# Shortleaf Pine Restoration Plan:
## Restoring an American Forest Legacy

Shortleaf Pine Initiative


**Principal Contributors:**

McRee Anderson, Lark Hayes, Patrick D. Keyser, Christopher M. Lituma, Robert D. Sutter, and Doug Zollner

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www.shortleafpine.net

# Preface

Photo by Clarence Coffey, Ouachita National Forest, AR

Shortleaf pine (*Pinus echinata)* is at last garnering the conservation focus it warrants as the most widely-occurring pine species in the eastern United States offering an abundance of ecological, economic and cultural benefits. Considering the severely diminished extent and condition of forests containing shortleaf pine, many will find it remarkable that the Shortleaf Pine Initiative, launched in 2013, constitutes the first concerted effort at the range-wide scale to address its future. This Plan for Shortleaf Pine (2015) will inform and guide this landscape-level Initiative during its initial five years. While anticipating that significant knowledge and insights will be gained as the Initiative matures and gains momentum, the Plan aims to elevate the visibility of shortleaf pine-dominated woodlands as a worthy part of the nation's forest legacy, sounding the alarm over their precipitous decline and charting the immediate steps for their restoration.

The Plan is focused on restoring woodlands in which shortleaf pine was the dominant or co-dominant canopy species. The Plan is intended for use by practitioners of such disciplines as forestry, wildlife and conservation biology, and natural resources management, as well as policy makers in state and federal governments, and most importantly, by the private landowners and public lands managers whose land management decisions are so vital to the future of shortleaf. The power of the range-wide Plan is to set forth a vision for shortleaf pine restoration, including specific goals and strategies, and to harness the efforts of the many diverse organizations and individuals willing to partner in this Initiative.

The Plan reflects the expertise and input of many foresters, wildlife biologists, and natural resource professionals with invaluable shortleaf experience, many of whom participated in a series of four stakeholder workshops held across the range of the species in 2013 and 2014. The Advisory Committee (see page ii) guided the development of the Plan; their contributions were essential and greatly appreciated. We also want to recognize the generous support of the USDA Forest Service Southern Region that has worked closely with the State Forester of Tennessee and the Department of Forestry, Wildlife and Fisheries at the University of Tennessee to make this effort possible.

Many individuals were instrumental in the efforts leading to the Initiative and the subsequent development of this plan. Bill Hubbard, George Hernandez, Bill Pickens and others organized a shortleaf workshop in September 2010 in Raleigh, North Carolina that led to the early Shortleaf Working Group. This formative group worked on early foundations to the Initiative as well as hosting the 1st Biennial Shortleaf Pine Conference in Huntsville, Alabama in September 2011. Some of the key members of this group were Becky Barlow, John Kush, John Gilbert, Andy Scott, Gary Peters, Pat Keyser, David Schnake, George Hernandez, Richard Shelfer, Bill Hubbard, and Kevin Guthrie. A special thanks to Ken Arney, USDA Forest Service, Region 8, for providing early funding for the Initiative, and also to Director Gary Myers (retired), Tennessee Wildlife Resources Agency, for the vision and challenge to prepare a Shortleaf Pine Restoration Plan.

The online "home" of the Shortleaf Pine Initiative is www.shortleafpine.net. Not only will the site provide the most up-to-date information on this rapidly developing Initiative, it will also offer ready access to the anticipated future iterations of the Plan and additional technical guidance for practitioners.


Most importantly, we encourage and welcome active involvement in the Initiative and the implementation of the Plan. Our success depends on the cooperation and contributions of partners working across the shortleaf range.

Mike Black

Director

Shortleaf Pine Initiative

Cover photo by Mike Black, Shortleaf Pine Initiative, Ouachita National Forest, AR

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# Executive Summary

Photo by Bill Pickens, North Carolina Forest Service

Shortleaf pine (*Pinus echinata*) has the largest geographic extent of the southern yellow pines, occurring in 22 states in the United States. Extensive logging, subsistence farming, the loss of open range grazing of livestock, and a lack of appropriate disturbance for subsequent regeneration have contributed to a 53% decline in its range since 1980. Commercially, shortleaf pine was a valued timber commodity. During the Revolutionary War and the early 1800's, shortleaf pine was a major timber source in the eastern part of its range for a myriad of products including shipbuilding and homes. In the western portion of its range, shortleaf pine dominated the forest industry during the mid to late 1800's and early 1900's until the Great Depression; it was so highly valued, loblolly pine timber was marketed as shortleaf.

There are two distinct and dominant shortleaf pine forest types defined by FIA: Shortleaf pine (often mixed with longleaf and loblolly pines, *Pinus palustris* and *Pinus taeda*), and Shortleaf pine–Oak (mixed with several species of oak including *Quercus stellata*, *Quercus alba*, *Quercus velutina*, and *Quercus falcata*). These two types would have existed along a continuum of fire disturbance, where frequent fire would have produced open shortleaf pine woodlands, and less frequent fire would have maintained shortleaf pine in oak woodlands. Shortleaf pine is a fire-adapted species, as evidenced by its capacity for re-sprouting when top-killed, survivability, and positive regeneration and seedling vigor responses post-fire. Historically, frequent fires would have maintained shortleaf pine in mixture with other southern pines which do not sprout, or do so much less reliably. Reductions in fire regimes through the 20$^{th}$ century, both in intensity and frequency, have contributed to drastic shifts in forest communities away from shortleaf pine to more fire-intolerant species.

Additional factors contributing to shortleaf pine decline include: loblolly pine (*Pinus taeda*) range expansion, commercialization, and hybridization; southern pine beetle (*Dendroctonus frontalis*) outbreaks; and littleleaf disease (*Phytophthora cinnamomi*), especially in the Atlantic Piedmont. Many wildlife species use forested ecosystems that include shortleaf pine components. Shortleaf pine seeds are an important food source for small mammals and birds, especially northern bobwhite (*Colinus virginianus*), and shortleaf pine trees are used as roosting and nesting habitat for woodpeckers and roosting habitat for bats. Shortleaf pine-dominated woodlands occurred as a result of frequent disturbance, which is conducive to species adapted to early successional habitats.

In 2013, the Shortleaf Pine Initiative (SPI) was formed to identify the threats facing shortleaf pine ecosystems and the strategies and partnerships that could address these threats. An Advisory Committee for SPI was formed and is comprised of representatives from natural resources agencies and organizations with a shared goal of maintaining, improving, or restoring these systems (see page iv for definitions of these terms). The vision of SPI is to create a highly motivated partnership that inspires the conservation of shortleaf pine and associated ecosystems range-wide with the full spectrum of socio-economic values and ecological viability. The SPI held four workshops during 2013-2014 to determine the status of, as well as threats and barriers to shortleaf pine management. The eight key components of the Shortleaf Pine Restoration Plan as identified through the workshops were: Partnerships; Public Lands; Private Lands; Economic Sustainability; Ecological Sustainability; Public Relations Communication, Outreach; Evaluation of Plan Actions; and Implementation of the Plan. This plan details range-wide shortleaf pine restoration goals, objectives, and key actions to achieving objectives.

### ***Definitions of Maintain, Improve, and Restore***

The Shortleaf Pine Restoration Plan has adopted the same terminology as America's Longleaf (America's Longleaf 2009) for describing the current ecological condition of shortleaf pine stands. The definitions are based on the presence and quality of the primary components of any forest stand: canopy composition and cover, and basal area of dominant species; mid-story density; and groundcover cover, composition, and diversity.

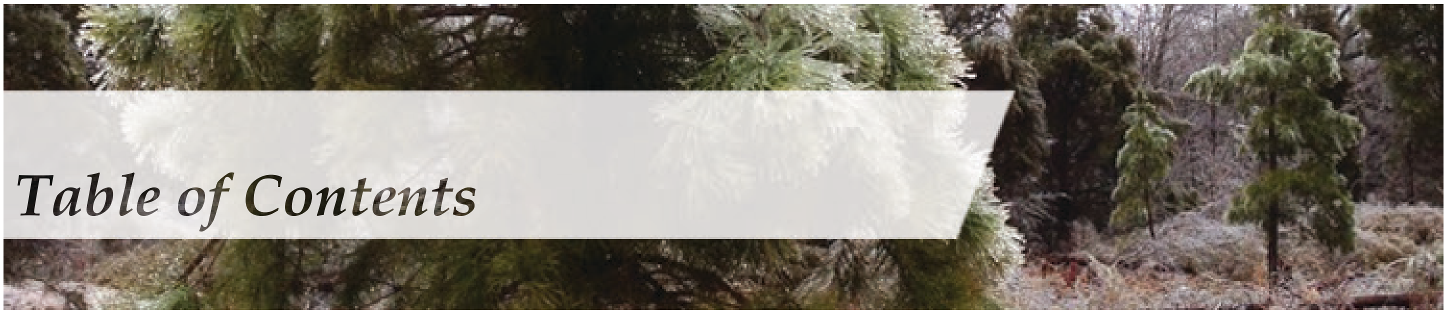
***Maintain*** describes stands where the existing condition of the canopy, mid-story, and groundcover are within or close to the desired ecological condition.

***Improve*** describes stands where one or more of the primary components is missing, degraded, or distant from the desired ecological condition.

***Restore*** pertains to sites that are suitable for a shortleaf pine natural community but are currently in other forest types or land classifications.

### ***Acronyms and Abbreviations***

| | |
|---|---|
| **CFLRP** | Collaborative Forest Landscape Restoration Program |
| **CHJV** | Central Hardwoods Joint Venture |
| **DFC** | Desired Future Conditions |
| **FIA** | Forest Inventory Analysis |
| **Ft.** | Feet |
| **IHSLPI** | Interior Highlands Shortleaf Pine Initiative |
| **M** | Meters |
| **SPB** | Southern Pine Beetle |
| **SPI** | Shortleaf Pine Initiative |
| **SPRA** | Shortleaf Pine Restoration Plan |



# Table of Contents

Photo by Rob Evans, North Carolina Plant Conservation Program


**Preface** ..... i
**Executive Summary** ..... iii
**Table of Contents** ..... v
**The Imperative for Restoration** ..... 1
**Vision** ..... 2
**Mission** ..... 2
**The Status, Ecology and Economics of Shortleaf Pine** ..... 3
- Forest History and Current Status ..... 3
  - *Forest History* ..... 3
  - *Status and Trend* ..... 4
- Ecology of Shortleaf Pine ..... 7
  - *Habitat Associations And Distribution* ..... 7
  - *Fire* ..... 7
  - *Wildlife and Biodiversity* ..... 9
- Economics ..... 10
  - *Economics and Forest Products* ..... 10
  - *Pests and Diseases* ..... 11
  - *Climate Change* ..... 11

**The Restoration Plan** ..... 13
- Guiding Principles ..... 13
- Defining Restoration ..... 13
- Plan Approach ..... 14
  - *Workshop Results* ..... 14
- Range-Wide Objectives of the Shortleaf Restoration Plan ..... 15

**Regional Goals** ..... 19
- Goals for the Interior Highlands Ecoregion ..... 19
- Goals for the West Gulf Coastal Plain Region ..... 25
- Goals for the Regions East of the Mississippi River ..... 25

**Literature Cited** ..... 27
**Appendices** ..... 32
- Appendix A. Shortleaf Pine Dominated Forests as Defined by Forest Inventory Analysis ..... 32
- Appendix B. Estimating the Historic Acreage of Shortleaf Pine ..... 33
- Appendix C. Shortleaf Pine Associated Forest Cover Types from Society of American Foresters ..... 35
- Appendix D. Shortleaf Pine Plant Community Associations from NatureServe ..... 36
- Appendix E. Wildlife of Conservation Concern and Management Interest within Shortleaf Pine Ecosystems ..... 39
- Appendix F. Scientific and Common Names of Grass and Herbaceous Species Typically Found in Shortleaf Pine Woodland Understory ..... 40
- Appendix G. Desired Future Conditions for Restored Shortleaf Pine Ecosystem in the Interior Highlands of Arkansas and Missouri ..... 48

# The Imperative for Restoration

Photo by Mike Black, Shortleaf Pine Initiative, Ouachita National Forest, AR

The first settlers to the coastal regions of the mid-Atlantic region of North America immediately encountered open pine dominated woodlands, rich with game and timber. The dominant pine in these forests was shortleaf pine (*Pinus echinata*). These forests supplied strong, straight timber from which many colonial buildings and ships were built. As the settlers pushed westward they found an ample supply of shortleaf pine – as a common canopy species from New Jersey, south to Georgia and west to the Mississippi River, and in more extensive stands in Arkansas, Missouri, Oklahoma and Texas – to meet their needs for lumber and game.

The status of the nation's shortleaf resource today stands in sharp contrast to its earlier abundance. While the exact acreage of shortleaf pine dominant forests at the time of European settlement and westward migration is difficult to estimate, available information suggests the historic acreage of shortleaf-dominated forests may have been between 70 and 80 million acres. Recent data estimate that only 6 million acres of shortleaf pine dominated forests exist today and that this acreage has declined by more than 50% since 1980. Much of the remaining shortleaf is found west of the Mississippi while it is considerably reduced to the east. It is clear that shortleaf pine and associated habitats have significantly declined in the United States, extant on less than 10% of its historic range, and now constitute one of the nation's most threatened legacy forests.

The causes of this extensive decline are many. Two hundred years of harvesting has greatly reduced the acreage of shortleaf pine, as have land use changes, the preference of planting loblolly pine for timber products, and disease and pests. But the most significant cause of decline to existing forests is the lack of fire. Along with longleaf and ponderosa pine, shortleaf pine is one of the three great frequent fire pine ecosystems in North America. The species is adapted to a frequent, low intensity fire regime and occasional high intensity, stand-replacing fires. Fire plays a critical role in perpetuating this ecosystem. Without fire, both the extent and condition of shortleaf pine dominated forests have diminished.

The shortleaf pine dominated forests that are the focus of the plan includes two broad forest types defined by USFS Forest Inventory Assessment (FIA). The two are the Shortleaf Pine forest type, in which shortleaf is a dominant species sometimes mixed with other pines, and the Shortleaf Pine–Oak forest type, in which shortleaf shares dominance with one or several species of oak (Appendix A). These forest types originally occurred as open woodlands, but with fire suppression many exist as closed forests. These forest types are the ones in which shortleaf pine provides distinctive and unique ecological and economic values.

The loss of these shortleaf pine dominated woodlands has resulted in a decline of many species of wildlife, especially those that depend on open, fire-maintained ecosystems. Among these are the federally endangered red-cockaded woodpecker, northern bobwhite (a species that has sharply declined over the last half century), Bachman's sparrow (one of the most rapidly declining bird species in North America), and several rare butterflies.

