The threat to shortleaf pine due to hybridization with loblolly pine; ecology and management implications
Shortleaf pine — species at risk

- Succession — disruption of fire regime
- Land use change
  - Urbanization
  - Fragmentation
  - Conversion to loblolly
- Climate change
- Hybridization with loblolly pine
“Stands of pure shortleaf pine once covered a much larger area than present. It is doubtful whether shortleaf is now found in pure type on more than 20 to 40 per cent of its former range.”
Matty Mattoon; 
The oracle of shortleaf pine

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No. 244

LIFE HISTORY OF SHORTLEAF PINE.
By Wilbur R. Mattoon, Forest Examiner.

NAME AND IDENTIFICATION.
It is important to distinguish clearly the true shortleaf pine (Pinus echinata Mill.)—variously known throughout portions of its range as "yellow," "old field," "rosemary," "two-leaf," "heart," and "spruce" pine—from other so-called shortleaf pines of the Southern States. Confusion occurs because of the custom, more or less generally prevailing throughout the South, of distinguishing only two kinds of pine, shortleaf and longleaf. Under this custom, the pine most commonly included with shortleaf islobolly pine, slash pine being classed in similar manner as longleaf pine. Shortleaf is most readily distinguished from loblolly pine by means of differences in leaf and cone, described on page 7. Other pines associated with shortleaf are the smaller, crooked-stemmed scrub pine and the northern pitch pine which seldom forms old-field stands and grows both in wetter and colder situations.

1 Shortleaf pine was first described botanically by Miller in 1807. In 1863, the elder Millham defined more fully the specific characters of the species under the name of Pinus flexilis, widely circulated in his work on American forest trees and largely used in botanical literature. The name Pinus echinata, first given to the tree by Miller, was not taken up by any author of note until the publication of Blazyn's Flora, Vol. 1, 1853, and by the accepted rule of priority, this is the correct name of the species.

2 Lobolly pine, known locally by various names, as "old field," "shortleaf," "swamp," "bull pine," etc.

Note.—This bulletin gives in detail the life history of shortleaf pine, known under various names throughout the South, where only it is found in commercial quantities.
“A long clear straight bole with small taper and short crown makes shortleaf pine almost an ideal tree for the saw. These characteristics are so much more pronounced in shortleaf than in several of its pine associates, for example, pitch, scrub, and loblolly pine, that they serve commonly as distinguishing marks.”
Among the timber trees of the Atlantic forest region the Shortleaf Pine ranks with the first of those noted for their economic importance. Equally abundant, distributed over a wider area, and in the quality of its wood but little inferior, it takes its place next to the Longleaf Pine. When maintenance of forest and production of timber under a rational system of forestry is to become the rule, this species above all others of southerly distribution will claim attention, for it can be safely asserted that of the coniferous trees adapted to the climatic conditions of the Southern Atlantic forest, no other can be found of better promise for the production of valuable timber in the shortest time.
“Among the timber trees of the Atlantic forest region the Shortleaf Pine ranks with the first of those noted for their economic importance. Equally abundant, distributed over a wider area, and in the quality of its wood but little inferior, it takes its place next to the Longleaf Pine. When maintenance of forest and production of timber under a rational system of forestry is to become the rule, this species above all others of the southerly distribution will claim attention, for it can be safely asserted that of the coniferous trees adapted to the climatic conditions of the Southern Atlantic forest, no other can be found of better promise for the production of valuable timber in the shortest time.”
Fast-forward to current day
Recent comparison between loblolly and shortleaf
Still an important role for shortleaf pine

- NIPF landowners who desire to use natural regeneration
- Government agencies and NGO’s with the primary goal of wildlife or ecosystem restoration
- Buffer against climate change
- Only pine native to areas of southeastern OK, northern AR, all of MO
Why has there been a dramatic increase in hybridization between loblolly and shortleaf pine?

Rodney E. Will, Curtis J. Lilly, John F. Stewart, C. Dana Nelson, Charles G. Tauer, Joshua Bradley
Risk of shortleaf pine extinction through introgression with loblolly pine
Rod Loves Loblolly Pine

~30 peer-refereed articles related to the productivity and biology of loblolly pine
Background

- Hybridization between shortleaf pine and loblolly pine was first documented in 1953 (Zobel 1953).
- Since 1950, hybridization between shortleaf pine and loblolly pine has increased from 3% to 46% in shortleaf pine and 2% to 27% in loblolly pine stands (John Stewart et al. 2012).
- Shortleaf pine especially in decline and may be at risk for ‘extinction’ due to introgression.
Why low previous hybridization?

