Many more years were involved in learning when, where, how much and how often to burn and the most efficient, effective and safe methods to burn. Winter burns eventually gave way to growing season and any season burns, greatly expanding the burnable days. Early efforts usually were one day burns of the entire tract, using crawler tractors with fire plows and sometimes helicopter ignition. Current techniques include dividing the property in to 40 to 100 acre burning blocks, using roads and natural boundaries such as creeks, branches, and swamps along with permanently located fire lines. Outside blocks are burned first, giving maximum flexibility and safety in burning remaining blocks. For the interior blocks a leaf rake or blower is often the only tool needed to turn a road into a firebreak. Burning is generally on a three-year cycle but occasionally annual burns are made. Areas with the highly volatile invasive, cogon grass, can be treated with a burn within hours of a rain, when the surrounding areas will not burn. Other lessons learned include the fact that except for the year after a good seed crop, you can’t burn too much, smoke management is the most critical element of burning, headfires and backfires must be used with caution and flank fires are frequently the answer.

The property has seen a variety of cutting regimes. From the first complete clearcut of the entire property in the early 1900’s to improvement thinning at 5-7 year intervals in the 1950’s, the present plan calls for harvesting at approximately ten-year intervals. Products have varied, but concentration has always been on growing larger more valuable sawlogs and poles, with pulpwood a by-product only. Since the cutout operation about 80 years ago, all tree removals have been based on single tree selection marking by experienced foresters and timber markers. Even for the salvage operation following Hurricane Frederic all trees removed were marked. Trees broken or damaged by that storm contained about 1/3 of the total stand volume, the same percentage volume removed in periodic harvests. Markers now consider the value of keeping stands thick as protection against hurricane wind throw. In the 1950’s Tom Croker of the USFS recommended creating 1 to 2 acre holes or gaps for regenerating longleaf. This led eventually to even and uneven aged groups of trees forming an all aged forest, which can be perpetuated indefinitely. All types of treatments are used, thinning, improvement, seed tree, shelterwood, and overstory removals. There is no one regeneration method, holes, shelterwood, and seedtrees may all be employed. Decisions are made by the marker with the paint gun in his hand judging the best treatment for each acre. With better equipment such as tractor mounted saw heads, and well-trained loggers, logging damage is not the concern it once was. Skidding a limbed tree through a thick patch of reproduction merely creates an eight-foot space, but excessive turning of trees is forbidden in the contract. With good markets, lump sum competitive bids have proven to bring the best price.

Rather than a formal written management plan, work is guided by the general objectives of maintaining a good stocking of sawtimber per acre, a good distribution of tree sizes, improving quality, and enhancing the recreational values. Planning for regeneration, harvests, roads, burning and recreation, is a continuous and never ending process best suited to annual plans and budgets. Experience of the current owners of this
tract has been strict management plans for even five or ten year periods are an inefficient exercise because natural and economic conditions and owner needs, preferences and objectives change so often. Estate planning to provide for ownership succession and payment of taxes requires in depth knowledge of accounting, legal and tax specialists and for the forest, is potentially the most important planning of all.

The right attitudes are critical for management of any forest property and include patience, acceptance and involvement. Waiting for trees to grow, seed crops to develop, weather to burn, income for improvements or children to grow up can all be pleasurable experiences if one is involved, patient and accepting. Because of the long time periods, forests need the frequent footsteps of successive owners. The owners of this longleaf property near Mobile Alabama realize multiple tangible and intangible benefits. They describe the property as providing some or all of the benefits of a health club, hobby, investment, savings account, retirement fund, therapist and church. In addition it provides recreation and social opportunities for family, friends, neighbors, church groups and Boy Scouts.
LONG-TERM IMPACTS OF FOREST FLOOR REMOVAL FROM A LONGLEAF PINE STAND

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ABSTRACT: Removal of forest floor litter during controlled burns or pine straw raking operations is likely to impact soil nutrient pools. While fertilizer additions may compensate for some changes in soil chemical pools, long-term changes in soil physical properties may persist. This study began in 1987 in a 35 year-old longleaf pine stand that has been raked or prescribe burned every three years, with and without application of nitrogen fertilizer. Bi-annual tree growth measurements have been collected and litter and soil nutrient pools calculated. Both burning and raking treatments decreased height and diameter growth, and pine straw production compared to control plots. Compensatory fertilization treatments were fully effective on burned plots and of significant enhancement to litter production on raked plots. Overall, fertilization increased litter production approximately 20-30% compared to controls. Nutrient removal from the site was greater from fertilized plots than non-fertilized, and from raked plots vs. any other. However, soil N and macronutrient concentrations were increased by fertilization, and were more concentrated in soils from which OM was removed. This response was especially noted in the burn plots, which retained the remnant ash. Long-term removal of pine straw can degrade some components of site nutrient availability, but fertilization treatments can compensate.
PROJECT LONGLEAF: Teaching Kids the Longleaf Story

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ABSTRACT: Interest in teaching children about the longleaf pine fire forest and the need to understand the protection and management of this forest has recently increased among educators across the southeastern U.S. and the nation as a whole. The study of the longleaf pine forest presents opportunities for school children to understand important biological concepts, the cultural history and modern conservation issues of a large portion of the South, i.e., information that is cross-curriculum. Surprisingly, however, children in southern states are often more knowledgeable about the rainforests of the distant tropics than the (once ubiquitous) longleaf forest in their own backyards. And yet, although this ecosystem is as rich in plants and animals as most tropical rainforests, it is in equal peril of permanent destruction. Environmental education is a powerful tool we can use to reverse this trend of decline in the south’s longleaf pine forests. Without proper education tools in place, little of the longleaf pine story is being conveyed to the public (let alone school groups).

Over the past several years, an increasing number of teachers from all over the country have made numerous requests to the Longleaf Alliance for educational materials on longleaf pine forests. Unfortunately, no such group has attempted to consolidate any information for distribution and use by educators. To address this deficiency, the Longleaf Alliance has been working with others to create classroom materials and activities related to longleaf pine forests; dubbed Project LONGLEAF—Teaching Kids the Longleaf Pine Story.
STAND MANAGEMENT ON PUBLIC LANDS

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SUMMARY
As social perspectives and expectations continue to change, many public land practitioners in the southeastern U.S. are finding themselves tasked with managing resources for values that range from woodpeckers to wood-production. Managing longleaf pine stands as an ecosystem can allow these practitioners to satisfy multiple objectives while still approximating the natural processes and conditions that existed prior to European settlement. The management practices on public land must be based on an understanding of how natural longleaf pine ecosystems function and developing silvicultural prescriptions consistent with such knowledge. Further, management activities should incorporate key ecological considerations that act to return a structure and function more typical of a longleaf pine forest.

KEY TO RECOVERY EFFORT
Public lands in the southeastern U.S. provide a vital opportunity to restore imperiled longleaf pine habitat and recover targeted species such as the red-cockaded woodpecker or other T & E species. Although only about 6% in the Southeast is under public ownership, some of the best (or potentially best) representations of longleaf pine are found on these lands. Current estimates (albeit likely conservative), suggest about 970 thousand acres of longleaf pine forest remain on public lands (Outcalt & Sheffield, 1996). Public land ownership is dispersed across different state and federal entities including the Department of Defense, U.S. Forest Service, U.S. Fish and Wildlife, Department of Energy and state forests and parks.

Large blocks of public lands are ideal for providing habitat for target species that require sizeable habitat as part of their natural history. Furthermore, large blocks of public land can provide prioritization for the allocation of government incentive moneys (CRP, Carbon Mitigation, etc.) earmarked longleaf forest restoration. Biologically speaking it makes more sense to target longleaf pine forest restoration on private lands surrounded by public land then by the present (landscape) shotgun pattern approach of money distribution.

ACHIEVING THE BALANCE OF ECONOMICS AND ECOLOGICALLY
Most every parcel of public land in the southeast has yet to reach the desired end condition of a functioning longleaf pine forest. As such, their management activities are often influenced by restoration practices. Several public lands stand out as having effectively employed practices that achieve this balance of making money off of restoring a fire-maintained, biologically diverse longleaf pine forest. However, there are still many public lands which try to meet these desired future conditions by employing inappropriate silvicultural techniques that do not incorporate conservation oriented management. More often then not, these silvicultural techniques triage the tree and not the ecosystem. Such follies in management are especially apparent in three areas: stand conversion, and site preparation, and the application of fire.

Stand Conversion
In the past, production oriented forestry directed the management of many public forestlands in the Southeastern U.S. As a result, vast acreages were planted in off-site pines like loblolly, slash, and sand pine. All fires were quickly suppressed. More recently, the message of restoring these public areas with the native longleaf pine overstory component has been effective. However, at times this “restoration” has been at the expense of the ecosystem. Management activities on public property should strive to restore or maintain an open-canopy, mature yellow pine forest that supports (and tolerates) a frequent fire regime, has a diversity of native plants in the groundcover and increases the fecundity of targeted species, i.e., red-cockaded woodpeckers, flat-woods salamanders, and other threatened and endangered species. Although this definition does not specify longleaf pine or wiregrass, bluestem, etc. all species are ideally suited for a system that is held together by fire. Also, from an economic standpoint, longleaf pine is ideal because of the high quality sawtimber and high percentage of poles that it is capable of producing.

Although longleaf pine is an essential component in the ecologically sound management of this system, it is only one piece of the puzzle. Sometimes, a quick conversion in overstory cover is not always the most
effective means to reach the end objective. As an example, one public land holding in Georgia had an approximately 50-year-old fire-maintained slash pine stand with intact, wiregrass-dominated groundcover. To restore this site back to a longleaf pine ecosystem, the prescription called for it to be clearcut, double chopped and replanted with longleaf pine. From a conservation-oriented perspective not much was gained by using the aforementioned technique to restore the site. Although longleaf pine was instantly added to the site and the timber sale likely maximized, a great deal of ecologic value was lost in the process; most notably, potential RCW habitat, continuity of fuels, and likely a large portion of the native groundcover (note that it has been shown that two passes with a drum chopper will nearly eliminate wiregrass from dry sites (Grelen, 1962)). In this example, satisfying both economic and ecologic objectives would have been met by other techniques. In particular, after recognizing that native ground cover was in place, a heavy thin of the slash pine overstory using some sort of aggregate retention system could have effectively been used. Minimizing the disturbance to the ground cover and replanting the openings in the slash pine canopy with longleaf pine would have brought a handsome revenue while still maintaining RCW habitat, groundcover diversity and fuel continuity. Initiating a fire regime into the stand early will help restore functionality as well as keep slash pine from becoming established in canopy openings planted with longleaf pine.

The previously outlined example would not have worked at another public land in Georgia. In the second example, most of the site had 100+ year old loblolly pine that had grown up out of old cotton fields (once a longleaf pine site). Although RCW were abundant in the loblolly pines, many of the mature trees were beginning to die from old age. Because fire was used aggressively at this site, a second size cohort of loblolly pine was often absent. In this situation a more aggressive harvesting campaign could (and should) be used to restore a more fire tolerant tree species and try to get a next generation of RCW habitat established rapidly. Because longleaf pine is a longer lived tree and more tolerant to fire, it would be ideally suited for this example. Larger canopy openings would allow growth of the longleaf pine to be maximized and facilitate their establishment of the next RCW cavity trees. Some may argue that since the groundcover (fuel) is not “virgin”, not as much attention need be focused on it. However, the groundcover has had about 100 years to recover from disturbance and may provide valuable habitat for targeted species (Rutledge and Conner, 2002). Also, seeding in by loblolly pine would be a problem in this situation. Thus it is vital to be able to burn. Preservation of fuels should be a high priority.

Site preparation

Many public land managers and beginning to understand the ecological value of native groundcover plants and the resultant continuity of fuels that they provide. However, the importance (or presence) of groundcover is not always communicated between the different branches of management when an area to be prepared for planting. As such, many areas that had intact ground cover in place prior to site preparation instead have to go back and restore the groundcover they had previously removed. The restoration of native ground cover is costly and seed-source is often uncertain. From both an economic and ecologic perspective, it makes the most sense to try and maintain what is on site prior to disturbance from site preparation.

On sites that have native ground cover in place, special attention should be given to its retention. In some areas where maximizing survival of planted longleaf pine is not an issue, fire remains the least destructive, most viable option for site preparation. Unlike mechanical or chemical site preparation, fire effects on native groundcover are ephemeral. In other areas where survival of seedlings is slightly more important, the judicious use of herbicides is a useful tool in the restoration and management toolbox. However, there is a tradeoff between maintenance of certain groundcover species, fuel continuity and site preparation. On the corollary, there is also likely a tradeoff between site-preparation, longleaf survival and initiation of height growth (however, research is lacking in this area). Rather then some generic prescription, the degree of site preparation should take into account what is in currently established, and the objectives of particular management unit. Often, the site preparation strategy should incorporate good communication between multiple disciplines within an organization; from forestry to botany to wildlife biology.

Some herbicides can be used to surgically remove certain competition while still maintaining key components of the understory. For example, Brockway, et al (1998) found that 1 – 2 lbs./acre application of hexazinone by broadcast application removed some plants that are of ecological importance to targeted
species, e.g., gopher apple. However, spot application at the aforementioned rates resulted in fewer effects on forb cover, species richness and diversity. Outcalt (1995) found that longleaf seedling survival at 66% with low rates of hexazinone application and hand planting. Machine planting in a scalped strip with low hexazinone rates resulted in slightly higher survival (though not significant). Disturbance to understory was slightly higher, though temporary in the later treatment. Note that these low rates of hexazinone apply to sandhill communities. In mesic flatwoods, such low application rates may only cause the aggravation of hardy plants like palmetto and the irritation of the land manager. Also, for the other “half” (the non-wiregrass half) of the longleaf range, much information is currently lacking on the groundcover objectives trying to be achieved, i.e., what are important components to maintain.

Application of Fire
There are some in the public sector who voice strong opinion against any form of human intervention on public lands (such as wilderness areas). However, with the lack of active management in longleaf pine forests (most notably prescribed fire), the very attributes that make that forest unique will be lost. Fire is the thread that holds the longleaf system together; the common denominator in its management.

Perhaps the largest hurdle in managing young stands of planted longleaf pine is the initiation of a prescribed fire regime. Fears of growth loss and young tree mortality are legitimate concerns when managing short-rotation, less fire-tolerant species such as loblolly pine. Unfortunately, many land managers have carried over the management strategies for loblolly pine to longleaf pine. The result of this management inertia is an application of fire that does not produce the desired objectives. In short, managers are waiting too long to burn young stands.

Waiting too long to burn either through being over-conservative or simply not having the fuels in place to burn may be detrimental to stand health. By delaying the timing of burning in longleaf pine, hazardous surface and ladder fuels begin to accumulate, early-successional habitat is lost, and plant-plant competition is increased as non fire tolerant pines aggressively seed-in and become established amongst the planted longleaf. Although the maintenance of biologically diverse ground cover may not fit the objectives of all public land holdings, the protection of the continuity grassy fuels to carry fire should be. Having these fuels in place allows the manager to burn at an early age and thus reduce competition from non-fire tolerant species.

A significant obstacle in reintroducing fire to mature longleaf pine stands that have not seen fire in decades is traditional silvicultural prescriptions that focus the practitioner’s attention more towards the tree crown rather then towards the forest floor. However, smoldering fires at the base of trees are as great of a concern for longleaf survival as fire in tree crowns (Ferguson et al, 1960). A prescribed fire that resides and smolders in duff accumulated at the tree base, stresses the tree either through the destruction of fine feeder roots or bole girdling. In such situations, a slow moving, backing fire may do little to brown canopy needles of the tree initially but stresses the tree enough to allow parasites (such as southern pine or turpentine beetles) to infest and later, kill it. The reintroduction of fire after decades of fire exclusion warrants special attention. The priority of these fires should be the gradual removal of the accumulated duff layer. Fire should be applied in a fashion that does not consume the entire accumulated duff in one fire. Unless midstory fuels (such as upland oaks) present a safety issue, their immediate removal should not be as high a priority.

Some public land managers are guilty of over-prescribing fire. Although fire is the quintessential tool in managing longleaf pine, the objectives of its use should be more defined then simply “keeping the fire within the plow lines”. In mature stands where surface fuels are under control, fires that scorch or consume a significant portion of the tree crown are not only unnecessary they are economically destructive. In stands where tree growth and an overstory pine structure are important considerations, the timing of the fire application is perhaps more important then the intensity. For example, young longleaf pines are resistant to fire at smaller sizes (prior to bud break). However, after bud break, the terminal bud elongates out of the protective sheath of needles and trees become susceptible to fire.
REACHING A MULTI-AGED FOREST
There are numerous “uneven-aged”, greentree retention methods that can be effectively used to meet both economic and ecological objectives on public lands. However, due to the complexity of the longleaf pine ecosystem and the variability of its past management, to prescribe a generic uneven-aged management regime would be both amiss and not necessarily complimentary to an institution’s mission statement. Nonetheless, as evidenced by past management recommendations, silvicultural prescriptions have traditionally placed more emphasis on volume production and did not incorporate ecological considerations. For example, Wahlenberg (1946) stated: “clearcutting appears to be the best system for longleaf because the species must be reproduced in even-aged stands. Further, of the five American methods for natural regeneration, only three—clearcutting, seed tree and shelterwood—need be considered for longleaf (Croker & Boyer, 1975). When special attention is given to advanced regeneration and competition, these even-aged methods are effective in maximizing volume production of longleaf pine timber. However, in a conservation-oriented context, even-aged silviculture is not a sound management tool. In particular, they can be deficient in sustaining fine fuels and maintaining the habitat required by certain target species (it takes several decades to grow a RCW cavity tree). That is not to say, however, that certain even-aged techniques are ineffective as a restoration tool. For example, even-aged techniques have been used to restore degraded scrub and wet-prairie habitat embedded within the longleaf habitat.