Along with the adverse consequences for wildlife, the economic opportunities offered by a robust shortleaf resource are also being lost. The species is used for lumber, plywood, structural materials, pulpwood and poles, and is favored because of its strong, dense, straight-grained wood. The species tolerates a wide range of soil and site conditions, including droughty sites, is adapted to fire, and is predicted to expand in abundance under future climate conditions. Shortleaf is an excellent option for private landowners seeking long-term economic and wildlife returns, and also meets the multiple objectives of public land managers.

Understandably, there is a widespread interest in restoring shortleaf pine across its range. The timber products, wildlife, and species diversity benefits are significant. Restoring the species and associated ecosystems through prescribed fire reduces the risk of hazardous fires. And restored shortleaf pine forests are expected to be more resilient to changes in climate, thus maintaining the system and its values for many generations. Restoring this legacy forest will regain these values on private and public lands. This forest of the past can be a forest of the future.

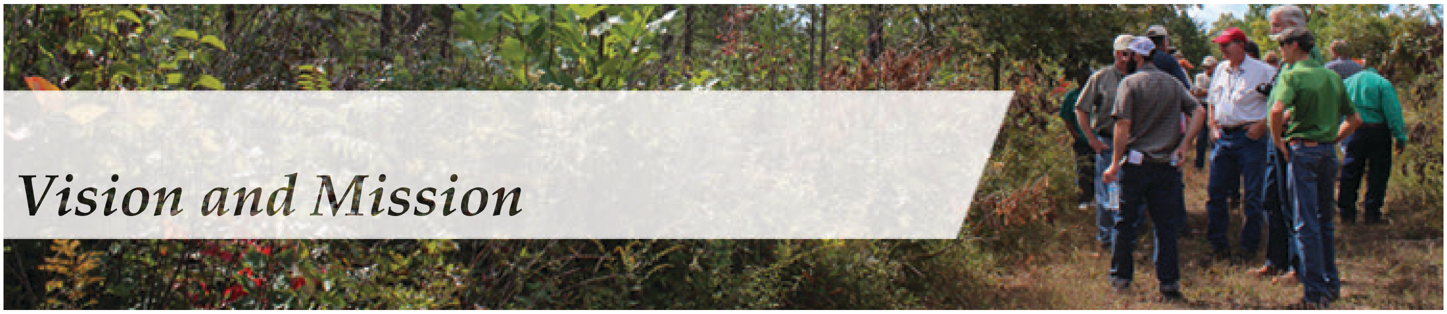


Photo by Laura Costa, Southern Regional Extension Forestry, Catoosa Wildlife Management Area, TN

# Vision and Mission

## VISION

The vision of the Shortleaf Pine Initiative is to restore the nation's legacy of shortleaf pine dominated woodlands for their full array of economic, ecological, and cultural benefits through a collaborative partnership effort across the historical range.

Elevating awareness of shortleaf pine ecosystems — both their largely unheralded values and greatly diminished extent — will be a challenge for the Initiative in its first five years. This is especially true in eastern portions of its range where shortleaf may well be "the forgotten pine" and relatively little remains. Embracing regional differences in the current status of shortleaf will be essential to seizing the opportunity to secure and expand the significant shortleaf pine resource still intact west of the Mississippi while initiating more basic restoration efforts to the east where shortleaf abundance is greatly diminished.

The Initiative acknowledges and will address important gaps in knowledge, expertise, and other information relative to shortleaf restoration and management. This is not unexpected considering the relative lack of attention shortleaf has received in recent decades, especially in the eastern part of its range. As the Initiative itself gets established and matures, much progress can be made in cooperation with its many partners in addressing these challenges and opportunities.

## MISSION

The mission of the Shortleaf Pine Initiative is to provide the leadership and collaborative partnership framework for the restoration of shortleaf woodlands on a range-wide scale. The Initiative acknowledges the earlier efforts of the Shortleaf Pine Working Group, as well as the several restoration projects already underway at local, and in some cases, multi-state scales.

The Initiative takes inspiration from these various shortleaf pine endeavors as well as the highly successful America's Longleaf Restoration Initiative (America's Longleaf 2009). The Plan seeks to build upon the outstanding work of many shortleaf partners and model the range-wide approach that has already proven effective in their projects.

As other landscape level projects have demonstrated, the power of an appropriately scaled effort driven by a written plan developed with ample partner participation, cannot be underestimated in terms of raising visibility, building capacity and coordination, and attracting resources. Now is the time for such an approach to shortleaf pine restoration. State and federal agencies, non-profit conservation organizations, private landowners and public land managers, natural resources professionals from many disciplines, and many other partners will all be needed for success. While challenges abound in building this new Initiative, the severely diminished status of the nation's shortleaf legacy and the benefits to be reaped by joining together in a partnership more than justify these future efforts.

# *The Status, Ecology, and Economics of Shortleaf Pine*

Photo by Clarence Coffey, Pusmataha Wildlife Management Area, OK

Shortleaf pine (*Pinus echinata)* has a complex ecology and history. It is the most widespread pine species in Eastern United States, occurring in 22 states, with a range of over 440,000 square miles (Larsen 1990). It is found in a wide diversity of habitats and different natural community types, sometimes in pine dominated stands, and elsewhere as a component of mixed oak forests. The species is adapted to frequent, two to twenty year return interval fire, requiring fire for natural regeneration (Guyette et al. 2012, King and Muzika 2014). Along with longleaf and ponderosa pine, it is one of the three great frequent fire pine ecosystems in North America. It has been an important timber species since European settlement and continues to be an important commercial tree today. Even with its wide occurrence and commercial value, shortleaf pine dominated forests currently occur on less than 6 million acres (Oswalt 2015), estimated here as less than 10% of its historic acreage.

This section covers topics on the forest history, status and trends, ecology and economics of shortleaf pine to provide appropriate context for the first iteration restoration strategies.

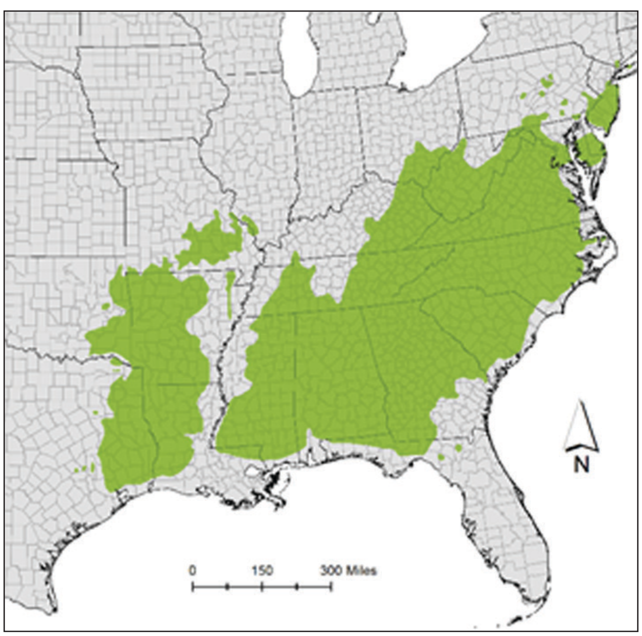



***Figure 1.*** *Shortleaf pine range map (Little 1971).*

## FOREST HISTORY AND CURRENT STATUS

### *Forest History*

Commercially, shortleaf pine has a long history of being a valued timber commodity (Harris and Maxwell 1912, Mattoon 1915b, Treiman et al. 2007). During the Revolutionary War and the early 1800's, shortleaf pine was a major timber source for a range of products. Shortleaf pine lumber was exported to Britain and the West Indies from the earliest days of colonization. In the mid-South, shortleaf pine was the dominant material used in house construction during European colonization and westward expansion. Additionally, shortleaf pine timber was valued for the shipping industry and used in dockyards of port cities such as New York, Philadelphia, and Baltimore. With this extensive harvesting shortleaf pine timber decreased dramatically along the east coast, and by the mid-1800's, the resource was nearly extirpated.

In the latter half of the 1800's, after harvest levels declined and regeneration increased on abandoned farm fields, shortleaf pine acreage dramatically increased in the east (Campbell 2015), so much that Mattoon (1915b) stated, "shortleaf pine is the only commercial conifer on more than 100,000 square miles of upland region between Virginia and northern Alabama and Mississippi." The early 1900's harvest of the species and the expansion of farming again greatly reduced the acreage of the species, once again followed by increasing acreage with regeneration on abandoned farm fields during the Great Depression.

Further west, shortleaf pine dominated the forest industry from the late-1800s through the first half of the 1900s in the Ozark Mountains of Missouri and Arkansas, and Ouachita Mountains of Arkansas and Oklahoma (Batek et al. 1999, Smith 2006, Treiman et al. 2007). In 1899, timber production peaked in the western part of shortleaf pine range, and by 1920 the resource had been nearly entirely harvested except for a few remnant patches in the Ozarks (Cunningham 2007) and Ouachita Mountains (Smith 2006). Larger forests remained in Oklahoma until the 1940s (Kurt Atkinson, personal communication).

### *Status and Trend*

The exact acreage of shortleaf pine at the time of European settlement is difficult to estimate. The first measurements of timber resources in the eastern U.S. came at the end of the 1800's and the early 1900's (Sargent 1884, Mohr and Roth 1896, Mattoon 1915a), after nearly 300 years of shortleaf harvesting and extensive land use changes. Those estimates did not differentiate between shortleaf forest types, some assessing only shortleaf acreage of commercial value and others assessing all acreage within which shortleaf occurred.

The geographic range of shortleaf pine includes 440 million square miles, much of which comprises forests that are not dominated by or include shortleaf pine (Larsen 1990). Early in the last century, the commercial range of shortleaf pine was estimated at 280 million acres across 14 states, which included substantial second growth forests on abandoned agricultural lands (Mattoon 1915a). Mohr and Roth's 1896 assessment of shortleaf-dominated forests provides the best picture of the historic range. Using their acreage for states west of Georgia and a conceptual model of the acreage before the depletion of the species in the Atlantic states and Tennessee, the historic range of shortleaf-dominated forests may have been between 70 and 80 million acres (Appendix B). More recent plot-based data show that only 6 million acres of shortleaf pine dominated forests exist today and that this acreage has declined by more than 53% since 1980 (Figure 2; Oswalt 2015). Even without exact estimates of historic acreage, it is clear that shortleaf pine has significantly declined as an ecosystem and community component in this country, extant now on probably less than 10% of its historic range.

More recent analysis from FIA data shows a more serious trend for the shortleaf-dominated forests (Oswalt 2015). The analysis focuses on two shortleaf pine forest types as defined by FIA, Shortleaf Pine (in which shortleaf pine is a dominant species sometimes mixed with other pines) and Shortleaf Pine–Oak (in which shortleaf shares dominance with one or several species of oak**;** Appendix A). The first is estimated to occur over 3,234,622 acres, while the later is found on over 2,795,599 acres. The majority of shortleaf-dominated forests (68%) occurs in states west of the Mississippi River (Arkansas, Missouri, Oklahoma, Texas; Figure 3 and 4), and is especially prevalent in Arkansas (33%; Oswalt 2015).

The data show a 53% decline in shortleaf-dominated forest acreage since 1980. The greatest losses in acreage over the last thirty years are in AL, AR, GA, MS, and TX. The data also show that shortleaf pine is disappearing from the coastal

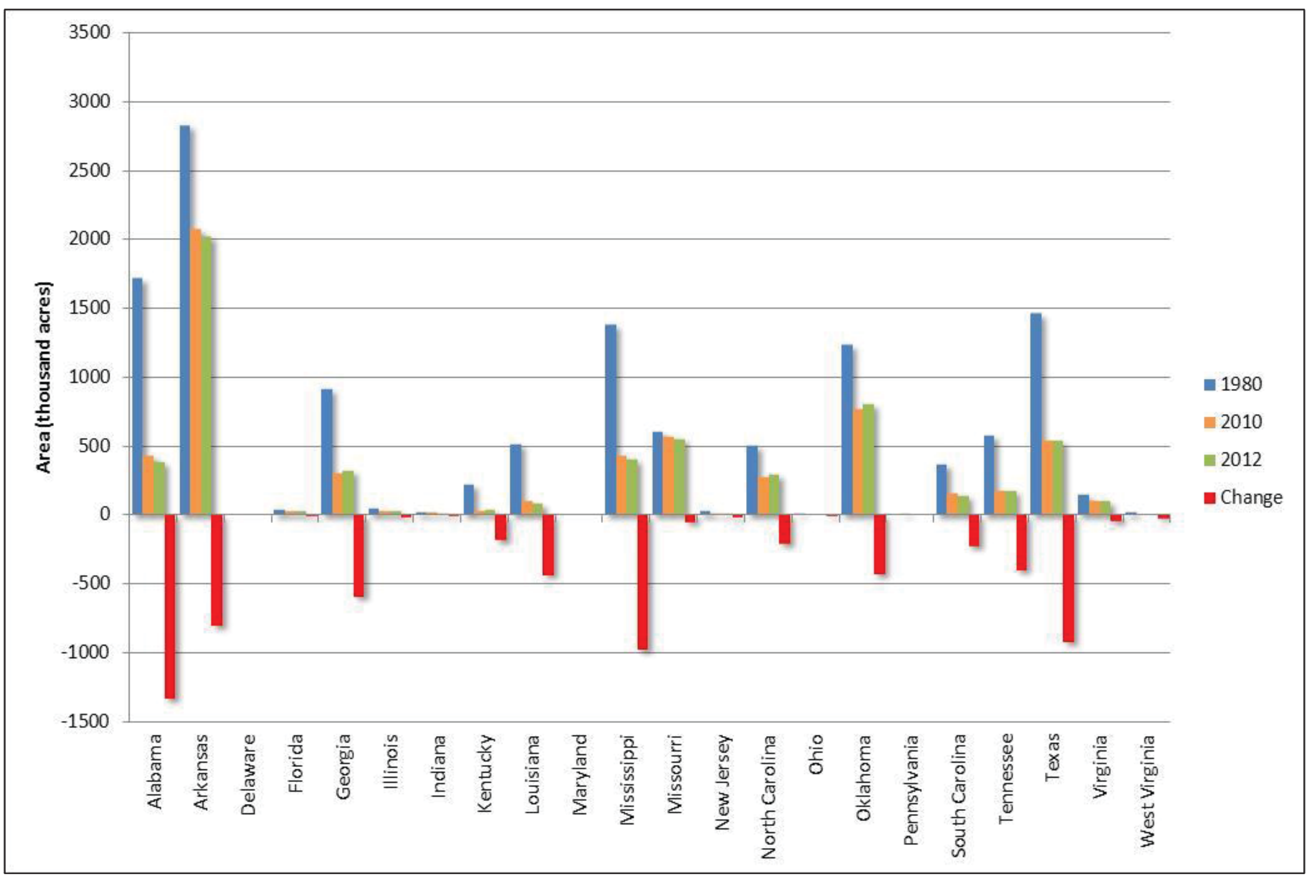



***Figure 2.*** *Decline in shortleaf pine acres on FIA forest plots within historic shortleaf pine range by state, 1980-2012 (Oswalt 2015).*