- Shortleaf and loblolly reproductively isolated by time of pollen shed (loblolly before shortleaf)
- Shortleaf and loblolly isolated due to environmental preferences (loblolly = mesic, shortleaf = xeric)
- Fire worked as a post reproduction selection pressure to reduce survival of hybrids and strengthen habitat preferences
What’s different now?

- Increased cross fertilization
  - Climate change and increased variability in weather leading to overlap in pollen shed
  - Wide scale planting of loblolly pine with nonlocal seed sources
  - Habitat fragmentation
- Removal of post-hybridization selection pressures against hybrids
- Fire exclusion
Why do we care?

- If loblolly, hybrids, and shortleaf all perform the same ecological function, does it matter?
- If hybrids grow faster than shortleaf isn’t that a good thing?
- Stuff happens
Why do we care?

- Resilience!
Shortleaf is more fire tolerant

Loblolly pine

Shortleaf pine
Shortleaf is more snow and ice tolerant

Loblolly pine

Shortleaf pine
Shortleaf is more drought tolerant

Loblolly pine

Shortleaf pine
Why do we care?

- Resilience - Shortleaf more drought, fire, cold, and ice tolerant
- Sudden increase in hybridization indicates a perturbation
- Once we cross the hybridization threshold, there may be no going back even if conditions change to favor pure shortleaf
- Intrinsic value of biodiversity
- I like shortleaf pine
Objectives

- To determine if there are morphological or physiological advantages that have allowed shortleaf pine x loblolly pine hybrids to increase over the last 60 years
- To determine the role of fire exclusion
- To evaluate management approaches that might be successful to perpetuate shortleaf pine
Stewart, J.S., Tauer, C.G., and Nelson, C.D. 2012. Bidirectional introgression between loblolly pine (Pinus taeda L.) and shortleaf pine (P. echinata Mill.) has increased since the 1950s. Tree Genet. Genomes 8:725-735


Background

- What we already know about hybrids:
  - Can grow as fast as loblolly
  - Has intermediate needle characteristics
  - Are resistant to fusiform rust like shortleaf
  - Has better cold resistance than loblolly
  - Has better form than loblolly

- What we don’t know about hybrids:
  - Fire adaptations – basal crook
  - Resprouting potential following topkill
  - Drought tolerance
The Study

- Planted seeds of 6 loblolly families, 6 shortleaf families, and 12 hybrid crosses

- Families originated from WGR states

TWO GROUPS

- Family block planting:
  - 4 reps
  - 24 plots each rep
  - Planted in 6x19 seed blocks

- Single tree planting:
  - 10 reps
  - Each family represented once
Results

- Growth through 3 seasons
- Effects of topclipping after 1\textsuperscript{st} growing season
- WUE during 2\textsuperscript{nd} growing season
- Effects of topkill after 2\textsuperscript{nd} and into 3rd growing season
- Crooking
Seedling size end of year 1
Seedling size end of year 2
Seedling size end of year 3
Topclipping/thinning Year 1
Year 1 - Almost all resprouted

Shortleaf pine 100%
Hybrid pine 99.8%
Loblolly pine 98.5%
Year 1 - Number of sprouts varied

<table>
<thead>
<tr>
<th>Tree Type</th>
<th>Number of Sprouts (± Standard Error) per Stump</th>
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</thead>
<tbody>
<tr>
<td>Shortleaf</td>
<td>17.9 ± 0.8 sprouts per stump</td>
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<tr>
<td>Hybrid</td>
<td>15.3 ± 0.6 sprouts per stump</td>
</tr>
<tr>
<td>Loblolly</td>
<td>7.8 ± 0.8 sprouts per stump</td>
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Physiology

- Leaf water potential
- Leaf gas exchange
  - Photosynthesis ($A_{\text{net}}$)
  - Leaf conductance ($g_s$)
  - Transpiration
  - Internal CO$_2$ concentration
- The hybrids and shortleaf were more efficient using water than was loblolly
Topclip and Year 2 and 3

- On each of four treatment dates
  - 4 Nov. 2010 (Dormant season after 2\textsuperscript{nd} year)
  - 7 Jan. 2011 (Dormant season after 2\textsuperscript{nd} year)
  - 10 Mar. 2011(Dormant season after 2\textsuperscript{nd} year)
  - 26 Apr. 2011 (3\textsuperscript{rd} growing season)
Harvesting after third growing season
Seedling survival after topkill