CONCLUSION
Determining if, how, or when a stand will be cut (or otherwise managed) must weigh economic considerations equally with ecological ones. Each public land organization must determine which management scheme best fits their mission. The public land pickle is in the implementation of these conservation-oriented management practices. To apply these practices, the practitioner must be knowledgeable of both the structure and function of a natural longleaf pine ecosystem and be able to develop silvicultural prescriptions consistent with such knowledge. But most importantly, each practitioner must have a vision of the future. Likely success will be measured in terms of ecological timeframes rather then the span of one’s career.

LITERATURE CITED
THE ESCAMBIA EXPERIMENTAL FOREST: PAST, PRESENT AND FUTURE DIVIDENDS FROM LONG-TERM LONGLEAF PINE RESEARCH

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ABSTRACT: Experimental forests are living laboratories where long-term research studies can be sustained for many decades. The Escambia Experimental Forest is a 3,000-acre longleaf pine (Pinus palustris) forest in southern Alabama. The forest was established in 1947, in cooperation with T.R. Miller Mill Company of Brewton, AL to help solve the principal longleaf management problems that existed at that time. Studies focused on problems related to natural regeneration, management alternatives, growth and yield, rotation lengths, thinning regimes, forest grazing and economic costs and returns. The forest continues to support many long-term (> 40yr) research studies and demonstrations related to stand management and silvicultural alternatives, growth and yield of even-aged natural stands, small woodlot management strategies and fire ecology. Research at the forest has produced numerous publications on natural regeneration of longleaf pine, especially in conjunction with successful application of shelterwood methods, which were specifically developed in pioneering studies on the Escambia Forest. Many other studies report on the effective use and long-term effects of prescribed fire. The value of these long-term studies will increase as the data base begins to be applied to new questions and issues related to forest fuel management, ground cover response to fire, climate change impacts and the feasibility of new revenue opportunities in forest management (e.g., carbon credits).

INTRODUCTION

Longleaf pine (Pinus palustris) was the key species in one of the most extensive forest ecosystems in North America. Before European settlement, it was the dominant tree on an estimated 92 million acres. Extensively exploited without regeneration since colonial times, less than 3 million acres now remain, with much in an unhealthy state due to the exclusion of fire. However, longleaf pine can still be found over most of the original range in small and large fragments. Despite the visual dominance of the overstory, this ecosystem contains some of the most diverse plant and animal communities in the temperate zone, including many threatened and endangered species. Economic and ecological values associated with longleaf pine forests, coupled with this species’ adaptability to a wide range of management objectives, make longleaf pine a suitable choice for many private landowners in the South, especially when utilizing low-cost natural regeneration strategies and relatively long rotations (> 40yrs). The tree is resistant to fire as well as most forest insects and diseases and produces high quality poles and other valuable wood products.

Experimental forests have been used for many years by research organizations as “living laboratories” where research studies can be set up and sustained for long periods of time. For forestry and related natural resources research, long-term research can often mean many decades of continuous study before the most meaningful results are obtained. The Escambia Experimental Forest was established in 1947, when the T.R. Miller Mill Company of Brewton, AL, provided land, at no cost, to the USDA Forest Service through a 99-yr. lease. This 3000- acre forest, located seven miles south of Brewton in southwest Alabama was selected as typical of a second-growth longleaf pine forest that, at the time, covered about 6.2 million acres in south Alabama and northwest Florida. Approximately 20 percent of the remaining longleaf stands in the south are within 75 miles of the experimental forest. A Forest Superintendent employed by the USDA Forest Service manages the forest on site. The USDA Forest Service, Southern Research Station, Silviculture Research Project located on the campus of Auburn University provides research direction and administration.
HISTORY

In 1874, a sawmill was built on the Conecuh River, not far from the mouth of Lindsey Creek. This creek and some of its tributaries on the Experimental Forest were ditched for water logging to supply this mill. A dam for a storage pond can still be seen. Some “sinkers” (heavy logs that sank to the bottom of the waterway or pond) have been recovered from creeks on the Forests. Railroads were built into the forest at the turn of the century, and nearly all-remaining merchantable timber was cut. Some residual stems, too small to cut, were later used in turpentine production.

About 80 percent of the forest is in the upland longleaf pine type and the remainder in slashpine-hardwood bottoms. Site quality for longleaf is extremely varied, but averages about 70 feet at age 50. When the experimental forest was established, pine stands in the 4-inch and larger DBH class 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 and is now 90 years. Since management began, about 1500 acres have been naturally regenerated to longleaf pine, and now contain stands ranging in age from 6 years (1996 seed crop) to 54 years (1947 seed crop). The forest is located on the Middle Coastal Plain physiographic province. The predominate ground cover is composed of bluestem grasses (Andropogon spp.) rather than wiregrass (Aristida spp.) which dominates many other longleaf pine sites. The subtropical climate is mild and humid. Annual precipitation is about 60 inches and average temperature range is from 20° to 100°F. The frost-free period averages around 235 days, from about March 15 to November 10. Soils are largely coarse to fine, loamy, siliceous thermic family of Paleudults. Principle series include Troup, Wagram, Benndale, Orangeburg, Lucy, Dothan, Ruston and Esto. Elevation ranges from about 100 to 275 feet above sea level. Topography is flat to rolling with most slopes in the 3 to 10 percent range and some slopes up to 20 percent.

RESEARCH ON THE FOREST

Past Accomplishments: Early studies focused on problems related to the natural regeneration of longleaf pine. This included flowering, seed production and dissemination, seedling establishment, survival and growth, and methods of competition control. The shelterwood method for longleaf pine natural regeneration was developed on the Escambia Forest. Other early studies were related to site quality, plant community classification, management alternatives, rotation lengths, thinning regimes, forest grazing and economic costs and returns. In 1948, forty acres of understocked second-growth longleaf pine forest were designated as a demonstration of small woodlot management. The initial goal was to produce high quality poles and logs. With virtually no capital investment, the site provides a regular income through periodic harvests. Management leads to optimum stocking and a balanced distribution of age classes.

Recent Activities: The forest continues to support many long-term (> 40yr) research and demonstration studies related to longleaf pine natural regeneration, cone and seed production, stand management and the use and effects of prescribed fire. The “Farm Forty” study site has now provided nearly 50 years of data on how to successfully manage longleaf pine in a small wood lot. 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 saw logs. Beginning in 1966, tests of the shelterwood system for longleaf pine natural regeneration were conducted on the forest and at several other locations in seven states. Observations have been completed on all but two sites. Many sites continue to be maintained as demonstrations. In 1964, a growth and yield study of even-aged natural longleaf pine in relation to age, site quality and stand density was initiated on the forest and later expanded to other locations in AL, MS, FL, GA and NC. This regional study also includes a replicated time-series experiment (at 10-yr intervals) in the 20-yr age class to evaluate potential climatic impacts on growth and yield. The fire ecology activities include short-term and long-term effects of season, frequency and timing of prescribed fire (or fire exclusion) on growth of dominant pine overstory, as well as effects on composition and structure of the hardwood midstory and woody and herbaceous vegetation in the understory. Some of these study sites are now being used by cooperators to address new objectives related to understory and mid-story plant community development and related wildlife habitat values.

Future Opportunities: Longleaf pine ecosystem restoration and management is now a priority on several National Forests and many other public lands in 8 Southern States. Private sector interest in longleaf pine management has also recently increased due to new incentives, improvements in planting technology and the opportunity to produce high valued products over somewhat longer rotations (> 40yrs).
New collaborative research studies will be needed to fill information voids related to these new region wide trends including: (1) optimizing natural regeneration alternatives, (2) evaluating the sustainability of management alternatives, (3) developing improved socio/economic evaluations of all ecosystem components, (including the potential for carbon credits and other sources of income such as pine straw, hunting leases, etc), (4) quantifying the role of fire in maintaining the structure, composition and functions of longleaf pine ecosystems and (5) evaluating the influence of environmental and climatic factors on site productivity.

In response to the recent concerns and questions about the sustainability of uneven-aged management strategies for longleaf pine, a new multi-site operational-scale research-demonstration study is now in the planning stage. The study will evaluate the short-term and long-term costs and benefits of five forest reproduction methods for managing longleaf pine including: (1) classic shelterwood, (2) irregular shelterwood, (3) group selection, (4) single-tree selection and (5) a no manipulation “naturalistic management” (control). Today the Escambia Experimental Forest constitutes a unique example of longleaf pine forests in all stages of development. The combination of stand ages, site types, and forest conditions found here exist nowhere else. To date, work on the Escambia has provided information for over 180 publications and dozens of workshops. Uncounted other reports have utilized data from the experimental forest. Long-term studies, often difficult to set up, secure and retain, are once again proving to be both an ecologically and financially sound research investment.
ABSTRACT: Prior to the arrival of settlers to the United States, natural communities dominated by longleaf pine occurred throughout most of the southern Atlantic and Gulf coastal plains. These communities once covered an estimated ninety million acres, or two-thirds of the area in the Southeast. It covered more acreage than any other North American ecosystem dominated by a single tree species. Dissimilar to other southern pines, longleaf pine tolerates a wide variety of habits. It is found growing on dry mountain slopes and ridges, to the low, wet flatwoods, as well as the excessively drained sandhills found along the coast and fall line. Exploitation of longleaf pine-dominated forests led to a steady decline of its acreage. Today, estimates indicate that less than 3 million acres remain. A 1995 Biological Survey Report listed the longleaf pine forest as the third most endangered ecosystem in the U.S. Private, state, and federal land managers have recently undertaken ecological restoration and reforestation in the longleaf pine forests of the southeastern United States. Research from the Escambia Experimental Forest and the long-term U.S. Forest Service Regional Longleaf Pine Growth Study will be used to present an overview of naturally regenerated longleaf pine stand dynamics. Among the topics discussed will be: its ability to sustain growth at high densities and older ages, over 150 years; recent observations of increased growth; factors affecting regeneration success; and its use for high-value wood products and long-term carbon storage.

INTRODUCTION

Longleaf pine ecosystems are considered to be in a perilous condition. A report by the U.S. Department of Interior lists the longleaf pine ecosystem as the second-most threatened ecosystem in the U.S. (Noss 1989). The original longleaf pine forest was self-perpetuating. It reproduced itself in openings in the overstory where young stands developed. The result was a park-like, uneven-aged forest, composed of many even-aged stands.

The character of the ecosystem is best maintained with natural regeneration, with optimum use of processes or treatments simulating the processes that have long maintained longleaf ecosystems over the millennia. However, no phase of longleaf pine management presents more complex and critical problems than does its reproduction. Solutions depend on understanding the prerequisites of the process, the characteristics of seed-bearing trees and longleaf pine seed crops, and the possible causes of failure after seed fall. Predicting seedling performance under varying levels of overstory competition is important for understanding the consequences of silvicultural systems.

Wahlenberg, in his landmark 1946 text, started off his chapter “Problems of Natural Reproduction” with this:

“Deliberate regeneration of longleaf pine has been rarely accomplished.”

Wahlenberg concluded the chapter with:

“Mismanagement of longleaf pine has been the rule rather than the exception, due to the ignorance of the unique life history and incomplete knowledge of factors determining the life and death of seedlings and hence the succession of forest types.”

Many of the factors governing the ability of longleaf pine to reproduce are obscure, and the innumerable ecological influences are so interrelated as to make their interpretation difficult. A major regeneration problem is irregular seed production. Seed crops considered adequate for regeneration occur at 5- to 7-year intervals with exceptions. Longleaf pine is generally considered the most intolerant of the southern pines. It is intolerant of competition from any source including overstory competition. Survival and growth are closely related to longleaf pine’s two unique silvical characteristics: its grass-stage and its high resistance to fire. The grass-stage usually lasts 4-5 years but may range from 1 to 20 years. If reproduction of competing species is allowed to grow freely, it will completely dominate the site while longleaf seedlings...
are still in the grass-stage. Once this has occurred, the longleaf pine stand can never regain dominance without some type of intervention.

Unsatisfactory regeneration in longleaf pine forests may be attributed largely to the lack of management or unwise management. Mismanagement may be the rule rather than exception, due to the ignorance of the unique life history of the species and the incomplete knowledge of factors determining the life and death of seedlings.

ARE THERE GAPS IN THE KNOWLEDGE CONCERNING NATURAL REGENERATION OF LONGLEAF PINE?

One of the best places to get an excellent overview of natural regeneration of longleaf pine is to examine the literature that has been already published. As of 2002, 122 sources deal with the topic of natural regeneration of longleaf pine. The most important are:


And several other publications by Dr. William Boyer

HIGHLIGHTS FROM CROKER AND BOYER THAT DEAL WITH CRITICAL ISSUES FOR NATURAL REGENERATION OF LONGLEAF PINE

• Important to achieving successful regeneration would be the monitoring of the seed crop.
• Poor timing of fires rather than competition causes excessive mortality of grass-stage seedlings under an overstory.
• Seedbed preparation must be carefully timed.
• Survival of seedlings appears better on autumn burns and growth may be improved over that on a winter burn made 9 or 10 months before seedfall.
• One of the most important components of naturally regenerating longleaf pine is the use of fire. “Burning is an art acquired by experience”. A keen knowledge of how fuels, weather, and topography affect the behavior and impact of fire is necessary.

REGIONAL LONGLEAF PINE GROWTH STUDY

In 1964, the USDA 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 cover a range of tree ages from 15 to 120+ years, densities from 30 square feet/acre to more than 180 square feet/acre, and site qualities from site index 50 to site index 90. The study accounts for change by adding a new set of plots in the youngest age class every 10 years.

The seventh re-measurement of these plots has just been completed. The RLGS represents a stable, long-term database and an active “field laboratory” for natural, even-aged longleaf pine stands. The value of this project increases as more and more ownerships in the South consider longleaf pine management alternatives. The plots are available for cooperative studies that do not harm the plots or interfere with future activities.

SURVIVAL OF LONGLEAF PINE SEEDLINGS

Two studies conducted on the Escambia Experimental Forest in the early 1970’s examined issues of seedling survival. The first study evaluated longleaf pine seedling survival and stocking in: 1-acre, one-half acre, and one-quarter acre patches.

RESULTS: After 3 years and one prescribed fire patch size had no effect on seedling survival, stocking, or mortality from prescribed burning.
The second study examined the effect of fire, including: fire treatment, soil type, and distance from a forest wall.

**RESULTS:** Two years later there were no major seedling losses in relation to fire treatment, soil type, or distance from a forest wall.

**CONCLUSION FROM BOTH STUDIES:** LONGLEAF PINE SEEDLINGS CAN BE BURNED UNDER A WIDE RANGE OF CONDITIONS AND SURVIVE BUT THE BURNING HAS TO BE DONE CAREFULLY.

**COOPERATORS IN THE REGIONAL LONGLEAF PINE GROWTH STUDY:** Region 8 of the USDA Forest Service, Apalachicola National Forest - Wakulla District, Talladega National Forest - Talladega District, Talladega National Forest - Oakmulgee District, Homochitto National Forest - Homochitto District, DeSoto National Forest - Black Creek District, Conecuh National Forest - Conecuh District, Escambia Experimental Forest (Brewton, AL), T.R. Miller Mill Company (Brewton, AL), Florida Forest Service - Blackwater River State Forest (Munson, FL), Cyrene Turpentine Company (Bainbridge, GA), Eglin Air Force Base (Niceville, FL), Southlands Experimental Forest - International Paper Company (Bainbridge, GA), Gulf States Paper Corporation (Columbiana, AL), Mobile County (Alabama) School Board, Wefel Family Trust (Atmore, AL), AmSouth Bank (Birmingham, AL), Kaul Trustees, North Carolina Division of Forestry - Bladen Lake State Forest (Elizabethtown, NC), Champion International Corporation (DeFuniak Springs, and Milton, FL), John Hancock Mutual/Resource Management Services (Opp, AL), Kimberly-Clark Corporation (Weogufka, AL)
NORTH CAROLINA SANDHILLS RED-COCKADED WOODPECKER SAFE HARBOR HCP: 
Current Status and Lessons Learned

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ABSTRACT: In the 1980’s and early 1990’s, a prevailing concern among private landowners in the North Carolina Sandhills (NC Sandhills) was that the presence of red-cockaded woodpeckers (RCW) (*Picoides borealis*) on their land limited their ability to economically utilize their land, as they deemed appropriate. In 1995 the U.S. Fish and Wildlife Service launched a new program, called Safe Harbor, designed to promote RCW habitat restoration on private lands. Since it began, the NC Sandhills Safe Harbor Program (Program) has been extremely successful. We have enrolled over 32,000 acres of private lands under 62 Safe Harbor Agreements providing cavity and/or forage habitat for 47 groups of RCWs. We have also provided over $180,000 in cost-share incentive funds to assist private landowners with voluntary habitat restoration. In addition, 2 new groups of RCWs have been successfully established on enrolled lands. The Program has enhanced our ability to work directly with private landowners and build trusting relationships. As a result, some landowners are now considering more permanent protection of their land and pine habitat by selling or donating conservation easements. Two landowners have already sold their property to conservation organizations, thereby guaranteeing the long-term protection and management of habitat that supports 9 groups of RCWs. While the Program is voluntary in nature and was not designed to provide in-perpetuity protection for RCWs, we have shown that it can play a significant role in keeping RCWs and their habitat on the landscape until more permanent protection mechanisms can be put into place.