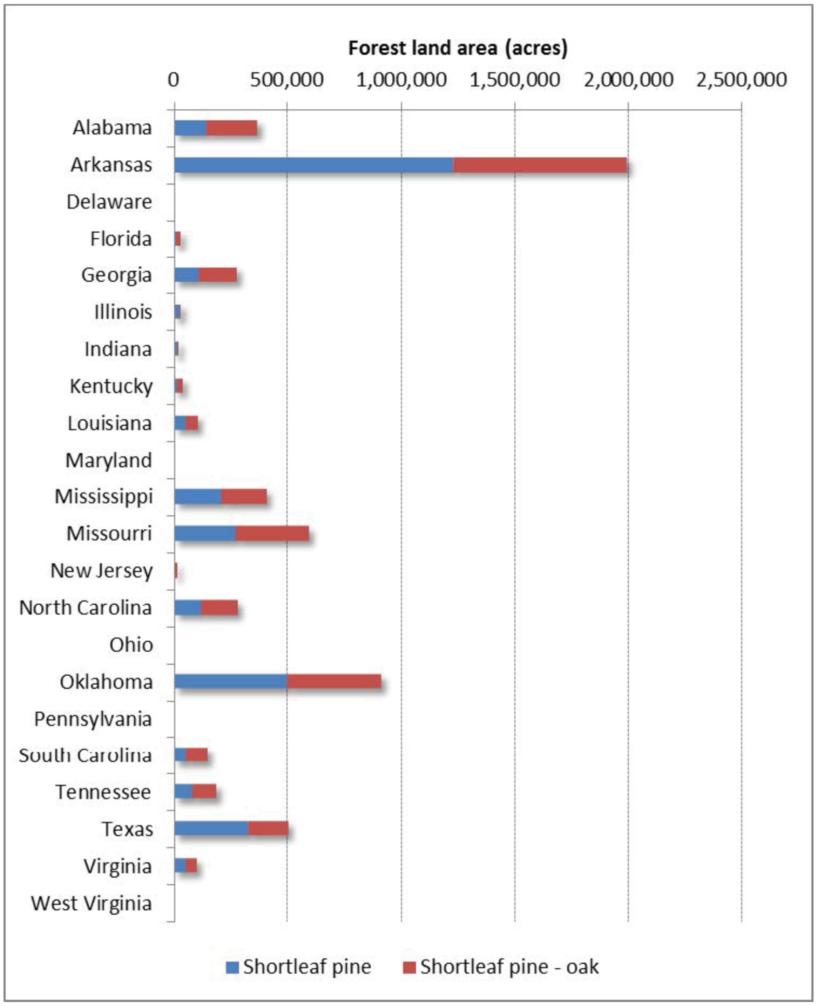



***Figure 3.*** *Acreage of Shortleaf Pine and Shortleaf Pine–Oak Forest types in each state from FIA data (Oswalt 2015)*

and piedmont VA, Atlantic Coastal Plain of NC, SC, and GA, and the Cumberland Plateau of TN and KY at particularly alarming rates (Figure 2).

The data also foreshadow future challenges to sustaining shortleaf pine across the range. The majority of shortleaf-dominated forests (both Shortleaf Pine and Shortleaf Pine–Oak forests as defined by FIA) occur in larger diameter size classes, 72% of the total acreage (Figure 5; Oswalt 2015). While this is an excellent condition for these forests and for maximizing timber and wildlife values, the relative lack of smaller diameter trees is a cause for concern. Outside of the western part of its range, shortleaf seedlings are found in only a minority of the FIA plots (Figure 6). Without regeneration, this suggests that shortleaf will continue to decline in the eastern part of its range in the absence of future restoration efforts (Oswalt 2015).

While some 62% of shortleaf-dominated forests are found on private lands at present, some trends are disturbing. In recent years (2005-2012), shortleaf removals (harvesting and land clearing) in the eastern US have exceeded growth and reduced shortleaf pine volume by nearly 5% (Oswalt 2015). Meanwhile, volume is increasing on public lands.

The causes of the extensive and ongoing decline in shortleaf forests are several. Two hundred years of harvesting has greatly reduced the acreage of shortleaf pine, as has land use changes. The preference of planting loblolly pine for industrial roundwood and fiber production has also contributed to this decline (Stewart et al. 2012, Hanberry 2013). Disease and pests have reduced the abundance of the species (Campbell 2015). A subtle but very significant cause of decline is the alteration of fire regimes across the range of shortleaf pine (Masters 2007). Shortleaf pine is adapted to a frequent, low intensity fire regime and fire plays a critical role in the establishment, maintenance, composition, and structure of shortleaf pine ecosystems. The suppression of fire has dramatically changed the shortleaf pine forest ecosystems (Sparks et al. 2002, Guyette et al. 2006, Land and Rieske 2006, King and Muzika 2014). In total, these causes of decline have resulted in shortleaf pine being greatly diminished as a legacy forest ecosystem in North America, especially east of the Mississippi.

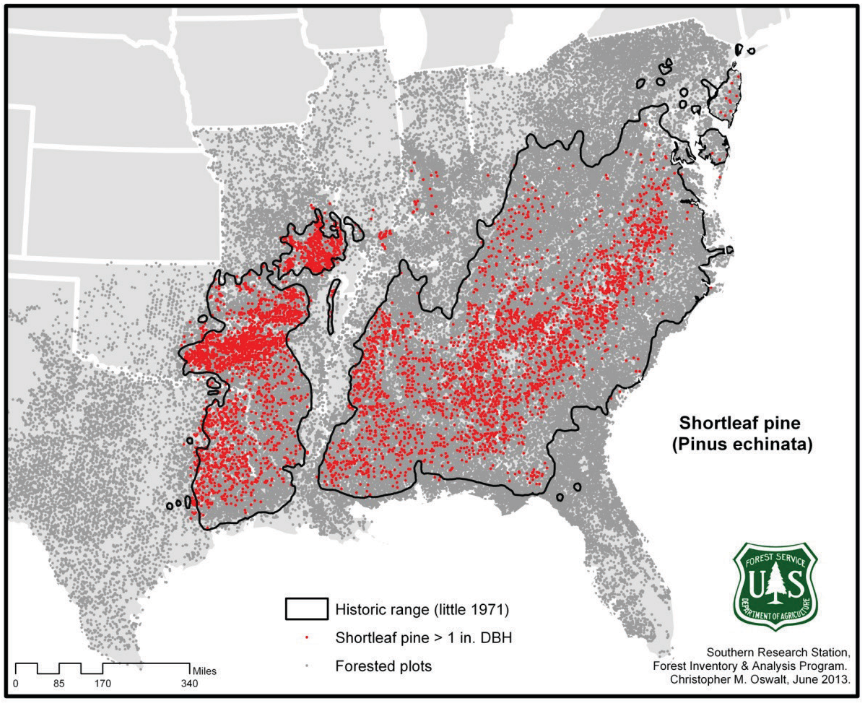



***Figure 4***. *Distribution of shortleaf pine on FIA forest plots within historic shortleaf pine range, 2012. Currently, shortleaf pines are found on 13% of all forested plots (Oswalt 2012).*

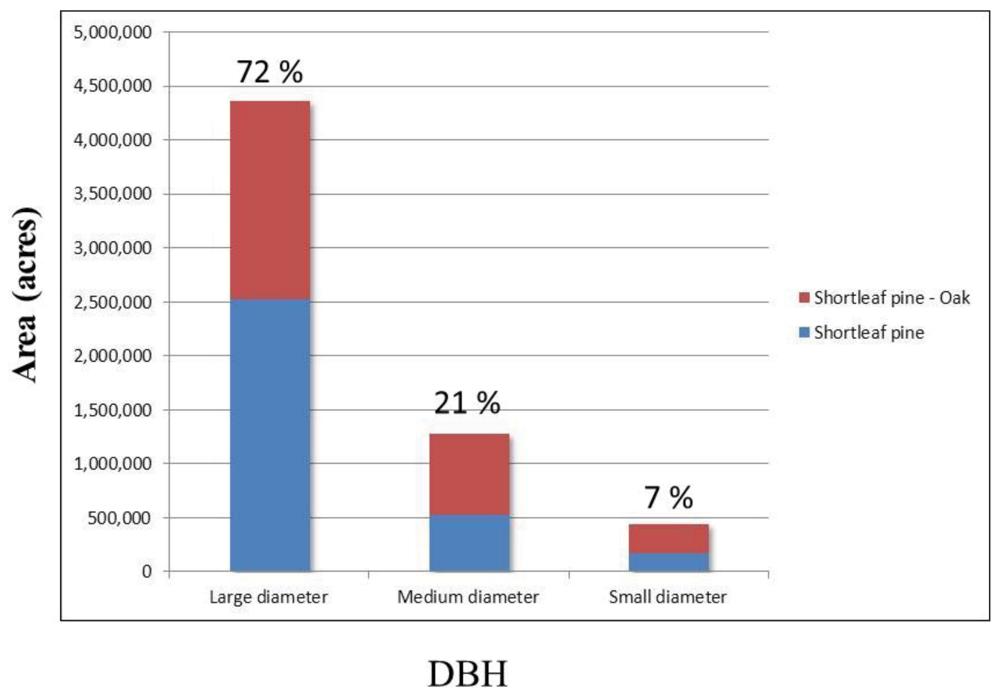



***Figure 5.*** *Acres of shortleaf pine-dominated and shortleaf pine–oak forests on FIA forest plots within the shortleaf pine range for large (>9-11 in DBH), medium (5-9 in DBH), and small (<5 in DBH) size classes, 2012 (Oswalt 2015).*

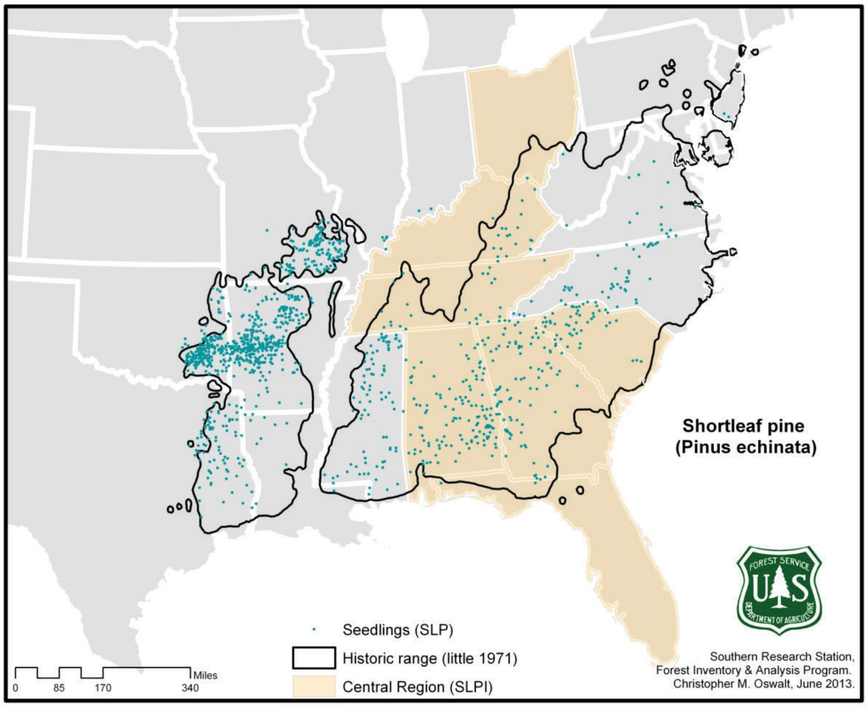



***Figure 6.*** *Distribution of shortleaf pine on FIA forest plots within historic shortleaf pine range containing shortleaf pine seedlings, 2012 (Oswalt 2012).*

## ECOLOGY OF SHORTLEAF PINE

### *Habitat Associations and Distribution*

Across its wide range, shortleaf pine occurs in a variety of habitats, from open woodlands to a component of hardwood forests. This diversity of community structure and composition is the result of geology, soils, aspect, hydrology, and the interaction with fire.

Shortleaf pine can grow on a range of soil types, aspects, geology, and hydrologic gradients (Arnold et al. 1996, Guldin et al. 2004, Guyette et al. 2007, Bried et al. 2014). It grows on xeric sandhills in Florida; xeric southwest-facing slopes in the Appalachians, the Ozarks, and the Ouachitas; and well-drained limestone hills on the Cumberland Plateau. It also occurs on mesic lowland areas in the Piedmont and Coastal Plain, such as the Pine Barrens in New Jersey and across the rolling uplands separating major and minor stream bottoms in the west Gulf region.

Within its range, shortleaf pine occurs in a number of different forest types. These forest types vary depending on the classification scheme. Shortleaf pine is associated with 18 forest cover types according to the Society of American Foresters (Eyre, F. H. 1980; Appendix C), and 60 NatureServe plant communities (NatureServe 2014; Appendix D). 68% of the 47 NatureServe natural community associations in which shortleaf is dominant or co-dominant are considered critically imperiled or imperiled (NatureServe 2014, Appendix D). The critically imperiled natural communities of shortleaf pine occur throughout the range of the species, including shortleaf-oak woodlands in NC, TN, GA, and MS, longleaf-shortleaf woodlands in GA, and shortleaf oak woodlands and mesic longleaf-shortleaf woodlands in LA and TX. Many of these forest types are the focus of conservation efforts.

In the New Jersey Pine Barrens and in the Appalachians, shortleaf pine is a close associate of pitch pine. In the eastern part of its range, shortleaf pine is found mixed with oaks, but today is rarely found in extensive stands. Conversely, in the western part of its range (Ozark Highlands and especially the Ouachita Mountains), shortleaf pine is the dominant canopy species either alone or in mixture with other pines, oaks, and hardwoods in the region. Along the Atlantic and Gulf Coastal Plains, shortleaf pine is found in varying degrees of mixture with three common southern yellow pine species: loblolly, longleaf, and slash. There is extensive overlap between the range of shortleaf and longleaf pine (Figure 7).