Treatment date

Percent surviving
0 20 40 60 80 100

Loblolly pine
Hybrid pine
Shortleaf pine
Height to first sprout

- shortleaf pine = 3.5 ± 0.6 mm SE
- hybrids = 7.7 ± 0.6 mm SE
- loblolly pine = 21.3 ± 1.5 mm SE
Conclusions

- Hybrid pines have several competitive advantages over their parent species:
  - Growth rate; Hybrids = Loblolly > Shortleaf
  - Water use efficiency; Hybrids = Shortleaf > Loblolly
  - Sprouting after damage; Shortleaf > Hybrids > Loblolly
  - Survival after damage; Shortleaf > Hybrids > Loblolly

- Hybrids lack a strong basal crook that can serve as an adaptation to resprout following surface fire

- Height to lowest sprout was shorter for shortleaf
Is the crook important?
How does prescribed fire affect resprouting of hybrids?

- Tall Timbers Research Station and Land Conservancy near Tallahassee, Florida
- Mixed canopy of shortleaf and loblolly pine
- Compared seedling populations
  - Not burned for 30+ years
  - Burned every 2 years
Fire eliminated loblolly and greatly reduced hybrids

- Seedlings from nonburned areas
  - Loblolly = 45%
  - Hybrids = 30%
  - Shortleaf = 25%

- Seedlings from burned areas
  - Loblolly = 0.0%
  - Hybrids = 15%
  - Shortleaf = 85%

- Of hybrids in burned areas, 10% of the 15% total were SLBC2
- None of the hybrids from the burned areas were LLBC
Conclusions

- Prescribed Fire does mostly eliminate hybrids
Shortleaf pine is not a fire-adapted species
Shortleaf pine is a fire-adapted species.

Quotes from Mattoon 1915

Shortleaf pine sprouts vigorously, and thus reproduces itself if killed back during the period of early life. This period fortunately is the time of greatest susceptibility to injury both by fire and various mechanical agencies. Its range over the drier uplands is coincident with a region of frequent forest fires, yet it is saved by notably abundant reproduction practically everywhere.

Stands of direct seedling origin are on the whole of insignificant area, because there are few localities protected against fire by natural barriers or by man. In one locality of optimum shortleaf development in Pike County, Ark.; the only stands of direct seedling origin found were located in low, moist situations where burnings have been infrequent.
Management implications

- Mechanical damage alone is not enough to eliminate hybrids (or loblolly pine) during the first several growing seasons
- Prescribed fire will reduce or eliminate hybrids
- Seedling age and season of treatment matter
Implications for artificial regeneration

- Remove hybrids from orchards
- The crook is important - Sow at wider spacing in nursery to allow crook to develop or, plant deeper to protect dormant buds
Prioritization for restoration

- Emphasize restoration efforts where fire can be used in management, i.e., without including fire, it probably doesn’t matter.
Ongoing research

- Planting same genotypes in the field to conduct surface fire treatments
- Greenhouse study with same genotypes to determine drought tolerance
- Determining hybrid frequency of seedling before and after prescribed fire
Shortleaf Pine Workshop Webinar Series

An exploration of shortleaf pine ecology, management, and research.