INTRODUCTION

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) (ESA), provides protection to endangered and threatened species found on private lands. Under the ESA, the Section 9 prohibition against “taking” an endangered species has the potential to significantly affect private landowners. “Take” is defined in the ESA and its implementing regulations to include activities that might “harm” individuals of an endangered wildlife species; harm includes “significant habitat modifications or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.” Thus with respect to the private landowner, the ESA seeks to deter activities harmful to endangered species through regulation and possible fines and imprisonment. While the ESA provides a tool in Section 10(a)(1)(b) for resolving conflicts between private landowners and endangered species through the habitat conservation planning process, it does not offer the private sector any incentive to proactively conserve endangered species.

The North Carolina Sandhills (NC Sandhills) red-cockaded woodpecker (*Picoides borealis*) population has been designated as one of the primary core recovery populations necessary to satisfy recovery criteria (U.S. Fish and Wildlife 2000). This primary core population is unique in that it contains some clusters on private lands. In the 1980’s and early 1990’s, a prevailing concern among private landowners in the NC Sandhills was that the presence of red-cockaded woodpeckers on their land limited their ability to economically utilize their property, as they deemed appropriate (U.S. Fish and Wildlife 1995). Rather than be constrained by government regulations, many private landowners harvested mature pine timber before red-cockaded woodpeckers could take up residence on their land (Michael 1999, Drake 2000).

Recognizing that red-cockaded woodpecker groups on private lands could play a valuable role in recovery of the NC Sandhills red-cockaded woodpecker population, the U.S. Fish and Wildlife Service (USFWS) launched a new program in 1995, called Safe Harbor which was designed to promote red-cockaded woodpecker habitat maintenance and restoration on private lands (Costa and Kennedy 1997). This innovative program was developed to encourage voluntary conservation of red-cockaded woodpeckers by offering private landowners regulatory relief, i.e., a “safe harbor” in exchange for protection and management of red-cockaded woodpecker habitat (Costa and Kennedy 1997).
In September 1992, the U.S. Department of the Army, Fort Bragg Military Reservation (Fort Bragg), in coordination with the USFWS, hosted a conference specifically to address red-cockaded woodpecker protection needs on private lands and to highlight the need for a coordinated multi-agency effort to protect this species on a population level in the NC Sandhills (U.S. Department of Defense 1992). A follow-up meeting was held in March of 1993, and an ad hoc working group was formed with representatives from the USFWS, Fort Bragg, North Carolina Wildlife Resources Commission, North Carolina Natural Heritage Program, North Carolina State University, and the Sandhills Area Land Trust. The ad hoc working group met regularly to develop a conservation strategy to recover the NC Sandhills red-cockaded woodpecker population. During this period, the group also met with Environmental Defense (formerly Environmental Defense Fund), which concurrently had initiated a project to develop economic incentives for private landowners to assist with red-cockaded woodpecker recovery in the NC Sandhills. The NC Sandhills Safe Harbor Program (Program) evolved from this combined effort and the recognition of the potential for habitat restoration by private landowners in pursuit of some other land use (Costa 1999). The Program began as a six-county wide regional habitat conservation plan (HCP) under Section 10(a) of the ESA but is unique in many respects. First, HCPs are typically designed to “mitigate” adverse impacts to endangered species that result from a planned development, timber harvest, or other lawful activity. The North Carolina Sandhills Safe Harbor HCP (Sandhills HCP) is designed to facilitate positive habitat improvements in advance of any specific project that may adversely affect the red-cockaded woodpecker. The Sandhills HCP was the first to offer positive incentives for voluntary actions to conserve an endangered species. This HCP is also unique in that the USFWS serves as the permit holder of the incidental take permit, which is valid for 99 years.

The Sandhills HCP covers the majority of six NC Sandhills counties including: Cumberland, Harnett, Hoke, Moore, Richmond, and Scotland located in south-central North Carolina. There are 5 simple steps followed in order to enroll a landowner’s property in the Program: (1) the landowner provides the following information, if available; a map of the property, any forest management plans or stand maps, any information on red-cockaded woodpecker occurrence (past or present), and any information or documentation on participation in any other federal cost-share program (i.e., Forest Incentives Program, Forest Stewardship Program); (2) the Service will gather information from established sources relative to known woodpecker occurrence on or adjacent to the subject property; (3) an on-site meeting is set-up to (a) discuss land use objectives, (b) determine red-cockaded woodpecker occurrence and habitat enhancement possibilities, (c) determine the baseline responsibilities regarding red-cockaded woodpeckers and their habitat (if woodpeckers are present) and (d) identify any other information needs necessary to complete a cooperative agreement; (4) if necessary, red-cockaded woodpecker cavity tree surveys and/or forage habitat analyses are completed; and (5) the USFWS’ Safe Harbor Biologist drafts a cooperative agreement for review by the landowner. Once this agreement is finalized and signed, the USFWS issues the landowner a “certificate of inclusion” which officially acknowledges participation in the Program.

Once enrolled in the Program, the Safe Harbor Biologist meets annually with each landowner to document habitat enhancement activities and any incidental take of red-cockaded woodpeckers above the baseline as agreed upon in the cooperative agreement. The Safe Harbor Biologist is responsible for monitoring red-cockaded woodpecker cluster status resulting from habitat enhancement activities. In addition, the Safe Harbor Biologist is responsible for maintaining a geographic information systems database and is required to generate an annual report (a permit requirement) summarizing the NC Sandhills HCP activities.

Since the Program began in 1995, 62 landowners have enrolled over 32,000 acres of private forests (22,108 acres), golf courses (8948 acres), a girl scout camp (750 acres), residential areas (293 acres), schools (285 acres), town parks (205 acres) and horse farms (17 acres) on which habitat is managed for 46 groups of red-cockaded woodpeckers. The short-term objective of the Program was to target land holdings that currently have existing groups of red-cockaded woodpeckers and could host more, or are located in areas that form critical demographic and genetic links to other portions of the NC Sandhills red-cockaded woodpecker population. The short-term objective has been successfully met as 75% of known woodpecker groups in the 6-county area have been enrolled. The long-term objective is to incorporate other lands into the program that do not presently have suitable red-cockaded woodpecker habitat but could contribute habitat in the future.
There are a variety of actions that private landowners engage in to provide suitable red-cockaded woodpecker nesting and/or foraging habitat on their land, and thus, participate in the Program. These include removal and control of hardwood midstory through prescribed burning, chemical application, or mechanical manipulation; installation of new red-cockaded woodpecker nesting and roosting cavities and snag preservation (for cavity competitors); improvement of abandoned cavities (i.e. cavities enlarged by other woodpecker species) through the placement of restrictor plates; pine tree planting (especially longleaf pine) and thinning; wiregrass and other native grass restoration (for insect production and soil stabilization); and minimizing bird feeders and ornamental midstory trees (that attract nest competitors).

To date, Safe Harbor landowners have made commitments to enhance and/or restore over 8000 acres of longleaf pine habitat using Endangered Species Landowner Incentive Funds (ESLIP) through prescribed burning, hardwood removal, artificial cavity provisioning, and planting of longleaf pine.

Many landowners have been willing to incur the costs of these management actions on their own because they meet other primary land management objectives (e.g. pine straw harvesters, golf courses) but others have been more inclined to participate in the Program because it resulted in their eligibility to receive ESLIP funds. To date, the USFWS has provided over $180,000 in cost-share incentive funds to assist private landowners in the NC Sandhills with these habitat restoration projects. The idea of eliminating regulatory disincentives through Safe Harbor and providing economic incentives through ESLIP funds has been very successful in recruiting landowners previously hesitant to voluntarily participate in red-cockaded woodpecker conservation (Costa et al. 2001). Some landowners have used funds from other federal programs such as Partners for Fish and Wildlife, Stewardship Incentive Program, and Forestry Incentive Program to complete habitat work on their property.

The NC Sandhills red-cockaded woodpecker population has been steadily declining for many years due to poor habitat conditions (Carter et al. 1995). The objective of much of the habitat work accomplished on Safe Harbor properties has been to stabilize the NC Sandhills red-cockaded woodpecker population. It has taken many years of non-management to result in the decline of the NC Sandhills red-cockaded woodpecker population; therefore, we expect it will take several years for the habitat work done on Safe Harbor properties to “bear fruit”. To date, we have documented three new “safe harbor” groups of red-cockaded woodpeckers on Safe Harbor properties that exist as a result of good management by the landowner and the installation of artificial cavities.

The Program has enhanced our ability to work directly with private landowners and build trusting relationships. As a result, some NC Sandhills Safe Harbor landowners are now considering more permanent protection of their lands and pine habitat by selling or donating conservation easements. Additionally, many enrolled landowners have been key in expanding the program by showing their friends and neighbors that the program works for them. Two participating landowners have already sold their property to conservation organizations guaranteeing the long-term protection and management of habitat that supports 9 groups of red-cockaded woodpeckers. For example, the North Carolina Department of Transportation (NCDOT) purchased the 2,500-acre Calloway tract in Hoke County. This property, which was previously enrolled in the Program, adjoins Fort Bragg’s southwestern border. The acquisition of this property will be used to mitigate impacts of highway construction projects in the NC Sandhills. Following a survey, NCDOT will turn the property over to The Nature Conservancy for long-term management, in consultation with the USFWS.

Today the USFWS considers the NC Sandhills Safe Harbor Program its “flagship”; a successful prototype that led to the development of a national Safe Harbor Policy. The success of the Program can be attributed to several things (1) having a dedicated person to administer the program, (2) enrolling key landowners in the community, (3) having long-term demographic data about the population of red-cockaded woodpeckers, and (4) having funds available to assist landowners with restoration of longleaf habitat.

By limiting the responsibility of landowners and providing them with certainty about the future, Safe Harbor has removed the fear that previously drove landowners to take actions such as clearcutting pines in order to prevent red-cockaded woodpecker “infestations” (Michael 1999, Progressive Policy Institute 1999, Drake 2000).
The Program clearly illustrates the benefits of investing time to patiently cultivate trusting and lasting relationships with private landowners. It also shows that all potential benefits of incentive programs are not necessarily achieved immediately. Just as you would invest funds to obtain long-term financial gains, agencies administering Safe Harbor permits must be willing and able to obligate the necessary resources to maintain these relationships in order to realize the long-term gains toward the ultimate goal of recovering endangered species.
ABSTRACT: Recent research at Ichauway has demonstrated how fire, hydrology and N availability play important, albeit complex, roles in determining the structure and function of longleaf pine (Pinus palustris) ecosystems. Greater than 90% of N in litter and understory was lost to volatilization during experimental burns, where 27.3 and 36.9 kg N/ha was lost for typical two- and three-year burning cycles. While fire may result in significant N losses, frequent fire also mineralizes immobilized P from litter and encourages the development of abundant populations of perennial legumes (43 species). Some legume species fix between 70-90% of the N in their biomass. Although recent reports have suggested that productivity gradients in southern pine forests may be more nutrient- than water-limited, overstory and understory ANPP at Ichauway were positively correlated with soil moisture yet negatively related to N mineralization, suggesting that water is the dominant limiting resource in these systems. Understanding how this ecosystem responds to hydrologic variation and fire has been limited by lack of experiments investigating regulating mechanisms. Our next phase of research includes long-term (15 yr) experiments that use manipulative approaches along both natural hydrologic gradients and in young planted stands of longleaf pine. They include: 1) experimental manipulation of water, N and fire to investigate controls on overstory and understory productivity; 2) an experiment examining how N manipulation and fire exclusion interact in regulating plant distribution and biodiversity; and 3) a "common garden" experiment on the interaction of N, P and fire effects on legumes, symbiotic N2-fixation and productivity.
ABSTRACT: The fire-maintained longleaf pine ecosystem of the southeastern coastal plain harbors nearly 200 rare and endangered plant species, many of which are dependent on frequent fire for persistence. One such fire-dependent species is the federally endangered hemiparasite, *Schwalbea americana* (American chaffseed) in the family Scrophulariaceae. Regardless of season of burn, fire stimulates flowering and subsequent seed production in this species; however, the specific mechanisms involved in this fire-induced flowering response are unknown. The purpose of this study was to determine the mechanism controlling the flowering response to fire. Using experimental treatments in both the field and greenhouse, we addressed the following question: Is flowering and subsequent viable seed production induced by fire a result of: a) increased light availability by removal of surrounding vegetation, b) partial plant destruction due to removal of the above-ground stem, c) pulses of phosphorus or ethylene released following fire, or d) smoke exposure? Our field treatments included fire, shading following fire, phosphorus addition, stem clipping, competing vegetation exclusion, stem clipping plus vegetation exclusion, and mowing plus raking. Our greenhouse treatments consisted of ethephon application, smoke incubation, and a combination of three light levels plus stem clipping. Our findings indicate that flowering is stimulated by a combination of clipping and light. Flowering was not induced by phosphorus, ethephon, or smoke treatments. An unexpected result of our field study was the occurrence of insect herbivory at one site, with the greatest amount of herbivory in the stem clipping plus competing vegetation exclusion treatment. These results may have management implications for this species during years in which prescribed fire is not possible.
MODIFICATION AND VALIDATION OF FUEL CONSUMPTION MODELS FOR USE IN LONGLEAF PINE TYPES OF THE SOUTHEAST

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ABSTRACT: Land managers across the country are increasingly expected to use prescribed fire as a landscape-level fuel treatment mechanism to improve ecosystem health and reduce the likelihood of catastrophic wildfires. Planning and execution of these prescribed fires require managers to operate fuel and fire management decision-support systems that rely heavily on the ability to assess fuel consumption. The purpose of this project is to modify and improve existing fuel consumption models to better predict the consumption of fuels during wildland fires in fuel types where there is a limited knowledge base and where there will be an increase in prescribed burning. This study will lead to better predictions of fuel consumption during the flaming and smoldering stage in longleaf pine fuelbed types. The empirical models derived from these new data will be implemented into Consume 3.0, a software program that allows users to predict fuel consumption and smoke emissions for wildland fire planning.

Thirteen 30-50 acre units were selected on Eglin Air Force Base in longleaf pine ecosystem variants for the study. The units were burned under wet, moist, dry, and very dry fuel moisture conditions as determined by the number of days since rain, monitoring of duff wetness from an onsite weather station, and from duff moisture samples. Preliminary analysis indicates that duff consumption is controlled by duff which can be roughly estimated by the number of days since significant rainfall (0.5 inch or greater).

This study and software development is supported by the Joint Fire Science Program, the National Fire Plan, and the Department of Defense, Air Force.
STereo Phto series for quantifying natural fuels in the americas

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ABSTRACT: The natural fuels photo series is a set of data and photographs that collectively display a range of natural conditions and fuel loadings in a wide variety of ecosystem types throughout the Americas from central Alaska to central Brazil. Fire managers are the primary target audience of the natural fuels photo series, although the data presented will also prove useful for scientists and managers in other natural resource fields.

The first six volumes of the natural fuels photo series are grouped and published by geographical region of the United States. Volume I included sites in mixed-conifer, western juniper, sagebrush, and grassland ecosystem types in the interior Pacific Northwest. Volume II included sites in black spruce and white spruce ecosystem types in Alaska. Volume III included sites in lodgepole pine, quaking aspen, and gambel oak ecosystem types in the Rocky Mountains. Volume IV included sites in pinyon-juniper, sagebrush, and chaparral ecosystem types in the Southwest. Volume V included sites in red and white pine, northern tallgrass prairie, and mixed-oak ecosystem types in the Midwest. Volume VI included sites in longleaf pine, pocosin, and marshgrass ecosystem types in the Southeast.

Additional published or in press volumes include sites in grassland, shrubland, woodland and forest types in Hawaii; jack pine in the Lake States; hardwoods with spruce succession in Alaska; and sand hill, sand pine scrub, hardwoods with white pine, and an extension of the longleaf and marshgrass types in the Southeast. A volume to characterize western oaks and manzanita/ceanothus types is currently being compiled and fieldwork is ongoing in pitch pine, balsam fir/red spruce, and mixed hardwoods types in the Northeast U.S. While the primary focus has been on ecosystems found throughout the United States, a volume has also been produced for savannah (cerrado) ecosystem types in central Brazil and a volume is under development for pine forest and other types in Mexico.