### *Fire*

Shortleaf pine is adapted to a frequent, low intensity fire regime (Guyette et al. 2007, Masters 2007, Vose 2015).

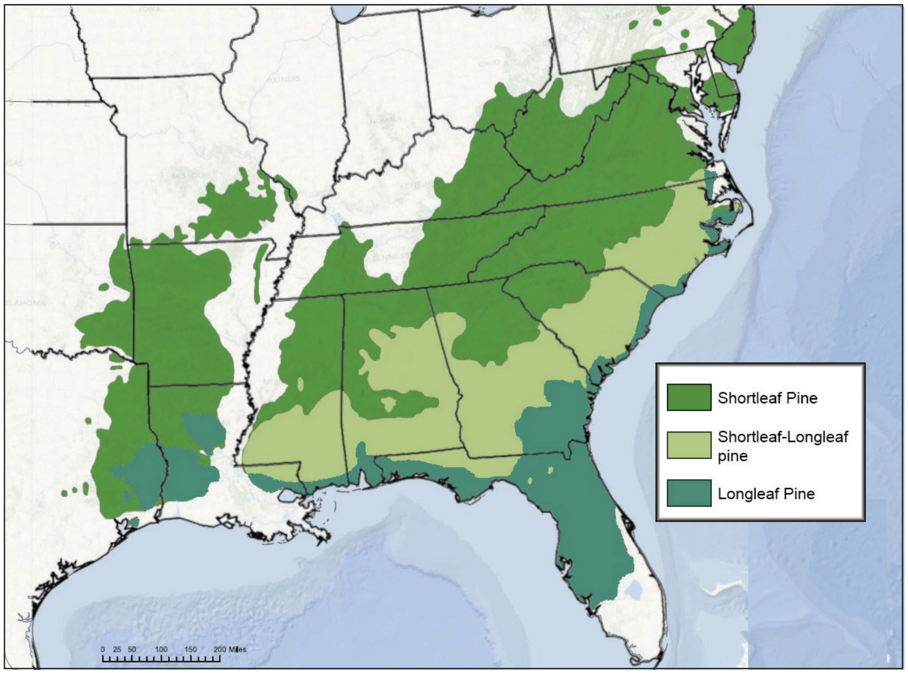



***Figure 7.*** *Distribution of shortleaf pine and longleaf pine.*

Fire plays a critical role in the regeneration, establishment, maintenance, composition, and structure of shortleaf pine ecosystems (Masters 2007). Windstorms and manmade disturbances also provide the bare soil conditions for shortleaf pine regeneration. In the absence of fire at the landscape scale, shortleaf pine communities succeed into hardwood-dominated forests.

Shortleaf pine evolved in a landscape that had a historic mean fire interval of two to twenty years from both natural (lightening) and human sources (Guyette et al. 2012, King and Muzika 2014). Fire plays a key role in maintaining forest structure. More frequent fires result in an open woodland structure, a habitat that is among some of the most imperiled in eastern North America. The more open woodlands (called savannas by some references) have a very sparse overstory and a well-developed herbaceous understory including grasses, wildflowers, and occasional understory shrubs (Keyser 2015). Woodlands with a higher density of trees would have understories that consist of lower grass cover and higher cover of woody plants (Keyser 2015). The increased light levels encourage the development of a native grass-herbaceous vegetative ground layer often dominated by little and big bluestem. The open structure provides habitat for a range of rare and restricted species. Fire limits the encroachment of fire-intolerant hardwoods and less fire-tolerant conifers (especially eastern redcedar). Even in closed canopy forests, infrequent fires would have maintained shortleaf pine forest types in mixed pine stands. For example, in Missouri the amount of shortleaf pine in Shortleaf Pine–Oak forests is negatively correlated with the mean fire return interval (Batek et al. 1999).

Photo by Tim Albritton, Natural Resources Conservation Service

Shortleaf pine has several fire-adapted traits allowing it to survive fire and colonize burned areas. Seedlings and saplings have the capacity to re-sprout when top-killed by fire due to axillary buds located in a basal J-shaped crook near the ground surface, a unique feature of the species (Mattoon 1915a). A thick platy bark and minimal quantities of resin production protect older trees from fire (Guldin 1986, Mattoon 1915a). Abundant seed crops and persistent cones allow seedlings to establish soon after fire (Mattoon 1915a).

An altered fire regime threatens future regeneration, maintenance, composition, and structure of shortleaf pine ecosystems. Altered fire regimes, both in intensity, frequency, and season of burn, have drastically changed the shortleaf pine forest ecosystems (Sparks et al. 2002, Guyette et al. 2006, Land and Rieske 2006, King and Muzika 2014). Fire suppression allows the establishment of fire-intolerant hardwood species such as oaks, sweetgum, tulip poplar, and red maple (Guyette et al. 2007, Coleman et al. 2008, Clewell 2011). Shortleaf pine recruitment is reduced due to a lack of fire (Gnehm and Hadley 2007). In the southern Appalachians where fire has been reintroduced, recruitment of shortleaf pine is lacking due to the absence of a seed source from mature trees (Land and Rieske 2006).

### *Wildlife and Biodiversity*

The open woodland structure of shortleaf pine ecosystems provides important habitat for wildlife, including game species and many rare and endangered species, and thus is a habitat type of conservation concern for many agency and non-profit conservation groups. Shortleaf pine woodlands have a lower canopy cover, a more diverse understory dominated by grasses and forbs, and greater numbers of bird and animal species (Masters 2007) than shortleaf pine–oak woodlands. The open woodlands are important forage habitat for game species such as white-tailed deer, bobwhite quail, and wild turkey. Bison and elk historically occurred through much of the range of these open shortleaf pine systems (Smith and Neal 1991, NatureServe 2015).

The species that is perhaps best known from shortleaf systems is the red-cockaded woodpecker (*Picoides borealis*). The red-cockaded woodpecker is a federally endangered species that is restricted to an open pine savanna habitat with a diverse understory composition (Conner et al. 1998b, Santos et al. 2010). This non-migratory species requires old-growth pine trees typically infected with red heart fungus for excavating nesting and roosting cavities (Jackson et al. 1979, Jackson 1977). Along with longleaf pine, shortleaf pine can act as nest cavity trees, especially in the northern part of the red-cockaded woodpecker range where longleaf pine is unavailable. In the Ouachita Mountains, management has focused on restoring open shortleaf woodlands as red-cockaded woodpecker habitat through frequent prescribed burning (Conner et al. 1998a, Masters et al. 1998, Guldin et al. 2004). The suppression of fire has resulted in the extirpation of red-cockaded woodpecker from shortleaf ecosystems in Missouri, Kentucky, and Tennessee.

Photo by Ted Borg, South Carolina Wildlife Magazine

Other declining bird species respond positively to management practices similar to those required by the red-cockaded woodpecker (Conner et al. 1998a, Masters et al. 1998, Cram et al. 2002, Guldin et al. 2004, Rudolph 2006, Rudolph et al. 2006, Perry et al. 2009). For example, the Northern bobwhite (*Colinus virginianus*), a species of conservation concern, has been declining throughout its range for five decades (Sauer et al. 2014, Cornell Lab of Ornithology. 2015). The reintroduction of fire following thinning reduces the accumulation of pine and hardwood leaf litter in the understory, promotes herbaceous cover, and maintains an open midstory, all of which improve conditions for northern bobwhite (Cram et al. 2002). Similarly, Bachman's sparrow (*Aimophila aestivalis*), considered to be one of the most rapidly declining bird species in North America (Butcher and Niven 2007), responds positively to prescribed burning because of increased shrub and grass components and open vegetation post-burning (Conner et al. 2005).

There are many other regionally declining, early successional and disturbance-associated bird species that respond positively to management practices that open the structure in shortleaf pine forests. These include red-headed woodpecker (*Melanerpes erythrocephalus*), brown-headed nuthatch (*Sitta pusilla*), prairie warbler (*Setophaga discolor*), pine warbler (*Setophaga pinus*), chipping sparrow (*Spizella passerine*), and eastern wood-pewee (*Contopus virens*) (Masters 2007).

Many other pine savanna obligate species benefit from the structure produced by effective shortleaf pine restoration. In Arkansas, spotted skunks (*Spilogale putorius*) select early-successional shortleaf pine stands over late-successional forest stands (Lesmeister et al. 2009). Small mammal relative abundance is slightly greater on red-cockaded woodpecker managed areas when compared to unmanaged areas, and the small mammal community is generally more diverse on sites post-burn (Masters et al. 1998, Masters et al. 2002, Masters 2007). White-tailed deer (*Odocoileus virginianus*) also use recently thinned and burned areas more frequently than unburned areas, due to the increased forage availability immediately following treatments (Halls 1973). In Arkansas during a 6-year study, big brown bats (*Eptesicus fuscus*) roosted exclusively in shortleaf pine snags, hoary bats (*Lasiurus cinereus*) readily roosted in shortleaf pine snags, and 55% of winter roost sites for silver-haired bats (*Lasionycteris noctivagans*) were in shortleaf pine trees (Perry and Thill 2007, 2008; Perry et al. 2010).

In the Ouachita Mountains, the relatively rare Diana fritillary (*Speyeria diana*) and the common star-spangled fritillary (*Speyeria cybele*) are more abundant on fire-maintained shortleaf pine sites than on control, closed-canopy sites, and migrating monarch butterflies (*Danaus plexippus*), a species that is declining rapidly across its range, occurs more frequently on recently burned sites, likely as a result of increased nectar resources (Rudolph 2006, Rudolph et al. 2006).

The wildlife, bird, and invertebrate diversity of these shortleaf woodlands is driven by the richness of the understory vegetation, which is maintained by frequent fire. The understory vegetation provides food (seed and insect) and nectaring resources for a wide range of species (Masters 2007). The understory may consist of the following grasses (bluestem species [*Andropogon sp.*], Indian grass [*Sorghastrum nutans*], bentgrass [*Agrostis sp.*], three-awngrass [*Aristida sp.*], panicgrasses [*Panicum sp.*], and muhly [*Muhlenbergia* sp.]), legumes (wild indigo [*Baptisia sp.*], tick trefoil [*Desmodium* sp.], bushclover [*Lespedeza* sp.], and goatsrue [*Tephrosia sp.*]), fall blooming composites (goldenrods [*Solidago sp.*], asters [numerous genera], ironweed [*Verbesina sp.*], and boneset [*Eupatorium sp.*]), and shrubs (blueberry [*Vaccinium sp.*], beautyberry [*Callicarpa sp.*], sumacs [*Rhus sp.*], and blackberry [*Rubus sp.*]). Some shortleaf pine communities include some rare and declining plant species, especially when the community is associated with mafic outcrops or tallgrass prairies.

A list of species associated with well-managed shortleaf pine woodland ecosystems across its range can be found in Appendix F.

## ECONOMICS

### *Economics and Forest Products*

The wood quality and its multiple uses make shortleaf pine a valued timber tree. It is used for lumber, plywood, structural materials, and pulpwood (Larson 1990). The species has strong, dense, straight-grained wood, tolerates a wide range of soil and site conditions including droughty sites, and is adapted to fire (Dickens et al. 2005, Campbell 2015, Pickens 2015). It is the most cold tolerant of the southern yellow pines (Schmidtling 2003); because of its shorter needles and flexible branches, it is more resistant to damage from snow and ice storm events than other southern pines.

The wood of shortleaf, when denser and of higher strength, is used in construction of bridges, docks, factories, trestles, homes, and warehouses (beams, joists, piles, posts, roof trusses), while lower density wood is used for interior finish, subflooring, joists, sheathing, boxes, pallets, and crates. When treated, shortleaf is also used for railroad crossties, piles, poles, and mine timbers. Shortleaf pine is particularly good for poles. Forty- to fifty-year-old shortleaf averages 40% poles, about the same as longleaf but twice the percentage of loblolly (White 2006, Dahlen 2015). Shortleaf pine poles are preferred over both species due to a smaller knot size and an excellent taper (White 2006, Dahlen 2015).

While the species has a slower growth rate than loblolly in its first 20 years, it equals and surpasses loblolly in older trees (Pickens 2015). Thus the species is a better timber tree for those interested in longer rotations (Smalley 1986, Pickens 2015). Longer rotations provide the public land managers and private landowner a broad range of management options, including those that combine timber value with wildlife habitat, hunting leases, conservation incentives, and leaving a legacy to future generations. With its many uses at different age classes, shortleaf can provide the landowners substantial flexibility to align income with markets and personal needs (Southern Group of State Foresters 2015).

Today, shortleaf pine remains a substantial timber commodity. In the Eastern U.S. there is significant harvesting of shortleaf pine for timber or land clearing, with nearly 5% of the shortleaf volume reduced since 1980 (Oswalt 2015). The species is experiencing significant harvest levels in Missouri (Treiman 2015). In the Ouachita Mountains, shortleaf pine comprises 46% of the live tree volume and 50% of the growing stock, which represents 67% of the sawtimber board-foot volume of that region (Guldin et al. 2004). The lack of markets in many parts of the range of shortleaf, however, limits the species' timber value.

### *Pests and Diseases*

While southern pines, including shortleaf pine, are susceptible to several pests and diseases, implementing recently developed guidelines for stand site selection and management practices reduce this risk. Shortleaf pine has comparable forest health risks to those of loblolly pine, although more research is needed on the control of pests and diseases (Southern Group of State Foresters 2015).

The most significant disease of shortleaf pine is littleleaf disease, caused by a pathogen (*Phytophthora cinnamomi*) in conjunction with specific site and soil conditions (low soil fertility, heavy clay soils or shallow soils with poor soil drainage, and the presence of nematodes and a specific pathogenic soil fungus; Southern Group of State Foresters 2015). The disease affects trees greater than 20 years of age, typically occurring between years 30 and 50. Symptoms of littleleaf disease are similar to those of nutrient deficiency; infected trees have thinning crowns, needle necrosis, stunted needle growth, and produce over-sized crops of undersized infertile cones; ultimately dying within 6-15 years (Belanger et al. 1986, Southern Group of State Foresters 2015). Historically, littleleaf disease is most prevalent east of the Mississippi River in the Piedmont ecoregion when shortleaf pine is found on heavily eroded clay soils from abandoned agricultural land (Belanger et al. 1986). Careful site selection, site preparation through improving soil fertility and soil drainage, and maintenance of stand vigor are the best defenses (Lawson 1990, Southern Group of State Foresters 2015).