Check in as a guest at
http://dasnr.adobeconnect.com/shortleaf_pine/

Homepage
http://sites.google.com/site/shortleafpinewebinarseries/

Schedule below are subject to change. CFE credit through SAF will be available
<table>
<thead>
<tr>
<th>Date and Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tr>
<td>Monday, April 21, 3:00 p.m. CDT</td>
<td>Rodney Will, Oklahoma State University</td>
<td>Introducing the Shortleaf Pine Workshop Seminar Series</td>
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<td>Jim Guldin, U.S. Forest Service</td>
<td>Shortleaf Pine Ecology</td>
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<td>Monday, April 28, 3:00 p.m. CDT</td>
<td>Thomas Lynch, Oklahoma State University</td>
<td>Shortleaf Pine Management—Plantations</td>
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<td>Chris Oswalt, U.S. Forest Service</td>
<td>Extent and Condition of Shortleaf Pine Resources</td>
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<td>Monday, May 5, 3:00 p.m. CDT</td>
<td>Don Bragg, U.S. Forest Service</td>
<td>Shortleaf Pine Management—Natural Regeneration</td>
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<td>Kurt Atkinson &amp; Erin Johnson, Oklahoma Forestry Services</td>
<td>Opportunities for Shortleaf in Private and Public Forestry</td>
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<td>Monday, May 12, 3:00 p.m. CDT</td>
<td>Barbara Crane, U.S. Forest Service</td>
<td>Genetic Resources Available for Artificial Regeneration</td>
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<td>Jane Fitzgerald, Central Hardwoods Joint Venture</td>
<td>Current Initiatives Related to Shortleaf Pine Management and Research</td>
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<td>Monday, May 19, 3:00 p.m. CDT</td>
<td>Rodney Will, Oklahoma State University</td>
<td>Hybridization in Shortleaf Pine</td>
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<td>Duncan Wilson, Oklahoma State University</td>
<td>Water Use of Shortleaf Pine</td>
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Two examples from the Ouachita National Forest

- Conversion of inherited loblolly pine plantation back to shortleaf pine
- Shortleaf pine-bluestem ecosystem restoration
Conversion of loblolly pine plantation to shortleaf pine

- In Oklahoma, Weyerhaeuser Co. traded 158,000 acres of its holdings in the Ouachita Mountains for 48,000 acres of the productive upper coastal plain in the late 1990's.
- Forest Service inherited loblolly pine plantations planted with ACC genotypes growing beyond the natural range.
- Goal to eventually convert back to shortleaf pine.
Conversion of loblolly pine plantation to shortleaf pine

- Manage existing plantations on ~100 year rotation
- Thin for an open canopy structure
- Burn when possible
- Discriminate against loblolly pine during harvest activities
- Replant local shortleaf pine sources
The objective is to restore dense, closed-canopy forest to an open-canopy forest with some large trees and a diverse and productive understory.

Ouachita National Forest, 155,000 acres restored, goal is 250,000.
FIRE EXCLUSION

Exclusion of fire has led to a closed-canopy forest with hardwood midstory

Reintroduction of fire alone cannot restore the system
Step 1 - Thin pines, remove midstory hardwoods, reintroduce fire to keep hardwoods in check

Step 2 – Additional thinning of pine leaving some large trees, continue with 3-year burn interval

Step 3 – Maintain structure that includes some large trees through uneven-aged management or by seed-tree or shelterwood with reserves (~120 yr rotation), continue fire
Potential success related to reducing hybrid frequency?

- Shortleaf pine-bluestem ecosystem restoration
- Conversion of inherited loblolly pine plantation back to shortleaf pine
Potential success related to reducing hybrid frequency?

- Shortleaf pine-bluestem ecosystem restoration
  Prognosis excellent!
  Future reservoir of pure shortleaf pine?

- Conversion of inherited loblolly pine plantation back to shortleaf pine
  Prognosis not so good
  Future hot spot of hybrids?
The Longleaf and Shortleaf pines are, in quantity and quality combined, the most important source of fires. Stands of direct seedling origin are on the whole of insignificant area, because there are few localities protected against fire by natural barriers or by man. In capacity of complete reproduction. A field investigation in 1912–13 showed clearly that comparatively very few seedlings reach ages of 3 to 6 years without being burned back, and that most forest stands have passed through this experience on repeated occasions.

Shortleaf pine sprouts vigorously, and is killed back during the period of early life, which is the time of greatest susceptability to injury by mechanical agencies. Its range over the southern Piedmont with a region of frequent forest fires, and its abundant reproduction practically everywhere, has kept it a species of considerable importance.

Second-growth forests of the Piedmont and Appalachian regions have been subject to frequent fires during more than a century. In general law, it may be stated that, in any specified locality, the proportion of shortleaf pine of seedling origin varies inversely with the frequency and general prevalence of fires. Stands of direct seedling origin are on the whole of insignificant area, because there are few localities protected against fire by natural barriers or by man. One locality of optimum shortleaf development in Pike County, the only stands of direct seedling origin found were located in moist situations where burnings have been infrequent. Of the the consequent encroachment of hardwoods. In the upper portions of the Atlantic coastal plain it is to a considerable extent being replaced by loblolly pine on abandoned fields. The early clearing for agriculture of the lighter and better-drained soils greatly decreased the shortleaf seed trees and correspondingly increased the relative proportion of loblolly seed trees, which were left growing along the watercourses and on low heavy soils, where they find a congenial home.