Generally, sites include wide-angle and stereo-pair photographs supplemented with information on living and dead fuels and vegetation, and where appropriate, stand structure and composition within the area visible in the photographs. The sites in each volume provide a basis for appraising and describing woody material, vegetation, and stand conditions in different ecosystems across the United States.

WHY IS THE PHOTO SERIES NEEDED?

The natural fuels photo series are land management tools that can be used to assess landscapes through appraisal of living and dead woody material and vegetation (i.e., fuels) and stand characteristics. Once an assessment has been completed, stand treatment options, such as prescribed fire or harvesting, can be planned and implemented to better achieve desired effects while minimizing negative impacts on other resources.

The photo series has application in several branches of natural resource science and management. Inventory data found in each volume can be used as inputs for evaluating animal and insect habitat, nutrient cycling, and microclimate, for example. Fire managers will find the photo series useful for predicting fuel consumption, smoke production, fire behavior, and fire effects during wildfires and prescribed fires. In addition, the photo series can be used to appraise carbon sequestration, an important factor in predictions of future climate, and to link remotely sensed signatures to live and dead fuels on the ground.
Ground inventory procedures that directly measure site conditions (e.g., fuel loading and arrangement, vegetation structure and composition, etc.) exist for most ecosystem types and are useful when a high degree of accuracy is required. Ground inventory is time-consuming and expensive, however, and photo series can be used to make quick, easy, and inexpensive determinations of fuel quantities and stand conditions when less precise estimates are acceptable.

HOW WAS THE PHOTO SERIES DEVELOPED?

Sites photographed for the various series are selected to show ranges of important ecosystem characteristics (e.g., down and dead woody material loading, understory composition, overstory development, etc.).

PHOTOGRAPHS AND INFORMATION ARRANGEMENT

Stereo-pair photographs are included in each photo series volume. The three-dimensional image obtained by viewing the photographs with a stereoscope improves the ability of the land manager to appraise natural fuel, vegetation, and stand structure conditions. Larger, wide-angle photographs are included for additional comparisons.

The photographs and accompanying data summaries are presented as single sites organized into series. Each site is arranged to occupy two facing pages. In most cases the upper page contains the wide-angle (50mm) photograph, and general site and stand information. The lower page typically includes the stereo-pair photographs and summaries of overstory structure and composition, understory vegetation structure and composition, forest floor composition and loading, and dead and down woody material loading and density by size class.

USING THE PHOTO SERIES

To use the photo series one makes a visual inventory of the site by observing fuel and stand conditions within their field of view and comparing them with the stereo-pair photographs. The user observes each characteristic of interest (e.g., 3.1-9.0-inch woody material loading) and selects a photo series site (or sites) that nearly matches or brackets the observed characteristics. The quantitative value of the characteristic being estimated can then be read from the data summary accompanying the selected photo series site, or a value can be interpolated using the data from more than one site. These steps are repeated for each size class or stand characteristic of interest and the total loading or stand condition can then be calculated by summing the estimates.

HOW DO I GET THE PHOTO SERIES?

Volumes I-VI are available for purchase from the National Interagency Fire Center, Great Basin Cache Supply office, Publication Management System working team in Boise, Idaho (Fax: 208-387-5573 or http://www.fire.blm.gov/gbk/pms.htm). The Hawaii and Brazil volumes are available upon request from the Pacific Northwest Research Station, Seattle Forestry Sciences Laboratory.

Photo Series Citations


DEVELOPING MANAGEMENT OPTIONS FOR LONGLEAF COMMUNITIES OF THE GULF COASTAL PLAIN

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ABSTRACT: Choosing treatments to reduce fuel loads and readjust structure and composition in longleaf communities of the Gulf Coastal Plains region is difficult because benefits and costs of possible treatment combinations are not fully known. The objective of this research project is to develop management options to reduce fuels and restore the ecosystem that are economically viable and socially acceptable. Research is being conducted in cooperation with Auburn University, which furnished appropriate longleaf stands and has collaborated in data collection on wildlife and soils and logistics support for treatment application. Pretreatment data was collected in 2001 and treatments consisting of thinning, burning and their combination were successfully applied in 2002, in spite of obstacles like a poor timber market and severe spring drought. Post year data collection is proceeding and has already yielded useful information on how to burn recently thinned longleaf stands without excessive crown scorch or tree mortality.

INTRODUCTION

Many U.S. forests, especially those that historically burned at short-intervals, are too dense and/or have excessive quantities of fuels. Widespread treatments are needed to restore ecological integrity and reduce the high risk of uncharacteristically severe and destructive wildfires. Among possible treatments, however, the appropriate balance among cutting, mechanical fuel treatments, and prescribed fire is often unclear. For improved decision making, resource managers need much better information about the consequences of alternative management practices involving fire and mechanical, i.e. fire surrogate treatments.

Longleaf (Pinus palustris) communities of the middle and upper Gulf Coastal Plains historically had an overstory dominated by longleaf pine with pockets of other southern pines and occasional hardwoods, while the understory was grass dominated with lesser amounts of woody shrubs. The open condition and grassy understory were maintained by frequent, every 2 to 5 years, low intensity fires from lightning and native American ignitions. Lack of burning for a number of years during the 1900’s allowed hardwoods to increase in the mid and overstory layers while woody shrubs gained understory dominance. These changes have resulted in a variety of impacts from lowered economic returns, to degradation of habitat for numerous species, to more severe wildfires during periodic droughts.

The reintroduction of fire seems like an appropriate treatment to reverse these changes, but the benefits and costs of such treatment is not fully known. The Fire and Fire Surrogate Study recently established on the Solon Dixon Forestry and Education Center, one of 13 nationwide locations, will help fill in these information gaps. The research objective is to develop realistic management options that can be used to treat fuels and restore ecosystems. To accomplish this the initial effects of fire and fire surrogate treatments on vegetation, fuel and fire behavior, soils and forest floor, wildlife, forest insects, tree diseases, and treatment costs and utilization economics will be quantified.

METHODS

The Solon Dixon Forest is representative of the longleaf ecosystem of the Gulf Coastal Plain stretching from Alabama to Louisiana. Currently 1 million acres of longleaf-dominated ecosystem remain in this area with 50 percent in the non-industrial private sector. An additional 2 million acres contain some longleaf pine mixed with other pines and/or hardwoods. Much of the forest in the area is dominated by longleaf pine but other southern pines are also abundant including loblolly (P. taeda), shortleaf (P. echinata), slash (P. elliottii), and spruce pine (P. glabra). In many areas, especially the numerous lower bottoms, there is a substantial hardwood component dominated by oaks (Quercus spp.). The understory is dominated by woody shrubs with yaupon holly (Ilex vomitoria) the most abundant and lesser amounts of blueberries (Vaccinium spp.) and gallberry (I. glabra).

The design is a randomized block with three blocks of four treatments each. Treatments include an untreated control (no fire or other disturbance), prescribed fire only, with periodic reburns as needed,
mechanical removal of excess trees, and a combination mechanical removal of excess trees and prescribed fire. Treatment units are operational in size at 30 to 40 acres each.

After a year of pretreatment data collection, trees were marked for thinning in appropriate units. Loblolly, slash and spruce pine and hardwoods, which had increased in abundance during fire control, were targeted for removal during thinning. Tree removal was done through a commercial timber sale. The operator used a feller buncher to cut trees, chainsaws to delimb, and grapple skidders to haul tree length material to the loading areas. The thinning, to reduced basal area to 50 to 60 square feet per acre, was began in January and completed in early April 2002. Prescribed burning was done in April and May by block following thinning operations. Data was collected during and following all burns.

RESULTS AND DISCUSSION

All treatment units were burned using backing, flanking, or spot fires. Unit 2, which took nearly 17 hours to burn, had the slowest moving fire with an average rate of spread of 100 ft/hr (Figure 1). There was significant bole char on trees in this area, but to date tree mortality has been minimal with only a few small pines lost. Units 1 and 10 also had rather slow moving burns, which required 10 hours to complete. The other areas required less time to burn with initial ignitions around 10 am and completion by 2 or 3 in the afternoon. Average rate of spread was influenced by both burning techniques and thinning treatment. Backing fires had a mean spread rate of 100 ft/hr while spot and flank fires spread rate was 170. In thinned units, spread rate was 135 ft/hr versus 200 in burn only stands. The burns in thinned units were also not as uniform because the skid trails interrupted the fire spread while the slash accumulations resulted in greater flame lengths and a longer residence time. Labor and therefore costs of burns were mostly dictated by the size and configuration of burn units rather than the thinning treatments. Both thinned and unthinned units required an average of 2 person hours per acre to install control lines and execute the prescribed burns.

Excessive tree damage was avoided by the pre-fire movement of slash accumulations away from leave trees. It took an average of 1.5 person hours per acre for this slash movement in the two units where many hardwoods were harvested. On the unit that contained mostly pine, no redistribution of slash was necessary prior to prescribed burning. Crown scorch was greater on hardwoods than on pines with no apparent effect due to thinning (Figure 2). Bole char conversely was generally minimal for hardwood stems but averaged about 2.5 m on pines, again with no difference between thinned and unthinned units. The greater crown scorch on hardwoods was likely a function of tree height as there were more short hardwoods than pines. Pre burn litter depth (Figure 3) was the same on burn and thin and burn treatment units, although there was certainly a lot more slash fuel on the thinned areas. Litter consumption was higher on areas thinned before burning, likely because of slash providing addition fuel that increased residence times and therefore litter consumption. Although some places burned down to mineral soil, even on the thinned units the humus layer generally remained with an average litter depth of 1 cm post burn.

This study shows that commercial thinning can be used to readjust structure and composition of the mid and overstory layers of longleaf communities of the Gulf Coastal Plains region. These stands can also be treated with growing season burns soon after thinning to dispose of slash and help control hardwood and woody shrub growth. This requires some movement of logging slash and the burns will be more spotty, but still successful with proper planning and execution. With this slash movement and careful burns, crown scorch for pines can be kept at less than 10 percent. At this low level, there will be no increase in tree mortality and growth loss in subsequent seasons will be minimal (Johansen and Wade 1987). All of the burns were somewhat more time consuming and thus costly than general prescribed burning, but this must be viewed against the minimal damage and mortality to the remaining stand. Once the stand has readjusted to growing season burns, costs will be more typical. Which of the treatments tested is best suited to management objectives of a healthy and productive longleaf community will require additional data collection over a longer time.
Figure 1. Influence of fire type and relative humidity on rate of spread during prescribed burns of different treatment units at the Solon Dixon Center in southern Alabama. Note unit 11 is two adjoining areas that were burned on consecutive days.
Figure 2. Crown scorch (a) and bole char (b) of southern pines and hardwoods from prescribed burning in stands, with or without prior thinning, on the Solon Dixon Center in southern Alabama.

Figure 3. Litter consumption from prescribed burns in stands, with or without prior thinning, on the Solon Dixon Center in southern Alabama.

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LITERATURE CITED
OVERSTORY RETENTION IN LONGLEAF PINE FORESTS: Resource Effects and Regeneration Responses

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ABSTRACT: Recent interest in restoring greater age structure to even-aged longleaf pine stands has led to the exploration of overstory retention approaches. This silvicultural approach is thought to more closely resemble the complex structure after natural disturbance and provide some benefit to unique ecosystem structures. However, the benefits of overstory retention are tempered by increased competition between seedlings and the overstory, causing reduced seedling survival and growth. Furthermore, the competitive environments and mechanisms that influence regeneration in longleaf pine systems differ substantially from that of closed-canopy ecosystems and those under even-aged management that have been much more extensively studied. We initiated a study in 1998 to address the effects of residual overstory structure and competing herbaceous vegetation on the survival and growth of planted longleaf pine seedlings. This presentation is a synthesis of several publications that have been recently published.

Stands were harvested to a similar residual basal area using three removal techniques: single-tree selection, small group (~0.20 ac) selection, and large group (~0.45 ac) selection. We also used an uncut control stand. Each treatment and control was randomly assigned to three replications. Subplots encompassed the range of overstory density in each stand. The understory in each subplot received either an herbicide solution to remove herbaceous vegetation or was left intact. We found that available nitrogen was low except in large gaps where the understory was also removed. Annual estimates of light transmittance reaching the understory varied significantly both spatially (intact canopy to gap center) and temporally (time of year and sky condition). Hemispherical photograph estimates of light reaching the understory were more precise and less biased than ten-minute average measures using photodiodes during overcast or cloudless days. Pine root production compensated for reduction in non-pine roots if understory vegetation was removed; however, in large gaps, non-pine roots quickly filled the area if the understory was left intact. Seedling growth was closely related to overstory density within a treatment, with the greatest growth in large gaps where the understory was removed. However, the spatial arrangement of overstory retention affected mean seedling growth response at a stand level. We argue that manipulation of the spatial distribution of remaining overstory trees may allow for land managers to retain the benefits of overstory retention while allowing for regeneration of longleaf pine.
DOES ELEVATED CO₂ MEAN CHANGES IN FIRE BEHAVIOR? An Experiment with Longleaf and Loblolly Pine Litter

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ABSTRACT: The effect of global change on fire regimes has received little attention due to experimental limitations imposed by the large (landscape) scale that fire depends on. While many experiments have investigated changes in the interaction between litter quality grown under elevated CO₂ with herbivory, decomposition, and mineralization for example, no studies have looked at the response of fire behavior. This study tested various hypotheses regarding the fire behavior of longleaf and loblolly pine litter grown under elevated CO₂ conditions. To assess changes in fire behavior, we burned litter samples of longleaf and loblolly pine grown under elevated and ambient CO₂. In a combustion chamber, we measured percent combusted, maximum flame height, flame time, ember time, total burn time, and mean weight loss rate. There were significant changes in fire behavior between species, however neither species showed significant (p < 0.05) changes in flammability properties between elevated and ambient CO₂ concentrations. Maximum flame height was only slightly significant (p = 0.098) for loblolly pine litter. In the future, we will compare litter chemistry properties (phenol content, % carbon and nitrogen, and non-structural carbohydrates) to fire characteristics. While these preliminary results show no significant effects of elevated CO₂ on fire behavior for longleaf and loblolly pine litter, we intend to investigate similar relationships for different plant functional groups including grasses. The potential effects of changing fire regimes under elevated CO₂ on global biogeochemical cycling, local decomposition and mineralization, and seedling survival and recruitment, merit this experimental approach.
VELPAR DF OR OUST EFFECTS ON GROWTH, AND SURVIVAL WHEN APPLIED OVERTOP OF FIRST YEAR LONGLEAF PINE SEEDLINGS

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ABSTRACT: The use of herbicides to accelerate longleaf seedlings out of the grass stage still has unanswered questions about the tradeoffs between increasing rates and increasing seedling injury. There is little information about the three most common forest herbicides, Arsenal AC, Oust, and Velpar-DF, when applied over-top of first year seedlings in old field conditions. To further understand the interactions between weed competition, herbicide toxicity, and pine growth, a multi-year study was conducted in 2001 involving six herbicide treatments. Pine measurements were taken 10 and 22 months after planting to determine the best rate for maximum seedling growth, for each of the three herbicides. A second objective was to determine if there was a relationship between root collar diameter and active height growth. The study was a randomized, complete block design with four blocks. The treatments included Velpar (0.56 and 1.12 kg ai ha$^{-1}$), Oust (0.21 and 0.42 kg ai ha$^{-1}$), Arsenal (0.56 kg ai ha$^{-1}$), and a control treatment. The pines were planted on January 26, 2001, and herbicides were applied on April 20-24, 2001. Herbicides were band applied (1.2 m) over top of the pines. The first year results show a quadratic relationship between increasing Velpar or Oust rates and root collar diameters. Seedling survival was not related to Oust rates, but did show a trend towards decreasing survival at the highest Oust rate. Seedling survival decreased at the highest Velpar rate. There was no active height growth at the end of the first growing season. Second year data will be collected in October 2002. Visual evaluations show that many of the 2-year old seedlings have started active height growth. The first year results indicate that the optimal rate for Velpar and Oust was 0.56 and 0.42 kg ai ha$^{-1}$, respectively, in terms of best survival, diameter growth for the seedlings. It is expected that the same pattern of growth will continue into the second growing season.

INTRODUCTION
A field study was conducted in Santa Rosa county, FL to evaluate the effects of two herbicides, Velpar DF and Oust, on newly planted longleaf pine seedlings. The herbaceous weed control study compared three application rates for each herbicide on the survival, growth and physiological functions of the seedlings planted under old-field conditions. Our objective was to determine the optimum rate that would increase both survival and root collar diameter growth in longleaf pine seedlings.