Southern pine beetle (*Dendroctonus frontalis*), a native species that ranges from New Jersey to Florida, and west to Arizona, Mexico and Central America (Thatcher and Barry 1982), occasionally causes tree mortality. The burrowing action of females during ovipositional construction and subsequent feeding by larvae causes damage that essentially girdles the tree. Southern pine beetle also exposes the tree xylem and phloem to deleterious fungi (Klepzig and Wilkens 1997). Infestations are usually localized but can affect hundreds of acres. They are most common in overcrowded, unthinned stands (Guldin 2011, Southern Group of State Foresters 2015). Recommended control methods include cutting and removing infested trees. Periodic thinning of stands and harvesting stands at maturity are the most effective methods to reduce susceptibility to Southern pine beetle infestations (Southern Group of State Foresters 2015).

A pest of young, plantation-grown shortleaf pines is the Nantucket pine tip moth (*Rhyacionia frustrana*). Larva of the moth bore into the leader and branch tips, stunting growth and deforming stems, resulting in substantial reduction of growth and yield (Southern Group of State Foresters 2015). The species, however, may have a short-lived impact on shortleaf, disappearing when the trees attain pulpwood size. Insecticidal controls may not have an economic advantage.

Annosum root rot (*Heterobasidion* root disease) is caused by a fungus (*Heterobasidion irregular*) which infects trees with open wounds. The root rot affects the large roots near the base of the tree, causing death or windthrow (Southern Group of State Foresters 2015). The primary source of the fungus is freshly cut stumps, thus recently thinned stands are the most vulnerable. Risk for the disease varies across soil types and can be controlled through the spacing of trees in plantations, the timing of thinning operations, and the treatment of stumps after thinning.

With proper silvicultural practices and routine monitoring for forest health issues, shortleaf pine can be successfully grown and managed on a variety of sites throughout its range (Southern Group of State Foresters 2015). In natural stands, fire or thinning followed by regular intervals of fire can be used to maintain a healthy density and promote natural shortleaf regeneration.

### *Climate Change*

The climate of the Southeastern and Mid-South sections of the United States will change in future decades. While there are many sources of uncertainty in the climate projections for the region, all predict that temperatures will be warmer, precipitation more variable and intense, and that wildfire events, through extreme drought conditions and increased ignition sources, will be more frequent (Mitchell et al. 2014).

Shortleaf pine has many characteristics that will allow it to thrive in these changing conditions, similar to those of longleaf and loblolly pine (National Wildlife Federation 2009, Mitchell et al. 2014, Landscape Change Research Group 2014). This includes its tolerance of a wide range of soil and site conditions, ability to withstand drought, and adaptation to fire (Guyette et al. 2007, Campbell 2015, Pickens 2015). Modeling potential suitable habitat for shortleaf pine under several global climate models and two emissions scenarios suggest that the species has the potential to increase its abundance in much of its current range and expand northward in Missouri, Kentucky, and West Virginia (Landscape Change Research Group 2014) with the appropriate ecological and silvicultural management.

The characteristics of the species will allow management for ecosystem resilience. Resilient sites are those with a high capacity to adapt to stress while still maintaining species diversity and ecological function (Gunderson 2000).

In shortleaf pine systems, fuels, vegetation structure, and landscape patterning can be managed through fire and thinning to increase resilience (Vose 2015). An emphasis on restoring areas with well-connected sites and a high geophysical diversity will provide a range of ecological conditions for associated wildlife (Anderson et al. 2014).

The restoration of shortleaf pine will provide ecological and economic values for current generations and, even in the face of an uncertain climate future, for many future generations.

Bob Williams, Pine Creek Forestry, Franklin Township, NJ

# The Restoration Plan

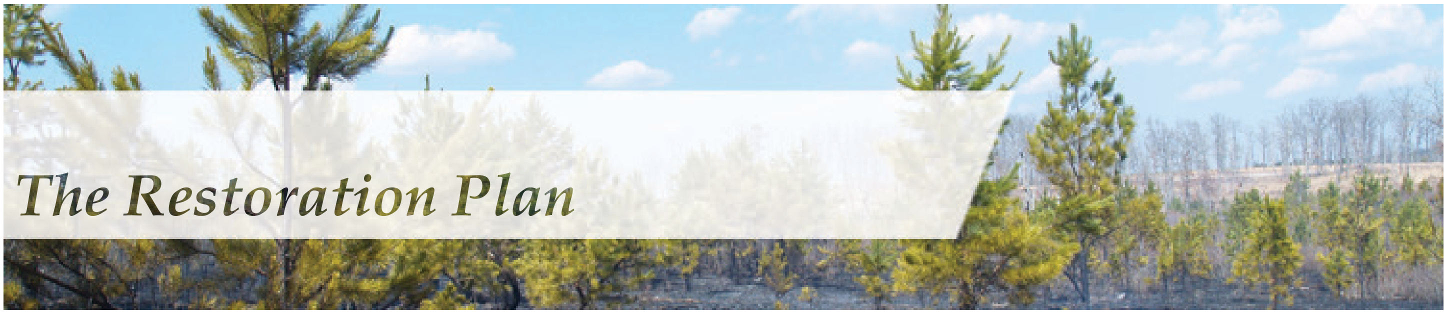


Photo by Clarence Coffey, Bridgestone Firestone Wildlife Management Area, TN

## GUIDING PRINCIPLES

These following principles will guide the implementation and evolution of the Shortleaf Pine Restoration Plan.

***Range-wide Restoration Plan*** **-** The Shortleaf Pine Restoration Plan will provide a range-wide structure that identifies the most significant actions needed to maintain, improve, or restore shortleaf pine ecosystems. The plan is based on the best available science and professional input. It will undergo a rigorous review process, with region-specific adaptive restoration strategies. As components of the plan gain momentum for shortleaf pine restoration, the plan will be reviewed and revised to adapt to new challenges.

***Partnerships and Collaboration*** **-** Successful implementation of the Plan requires the cooperation and collaboration of many individuals, agencies, and organizations at local, state, regional, and national levels. If site-based restoration of shortleaf pine is going to be successful, then public and private partnerships must play a critical role. Additionally, partners must identify region-specific barriers to on-the-ground restoration and develop planning strategies to address the identified barriers.

***Site-based Conservation*** **-** Fundamentally, shortleaf pine restoration will need to target site-specific areas within its range. The Plan will identify key regional practitioners and partners to support restoration efforts. This network of people and organizations will work with private landowners interested in restoration, conduct field days, establish demonstrations of shortleaf pine restoration, share technical information among professionals, and promote site-based conservation actions.

***Strategic and Adaptive Approach*** **-** Ultimately, the success of any restoration plan will be determined through achievement of defined measurable objectives and outcomes.

The detailed components of the shortleaf pine restoration plan, including objectives and key actions to achieve those objectives, follow sections on defining restoration and the approach of the plan.

## DEFINING RESTORATION

In order to maintain, improve, or restore shortleaf pine across its range, we must identify and define what “restoration” means in terms of specific temporal and spatial conditions for the species and goals. Shortleaf pine occurs across a broad geographic range and under a variety of abiotic conditions within many different forest associations. Often, historical conditions are used as a reference for species restorations. It is often impractical to attempt to restore a species or ecological system to past conditions, given that present limiting factors may not be the same as those in the past. Thus, it is more informative to explicitly define desired species or ecological system conditions prior to restoration efforts, and base desired conditions on the current status of the species or ecological system of interest. The limiting ecological factors that will influence desired conditions should then become the focus of how to proceed with a restoration plan. For shortleaf pine, it is ecologically relevant and practical to consider Shortleaf pine or Shortleaf pine–Oak forests which both occur east and west of the Mississippi River as four shortleaf pine restoration categories. Additionally, within each of these four restoration categories, Shortleaf pine or Shortleaf pine–Oak forests will occur along a gradient of fire disturbance. Different fire regimes with respect to intensity, frequency, and season of burn will have different effects on Shortleaf pine or Shortleaf pine–Oak forests. Under certain restoration prescriptions, Shortleaf pine or Shortleaf pine–Oak forests can become very open and considered woodlands whereas alternate restoration prescriptions could maintain or result in a closed-canopy Shortleaf pine or Shortleaf pine–Oak forest. Determining the current status and condition of existing Shortleaf pine or Shortleaf pine–Oak forests will be foundational to guiding this restoration plan process. In all cases, restoration must be based on site-specific constraints and landowner objectives.

## PLAN APPROACH

In 2010, a diverse group of resources management leaders from across the shortleaf pine range formed the Shortleaf Pine Working Group to begin to define and identify the status of, as well as threats and barriers to, maintaining, improving, or restoring Shortleaf pine or Shortleaf pine–Oak systems. The group gathered regional information and resources about shortleaf pine and highlighted the extensive and rapid range-wide loss of the species. Additionally, the Shortleaf Pine Working Group identified critical ecological, economic, and social issues of importance to shortleaf pine conservation. As a result of the Shortleaf Pine Working Group's efforts, a Shortleaf Pine Conference was held in Huntsville, AL in 2011 (Kush et al. 2012). The conference was successful in attracting more than 120 resource managers and convincing them that an investment in extensive range-wide shortleaf pine conservation was warranted.

### *Workshop Results*

Four workshops were held in different sections of the shortleaf pine range between June 2013 and June 2014. During the workshops, participants identified the status of, as well as threats and barriers to, restoration of shortleaf pine ecosystems in their regions. Although these key components varied in priority across the range, the following lists were common to all workshops.

**Current Status of Shortleaf Pine and Associated Ecosystems**

- Pure stands of Shortleaf pine are more common west of the Mississippi River
- Declining range-wide
- Minimal private lands management for shortleaf pine
- Lack of shortleaf pine recruitment and regeneration
- Younger shortleaf pine age-class is absent or disappearing
- Lack of appropriate disturbance and management
- Shortleaf pine is often considered co-dominant in mixed-hardwoods forests. However, due to a lack of disturbance, forest composition has shifted toward oak dominance
- Shortleaf pine is being outcompeted by hardwood and other pine species (e.g., loblolly)

**Threats to Shortleaf Pine Habitats/Ecosystems**

- Altered fire regime/lack of prescribed fire/fire suppression
- Conversion to intensive (mostly loblolly) plantation silviculture
- Genetic swamping (loblolly)
- Conversion to urban-suburban or other non-forest uses
- Lack of familiarity (public and professional) with shortleaf pine
- Poor timber markets (lack of resources for public and private landowners to manage forests)
- Southern pine beetle outbreaks

**Barriers to Shortleaf Pine Restoration**

- No plan for shortleaf pine restoration
- Lack of funding and personnel for prescribed fire/smoke management
- Economic hurdles, especially with private landowners
- Fear of additional southern pine beetle outbreaks
- Lack of resources and trained personnel familiar with shortleaf pine restoration
- Poor seedling quality/low survival
- Lack of fundamental research about shortleaf pine restoration in different forest systems

The information from the following workshops has been incorporated into the Plan:

- Central Range (AL, FL, GA, KY, OH, SC, TN), held June 27-28, 2013, in Knoxville, TN
- Eastern Range (OH, NC, VA, WV), held October 11-12, 2013 in Roanoke, VA
- Western Range (AR, IL, LA, MO, MS, OK, TX), held December 4-5, 2013, in Ft. Smith, AR
- Northeastern Range (DE, MD, NJ, PA), held June 10-11, 2014, in Waretown, NJ

## RANGE-WIDE OBJECTIVES OF THE SHORTLEAF RESTORATION PLAN

During the regional workshops, participants developed a list of priority components for shortleaf pine restoration based on collectively identified **Status, Threats, and Barriers**. The eight components listed below were common to all regions:

1. **Partnerships**
2. **Public Lands**
3. **Private Lands**
4. **Economic Sustainability**
5. **Ecological Sustainability**
6. **Public Relations, Communication, and Outreach**
7. **Evaluation of Plan Actions**
8. **Implementation of the Plan**

**Partnerships**: Shortleaf pine workshops and conferences have been occurring within states and regionally for a number of years. Many local and state partnerships already exist. A range-wide partnership has been developed to compose the Shortleaf Pine Restoration Plan. Working within and maintaining this supportive community is a priority for the Initiative. Providing a framework for technical workshops for professionals was the number one request during the four workshops.

**Objective**: Develop and maintain range-wide and regional partnerships that will facilitate plan implementation, share information about best practices and challenges to Maintain, Improve, and Restore Shortleaf pine or Shortleaf pine–Oak woodlands or forests, and obtaining funds.

**Key Action**: Identify and work with key partners to create and maintain support for increased cooperation in shortleaf pine ecosystem conservation, annually.

**Key Action**: Maintain biennial Shortleaf Pine Conference.

**Key Action**: Schedule technical meetings at least annually in states west of the Mississippi River (AR, LA, MO, OK, TX) to engage and develop partnerships and where professionals can exchange information about how to overcome barriers to implementing shortleaf pine restoration.

**Key Action**: Schedule technical meetings at least annually in states east of the Mississippi River (AL, DE, FL, GA, KY, MD, MS, NC, NJ, PA, SC, TN, VA, WV) to engage and develop partnerships and where professionals can exchange information about how to overcome barriers to implementing shortleaf pine restoration.

**Public Lands Assessment and Management**: The best opportunities for Shortleaf pine or Shortleaf pine–Oak woodland or forest restoration at large geographic scales exist on public lands. Approximately 38% of existing shortleaf pine occurs on public lands. However, range-wide inventory and assessment of current shortleaf pine forest condition is lacking.

**Objective:** Establish Shortleaf Pine Restoration Areas (SPRA), which are defined as areas where there is significant opportunity to Maintain, Improve, and Restore Shortleaf pine or Shortleaf pine–Oak woodland or forest and that can serve both as laboratories and demonstration areas for best practices for shortleaf pine at a landscape scale.

**Key Action**: Conduct a range-wide assessment of current on-the-ground conditions of Shortleaf pine or Shortleaf pine–Oak systems to identify appropriate SPRA and determine if areas are to be Maintained, Improved, or Restored to woodlands by end of Year 0.5.

**Key Action**: Develop desired ecological conditions and response metrics to assess current conditions and progress in SPRA, by end of Year One.

**Key Action:** Initiate implementation of 5 SPRA (2 western and 3 eastern) by end of Year Two.

**Key Action**: Implement restoration plans in SPRA over 5-year period.

**Key Action**: Collect post-treatment data to assess the success of SPRA plan implementation on an annual basis.

**Private Lands Assessment and Management**: Approximately 62% of Shortleaf pine and Shortleaf pine–Oak woodlands and forests occur on private land, thus there is an excellent opportunity for potential restoration. Foresters typically recommend loblolly pines for landowners who desire an economic benefit from their forested lands, but shortleaf pine can be a viable economic option. For Shortleaf pine or Shortleaf pine–Oak woodland or forest restoration to be successful on private lands, economically viable restoration options must be available to landowners, and foresters must be educated about these options.