METHODS
The field study was conducted at the University of Florida’s West Florida Research and Education Center, in Jay, FL (30.46N, 87.11W). The site was an agricultural field (slope 0-2%) that had been abandoned for 8 – 10 years. The soil is characterized by a well-drained, Redbay sandy loam (Fine-loamy, siliceous, thermic Rhodic Paleudult), with an average water table of six feet. Soil samples from the site averaged 1.6 % organic matter, pH of 5.5, and a cation exchange capacity (CEC) of 3.9 cmol kg$^{-1}$.

The study was a randomized, complete block design, with four blocks. Uniform one-year-old containerized longleaf pine seedlings were planted as four-inch plugs in January 2001. The seedlings were planted at a spacing of 8 x 8 ft with 40 seedlings per plot. The herbicides were applied overtop on April 20 – 24, 2001, approximately three months after planting (MAP). The herbicides were Velpar DF and Oust. Velpar DF product rates were 0, 0.67, and 1.33 lb ac$^{-1}$ and the Oust product rates were 0, 0.25, and 0.5 lb. ac$^{-1}$ (broadcast acre basis). The herbicides were band applied with a CO$_2$ backpack sprayer and a three-nozzle boom. The spray volume was 20 gallons ac$^{-1}$, applied at 20 PSI, in 4 ft-wide bands. A blended, organsilicone surfactant, Kinetic, was mixed with each herbicide at 0.1% (v/v) of the spray volume.

Physiological measurements included net photosynthesis (Pn), stomatal conductance (G), and transpiration (E) measured under uniform environmental conditions using a Li-COR infrared gas analyzer (LI-COR, Lincoln, Nebraska). Six seedlings were randomly selected for these measurements in each plot, for a total of 24 foliar samples per treatment. Environmental conditions within the needle chamber were held constant across all sampling times. Uniform environmental conditions helps separate the confounding
factors of varying light intensity, air flow, variation in CO₂ concentrations, and temperature from the effects of the herbicide including seedling phytotoxicity and the degree of weed control. The light intensity was 1,600 µmol m⁻² s⁻¹, temperature was 28.4 °C, and CO₂ for the reference chamber was 404 mg l⁻¹. The number of pine needles in the leaf chamber varied from 9-12 needles. Total needle surface area for each sample was calculated from fascicle measurements using the following equation (Grace 1987):

**RESULTS**

Survival in May differed between the two herbicides, but did not differ with increasing rates for either Oust or Velpar DF. Oust (0.5 lb. ac⁻¹) had the highest survival, while Velpar DF (1.33 lb ac⁻¹) had the lowest survival. Seedling survival in October differed between Velpar DF and Oust, and for increasing rates of Velpar DF. By October there were no differences in survival among the three Oust rates, however there was a trend for the middle Oust rate to have the best survival. With one exception, when Velpar DF was applied at 1.33 lb. ac⁻¹, there were no differences in survival between Oust and Velpar DF. A longleaf pine HWC study, planted in a converted peanut field with the applications on April 6, found no differences in survival among 12 herbicide treatments that included tank mixes with Velpar-L, Oust, and Arsenal AC (Sloan and Mixson 2000).

Root collar diameters at the end of the first growing season were comparable between Oust and Velpar DF, except for the control treatment. Each of the herbicides, however, had significant quadratic relationships with increasing application rates. Mean root collar diameters were 15.4, 15.3, and 13.2 mm for Velpar DF, Oust and the control treatments, respectively, when the middle rates were applied. At the highest rates, mean root collar diameters were 15.6, and 15.5 mm for Velpar DF and Oust, respectively, showing a leveling off pattern in diameter growth. A longleaf herbaceous weed control study had a root collar diameter of 18.8 mm, one year after treatment, when a tank mix of Velpar and Oust (14 fl oz + 3 oz) was broadcast applied (Ramsey et al. 2002).

Foliar measurements provide a snapshot of the foliar physiology (6 MAT) just before the growth starts to decline in late fall. Except for the control treatment, there were no differences in net photosynthesis between Velpar DF and Oust. Analysis of rate effects, however, shows a quadratic relationship for Velpar DF and a linear relationship for Oust. In relative terms, the highest rate of Velpar DF had the highest net photosynthesis. However, analysis for rate effects shows that net photosynthesis was leveling out for Velpar DF but not for Oust. Stomatal conductance followed the same pattern as net photosynthesis when comparisons between Velpar DF and Oust were tested. With the exception of the control treatment, there were no differences in G between the two herbicides. However, both Velpar DF and Oust show a positive, linear increase in G with increasing application rates. There was no indication of leveling off in G with increasing application rates for either herbicide. Qualitative analysis for transpiration shows differences between Velpar DF and Oust. As expected the lowest rate of transpiration was for the control treatment, which indicates there was competition for soil moisture between the pine seedlings and the neighboring herbaceous weeds. The highest rate of transpiration occurred in the Velpar DF (1.33 lb. ac⁻¹) treatment, which suggests these plots had the highest soil moisture. Soil moisture content is generally related to the amount of weed competition. Testing for rate effects shows a positive linear relationship between transpiration and increasing application rates for both herbicides.

Volumetric soil moisture may be used either as a direct measure of water availability to the pine seedlings, or as an indirect measure of weed competition for water (Carter et al. 1984, Nambiar et al. 1993, Zutter et al. 1986). The overall pattern in soil moisture over the four sampling dates showed that the May and July dates had lower moisture readings. These readings are in accord with the spring and early summer drought that occurred in 2001. Soil moisture for both the May and July dates was positively related to increasing rates for Velpar DF and Oust. By late summer, however, these differences in soil moisture vanished and there was no relationship with the herbicide rates. The August and October soil moisture readings were higher than the mid summer means despite the reemergence of weed cover in many of the plots. Correlation analysis between root collar diameter and soil moisture shows that early spring moisture had a stronger effect on longleaf seedling growth than soil moisture in late summer. In May 21 and 18% of the variance in RCD could be explained by soil moisture for Velpar DF and Oust, respectively. The correlation between RCD and soil moisture decreased steadily as the summer progressed. There was no overall significant relationship between root collar diameters and soil moisture for any of the sampling dates. The
low correlation values suggest that many other environmental variables and/or herbicide effects are interacting with the seedling growth.

DISCUSSION
Soil moisture is influenced by rainfall, organic matter, soil texture, debris mulches, and competitive vegetation. The interaction of all these variables makes any correlation between seedling growth and soil moisture a speculative venture, with many potential confounding factors. The results from our study show that soil moisture was positively related to herbicide rate up until August. Seedling diameters also increased with increasing herbicide rates, thus providing some evidence that soil moisture levels and seedling growth may be positively associated with each other. The loss of herbicide effects on soil moisture, starting in August, suggests that delayed germination of weeds had occurred, resulting in a more uniform transpiration rate across the treatment plots. A herbaceous weed competition study found soil moisture differences between weed species and levels of weed control (Morris et al. 1993). An herbaceous weed control study on loblolly pine seedlings found that soil moisture decreased from approximately 10 to 4% when weed biomass increased from 0 to 3,000 kg ha\(^{-1}\) (Zutter et al. 1986).

Although there was no effect of soil moisture on longleaf root collar diameters, the results suggest that application timing may be important in improving seedling growth. The high correlations between RCD and soil moisture in the springtime indicates that late winter applications may provide weed control in early spring when soil moisture availability is most important. However, there is other evidence that late spring applications result in higher seeding survival rates and higher growth rates due to less foliar uptake and thus less herbicide injury. Another HWC longleaf study also mentions that timing of applications is important in minimizing damage to the seedlings (Hainds et al. 2000). Our findings that weed control improved volumetric soil moisture were collaborated by a loblolly study involving HWC applications (Rahman et al. 2002). They found that weed control increased from 6.9 to 10.3% for the control and HWC plots in June, respectively. There was still a significant difference in soil moisture in August, contrary to our findings, showing soil moisture at 4.9 and 7.1% for the control and HWC plots.

The application dates for our study was April 20-24, 2001, which was relatively late in the season. Most of the herbaceous weed cover was already one third to one half meter in height by this date. As a direct outcome of the late application date, the weed cover intercepted most of the foliar spray, which in turn resulted in less foliar injury to the pine seedlings. In addition, our study had a relatively finer textured soil than the other studies. Soils with more silt and clay tend to have a higher adsorptive capacity, which usually results in reduced seedling injury from soil active herbicides (Rhodes 1980).

At the whole plant level there was little differentiation in pine responses to the two herbicides. In terms of survival, only Velpar DF, at the highest rate, negatively affected survival by October. Survival only differed by one percent when either herbicide was applied at the middle rate. Seedling diameters were comparable, at either the middle or high rate, for both herbicides. Thus the performance of either herbicide, in terms of improved survival or groundline diameter, was virtually identical at the middle rates. If the seedling responses are comparable for either herbicide then chemical costs between either herbicide, or between application rates should be the deciding factor for forest managers. In 2001 Oust was $539 lb\(^{-1}\), while Velpar DF was only $24 lb\(^{-1}\). These prices translate into a chemical cost of $135 ac\(^{-1}\) versus $16 ac\(^{-1}\) for Oust (0.19 lb ac\(^{-1}\)) and Velpar DF (0.67 lb ac\(^{-1}\)), respectively.

Oust had slightly higher survival but lower diameter growth, when comparing results between the middle and highest rates. Forest managers would need to decide if the extra expense of doubling the Oust rate was worth a gain of 0.2 mm in diameter growth that was offset by a 6% loss in survival. In comparison, the highest rate of Velpar DF resulted in poorer survival than the middle rate. It is interesting to note, however, that there was not a concomitant decrease in diameter growth associated with higher mortality rates. Lack of evidence for stunting at the highest Velpar DF rate suggests that mortality might to due other study factors, such as less initial weed cover to intercept spray droplets, or higher water stress for seedlings planted on the plowed terraces of the old cotton field. Velpar DF inhibits photosynthesis, while Oust inhibits branched chain amino acid production. Six months after application there is no indication of phytotoxic injury to the seedlings by either herbicide, relative to the control values. In general all of the
foliar responses were linearly related to increasing rates for both herbicides, except for Pn at the highest rate of Velpar DF.

REFERENCES
LONGLEAF PINE SURVIVAL, GROWTH, AND UNDERSTORY SPECIES DYNAMICS FOLLOWING VEGETATION CONTROL ON A FLATWOODS SITE

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ABSTRACT: Longleaf pine (Pinus palustris) ecosystems, once widespread throughout the southeastern United States, have declined due to harvesting of timber, land use changes and suppression of periodic fires. Thousands of acres are planted with containerized and bare-root seedlings every year to restore longleaf pine ecosystems. There is an increasing need for better understanding the competitive interactions between the seedlings and herbaceous and shrubby weeds to ensure the success of these restoration efforts. This study was established to examine longleaf pine survival, growth and understory species dynamics to competition control treatments on flatwoods sites. The effect of herbicides on nitrogen mineralization and the movement of herbicides in the soil were also monitored. One-year-old longleaf pine seedlings were planted on a flatwoods site in northwest Florida (December 2001) after site preparation involving drum chopping (October 2001) and burning (November 2001). Herbicide treatments [Oust (5oz/acre), Velpar (32oz/acre), Oust (5oz/acre) + Velpar (32oz/acre), Arsenal (6oz/acre) and a control] were band applied to minimize damage to native vegetation. Seedling survival, height, root collar diameter, and percentage out-of-grass stage would be measured at the end of first and second growing seasons. A preliminary survey was done (June 2001) on the understory vegetation to assess the species composition, diversity and richness of the site. The understory vegetation was resurveyed 6 months after planting. Subsequent surveys would be conducted at 12 and 24-month intervals after planting. Change in species composition, diversity and richness would be quantified using Canonical correspondence analysis. N-mineralization rate will be monitored for a year using the in situ buried bag technique. The fate of the applied herbicides in the soil would also be monitored at 0, 15, 30, 60, and 120 days after herbicide treatments.
EVERYTHING BEING CONSTANT: Do Diameter Growth Rates Change Over Time?

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Ralph S. Meldahl (School of Forestry & Wildlife Sciences, 108 M. White Smith Hall, Auburn University, AL 36849)

ABSTRACT: Everything else being constant, other than the weather, has there been an increase in longleaf pine growth? In an effort to answer this question, a long-term data set was examined to see what trends there have been in longleaf pine growth. In 1964, the U.S. Forest Service established the Regional Longleaf Pine Growth Study (RLGS) in the Gulf States to study the dynamics of 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. To detect possible changes in productivity with time, a series of time replication plots (referred to as “timeres”) in youngest age class (ages 9 – 15 years) has been established and periodically measured on the Escambia Experimental Forest (EEF) in Brewton, Alabama. The first sets of plots were established in 1964 and new sets of plots have been added in this age-class every 10 years. Three more sets have been established since. These plots have been used to investigate differences in growth due to differences in climatic factors (represented by different time periods) after accounting for the differences in initial stand characteristics. The controlled nature and close proximity of the timeres plots isolates most of the effects induced by stand characteristics and site quality. This presentation will report on the growth trends observed in the four sets of time replication plots that spans more than a 35-year period.

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 has completed its seventh measurement period (35-year measurement).

To detect possible changes in productivity with time, a series of time replication plots (referred to as “timeres”) in youngest age class (ages 9 – 15 years) has been established and periodically measured on the Escambia Experimental Forest (EEF) in Brewton, Alabama. The first sets of plots were 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. Currently, there are a total of 21, 15, 29 and 15 plots in the four timeres (1, 2, 3, and 4) respectively. The timeres 1 plots were installed in 1964, timeres 2 in 1973, timeres 3 in 1985, and timeres 4 in 1995. The basic purpose of establishing timeres plots was to investigate differences in growth due to differences in climatic factors (represented by different time periods) after reducing the differences in initial stand characteristics as much as possible. In order to establish an effect due to climate, the effects due to other factors, like stand dynamics, must be explained as much as possible. The controlled nature of the timeres plots already isolates most of the effects induced by stand characteristics. For instance, the close proximity of plots to each other and similarity of soil types have isolated most of the effects due to site quality.

APPROACH

The study utilizes the existing procedures used for the Regional Longleaf Pine Growth Study. 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 in size surrounded by a similar and like-treated one-half chain wide isolation strip with both surrounded by a one-half chain wide protective buffer strip that receives extensive management.

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. Each tree has its DBH recorded to the nearest 0.1 inch, and crown class determined. A systematic sub-sample of trees from each one-inch DBH class is 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.

THE DATA SET

RESULTS
In order to compare whether there were differences in diameter growth over time, basal area increment was calculated for each of the first re-measurement period for each of the time series, that is: for the first series the years were 1964 to 1969, the second 1975 to 1980, and so on. An analysis of variance examining basal area increment found statistically significant differences between the time series.

The following tables present the basic statistics for various stand variables with the four series of time replication plots for their initial re-measurement.

TIME SERIES 1 (1964)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (N = 20)</th>
<th>Range</th>
<th>Std. dev.</th>
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</thead>
<tbody>
<tr>
<td>Basal area (ft²/ac)</td>
<td>33.0</td>
<td>(10.1,61.8)</td>
<td>15.7</td>
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<tr>
<td>Stand age (yr)</td>
<td>17.9</td>
<td>(15.2,20.7)</td>
<td>1.60</td>
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<tr>
<td>Site Index (base age 50)</td>
<td>61.5</td>
<td>(48.8,73.9)</td>
<td>7.18</td>
</tr>
<tr>
<td>Basal area increment (ft²/ac/yr)</td>
<td>5.4</td>
<td>(2.4,7.1)</td>
<td>1.17</td>
</tr>
<tr>
<td>Stand height (ft)</td>
<td>28.5</td>
<td>(22.8,39.1)</td>
<td>4.6</td>
</tr>
<tr>
<td>Quadratic mean diameter (in)</td>
<td>2.8</td>
<td>(2.3,3.7)</td>
<td>0.37</td>
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<tr>
<td>Number of trees/ac</td>
<td>726</td>
<td>(365,1360)</td>
<td>259.88</td>
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TIME SERIES 2 (1975)

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<tbody>
<tr>
<td>Basal area (ft²/ac)</td>
<td>55.3</td>
<td>(23.9,87.8)</td>
<td>17.1</td>
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<tr>
<td>Stand age (yr)</td>
<td>17.5</td>
<td>(14.8,20.2)</td>
<td>1.17</td>
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<tr>
<td>Site Index (base age 50)</td>
<td>79.1</td>
<td>(67.4,89.5)</td>
<td>5.46</td>
</tr>
<tr>
<td>Basal area increment (ft²/ac/yr)</td>
<td>5.4</td>
<td>(3.1,8.3)</td>
<td>1.48</td>
</tr>
<tr>
<td>Stand height (ft)</td>
<td>34.8</td>
<td>(25.9,44.5)</td>
<td>4.73</td>
</tr>
<tr>
<td>Quadratic mean diameter (in)</td>
<td>3.7</td>
<td>(2.6,5.3)</td>
<td>0.69</td>
</tr>
<tr>
<td>Number of trees/ac</td>
<td>848</td>
<td>(285,1465)</td>
<td>388.90</td>
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</table>

TIME SERIES 3 (1985)

<table>
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<th>Range</th>
<th>Std. dev.</th>
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<tr>
<td>Basal area (ft²/ac)</td>
<td>63.1</td>
<td>(24.8,102.6)</td>
<td>19.8</td>
</tr>
<tr>
<td>Stand age (yr)</td>
<td>17.1</td>
<td>(15.7,19.9)</td>
<td>1.21</td>
</tr>
</tbody>
</table>
In addition to the increase in diameter growth that has been observed in this time series study on the Escambia Experimental Study, an increase in site index has been observed at the same location between second and third growth stands. The following is an abstract from: Boyer, W. D. 2001. A generational change in site index for naturally established longleaf pine on a southern Alabama Coastal Plain site. Southern Journal of Applied Forestry 25(2): 88-92.

**ABSTRACT**: … Site index data revealed that estimated site index values for third growth generally exceeded those for second growth. Age 50 site index in 16 study compartments with second growth near index age averaged 66 feet. Estimated site index for third-growth stands recorded in 17 different compartments averaged 81 feet. In a direct comparison site index for second growth averaged 65 feet (61 to 70) while third growth averaged 83 feet (77 to 87). Reasons for this large increase in apparent site quality are unknown but since the soils are the same, some change in climate may be suspect.

**CONCLUSIONS**
Everything else being constant, diameter growth rates do change over time. Everything else being constant, something other than stand and site conditions have caused changes in diameter growth of longleaf pine.

**ACKNOWLEDGEMENTS**
The authors wish to acknowledge Dr. Robert M. Farrar, Jr. for his foresight in establishing these sets of time series plots on the Escambia Experimental Forest. The work on the Escambia Experimental Forest could not be conducted without the support of T.R. Miller Mill Company. They have provided use of the Escambia Experimental Forest for research purposes for more than 50 years and are gratefully acknowledged.
MANAGEMENT AND RESEARCH OF LONGLEAF PINE COMMUNITIES ON ST. MARKS NATIONAL WILDLIFE REFUGE, FLORIDA, 1940-2002

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ABSTRACT: The St. Marks National Wildlife Refuge has actively managed longleaf pine sandhill and flatwoods forests by prescribed fire and overstory manipulation since 1940. This management has evolved over time from dormant-season prescribed fires and even-aged pine management to prescribed fires throughout the year and multi-aged pine management. Research of these management activities has been ongoing since the late 1970's. Season of fire study plots were established in 1980 in conjunction with Tall Timbers Research Station and continue to be managed and evaluated. Fire research has documented plant responses including viable wiregrass (Aristida berychiana) seed production and seedling growth, shifts in groundcover flowering, longleaf pine recruitment, and overstory and midstory oak (Quercus spp.) declines as a result of a shift from dormant-season to growing-season fires. Research has also evaluated groundcover responses to mechanical site preparation techniques, wiregrass restoration, and methods of restoring longleaf pine overstories and groundcovers in slash pine (P. elliottii) plantations. Studies of wildlife associated with longleaf pine communities have included red-cockaded woodpeckers (Picoides borealis), indigo snakes (Drymarchon corias couperi), flatwoods salamanders (Ambystoma cingulatum), striped newts (Notophthalmus perstriatus), and neotropical migratory birds. The refuge continues to seek partnerships with researchers interested in examining various aspects of longleaf pine ecology, restoration, and management.

LITERATURE FROM REFUGE LONGLEAF PINE-RELATED RESEARCH


LONGLEAF PINE ACTIVITIES IN VIRGINIA, 2000 – 2002

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ABSTRACT: Native Virginia longleaf pine is very rare with fewer than 4432 trees remaining on less than 800 acres. Over the past two years several promising events occurred in Virginia for longleaf pine: documentation of an additional native stand, development of a native Virginia longleaf pine preserve, longleaf restoration efforts by landowners with small parcels utilizing “sense of place” techniques. The newly documented native Virginia longleaf pine colony is located on International Paper property in the City of Suffolk. The stand contains a total of 34 trees with an outstanding specimen at 31.5 inches dbh, a new champion longleaf pine for the state. Development of a native Virginia longleaf pine preserve is occurring in Sussex County and is known as the Joseph Pines Preserve. The preserve is focused on restoring an extinct community in Virginia, a longleaf pine/bluestem ecosystem. Efforts are directed at capturing the entire native Virginia longleaf pine genome and integrating fragmented rare floristic elements left on unprotected land to maintain germplasm for future restoration. While there has been lamentation for the demise of longleaf pine on small parcels of land, we highlight a pilot project by dedicated landowners to restore longleaf pine in an “earth friendly” manner. Techniques include hand clearing of vegetation for therapeutic effects, use of downed wood for home heating and solar and wind power for minimal footprint on the landscape, on-site raising of seedlings for in-situ restoration, and overall design to provide the multiple benefits of a longleaf pine forest.
THE EFFECTS OF HARDWOOD MID-STORY REMOVAL IN MONTANE LONGLEAF PINE
(Pinus palustris) STANDS ON BREEDING BIRD COMMUNITIES IN THE TALLADEGA
NATIONAL FOREST, ALABAMA: Preliminary Results

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G. R. Cline (Department of Biology, Jacksonville State University, Jacksonville, AL)
R. E. Carter (Department of Biology, Jacksonville State University, Jacksonville, AL)

ABSTRACT: Recent avian research in longleaf pine (Pinus palustris) forest management has focused on
the endangered Red-cockaded woodpecker (Picoides borealis; or RCW), however the longleaf pine
ecosystem has been shown to provide critical habitat for a number of other avian species. While bird
communities of Coastal Plain longleaf forests have been well studied, montane longleaf ecosystems have
received little attention. This study compares preliminary results of breeding bird inventories in open
montane longleaf stands managed for RCWs (via mechanical hardwood mid-story removal and burning)
versus unburned stands with relatively dense hardwood mid-stories. Species richness (n=40, managed;
n=42, unmanaged) and species diversity indices (Shannon-Weiner, H'=1.36 managed; H'=1.41
unmanaged) were similar for both management practices. While data are too limited to support statistical
inferences, notable numbers of breeding species in managed stands seem to be displaced by a different
community type as hardwood mid-story is reduced. Species of special concern (e.g., Aimophila aestivalis
and Sitta pusilla) were observed more frequently in managed versus unmanaged stands. Surveys will
continue in the 2003 spring breeding season. This study should improve understanding of the role montane
longleaf pine ecosystems play in regard to breeding bird communities.

REFERENCES

Auk 107:463-472.


A land manager’s guide to point counts of birds in the southeast. Gen Tech. Rep. SO-120. Ashville,

22:133-137.

Schafale, M. P. 1994. Inventory of longleaf pine natural communities. NC Department of the Environment,
Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh,
ABSTRACT: There has been a recent focus on reforesting with longleaf pine (*Pinus palustris*) on appropriate sites in its historical range. While the benefits to wildlife of natural longleaf forests have been well documented, the effects of a variety of silvicultural techniques on wildlife are less well understood. On the Savannah River Site, a National Environmental Research Park near Aiken, South Carolina, we established a long-term study in 1993 to assess restoration techniques. In a randomized complete block design with a factorial arrangement of treatments, we are evaluating the use of silvicultural techniques to accelerate stand development and their impacts on understory floristics and the vertebrate community. Within 6 sites that were established between 1982 and 1985, the 3-7 ha treatment areas received combinations of pine thinning and woody competition control with an herbicide regimen, imposed on 4 year prescribed fire frequency. The wildlife sampling includes winter and summer bird surveys, and small mammal and herpetofauna trapping. Habitat assessment includes overstory and understory vegetation sampling, and vegetation height diversity measurement. Preliminary results indicate that for all vertebrate groups, abundance and species diversity was lowest in the control areas. Birds and mammals were more abundant and diverse in thinned treatments. Herpetofauna were more numerous in woody competition control treatments. Ground cover and species density of herbaceous plants was enhanced in stands receiving thinning and woody competition control.
CAROLINA SANDHILLS AND CAROLINA BAYS - UNIQUE FEATURES IN THE LONGLEAF FOREST

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THE CAROLINA SANDHILLS REGION

I assume that most of you are familiar with plant communities that occur in sandhill ecosystems, since they occur in every Southeastern state. For those of you who are not, permit me to briefly describe them. First, they occur on deep sand deposits, which may be ancient ocean dunes or alluvial deposits along rivers. All have been shaped by wind and water erosion. The porous soils are generally dry to xeric and highly acidic. Some sandhill soils have been augmented by wind-borne particles and others by material washed down from the piedmont or mountain regions. Over long periods of time, local areas may receive enough nutrient input (especially via decay of vegetation) to produce mesic soils.

In general, sandhill ecosystems support longleaf pine (Pinus palustris) in variable densities, under which grow scrubby oak trees (Quercus spp.). In Florida many sandhill communities support sand pine (Pinus clausa) instead of longleaf or in conjunction with longleaf. Various shrubs occur but there is no well-defined shrub layer as such. The herb layer may be sparse or dense, depending on soil moisture and nutrients, and is often dominated by grasses such as wiregrass (Aristida stricta, A. beyrichiana). A healthy and well-developed herb layer is essential to carry periodic low-intensity fire through the community. Recurring fires maintain the longleaf pine community indefinitely by temporarily reducing grass cover and allowing germination of pines as well as a wide diversity of herbaceous plants. The most xeric communities support less wiregrass and other ground cover and tend to burn less frequently.

The Sandhills Ecoregion of the Carolinas is very large, very old, and very complex ecologically. Although there are other sandhill areas in the Carolinas, when I speak of the Sandhills Region I refer only to the innermost part of the coastal plain. Because they lie adjacent to the piedmont, these sandhills are often referred to as the Fall-line Sandhills. The area is noted for its rolling topography: hilltops may exceed 600 feet. Downtown Southern Pines sits at 500 feet. The entire region is dissected by innumerable streamheads and creeks, so that wetlands are an integral part of the Sandhills longleaf pine ecosystem. Unlike the rest of the coastal plain, much of the Sandhills Region has remained above sea level for the past 40 million years. This extremely long period of time has allowed the evolution of numerous endemic plant and animal species, and several locally endemic plant communities. It is these unique natural features that I will discuss today, rather than common and widespread types. The following community types all occur embedded within the longleaf pine ecosystem.

1. Streamhead Pocosins and Sandhill Seeps. In the highly dissected topography of the Sandhills, thousands of stream headwaters occur. They form whenever groundwater is forced to the surface by impermeable clay layers. They usually form at the bottoms of slopes, in which case they are called Streamhead Pocosins, but may occur at mid-slope and are called Sandhill Seeps. Sandhill Seeps are usually found at sharp breaks in local topography. Streamhead Pocosins are so named because they support dense thickets of shrubs and cattails, as in true pocosins of the middle and outer coastal plain (about which I will speak later). Unlike true pocosins, Streamhead Pocosins have a relatively dense tree canopy, composed mostly of swamp black gum (Nyssa biflora), pond pine (Pinus serotina), red maple (Acer rubrum), and tulip poplar (Liriodendron tulipifera). Narrow or less wet streamheads will burn right through, although patchily. Hot fires may kill some canopy trees, as we have seen during conference field trips. Following fire, narrow to broad ecotones support a diverse array of grasses, sedges, and flowering herbs in the moist zone between the wet streamhead and the dry upland. Most of these plants are characteristic species of moist to wet savannas of the outer coastal plain; thus, streamhead ecotones look like linear savannas. Pitcher plants, sundews, toothache grass, asphodels, milkworts, orchids, yellow-eyed-grasses, and meadow beauties are just some of the plants shared by savannas and streamhead ecotones. In addition, several endemic plants occur: Coker’s bugleweed (Lycopus cokeri), streamhead lobelia (Lobelia batsonti), Rayner’s blueberry (Vaccinium crassifolium ssp. sempervirens), and Sandhills lily (Lilium pyrophilum). The federally endangered roughleaf loosestrife (Lysimachia asperulifolia) also occurs in...
streamhead pocosin ecotones and the federally endangered St. Francis satyr butterfly (*Neonympha mitchellii* ssp. *francisci*) occurs there and in beaver-impacted streamheads. Pine Barrens treefrog (*Hyla andersonii*), once considered rare, is actually quite numerous and widespread where fire is part of habitat management.

In contrast, Sandhill Seeps support few trees (scattered longleaf or pond pines) and they tend to be less densely shrubby. Depending on the volume of seepage, they may or may not connect with downslope streamheads. This community is known primarily from the NC-SC Sandhills, but a few examples are known in the outer coastal plain. I have seen analogous communities in the Florida panhandle (Eglin AFB and Blackwater River SF), but they are rare.

2. **Canebrakes.** A component of nearly all Streamhead Pocosins is switch cane (*Arundinaria tecta*). This is not the giant cane (*A. gigantea*) of brownwater river bottomlands, but the cane of pocosins, streamheads, and blackwater creeks. Switch cane often forms dense colonies at the very ends of streamheads. With increased fire frequency, and especially if the canopy is opened up, switch cane may become the dominant plant for a considerable length of the streamhead. These streamhead canebrakes are ecologically very different from riverine canebrakes in that they appear to require annual or biennial fire to maintain them. In the Carolinas today, nearly all examples are found within the Sandhills Ecoregion. Remarkable canebrakes hundreds of acres in extent occur on Fort Bragg, especially within ordnance impact areas. Less spectacular examples occur on the Sandhills Game Land in NC. One of the latter, the Laurel Hill Annual Burn Site (one of the stops on the conference field trip) was created by applying intense annual fire to a broad streamhead; within ten years the community lost its tree canopy and now is dominated by switch cane.

3. **Pea Swales.** In level terrain or in slight topographic depressions, leaching of the soil is less pronounced and nutrients and minerals build up relative to surrounding areas. These local microhabitats produce loamy sand soils and are noted for high plant diversity, especially grasses, composites, and legumes. As many as 25 members of the bean family have been documented from a single site, giving rise to the local term pea swale, or as I like to call it, bean dip. Well over 100 species have been recorded from individual 20x50 meter vegetation sampling plots, making these some of the most species-rich habitats within the longleaf pine ecosystem. Pea swales are important areas for several rare species, such as Sandhills milkvetch (*Astragalus michauxii*, now rare rangewide) and the federally endangered Michaux’s sumac (*Rhus michauxii*).

**CAROLINA BAYS**

Carolina bays are one of the geological curiosities of the world. They are elliptical depressions that vary tremendously in size but nearly all are oriented in a northwest-southeast direction. As many as 10,000 of them are scattered across the landscape from eastern North Carolina to southern Georgia and north Florida, and similar depressions occur north to New Jersey. The formation of Carolina bays remains an unsolved puzzle. One theory favored by some researchers involves the action of prevailing winds upon recently exposed land as the sea retreated during the past 100,000 years. Once depressions formed, rainwater filled them and provided additional scouring via wave action. Many bays show a distinct sand rim at the southeast end or along the east side.

The vegetation of Carolina bays varies greatly, depending in basin depth, impermeability of the substrate, water input, and whether or not peat has formed. Some bays, such as Lake Waccamaw and White Lake in NC, are completely open bodies of water. Some are cypress-gum swamps that experience large fluctuations in water level. Very shallow bays with more moderate water fluctuation may have cypress-gum at the center, but loblolly pine-sweetgum-red maple throughout the rest. Peat-filled bays support pocosin communities of two types: high and low. Both are densely shrubby with scattered pond pines and abundant blaspheme vine (*Smilax laurifolia*). While low pocosins can be traversed with difficulty, high pocosins are virtually impenetrable. The most striking vegetation type occurs in clay-based bays of the middle coastal plain, where beautiful grass-sedge-herb savannas occur beneath an open canopy of pond cypress (*Taxodium ascendens*). Recurring fire is an important part of the ecology of clay-based bays and pocosin bays.
Carolina bays support a number of rare plants, including the federally endangered Canby’s dropwort \( (Oxypolis canbyi) \). Examples include white wicky \( (Kalmia cuneata) \), Boykin’s lobelia \( (Lobelia boykinii) \), and awned meadow-beauty \( (Rhexia aristosa) \). Because of their fluctuating hydrology and isolation from creeks, many Carolina bays provide ideal habitat for breeding amphibians and crayfish, including Carolina gopher frog \( (Rana capito \text{ ssp.} \text{ capito}) \) and tiger salamander \( (Ambystoma tigrinum) \). Lake Waccamaw, the largest and perhaps most unique of all Carolina bays, is home to several endemic fish and mussels. Bears and red wolves also inhabit bays. A few xeric bay rims support populations of woody goldenrod \( (Chrysoma pauciflosculosa) \), rare in the Carolinas.

Sadly, however, Carolina bays have been decimated over the years by ditching, draining, filling, conversion to agriculture, conversion to pine plantations, creation of impoundments, and other desecrations. Today there are probably less than 10% that remain in a relatively natural state and pristine examples are very rare.