**Objective**: Identify 5 SPRA (2 west and 3 east of the Mississippi River) on private lands that are within close proximity to public land SPRA. Identified private lands would ideally be those forest types that are underrepresented on public lands.

**Key Action**: Complete assessment of the condition of Shortleaf pine and Shortleaf pine–Oak areas on private lands within close proximity to public lands for 5 designated Private lands SPRA to Maintain, Improve, or Restore, by end of Year One.

**Key Action**: Engage local foresters and private lands biologists in private lands restoration processes on an annual basis.

**Key Action:** Initiate implementation of 5 private lands SPRA (2 western and 3 eastern), by end of Year Two.

**Economic Sustainability**: Shortleaf pine was once a valued timber crop and ranks second to loblolly pine for total softwood harvested in the southeast. It produces high quality sawtimber that can be used for lumber, plywood, and structural materials, as well as pulpwood. Though it is slower growing than loblolly pine, it can still be managed for economic benefit in a forested landscape.

**Objective**: Identify regional economic opportunities for shortleaf pine products and ecosystem services that are available for private landowners.

**Key Action**: Identify potential cost-share programs for private landowners to Maintain, Improve, or Restore Shortleaf pine and Shortleaf pine–Oak areas, by end of Year One.

**Key Action**: Conduct and complete a market assessment for shortleaf pine timber in SPRA project areas, by end of Year Two.

**Key Action**: Conduct economic analyses using existing models but with updated (where available) growth and yield data and simulate different management scenarios for shortleaf pine restoration activities, by end of Year Three.

**Key Action**: Identify alternative non-consumptive economic benefits for shortleaf pine ecosystems such as wildlife, hunting leases, carbon sequestration credits, and water quality benefits, by end of Year Two.

**Ecological Sustainability**: Shortleaf pine is an important ecosystem component for many woodland types across its range. Fire is the major disturbance that contributes to the maintenance of Shortleaf pine and Shortleaf pine–Oak woodlands. For the Shortleaf Pine Restoration Plan to be successful, fire must be included as a forest management prescription. However, there are challenges to widespread use of fire in many portions of shortleaf pine range. These include regulatory, smoke management, and public support for prescribed fire. Additionally, there are logistical challenges including, availability of trained crews, limited manpower, planning, and sufficient financial resources. Fortunately, there are fire partnerships, organizations, consortiums, and networks that support prescribed burning across the shortleaf pine range. The SPI can utilize these resources and draw from their expertise.

Because shortleaf pine occurs across a broad range and in different forest types, ecological sustainability requirements will vary geographically. For instance, information about shortleaf-longleaf pine and shortleaf pine–hardwood ecosystems is limited, though there is a substantial body of research and knowledge about shortleaf pine in the western part of its range. Thus, ecological restoration of shortleaf pine in the eastern, southeastern, and northern parts of its range may require additional research. Climate change may yet play a role in ecological sustainability of future shortleaf pine systems, though there is limited research about this topic.

**Objective**: Create and maintain the capacity to apply prescribed fire to Maintain, Improve, or Restore Shortleaf pine and Shortleaf pine–Oak systems throughout its range.

**Key Action**: Conduct research and/or document impacts of fire intensity, frequency, and seasonality on Shortleaf pine and Shortleaf pine–Oak systems.

**Key Action**: Use the 5 public SPRA to demonstrate use of prescribed fire in shortleaf restoration and management, annually following initial implementation of these 5 sites.

**Key Action**: Support the development of statewide partnerships to build capacities to facilitate fire restoration, annually in at least five states.

**Key Action**: Work with state fire councils to maintain the use of fire in open shortleaf pine systems, annually in at least five states.

**Key Action**: Work proactively with existing fire coalitions that are experienced with smoke management and EPA regulatory standards to eliminate barriers to burning associated with smoke management issues/regulations, annually in at least five states.

**Key Action**: Develop Best Management Practices (BMP) for prescribed fire in shortleaf pine ecosystem restoration tailored for public and private lands, by end of Year Two.

**Objective**: Use fire to promote recovery of an herbaceous understory and regeneration of desirable overstory species.

**Key Action**: Use the 5 public SPRA to demonstrate herbaceous understory response to fire frequency and stages of shortleaf pine restoration post-fire disturbance, annually following initial implementation of these 5 sites.

**Key Action**: Develop protocols that will restore a shortleaf pine co-dominant/dominant overstory in Shortleaf pine–Oak and Oak –shortleaf pine systems, by end of Year Two.

**Key Action**: Explicitly target longleaf pine conservation groups to ensure the incorporation of shortleaf pine into future longleaf pine prescribed fire restoration plans on an annual basis.

**Objective**: Use research to develop restoration strategies for eastern, extreme western, and northwestern portions of the range where hardwoods are, and likely were, an important component of shortleaf forests.

**Key Action**: evaluate restoration strategies on a variety of sites/forest conditions in the eastern portion of the range to determine the response of shortleaf, hardwoods, and ground layer components, beginning in Year Two.

**Key Action**: based on this research, develop technical guidance for landowners and managers for shortleaf pine–hardwood management, by end of Year Four.

**Objective**: Use research to gain insight into the likely impacts of climate change on shortleaf pine ecosystems.

**Key Action**: Model climate change scenarios and their potential effects on shortleaf pine ecosystems range-wide, by end of Year Two.

**Key Action**: Develop protocols for shortleaf pine ecosystem restoration and for existing shortleaf given varying climate change scenarios, by end of Year Two.

**Public Relations, Communication, and Outreach**: In order for the Shortleaf Pine Restoration Plan to have an impact at a landscape scale, there must be an aggressive public education and outreach campaign. The ability to communicate with a diverse audience that includes resource management professionals, private landowners, the general public, and industry professionals will be fundamental to successful implementation of the Shortleaf Pine Restoration Plan. Additionally, development of outreach strategies through teaching, demonstration sites, and media promotions will be integral outreach components.

**Objective**: Educate public and private entities about Shortleaf pine and Shortleaf pine–Oak systems. Determine who target audiences are, specifically within areas surrounding shortleaf pine demonstration sites.

**Key Action**: Maintain an active and supportive Advisory Committee, including an annual meeting.

**Key Action**: Schedule shortleaf pine presentations so individuals interested in SPI have opportunities to learn and interact with restoration efforts on an annual basis.

**Key Action**: Maintain a SPI website for practitioners and interested parties to find relevant shortleaf pine information and contact information.

**Key Action**: Conduct at least 5 public outreach sessions including field days, in-service trainings, and tours for each SPRA in conjunction with key partners on an annual basis.

**Objective**: Make materials for shortleaf pine restoration available through communication and outreach.

**Key Action**: Summarize pre-existing shortleaf pine information and literature through a series of published products, by end of Year One.

**Key Action**: Develop range-wide marketing materials, by end of Year One.

**Key Action**: Develop technical bulletins and materials that are available on the website and that are disseminated at workshops and meetings to cover topics identified in this plan: restoration for private landowners, growth and harvest plans under different economic scenarios; regional market availability for shortleaf pine timber; Best Management Practices (BMP) for prescribed fire; protocols that will restore a shortleaf pine co-dominant/ dominant overstory in hardwood systems; protocols for shortleaf pine–hardwood management; guidelines for natural shortleaf pine regeneration; and responses to climate change scenarios, by end of Year Three.

**Evaluation of Plan Actions**: Strategic monitoring and successive adaptive management will be required to determine success of shortleaf pine restoration actions in achieving objectives on SPRA. The Initiative must stay involved with public and private partners to ensure desired shortleaf pine ecosystem conditions are achieved.

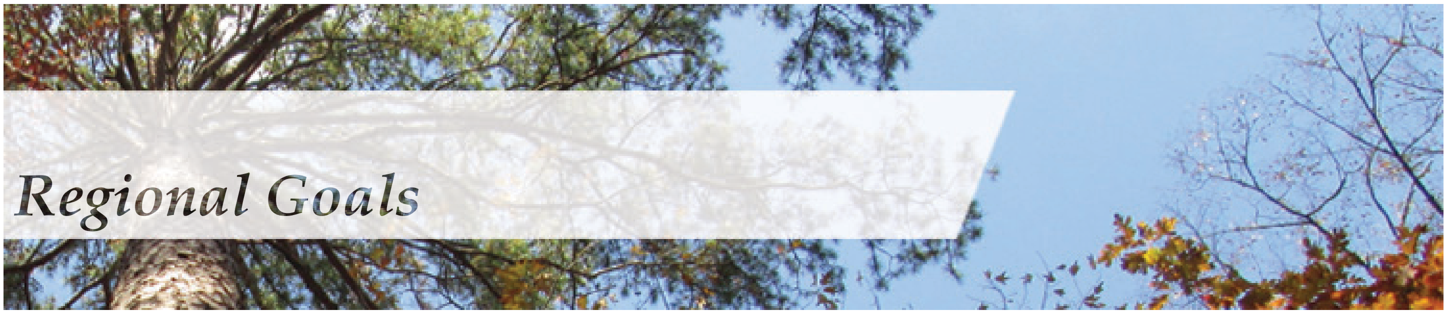
**Key Action**: Continually gather feedback from partners and practitioners about the Shortleaf Pine Restoration Plan and identify areas for improvement.

**Key Action**: Prepare a report that addresses progress against goals for all six plan components addressed above, annually by October 31.

**Implementation of the Plan**: Within 5 years, the Shortleaf Pine Restoration Plan and SPRA as described in this plan will be entirely completed. Support teams at local and state levels will carry out on-the-ground implementation. A voluntary working group will provide logistical support for local and state efforts.

**Key Action**: Create a formal institutional structure for the Shortleaf Pine Initiative, by end of Year One.

**Key Action**: Coordinate implementation of all **Key Actions** described in this plan on an annual basis.



# Regional Goals

Photo by Holly Campbell, Southern Regional Extension Forestry, GA

The range of diversity in the historic and current condition of shortleaf pine woodlands and the current context of restoration necessitates a regional approach to the development of goals, desired future conditions, and appropriate strategies. The circumscription of these regions is ongoing.

Included in this version of the Plan are the goals for the Interior Highlands Region, the West Gulf Coastal Plain, and the regions east of the Mississippi River. The I**nterior Highlands Region**, also referred to as the Ozark-Ouachita Region, encompasses four Level III ecoregions: the Ozark Highlands, the Boston Mountains, the Arkansas Valley and the Ouachita Mountains in the states of Arkansas, Missouri, and Oklahoma (U.S. Environmental Protection Agency, 2013). This region has some of the most extensive stands of shortleaf pine.

The **West Gulf Coastal Plain** ecoregion extends across southeastern Arkansas, southwestern Oklahoma, western Louisiana, and eastern Texas. The area reaches from the Arkansas River Valley in Arkansas and Oklahoma in the north to the coastal prairies and marshes in Louisiana and Texas to the south, and from the Mississippi Alluvial Valley in the east in Arkansas and Louisiana, and west to the Oaks and Prairies in Oklahoma and Texas. Historically, shortleaf pine mixed with oaks (*Quercus spp*.) and hickories (*Carya spp*.) was the predominant pine forest type outside of areas dominated by longleaf pine. Much of the shortleaf pine has been replaced by loblolly pine (Jim Neal, U. S. Fish and Wildlife Service, Nacogdoches, TX).

The area **east of the Mississippi River** encompasses a diverse landscape from the Cumberland Plateau and Ridge and Valley to the Southeastern Plains and the Southern and Northern Piedmont ecoregions. (U.S. Environmental Protection Agency, 2013). Common to these ecoregions is that shortleaf pine has been greatly reduced in abundance and distribution. In the future, this region may be divided into smaller units more appropriate for strategic actions and agency leadership.

## GOALS FOR THE INTERIOR HIGHLANDS ECOREGION

### The Interior Highlands Region

The Interior Highlands, also referred to as the Ozark-Ouachita Region, encompasses four broad-scale (Level III) ecoregions: the Ozark Highlands, the Boston Mountains, the Arkansas Valley, and the Ouachita Mountains (Omernik, J. M. 1987, U.S. Environmental Protection Agency, 2013; Figure 8).

The Ozark Highlands ecoregion occupies most of southern Missouri and extends into northwestern and north-central Arkansas. It is comprised of dissected plateaus that resulted from erosion of a geologic dome uplifted during the Paleozoic era, along with the St. Francis Mountains, the granite core of the Ozarks. The Boston Mountains ecoregion extends from north-central Arkansas into Oklahoma. It is the highest and youngest of the Ozark plateaus, and the most ruggedly dissected. The Ouachita Mountain ecoregion, extending from central Arkansas west into eastern Oklahoma, has been extensively folded and faulted, resulting in the distinct east-west ridges that are evident in the landscape today. The Arkansas Valley ecoregion, a structural valley but much modified by the Arkansas River, lies between the Boston Mountains and Ouachita Mountains in west-central Arkansas, and extends into eastern Oklahoma.

Oak-hickory forests and woodlands currently predominate throughout much of the Ozarks, with mixed pine–hardwood or pine communities more common in the Ouachitas. Prairie grasses and forbs are found in the understory of woodlands that are subject to recurrent fire. Glades and barrens occur throughout the region where thin soils and dry exposures limit woody growth. Although warm-season grasses and a diversity of forbs characterize glades, eastern redcedar (*Juniperus virginiana*) and Ashe's juniper (*Juniperus ashei*) invade glades during fire-free intervals. Their presence gave rise to the term "cedar glades," which often is used colloquially.

The Ozark Highlands (Level III) ecoregion is comprised of eleven Level IV ecoregions that are differentiated by geologic history, topography, drainage, soils, biota and other features. Elevations range from 144-650 m (400-1800 ft.) above sea level, with local relief of 100 or more meters (300 ft.) typical of the region. The potential natural vegetation is pine, mixed pine–hardwood, oak-hickory forests and woodlands, prairie and glade-woodland complexes. The Missouri range of short-leaf pine (*Pinus echinata*) is centered in the Ozarks of south-central Missouri (Thom and Wilson 1983).

The Boston Mountains (Level III) ecoregion is comprised of two Level IV ecoregions distinguished by elevation, temperature, precipitation, biota and other features. Gorges and ravines up to 385 m (1250 ft.) in depth are common. The juxtaposition of forest and woodland types across the Boston Mountains are determined largely by topography. South-to-west facing slopes on sandstone often are dominated by shortleaf pine mixed with drought-tolerant hardwoods such as blackjack oak (*Quercus marilandica*), post oak (*Quercus stellata*), and black hickory (*Carya texana*), while white oak (*Quercus alba*), northern red oak (*Quercus rubra*), and black oak (*Quercus velutina*) are dominant on other slopes. American beech (*Fagus grandifolia*), basswood (*Tilia sp.*), and umbrella magnolia (*Magnolia tripetala*) can be found in deep hollows, ravines, and other mesic sites, principally in the Upper Boston Mountains (Level IV) ecoregion.