This has been a thumbnail sketch of the Sandhills Ecoregion and Carolina bays. As the longleaf pine ecosystem becomes increasingly threatened by fragmentation and loss, the remaining Sandhills and bay habitats have become critical refugia for native flora and fauna.
LEGUMES OF THE SANDHILLS REGION

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ABSTRACT: The North Carolina Sandhills region encompasses portions of seven counties. The natural vegetation is dominated by longleaf pine (*Pinus palustris*), wiregrass (*Aristida stricta*) and various scrubby oak species (*Quercus spp*.). Fire is the major factor that maintains the longleaf communities; in its absence hardwoods and loblolly pines eventually replace the longleaf. Prominent in the herb layer of well-burned longleaf are numerous species of legumes (Fabaceae): 61 native species are known from the NC Sandhills. An additional 26 are alien species, mostly adventive in agricultural crops, roadsides, former house sites, and other disturbed areas. The ratio of native species to adventive species of legumes in the NC Sandhills is 70%. However, in natural longleaf pine communities the ratio is significantly higher and at most sites approaches 100%. For example, the Sandhills Game Land supports 56 natives and 14 alien legumes (Sorrie 1998), but within regularly burned longleaf habitats a maximum of 5 aliens have been documented. Most alien legumes are found in wildlife food plots, bird dog field trial courses, and roadsides. Recurring fire seems to prevent the establishment of alien seedlings and, apparently, the aliens cannot compete with the natives in fire-maintained habitats. Although native legumes are distributed widely across the NC Sandhills and occur in many habitat types, there is one community in which they are especially prevalent--the pea swale or bean dip. Thirty-six of the 61 native legume species have been documented from pea swales and as many as 25 species have been recorded in a single swale. These loamy soil areas are also rich in grasses and composites and rank among the highest diversity plant communities in the Atlantic Coastal Plain. They may be considered to be natural feeding stations for wildlife, especially bobwhite quail.

The North Carolina Sandhills Region encompasses portions of seven counties at the inner edge of the coastal plain. The area’s rolling topography (high points exceed 600 feet), variable soils, and abundant streamheads and creeks produce a wide diversity of plant communities, flora, and fauna. Throughout most of the uplands the natural vegetation is dominated by longleaf pine (*Pinus palustris*), wiregrass (*Aristida stricta*) and various scrubby oak species (primarily *Quercus laevis*, *Q. marilandica*, *Q. incana*, and *Q. margarettiae*). Longleaf communities are disturbance dependent for longterm viability and to perpetuate floristic diversity. Fire is the major ecological factor that maintains these communities; in its absence hardwoods and loblolly pines eventually replace the longleaf and shade out most of the herbaceous flora.

Prominent in the herb layer of well-burned longleaf ecosystems are numerous species of legumes (Fabaceae): 61 native species are known from the NC Sandhills Region. Although this figure represents about 6% of the total Sandhills flora, within certain habitats legumes may be very important members of the herb layer, approaching 20% of species present. An additional 26 legumes are alien species, mostly adventive in agricultural crops, roadsides, former house sites, and other disturbed areas.

The ratio of native species to adventive species of legumes in the NC Sandhills is 70%. However, in natural longleaf pine communities the ratio is significantly higher and at most sites approaches 100%. For example, the 60,000 acre Sandhills Game Land supports 56 native and 14 alien legumes (Sorrie 1998), but within regularly burned longleaf habitats a maximum of 5 aliens have been documented. Most alien legumes are planted in wildlife food plots and bird dog field trial courses, but others are adventive along roadsides. Recurring fire seems to prevent the establishment of alien seedlings and, apparently, the aliens cannot compete with the natives in fire-maintained habitats.

Although native legumes are distributed widely across the NC Sandhills Region and occur in many habitat types, there is one community in which they are especially prevalent: the pea swale or bean dip. 36 of the 61 native legume species have been documented from pea swales and as many as 25 species have been recorded in a single swale. These loamy soil areas are also rich in grasses and composites and rank among the highest diversity plant communities in the Atlantic Coastal Plain. They may be considered to be natural feeding stations for wildlife, especially bobwhite quail, sparrows, and doves. Once a common feature on the landscape, loamy swales and flats have become rare through fire suppression, conversion to agriculture, and conversion to pine plantations.
ABSTRACT: In 1997 an Ecological Classification System designated 21 unique ecological communities on Ichauway using physiographic and soil characteristics in conjunction with subjective sampling of vegetative features. Soil and physiographic characteristics were the most influential features defining the communities. A long-term inventory and monitoring program was initiated in 2001 to characterize the current Ichauway land base (11,400 ha) and quantify the communities represented, and to monitor the effects of management through time. The sampling frame for this monitoring was derived by consolidating the 21 ecotypes into 8 distinct community types based upon common physiographic, soil and fire tolerance features. A multi-density unequal probability sample distributed 432 sampling sites across the 8 community types. In 2001-2002 all sample sites were visited to establish a 0.1 ha circular plot in which all overstory trees were measured, photo points established, plot habitat types mapped, exotic species listed, and micro plots established to characterize ground cover and count seedlings and saplings. Following establishment, plots will be visited on a four year cycle (1/4 per year) for inventory and monitoring. These subsequent visits will establish additional 0.1 ha plots to characterize overstory conditions and quantify coarse woody debris, vegetation density, and dominate understory vegetation, and one hectare circular plots will be installed to assess the number and status of gopher tortoise burrows and pocket gopher activity. All applicable site-wide wildlife censuses will also be linked to these inventory plots. This inventory provides the basis of a long term monitoring program and provides managers with feedback on community conditions for adaptive management.
ON TOP OF OLD SMOKEY ALL COVERED WITH LONGLEAF

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ABSTRACT: Many organizations in the coastal plain have recently experienced successful outreach efforts and have brought attention to the open and airy “longleaf pine-wiregrass” ecosystem. However, this wonted wiregrass talk has improperly characterized many unique longleaf pine communities. Contrary to the sandhill bias, longleaf and wiregrass are not synonymous. One longleaf pine community that deserves special attention can still be found in an overlooked place. Long forgotten in North Alabama and Georgia, scattered longleaf pine trees stretch out of rocky mountainsides like long arthritic fingers. Unlike the flat topography of the coastal plain, fire (on those few sites where it is still applied) races up steep slopes and ridgelines and leaves behind a fascinating mixture of native grasses, legumes, and forbs. Like the “other half” of the longleaf range, nary a sprig of wiregrass is found. These mountains are in bluestem country.

Today, the sound of chainsaws and earthmovers echo through these valleys as longleaf sites are cleared and turned into the country retreats of urban dwellers from Atlanta, Birmingham, Huntsville, etc. The haze from the woods fires that helped give Old Smokey its name is viewed by many urbanites as akin to the city smog they were trying to escape. As restrictions on prescribed burning continue to intensify, many of these mountain longleaf sites languish under a hazardous accumulation of fuel. All the while, fire waits patiently for the hottest, driest day of the summer-- as the new urban/wildland dweller sits on the porch of his retreat smoking a cigarette.
FOREST STEWARDSHIP COUNCIL FOREST MANAGEMENT CERTIFICATION AND LONGLEAF PINE FORESTS

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ABSTRACT: Voluntary, third-party certification of forest management operations via the Forest Stewardship Council (FSC) can improve and expand management of longleaf pine forests with commercial and/or conservation objectives.

FSC is a non-profit, membership based organization that coordinates development of forest management certification standards. All standards developed by FSC strive to address and balance ecological, economic, and social aspects of forest management operations.

As developed by the FSC’s Southeast Working Group, the Southeast Regional Standard emphasizes the use, protection, and maintenance of native communities within the context of timber, game and recreation management. For owners and managers of longleaf pine forests interested in timber production, the Southeast Regional Standard provides rigorous guidelines for doing so while minimizing negative environmental impacts and maintaining profitability.

In the southeast, FSC-certified resource managers and landowner associations formed for cooperative management and marketing of forest products hold great promise for the preservation and expansion of longleaf pine forests. Landowner associations and certified resource managers have emerged as an economically feasible way for non-industrial forest owners to profitably manage their forest while achieving conservation goals.

Certified landowner associations and certified resource managers can reduce costs of technical assistance, services and inputs through group purchasing; place larger areas of land under coherent management; facilitate access to lower-cost group certification and associated technical assistance; and afford landowners more leverage through group marketing of high-quality longleaf pine products to traditional buyers and the emerging certified wood products market.

INFLUENCE OF GROUNDCOVER COMPOSITION ON RED-COCKADED WOODPECKER PREY BASE

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Jeff Walters (Biology Department, Virginia Tech, Blacksburg, VA)
ABSTRACT: Little is known about arboreal arthropod communities inhabiting longleaf pines in the southeastern United States. This information is of particular importance because arboreal arthropod communities serve as the food base for the federally endangered red-cockaded woodpecker (RCW). In a recent study, this arthropod community has been suggested to be the mechanism by which RCW reproductive success is correlated to the groundcover composition of the forest (which is a reflection of the forest’s fire history). If the arthropod community is the link between the groundcover and the RCWs’ reproductive success, then higher amounts of arthropods should be found in areas with groundcover that is indicative of frequent burning, i.e., high amounts of grasses and forbs and low amounts of woody species. We conducted a one-year study at three sites containing RCWs (Camp Lejeune Marine Corp Base in Jacksonville, NC, Savannah River Nuclear Site in Aiken, SC, and Fort Gordon Army Base in Augusta, GA) to determine whether the groundcover composition of the forest influences the abundance and mass of the arthropod communities on longleaf pines. We focused on impacts of groundcover composition on arthropods by controlling for tree species, tree age, soil type, hardwood midstory density, and overstory basal area. Results indicate that groundcover indicative of frequent burning, herbaceous and graminoid species, is positively correlated with greater arthropod biomass on the pine boles. Thus, prescribed burning has indirect positive effects on RCW reproductive success through increases in arboreal arthropod biomass, which are mediated by changes in groundcover composition.
ABSTRACT: A mixed planting (50% longleaf pine and 50% slash pine) is proposed to lower the cost of establishment of longleaf pine stands. This "two-species" plantation is established by alternating rows of longleaf pine and slash pine. The slash pine can be considered a trainer species since the objective is to remove all the slash pine during the first commercial thinning (about age 13-16). Therefore, when using a 10-foot row spacing (and 7.2 feet between rows), 303 longleaf pines and 303 slash pines will be planted per acre. At this stocking, total establishment costs can be reduced by $9 to $40 per acre (depending on longleaf pine stock type). Establishment costs could be reduced even further when only the longleaf rows are treated with an herbicide. A simple analysis was conducted to show the relative effects of a mixed stand vs. pure stand on stand economics. In the absence of subsidies from the conservation reserve program (CRP), the mixed planting had a higher NPV (at age 15) than the pure stand. In cases where survival of longleaf is low but the survival of slash pine is good, the cost of replanting the stand can be eliminated. The advantages and disadvantages of this type of establishment are discussed. Examples of "two-species" plantations in south Alabama are now over 5 years old.

INTRODUCTION

Government subsidies with CRP have increased the demand for longleaf pine seedlings. In 1980, about 10 million longleaf pine seedlings were grown (Boyer and South 1984). By 1999, this number had reached 81 million. In some years, the demand for longleaf pine seedlings exceeded the supply. As a result, we estimate that longleaf pine seedlings were planted on fewer than 180,000 acres during the winter of 1999-00. This acreage could have been increased if some plantations had been established using alternate-row plantings (i.e. longleaf in one row and slash pine in the next row) with the intent of removing all the slash pine at the first thinning (around age 13-15). This method of establishment has several advantages over the traditional method of planting pure longleaf pine. Advantages include: (1) lower establishment cost; (2) reduced probability of additional establishment costs associated with planting failure; (3) additional acreage established with longleaf pine in years when seedling demand exceeds supply; and (4) benefits to certain wildlife species after the slash pine is removed from the stand. In some cases, the discounted value of slash pine harvested at age 15 will exceed the cost of establishment.

Longleaf pine can be difficult to regenerate (Boyer 1985, Shoulders 1985). Due to higher seedling costs and a greater need to control herbaceous weeds (Bales et. al. 1999), establishing longleaf pine by planting can be $15 to $100 or more per acre than planting slash pine. In addition, the probability of failure is greater when longleaf pine seedlings are planted by hand. One survey indicated an average survival for container longleaf pine of 85% while bareroot stock might average 65% survival (Boyette 1996). A 2-species stand would help protect against a complete loss of a landowner's investment in establishing pine. Although results for any given site will vary, overall a mixed stand (containing 50% longleaf pine and 50% slash pine) will have an initial survival in between that expected for slash pine and longleaf pine (Figure 1). Of course, the spacing of longleaf pine within the row could be manipulated depending on the landowners desires and expectations. Survival of loblolly pine and slash pine is typically greater than longleaf pine (Shoulders 1985). In one study, machine planted longleaf pine averaged 79% survival while machine planted loblolly pine averaged 92% survival (Cram et al. 1999).
Figure 1. Hypothetical cumulative probability curves for initial survival of pure plantations versus a mixed stand of bareroot slash pine and longleaf pine. For slash and longleaf pine, 40% and 82% of the stands, respectively, had less than 80% survival.

The purpose of this study was to determine if conducting a pulpwood thinning of the slash pine component at age 15 would break-even the reforestation costs. If this occurs, then some landowners might choose to establish longleaf stands without additional government subsidies.

METHODS

Economic analyses were conducted to determine if conducting a thinning of all slash pine rows at age 15 would account for all regeneration costs. The costs included site preparation ($100/acre), seedlings (slash pine = 4 cents each; bareroot longleaf = 7 cents each; container longleaf = 16.8 cents each) planting (slash pine = 5 cents each; bareroot longleaf = 9 cents each; container longleaf = 5.6 cents each) and a banded post-planting herbaceous weed control treatment ($40/acre). The distance between rows was fixed at 10 feet. Seedling costs were obtained by averaging the prices for the 2002-2003 planting season from state nurseries in Texas, Louisiana, Mississippi, Alabama, Georgia, and Florida and from International Forest Company for bareroot and container-grown seedlings. Various pulpwood prices, planting densities, and interest rates were examined. Growth of slash pine was obtained using the WinYield growth and yield program. Growth of longleaf pine on old-fields (SI 80 – base age 25) and cut-over sites (SI 60 – base age 25) was assumed to be the same as slash pine (Shoulders 1985). An interest rate of 6% was used, an annual tax of $4/acre and an income tax rate of 28% was assumed.

RESULTS AND DISCUSSION

All but one of the old-field plantations resulted in positive NPVs. The amount of wood harvested from the old-field was twice that from the cutover site (Table 1). As a result, the reforestation cost was recouped by thinning the slash pine on the old-field site. However, negative NPVs were obtained on the less productive cutover site. Harvesting 6 to 7 cords of pulpwood per acre was insufficient to cover the costs of establishment.

Regardless of site or stock type, mixed plantings had higher NPVs than pure stands. This was directly due to lower establishment costs with mixed plantings. When planting bareroot longleaf pine, the mixed stands cost $14 to $28 less to establish. When planting container-grown longleaf pine, the mixed stands were $27 to $54 less expensive. Before tax NPVs would be directly proportional (1 for 1) to establishment costs. Due to the 7-year amortization of establishment costs (Section 194 of the Internal Revenue Code, referred to as the Reforestation Investment Tax Credit and Amortization), the differences due to mixed plantings are not very great when considering after-tax NPVs.
The difference in NPV between equivalent mixed stands and pure stands was less than $10 per acre. This difference would have been greater had we assumed higher survival and greater volume growth with slash pine than with longleaf pine. The NPV differences would also be greater if we had assumed only longleaf pine rows were provided with herbaceous weed control. Therefore, the economic justification for establishing 2-species stands are likely greater under real-world conditions.

With container-grown stock, stocking after thinning might range from 162 to 324 trees per acre (Table 1). Predicted stocking for bareroot seedlings might range from 100 to 280 trees per acre (data not shown). Stocking levels as low as 118 trees per acre (age 38 years) can generate good revenue from the sale of sawlogs (Kush et al. 1999). Since the analysis in Table 1 does not include any revenues after age 15, the NPVs should not be used to determine the optimal spacing.

After the thinning, the spacing ranged from approximately 20 feet by 5.4 feet at the higher stocking level to about 20 feet by 10.9 feet at the lower stocking. Since many longleaf pines are greater than 30 feet tall at age 15 years (Boyer 1983), we consider this degree of rectangularity (imposed at age 15) to be of minor economic importance. Live crowns do not move down the stem after a thinning.

Our analyses demonstrates that after establishing a mixed plantation on old-fields, removing all the slash pine at age 15 can result in an essentially “free” stand of longleaf pine. The revenue from the slash pine can exceed establishment costs. Although there is little need for a “free” stand under the CRP (where landowners are provided an annual payment from the government for 15 years), this program will not last forever. When government subsidies for planting longleaf pine cease, landowners will again need innovative ways to lower the cost of establishing longleaf pine stands. If establishment costs for planting longleaf pine remain relatively high, many landowners may revert to planting less expensive pines with typically higher success rates.

Although results in Table 1 are hypothetical, examples of mixed plantations do exist. Alternate-row plantings were established in January 1997 at the Solon Dixon Center. The area was not scalped before planting and herbaceous weed competition was high. At this location, initial survival of longleaf pine was good but the weed competition resulted in suppressed growth and eventual mortality of longleaf pine. The remaining rows of slash pine are doing well.