The Arkansas Valley ecoregion occupies a transitional zone between the Ozarks and Ouachitas. The (Level III) Arkansas Valley is comprised of four Level IV ecoregions distinguished by topography, biota, and other features. While a large part of the valley is undulating lowland, flat-topped synclinal mountains, remnants of eroded plateaus, and long ridges also are present. The highest elevation in the state is on Magazine Mountain, an isolated, flat-topped mountain within the Arkansas Valley. South-to-west facing slopes on sandstone are often dominated by shortleaf pine along with drought-tolerant hardwoods, while upland hardwood forests are dominant on other slopes. Extensive prairies occurred on undulating topography over shale. Bottomland hardwood forests and swamps can be found along the Arkansas, Petit Jean, and Fourche rivers, and seasonally wet-dry hardwood flatwoods occur on poorly-drained flats above the floodplains.

The Ouachita Mountains ecoregion is characteristically a ridge and valley system of east-west trending mountains lying to the south of the Arkansas Valley. The Level III ecoregion is comprised of five Level IV ecoregions distinguished by topography, geographic substrate, drainage, biota and other features. The Fourche Mountains, the most northern of the Level IV ecoregions, occupy more than half of the Natural Division and have the most typical character, with high east-west trending ridges separated by wide valleys having a relatively large, low-gradient stream that follows the structural valley. Local relief can be as much as 540 m (1800 ft.). Pine–Oak and oak-hickory forests and woodlands occur in repeating east-west bands on the slopes of the ridges, although purer stands of shortleaf pine occur on sites with large areas having few barriers to fire propagation. Prairies appear never to have been common, although bluestem grasses are associated with glades, savannas, and woodlands. Mesic vegetation is restricted to steep, north-facing, protected slopes.

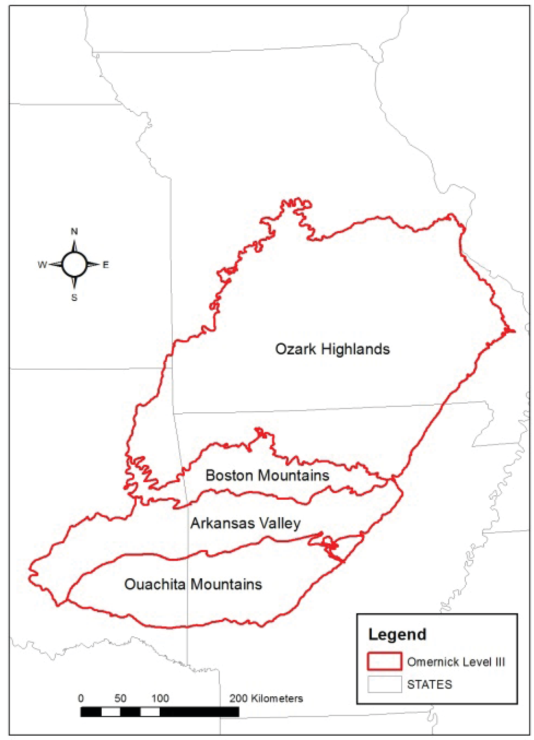



***Figure 8.*** *Ecoregions of the Interior Highlands.*

**History of Shortleaf Pine in the Interior Highlands Region**

Shortleaf pine is the only pine native to the Interior Highlands, with the exception of a relatively small acreage of loblolly pine found on limited, moist sites in the Ouachita Mountains. Shortleaf pine–bluestem and pine–Oak woodlands once occurred in very large acreages and across vast landscapes in the Interior Highlands, favored by periodic, large-scale fires (Guldin 2007, Guyette et al. 2007). Euro-American settlement of the Ozark/Ouachita region began in the early 1800s, although the population grew more rapidly in the latter part of the century after railroads reached the region (Stroud and Hanson 1981, Smith 1986, Stone County Historical Society 1989, Cunningham 2007). Shortly thereafter, a logging boom ensued, and by 1909, Arkansas ranked 5th in the nation for lumber production (Smith 1986). The bulk of the state's production consisted of shortleaf pine harvested in the Ouachitas. Large volumes of oak were cut in areas where deciduous forests predominated; 500,000 white-oak railroad ties, for example, were shipped via rail from a small town in the White River subdivision of Missouri in 1912 alone (Stone County Historical Society, 1989).

The virgin timber supply was largely exhausted in the region by the 1920s and further west by the 1940s. Natural regeneration occurred, although the stands were characteristically even-aged and/or the original species composition altered. Vast acreages also were planted with pine seedlings, mostly loblolly pine. Fire suppression was encouraged throughout the region to protect tree seedlings and saplings (Smith 1986, Palmer 1991). Some cut over areas were converted to agricultural uses, primarily for livestock production in the uplands and to cropland in the bottoms.

Prior to the 1990s, especially on the national forests, even-aged management, or "clear cutting," was the most widely used silvicultural prescription for managing forests. This began to change when the USDA Forest Service adopted a "New Perspectives and Ecosystem Management" approach following a visit by then Chief F. Dale Robertson to the Ouachitas in 1990 (Robertson 2004). Other management techniques (e.g. group selection and shelterwood cuts) began to be tested as methods for managing pine systems in the Interior Highlands during the 1990s and were the focus of a symposium on ecosystem management in the Interior Highlands in 1999 (Guldin 2004).

The role of fire in structuring historic shortleaf pine communities was also coming to the attention of managers, but the concept was adopted more slowly. Mark Twain National Forest staff, for example, noticed very positive grass and forb effects following a wildfire in pine woodlands in the early 1980s. Both excited and curious about the effects of the fire and its implications for the ecosystem, Forest Service staff selected two relatively small sites for pine woodland demonstration areas. They burned a 118 acre site in the spring of 1987, 1989 and 1992 following thinning with horses in 1986, and another 139 acre site in spring of 1988, 1989 and 1992, again following understory thinning (Paul Nelson, personal communication).

The listing of the Red-cockaded Woodpecker, a pine–woodland obligate, as federally endangered played a key role in terms of increasing interest in pineland restoration projects around that time; the development of a recovery plan for the species, beginning in 1985, helped identify the scale at which restoration would be needed, as well as the structural characteristics that managers would need to work toward. The Ouachita National Forest, with a small population of the woodpecker, committed to the restoration of some 250,000 acres of shortleaf pine–bluestem ecosystems with the revisions of their forest plans in 1994, 1996, 2002, and 2005 (Hedrick et al. 2007).

In 1998, managers began work to identify sites and landscapes with the best restoration potential in the Missouri Ozarks as well. The Nature Conservancy developed and implemented a rapid ecological assessment technique to identify those sites with the best restoration potential based upon their current condition, remnant vegetation, and floristic quality, and determined that the only opportunities to recover Missouri's historic pineries at a large or landscape-scale were on the Mark Twain National Forest (Ladd et al. 2007). The assessment led to the selection of the Pineknot project area in Carter County, Missouri, initially targeting a tract of more than 12,000 acres, although the thinning and burning needed to restore the woodlands at Pineknot weren't fully implemented until 2006.

By the early 2000s, pine–bluestem and pine–Oak restoration had gained traction among a wide array of conservationists in both Missouri and Arkansas. By 2005, both states had completed their first State Wildlife Action Plans, which emphasized natural community restoration of glade-woodland complexes, oak woodlands, and pine and oak-pine woodlands. The number of acres that could be treated, however, was limited by the amount that management agencies on both sides of the state line could fund in addition to their traditional responsibilities. A cross-border partnership came together and successfully applied for a Doris Duke Foundation grant to not only accelerate the habitat work, but also to foster better regional communication and coordination (Nigh 2007). Once those funds were expended, however, outside funds for restoration work remained largely unavailable and the partnership ceased to meet.

In 2009, an opportunity to secure significant funding for woodland restoration work was made available through passage of Title IV of the Omnibus Public Land Management Act and establishment of the Collaborative Forest Landscape Restoration Program (CFLRP). The CFLRP, administered by the U.S. Forest Service, was intended to encourage collaborative, science-based ecosystem restoration of priority forest landscapes on and around National Forest lands across the United States. Re-establishing natural fire regimes to reduce the negative consequences of uncharacteristic wildfire are also part of the goal. As a result, up to $40 million can be appropriated annually from 2009-2019, with up to 4 million a year available for any particular project.

**Development of the Interior Highlands SLP Restoration Initiative**

The opportunity to secure significant levels of funding for accelerating shortleaf pine and pine–Oak restoration through the CFLRP, with its emphasis on partnerships and collaboration, provided a renewed incentive for land-managing agencies and organizations with a focus on natural community restoration of shortleaf systems in the Interior Highlands to come together once again. Partnerships formed in the Missouri Ozarks, Arkansas Ozarks, and Ouachitas in support of each national forest's CFLRP proposal, and in January 2011, key federal, state, and non-governmental organizations and agencies were brought together by the Central Hardwoods Joint Venture in an effort to communicate and collaborate on shortleaf-related restoration efforts across the Interior Highlands as a whole.[1]

A subcommittee consisting of community ecologists from multiple agencies in both states was tasked with developing a set of desired future conditions, or DFCs, for pine–bluestem and pine–Oak communities as a result of the 2011 meeting. The draft DFCs were presented to the larger partnership at its second meeting in April 2012 (see Appendix G). By the time of the April meeting, all three National Forests in the region had been awarded more than $2 million in funding, via the CFLRP or related programs, for restoration work in 2012, with the potential for that amount or more each year, through 2019. If congress continues to support and fund the CFLRP, more than 500,000 acres of pine and pine–Oak woodlands should be well on its way toward restoration within the next decade on National Forest lands alone. In more recent years, the partnership has continued to meet periodically to communicate successes and challenges and consider new needs and opportunities to keep pine restoration moving forward.

*The Partnership's Capacity*

*Number of Partners and Varied Expertise:* As of spring 2015, numerous state and federal wildlife and land-managing agencies, non-governmental organizations, and a university have been represented at meetings of the Interior Highlands Shortleaf Pine Restoration Initiative (IHSLPI; Table 1). This diverse group reflects expertise in timber management, restoration ecology, community ecology, research, wildlife conservation and private lands programs, exemplifying the depth and breadth of the partnership and its ability to integrate the multiple facets of a restoration enterprise.

| |
|---|
| American Bird Conservancy |
| Arkansas Forestry Commission |
| Arkansas Game and Fish Commission |
| Arkansas Natural Heritage Commission |
| Central Hardwoods Joint Venture |
| L-A-D Foundation |
| Lower Mississippi Valley Joint Venture |
| Missouri Department of Conservation |
| Missouri Department of Natural Resources |
| National Bobwhite Conservation Initiative |
| Natural Resource Conservation Service |
| Oak Woodlands and Forests Fire Consortium |
| Shortleaf Pine Initiative |
| Southeast Conservation Adaptation Strategy |
| The Nature Conservancy |
| University of Missouri, Columbia |
| U.S. Fish and Wildlife Service |
| U.S.D.A. Forest Service (National Forests) |
| U.S.D.A. Forest Service (Research Stations) |

***Table 1.*** *Agencies and organizations associated with the Interior Highlands Shortleaf Pine Restoration Initiative.*

1 The Central Hardwoods Joint Venture, a public-private partnership for bird conservation (see www.chjv.org), has targeted shortleaf pine and pine-oak systems as natural communities capable of providing high-quality habitat for several bird species of conservation concern, including the Red-cockaded Woodpecker, Bachman's Sparrow, Brown-headed Nuthatch, and Prairie Warbler, Northern Bobwhite, and others. While the CHJV's mission is to conserve viable populations of priority bird species within the Central Hardwoods Bird Conservation Region, it also recognizes the importance of shortleaf restoration to support other flora and fauna of conservation concern (see Masters 2007).

The vision, mission and operating principles of the IHSLPI have been defined as follows:

*<u>Vision</u>* - A future where shortleaf pine and associated natural communities regain prominence, enhance biodiversity, and provide sustainable natural resource commodities throughout their historic range within the Interior Highlands region.

*<u>Mission</u>* - Provide a forum for professional land managers, research scientists and others to work together to advance the restoration of shortleaf pine and pine–Oak communities within the Interior Highlands of Arkansas, Missouri and Oklahoma for the benefit of biodiversity and people.

*<u>Operating Principles</u>* - In working to fulfill our Vision and Mission, the Interior Highlands Shortleaf Pine Restoration Initiative embraces the following operating principles:

- *Science-based Foundation* – Our actions and decisions are firmly rooted in science.
- *Strategic and Adaptive Approach* – Restoration is targeted to those sites and landscapes most capable of recovering and sustaining shortleaf pine and associated natural communities over the long term. Our practice of conservation incorporates evaluation and adaptive learning.
- *Partnerships and Collaboration* – Our diverse partnership will share our experiences in shortleaf pine restoration with each other and our constituents to promote effective management practices suitable to the restoration of shortleaf pine and associated natural communities.

**Criterion and Acreage Goals for the Interior Highlands**

Shortleaf Pine Natural Communities in Interior Highlands (AR/MO/OK) region:

<u>Natural Community Definition</u>*:* Natural communities are distinct assemblages of native plants, animals and microorganisms that occur in repeatable and often mappable patterns across the landscape. Interior Highlands natural communities in which shortleaf pine is dominant or important are the result of specific combinations of factors related to soils, bedrock and disturbance patterns (e.g. drought, fire, wind and ice storms). Shortleaf pine occurs primarily within dry and dry-mesic chert, sandstone and igneous woodlands across Missouri, but also occupies igneous and sandstone glades and igneous, chert and sandstone cliff tops. It occurs in similar sites in the Arkansas Ozarks, except that igneous substrates are lacking, and novaculite provides a unique substrate. In the Ouachitas, it is typically on south-facing aspects of extensive east-west trending ridges, and pine–dominated areas are typically larger than in the Ozarks. Mixed hardwood-pine communities are relatively more common in the Ozarks than in the Ouachitas (Guldin 2007).

While drought, wind, and ice storms influenced shortleaf pine ecosystems, fire was the most consistent disturbance. Fire regimes are affected by site conditions described above and involve variability in intensity, seasonality (time of year), and frequency (time between fires). Large-scale fires occurred over portions of the landscape roughly every 20-40 years, in conjunction with severe droughts.