SUMMARY

A mixed-species plantation can reduce establishment costs for longleaf pine stands by $14 to $54 per acre or more. However, the amortization of establishment costs, this difference in after tax NPVs is usually less than $10 per acre (when survival of longleaf pine is acceptable). However, the use of mixed-species planting reduces the risk of plantation failure (which is difficult to quantify economically). The incentive for establishing mixed-species plantings will likely increase when government subsidies for planting longleaf pine cease.
Table 1. After-tax Net Present Values (NPV - $/acre) of a thinning conducted at age 15 years in stands comprised of 50% slash pine and 50% longleaf pine, or 100% longleaf pine. All slash pine seedlings are bareroot while longleaf pine stock is either bareroot or container-grown. A discount rate of 6% was used.

The cutover site had a site index of 60-ft. (base age 25) and the old-field site had a site index of 80 ft.

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| Establishment costs per acre: | 800   | $240.00 | $265.60 | $268.00 | $319.20 |
|                               | 600   | $215.00 | $234.20 | $236.00 | $274.40 |
|                               | 400   | $190.00 | $202.80 | $204.00 | $229.60 |

LITERATURE CITED


FOREST FLOOR STRUCTURE AND COMPOSITION IN LONG-UNBURNED LONGLEAF PINE FORESTS: Implications for Re-introduction of Fire

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ABSTRACT: Reintroducing fire into southeastern pine stands after long periods of fire exclusion results in substantial pine mortality, likely the result of ground fire within the forest floor. Since southern pine forest floor is the result of fire-exclusion, we have a poor understanding of their composition, structure, and fuel behavior. To address these shortcomings, we studied the forest floor in a long-unburned longleaf pine (*Pinus palustris*) stands in northwestern Florida. Composition and structure of forest floor influence ignition, combustion, and extinction of ground fires. The forest floor was comprised of bark, needles, roots, cones, hardwood leaves, and coarse woody fragments; all with differing fuel characteristics. Composition changed with distance from tree, with bark comprising 67% of near tree samples, and only 16% at 2 m from the tree. Pine needle litter, conversely, comprised 16% and 63% at 0.3 and 2 m from the stem, respectively. Pine roots, their death suggested to be the primary cause of tree mortality, were prolific in these surficial horizons, with little variation within the first 2 m away from the tree. As with composition, structure varied with distance from stem. Forest floor was mounded around tree bases, with declining depths as distance from tree increased. Particle size of the forest floor varied, generally decreasing with distance from stem. These data are preliminary, representing the early stages of a larger study to assist restorationists with re-introducing fire into southern pinelands.
OLD-GROWTH LONGLEAF PINELANDS – RECENT SIGHTINGS & RUMORS

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ABSTRACT: Old-growth forests and savannas dominated by longleaf pine are a topic of great interest to scientists, conservationists, and the public. Comprehensive old-growth inventories are lacking for most of longleaf pine’s natural range. We searched the literature, interviewed regional experts, queried email discussion lists and newsletters, and performed field research to compile a revised list of old-growth longleaf pine acreage and status. The revised list contains 15 sites, ca. 13,637 acres, in 5 states. New additions to the old-growth list were located in Florida (2 sites & significant additions at Eglin Air Force Base), Texas, and Georgia. These additions represent increases in representation of both flatwoods and sandhills. Re-appraisal of Eglin AFB’s stands are responsible for most of the increases in acreage; new data and conversations with Eglin managers added >8,000 acres. We still know of no remnant old-growth stands in Mississippi, South Carolina, or Virginia. Since a similar 1996 report, the acreage increased markedly; with three stands omitted and two new sites added. Stand ownerships are diverse, with large holdings (> 1000 acres) in both public (Eglin AFB) and private (South Georgia) ownerships. A significant percentage of sites (at least 7 of the 15 sites, ca. 10,000 acres) face serious fuels management threats (accumulated forest floor and duff), due to erratic fire management histories. In light of the shrinking nature of this resource, statewide searches, restoration, and conservation should continue with earnest.
COMPARISON OF SPECIES RICHNESS IN MONTANE LONGLEAF STANDS WITH DIFFERING FIRE REGIMES

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ABSTRACT: This paper discusses the affect of stand type and frequency of fire on the species richness of wintering songbirds in northeast Alabama. Our study site was located in the Shoal Creek Ranger district of Talladega National Forest. The stands used for our study were separated into two types. The young stands and mature stands. Fire frequency of stand types was evaluated. The Fire management officer for the district provided information on the fire regimes for all stands. Stands were labeled frequent or infrequent based on that information. Our bird Census utilized line transects and point counts. Our data showed species richness scores were highest for mature stands with frequent burning. We concluded species richness scores negatively correlated with decreasing stand age and fire frequency. Although the overstory of the stands with the highest species richness was comprised mainly of loblolly and shortleaf pine, the results lend a strong argument for longleaf pine management on these sites. The need for frequent fire and mature trees indicate longleaf as the obvious management choice. This is due to longleaf pine ability to thrive under frequent fire and longleaf longevity 300-400 years. The last but strongest argument for longleaf management is that it would have historically dominated the sites we conducted our study.
ABSTRACT: Reduction of the historic range of the longleaf pine forest from 93 million acres to less than 3 million acres in the southeastern U.S. has been well documented. Losses in number and diversity of vertebrate species adapted to this fire-dependent ecosystem have also occurred. In addition to the often-studied red-cockaded woodpecker, few animal species face as many threats as the northern pine snake (*Pituophis melanoleucus* melanoleucus) and the southern hognose snake (*Heterodon simus*), both fossorial species dependent on the sandy soils of the Sandhills Region. Centered on Southern Pines and Ft. Bragg, the Sandhills ecosystem, comprised of six counties, is characterized by increasingly intense residential, commercial, industrial, agricultural, recreational and military use. Other than descriptive and generalized range information, there has been no formal research describing the ecology of the northern pine snake or the southern hognose snake in any part of their southeastern U.S. range. This lack of basic life history information leaves resource managers and regulatory personnel unable to plan for the conservation of these Federal and State listed species.

A minimum of six wild-caught adults of each species will be surgically implanted with radio-transmitters and released at the capture site. Snake locations and real-time observations obtained through telemetry on a daily/weekly and seasonal basis will document: (1) habitat selection/use, (2) activity patterns, such as prey location and manipulation, (3) reproduction, including nest site selection and excavation behavior, and (4) thermoregulation activity including selection and use of summer aestivation and winter hibernation sites. When possible, additional data will be collected pertaining to mortality factors (e.g. road-kill, predation), human encounters, and land-use activities/impacts such as silvicultural practices, military exercises, controlled burn cycles, and pine straw raking.

The initial objectives of the present study are, therefore, to provide descriptions of daily and seasonal habitat requirements and other important life history components needed by both species to remain a viable part of the North Carolina Sandhills longleaf pine ecosystem. The U.S. Fish & Wildlife Service (Raleigh office) recently provided funds for project initiation.

Description/Objectives/Need: Reduction of the historic range of the long leaf pine forest from 93 million acres to less than 3 million acres remaining today in the southeastern U.S. has been well documented. Losses in numbers and diversity of vertebrate species adapted to this fire-dependent ecosystem have also, unfortunately, occurred. Perhaps the most often studied species of animal to be affected by this habitat reduction and degradation is the red-cockaded woodpecker. However, many other animal species continue to be negatively impacted by humans’ increasing utilization of this habitat type. The aggregate loss of these species must be curtailed before permanent harm occurs to the successful functioning of the entire ecosystem. Few animal species in this ecosystem face as many potential and actual threats as the northern pine snake and the southern hognose snake, both fossorial species dependent on the sand soils and other unique habitats that are the foundation of the Sandhills long-leaf pine ecosystem.

Other than descriptive and generalized range information, there has been no formal research describing the ecology of the Northern Pine Snake (*Pituophis melanoleucus melanoleucus*) or the Southern Hognose Snake (*Heterodon simus*) in any part of their southeastern U.S. range and, more specifically, of populations in North Carolina. This lack of basic life history information leaves resource managers and regulatory personnel unable to plan for the conservation of these species. The initial objectives of the present study are, therefore, to provide descriptions of daily and seasonal habitat requirements and other important life history components necessary for both species to remain a viable part of the Sandhills longleaf pine ecosystem. This is an area of increasingly intense residential, commercial, industrial, agricultural, recreational and military use. These activities, in addition to the probable continuation of illegal collection for the “pet” trade, subject the remaining populations of each of these snakes from
Expected Results/Benefits: The results of this project will be based on the movements of newly caught pine and southern hognose snakes in their selection and use of available habitats to fulfill life history needs over an annual period at several sites within the Sandhills ecosystem. Results obtained from this study should identify the size of home ranges and types of habitats critical to the changing needs of both species (male and female adults) over an annual period. Comparison of specific habitat use with availability at each capture site would provide resource biologists with useful information needed for management of these species and, in the case of the northern pine snake, allow comparisons with research results documented from long-term studies on a disjunct population from the New Jersey Pine Barrens region (e.g. Burger and Zappalorti 1988, Burger and Zappalorti 1991).

Quantification of structural habitat components and other attributes of macro- and microhabitats should identify descriptors of viable habitats and aid in the planning for enhancement and remediation of degraded, destroyed, or fragmented habitats. There appears to be adequate redundancy, excluding unforeseen climatic extremes, to obtain...
data on most aspects of each of these snakes’ habitat selection and other behaviors during the study time span to allow comparisons between years and document any changes in nesting and/or hibernacula site selection. Additional basic life history information, including various aspects of population dynamics, will be collected for the first time in the southeastern range of the N. pine snake.

A diversity of capture and release sites should help in understanding whether these species can co-exist successfully in close proximity to human activities or must have large expanses of undisturbed habitat. For example, coordination with military and natural resource agencies (TNC, NCWRC, etc.) land-use activities and silvicultural practices such as troop training, controlled burn cycles, pine straw raking, and timber harvests/silvicultural practices, among others, will allow collection of snake behavior and habitat selection not previously documented.

LITERATURE CITED


THE FLOMATON NATURAL AREA (FNA): Demonstrating the Benefits of Fuel Management and the Risks of Fire Exclusion in an Old Growth Longleaf Pine Ecosystem

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ABSTRACT: Damaging wildfires in the West and South have exposed the critical need for forest fuel management in fire-adapted ecosystems. The Flomaton Natural Area (FNA) is a 25 ha stand of old growth longleaf pine in south Alabama currently owned by International Paper. Prior to the initiation of recent restoration efforts, the site had been fire suppressed for more than 40 years allowing for an accumulation of ground, mid-story and ladder fuels. With the application of fuel management treatments (prescribed fire and mechanical removal of hardwoods) since 1995, accumulated fuels and the risk of wildfire have been greatly reduced. The reintroduction of fire has also opened the stand for recovery of its native understory structure and composition. Although the FNA is small, it is highly accessible, and well suited for development as a demonstration site. In 2002, the FNA was selected by the national Joint Fire Science Program (JFSP) as one of several sites in the South to demonstrate the benefits of forest fuel management. Since it is the only site under private ownership, it offers a unique opportunity to teach both the public and managers about the benefits of fuel management and the need for cooperation among public and private ownerships. This poster will summarize research findings related to the fuel management treatments and their effects on overstory mortality, understory plant community dynamics and soil nutrients. In addition, it will outline plans to meet the new JFSP Demonstration Site objectives. An interpretive trail and guidebook are now being developed to provide information on fuel management, fire ecology and ecological restoration of longleaf pine ecosystems. A web site will also be constructed to provide resource material for educators and managers.

HISTORICAL VIEW OF LONGLEAF PINE ECOSYSTEMS

The landscape that may have greeted the first European travelers to the Southeast was dominated by longleaf pine and many groundcover species of grasses and herbaceous plants. The landscape was largely the result of frequent fire. Low intensity, non-killing fires swept through the pre-settlement longleaf pine landscape about every 1 to 10 years. These fires would kill hardwood seedlings and sprouts without killing the large longleaf pine and many of the longleaf seedlings. Lightning strikes or Native American burning started fires. Native Americans burned the forests to keep the grasses and herbaceous plants liked by the wildlife they hunted.

WELCOME TO THE FLOMATON NATURAL AREA INTERPRETATIVE TRAIL

The Flomaton Natural Area is an old-growth stand of longleaf pine. It is one of only four remaining longleaf pine stands in the world considered virgin, having never been logged. The Flomaton Natural Area is a microcosm of the recent history for longleaf pine and the many threats it faces. Many of the remnant old-growth longleaf pine stands remaining have been reduced to isolated, often degraded patches in the southern landscape. The Flomaton Natural Area was one of these stands. In an effort to restore this longleaf pine habitat, an agreement to restore, manage, conduct research and to use to the stand for education was entered into by and among International Paper, Auburn University School of Forestry and Wildlife Sciences, the Southern Research Station of the USDA Forest Service, Alabama Forestry Commission, The Nature Conservancy, and the Alabama Natural Heritage Program.

The Flomaton Natural Area is open to visitors. There is a parking area located just north of the highway on the East Side of the forest.

WILDFIRE IN A FIRE-ADAPTED/MAINTAINED LONGLEAF PINE ECOSYSTEM

“Let it burn, it won’t hurt anything”

These were the words used to describe a small wildfire that occurred on the northeast side of the Flomaton Natural Area in May 1993. The fire killed 91% of the old-growth longleaf pine greater than 38-cm...
diameter at breast height (DBH). One of those trees had a 91-cm DBH and was 340 years old. The fire had no impact on the hardwoods, which were in the stand.

WHAT HAPPENED?
How does a small ground-fire kill what is suppose to be one of the most fire-adapted species on the planet? Pine needle litter depth at the bases of trees were substantial, dangerous, and potentially lethal if care was not taken. The aspect of danger associated with pine litter occurs when 1) heavy amounts accumulate under large trees and 2) feeder roots invade this rich organic layer. Prior to the re-introduction of fire in 1995, the average litter depth was 18.3 cm and averaged 23.1 cm for trees greater than 38 cm DBH.

The lethal nature of heavy litter accumulations appears when a fire either kills a large portion of the feeder roots that have developed in the organic layer or the basal litter burns, girdling the tree. The largest trees in the stand were girdled at their bases from the heat generated by the burning litter. The trees were girdled due to the residence time of heat in the organic litter around the base of the tree. The fire was not hot enough to consume much of the litter away from the tree.

RESULTS
Basal area remained static (17.9 to 17.8 m²/ha) from 1993 to 1997. Considering the high rate of mortality and an added complication of bark consumption by fire (reducing diameter of large trees inordinately more than smaller trees), this figure is remarkable. Mean DBH of all longleaf pine shifted from 24.0 to 27.5 cm from 1993 to 1997. Tree density decreased from 280 trees per hectare (TPH) in 1993 to 230 TPH in 1997. In the 40+ years of fire suppression at the Flomaton Natural Area, herbaceous plant species abundance and diversity plummeted. After hardwood removal (1996) and three prescribed fires, the presence of herbaceous plants went from one species in 1993 to 34 in 1997. A possible reason for this phenomenon may be attributed to the seed bank present within the stand. Owing to the isolation of the stand from other forests and its proximity to residential and cultivated land, the resurrection of these herbaceous plant species is bewildering.

Longleaf pine mortality following the three prescribed fires (1995, 1996, and 1997) and fuelwood removal (1996) has been substantial, especially in the lowest diameter classes. Annual mortality for all longleaf pine over the study period averaged 4.2%; and 100% for all sampled trees below 7.5 cm DBH. These data contrast sharply with prior observations of less than 1% annual mortality in longleaf pine forests. Reasons for this disparity are partially associated with the exclusion of small trees in these studies. However, even with the exclusion of small trees, mortality is noticeably different.

Longleaf pine mortality causation has differed from prior observations. Overstory suppression was the most common agent (41%) of all longleaf pine mortality, followed by fire (17%), mechanical (14%), beetles (8%), lightning (3%), wind (2%), and disease (2%). These figures are somewhat skewed due to 13% of all trees’ mortality agent being unidentifiable. In previous studies, lightning strikes and windthrow have been the most common causes of mortality. Again, the inclusion of smaller trees in this study probably explains this deviation.

At the onset of restoration efforts at the Flomaton Natural Area, pine needle litter depths at the bases of trees was substantial and potentially lethal. Following three fires, significant reductions in both litter depth amount (t-test p< 0.001) and variability (1993 variance = 18.6; 1997 = 9.1) have occurred.

Soil elemental dynamics following 4 years of restoration at the Flomaton Natural Area have been dramatic. All elemental contents measured, except potassium, % N, and % C, have been significantly changed (t-test, alpha = 0.05). Strong increases (> 40%) have been observed in copper, barium, zinc, magnesium, calcium, and chromium. Losses have been the greatest (> 30%) in boron, cobalt, and manganese. For several elements, responses have been variable, that is they increased after the first fire, then decreased after the third. Further analysis and measurements are planned to track soil elemental change during the ecological restoration process.
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