The purpose of restoration is to recover the biodiversity associated with these shortleaf community types, especially the highly diverse grass/forb component of the groundcover (Masters 2007). Not all shortleaf restoration work in the Interior Highlands is focused on recovering biodiversity and natural community structure and function per se, but that is a main impetus for the work on some state agency lands as well as the three National Forests, where the acreage targeted is by far the greatest.

Following the development of the IHSLPI in 2011, a subcommittee consisting of community ecologists from multiple agencies in both states was tasked with developing a set of DFCs for pine–bluestem and pine–Oak communities (see Appendix G: Desired Future Conditions for Shortleaf Pine Communities in the Interior Highlands). For the public lands, acreage targets are presented here as “at or near desired condition,” “restoration (thinning and/or burning) implemented,” or “restoration is planned but not started” (Table 2). Acreage targets are provided for the following three pine and pine–oak combinations:

<u>Shortleaf pine–bluestem</u>*:* This shortleaf association exhibits the most open canopy condition of the three described here, as a result of frequent fires of varying intensity and seasonality that serve to control most other woody growth. The herbaceous ground cover is abundant. These communities occur on less dissected landscapes where larger areas of relatively gentle topography allowed for greater and more frequent disturbances, especially from fire. Pine comprises roughly 85% of the canopy and canopy cover typically ranges from 30-60%.

<u>Shortleaf pine–Oak</u>, where pine comprises more than 50% of the stand or landscape. This can occur as a Dry-Mesic Pine–Oak community, where shortleaf pine mixes with oak species (either can be dominant) on more deeply dissected hills, even on upper north-facing slopes, and canopy varies from 50 - 80%, or as Dry Pine–Oak, where shortleaf mixes with oak species on steep, south-facing upper slopes and ridgetops, and canopy varies from 30-50%.

*Oak-shortleaf pine*, where oak comprises more than 50% of the stand or landscape. Again, this is typically associated with a Dry-Mesic Pine–Oak community, where shortleaf pine mixes with oak species (either can be dominant) on more deeply dissected hills, even on upper north-facing slopes, and canopy varies from 50 - 80%.

**Interior Highlands Acreage Goals for Private Lands**

Of the 4.1 million acres of Shortleaf Pine in the western region it is estimated that 3.5 million acres (85%) occurs on private land. Therefore private land, and private forest landowners, will play a critical role in the success of the SLPI. Except for a few cases it is understood that we cannot expect most private SLP forest to be managed and maintained to the same desired future conditions as planned on public land. However, private land forests are critical in maintaining the distribution and health of shortleaf pine in its western range.

To be successful, the Initiative will need to ramp up the commitment and economic support to assist landowners in conserving SLP on their lands. At a minimum we must encourage landowners to at least maintain SLP in their existing stands and encourage regeneration of new cohorts across the region. As we build awareness of the cultural, ecological and economic importance of the SLP resource in the region we must provide increased incentive and technical assistance to forest landowners who want to expand or enhance SLP within their ownerships. To sustain progress on private land, a concerted effort must be made to maintain existing markets in the southern portion of the range and develop new markets in the north. In addition, private forest adjacent to public lands will be important to achieving landscape-level restoration projects and should continue to be included as plans are developed.

Though it varies by state, recent programmatic data indicate that resource professionals are presently working with less than 0.5% of private forest landowners in the region and effect approximately 12,000 acres of forest land per year (all forest land, not just SLP acres). With additional incentives, awareness campaigns, and increasing technical assistance capacity, it is estimated we can achieve a goal of improving or restoring 36,000 acres of shortleaf pine annually.

A critical part of the Initiative will be monitoring progress. Presently there is no protocol or record keeping system to track SLP improvements on private land. The Initiative will need to work with all private land conservation partners in the region to develop or modify existing data systems to capture progress.

| | At or Near Desired Condition | Restoration Implemented | Restoration is Planned But Not Started |
|---|---|---|---|
| Shortleaf Pine–Bluestem | 215,000 | 215,000 | 125,000 |
| Pine–Oak | 65,000 | 70,000 | 110,000 |
| Oak–Pine | 2000 | 20,000 | 40,000 |

**Table 2.** *Interior Highlands Acreage Goals for Public Lands*

## GOALS FOR THE WEST GULF COASTAL PLAIN REGION

Formerly common within the West Gulf Coastal Plan (WGCP), shortleaf pine forests were historically maintained by periodic fires. With fire suppression and conversion of native shortleaf pine forest to high-density loblolly pine plantations, many of the floral and faunal species dependent upon this open pine ecosystem have markedly declined. As an example, open pine–dependent bird species (e.g., Bachman's sparrow, brown-headed nuthatch, red-cockaded woodpecker) have experienced steep population declines since the mid 1960's, with even modest habitat deficits estimated at more than 350,000 acres in the WGCP. Therefore, conservation of open pine habitat is a high priority action for natural resource agencies and organizations in the WGCP. Much work is needed to effectively identify shortleaf stand distribution and condition in this geography, as well as optimal sites for restoration. Existing partnerships in the WGCP are poised to assist in this task.

Opportunities exist on public lands within the WGCP to restore and maintain shortleaf pine and shortleaf pine–oak forest. However, the initial goal on public land is to quantify forest stands with a shortleaf pine component in need of restoration and maintenance in the desired condition. These shortleaf pine and shortleaf pine–oak stands can be utilized as demonstration sites to build from and support efforts on private lands.

The vast majority of forestland within the WGCP is in private ownership. In addition to demonstrating to private forest landowners the various benefits of shortleaf pine dominated forest, it is critical to provide technical assistance and economic incentives for those landowners. Our goal within the WGCP is to provide shortleaf pine workshops and technical assistance to landowners, and to identify and maintain desired conditions on shortleaf pine dominated stands on private land. Additionally, our target will be to improve and/or restore shortleaf pine and shortleaf pine–oak forest on private lands.

## GOALS FOR THE REGIONS EAST OF THE MISSISSIPPI RIVER

Shortleaf pine has declined most significantly in states east of the Mississippi River. On the Cumberland Plateau in Tennessee, southern pine beetle (SPB) affected approximately one million acres of forests where shortleaf pine was a major component. Similarly, SPB has damaged shortleaf pine in the Piedmont from New Jersey to Georgia. Only 35% of Shortleaf pine and Shortleaf pine–Oak forests occur in states east of the Mississippi River. Due to this east-west dichotomy of acreages and forest conditions, areas to Maintain, Improve, and Restore are treated separately.

***Maintain (AL, FL, GA, KY, MS, NC, SC, TN, VA, WV)***

We will maintain existing Shortleaf pine and Shortleaf pine–Oak woodlands in Piedmont, Coastal Plain, Cumberland Plateau, Pine Barrens where it may still exist (<1,000 acres) via selective harvests and thinning, herbicide application, and prescribed burning.

We will maintain existing Shortleaf pine and Shortleaf pine–Oak closed canopy forests in Southern Appalachians, Piedmont where it still exists via selective harvests and thinning, herbicide application, and prescribed burning. This acreage will require continued management and disturbance for maintenance.

***Improve (AL, DE, FL, GA, KY, MD, MS, NC, NJ, PA, SC, TN, VA, WV)***

Other opportunities for improvement across shortleaf pine range include existing Shortleaf pine and Shortleaf pine–Oak closed canopy forests where fire suppression has led to encroachment of fire-intolerant hardwoods. Currently there are 1.9 million acres of Shortleaf pine and Shortleaf pine–Oak forests within these states. We will improve 150,000 acres of Shortleaf Pine forests on the Cumberland Plateau (TN), along the Coastal Plain (AL, FL, MS), in the Piedmont (GA, NC, SC), and in the Pine Barrens (NJ) through selective harvests and thinning, herbicide application, and prescribed burning. Improved areas will be considered improved based on continued monitoring and achievement of acreage goals and desired forest structure conditions: shortleaf pine comprises 60% of the overstory and fire-intolerant midstories/regeneration comprise <30% of those strata.

Additionally, we will seek other areas for improvement of Shortleaf pine and Shortleaf pine–Oak closed canopy forests within states east of the Mississippi, where fire suppression has led to encroachment of fire-intolerant hardwoods species (KY, MD, NC, PA, SC, TN, VA, WV). Closed canopy forests will be considered improved once shortleaf pine comprises 60% of the overstory and fire-intolerant midstories/regeneration comprise <30% of those strata.

***Restore (DE, MD, KY, MD, NC, PA, SC, TN)***

We will target 300,000 acres for Shortleaf pine and Shortleaf pine–Oak restoration based on historical records and accounts describing either Shortleaf pine or Shortleaf pine–Oak forests or woodlands. Restored areas will be deemed successful based on continued monitoring and achievement of acreage goals and desired forest structure conditions. Additionally, we will identify and prioritize areas that have been affected by SPB outbreaks.

We will also target areas to restore based on their proximity, and potential connectivity to existing Shortleaf pine–Oak forests or woodlands, to create a more contiguous landscape.

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Photo by Holly Campbell, Southern Regional Extension Forestry, Clarke County, GA

## APPENDIX A: SHORTLEAF PINE DOMINATED FORESTS AS DEFINED BY FOREST INVENTORY ANALYSIS

**Shortleaf Pine Forest Type**

- Canopy – pines comprise 50% of the canopy species present in a forest stand and shortleaf is the most common pine
- Associates – white oak (*Quercus alba*), southern red oak (*Quercus falcata*), scarlet oak (*Quercus coccinea*), black oak (*Quercus velutina*), hickory (*Carya sp.*), post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), blackgum (*Nyssa sylvatica*), red maple (*Acer rubrum*), pitch pine (*Pinus rigida*), and Virginia pine (*Pinus virginiana*)
- Sites – low, well-drained ridges to rocky, dry south slopes and the better drained spur ridges on north slopes and also on old fields

**Shortleaf Pine–Oak Forest Type**

- Canopy – contains 25-50% pine coverage and shortleaf is the dominant pine species
- Associates – oaks generally include white oak (*Quercus alba*), southern red oak (*Quercus falcata*), scarlet oak (*Quercus coccinea*), black oak (*Quercus velutina*), post oak (*Quercus stellata*), and blackjack oak (*Quercus marilandica*), hickory (*Carya sp*.), blackgum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), pitch pine (*Pinus rigida*), and Virginia pine (*Pinus virginiana*)
- Sites – generally in dry, low ridges, flats, and south slopes

## APPENDIX B: ESTIMATING THE HISTORIC ACREAGE OF SHORTLEAF PINE

The historic acreage of shortleaf pine in recent publications has been reported as either Little's range of shortleaf pine (440 million square miles; Larson 1990) or Mattoon's 1915 (1915a) assessment of total commercial acreage (280 million acres). The first estimate includes all forest types within a 22 state area, including areas in which shortleaf pine does not occur, such as the high elevations of the Southern Blue Ridge and the Mississippi River delta, so it is a gross overestimate of shortleaf pine acreage. The second estimate occurred after there was massive regeneration of shortleaf on abandoned farm fields in the late 1800s and includes 14 states. Additionally, comparing these numbers with recent FIA data is like comparing apples and oranges. The FIA data includes two forest types where shortleaf is dominant or co-dominant while the earlier estimates included any forest type that contained shortleaf pine.

Of the historic reports on the forests of the Southeast US, Sargent (1884), Mohr and Roth (1896), and Mattoon (1915a), only Mohr and Roth provide estimates of area coverage (square miles) of shortleaf pine in states where the species was still abundant. The paper also discusses the former distribution of the species in states where it has been greatly reduced through harvesting. Using this paper's acreage in states where shortleaf was still abundant and developing a process for estimating acreage in areas where the species was depleted, an estimate of historic acreage was calculated for this restoration plan.

**1. States with acreage estimates of shortleaf pine**

Mohr and Roth (1896) provide estimates of the square miles of shortleaf pine for states west of Georgia, not including the states of Tennessee and Kentucky. To use these as estimates of the historic acreage of shortleaf pine, several assumptions are made:

- The estimates include only forests where shortleaf pine is the dominant or co-dominant species. Mohr and Roth (1896) are reporting on forest resources, so one can assume that if the amount of shortleaf is enough to be considered a forest resource, that the species is either a dominant or co-dominant.
- The estimates of square miles are relatively accurate. The authors do not provide background of how the square miles estimates were derived. They do provide a map of the species' distribution, which may have been the source for the estimates.

The square miles and acreage of shortleaf pine reported by state in Mohr and Roth (1896) are shown in Table B.1.

| State | Square Miles | Acres |
|---|---|---|
| Alabama | 8,000 | 5,000,000 |
| Mississippi | 5,000 | 3,000,000 |
| Louisiana | 5,000 | 3,000,000 |
| Texas | 31,000 | 20,000,000 |
| Arkansas | 19,000 | 13,000,000 |
| Missouri | -- | 3,000,000 |
| **Total** | | **47,000,000** |

***Table B.1.*** *Square miles and acres of shortleaf pine reported for states west of Georgia, not including Tennessee and Kentucky.*

**2. States with depleted shortleaf pine and no acreage estimates**

Physiographic regions where shortleaf dominated communities would have occurred, using Mohr's map and his written comments, were used as the basis for making an estimate of historic acreage. The primary physiographic regions in which shortleaf pine was dominant or co-dominant in forests are the Piedmont of the Atlantic Coast, from Georgia to New Jersey (80,000 sq. miles) and the Southern Cumberland Plateau of Tennessee and Kentucky (1620 sq. miles). Shortleaf shifts from the Piedmont of Virginia, Pennsylvania, and New Jersey to more coastal areas, but it is assumed that it is an approximate 1 to 1 acre trade off. Through the rest of the range of the species outside of these two regions, central TN and the sandhills and coastal plain of NC, SC, GA, AL, and MS, the assumption is made that shortleaf rarely occurred as dominant or co-dominant. For the Piedmont and Southern Cumberland Plateau, it is assumed that shortleaf-dominant or co-dominant forests had the potential to occur on 50% of the landscape, that being the upland dry flats and south-facing ridge and ridgetop areas in those regions, areas where fire would have been frequent. The resulting numbers for this rapid analysis are shown in Table B.2.

| Region | Square Miles | Total Acres | 50% of Total Acres |
|---|---|---|---|
| Piedmont from GA to NJ | 80,000 | 51,000,000 | 25,500,000 |
| S. Cumberland Plateau | 1620 | 1,000,000 | 500,000 |
| **Total** | | | **26,000,000** |

***Table B.2.*** *Estimate of acres of shortleaf pine dominant or co-dominant forests in two physiographic regions in the eastern U.S.*

### 3. Total shortleaf acreage across historic range

The total pre-settlement estimate of shortleaf dominant or co-dominant forests is 73 million acres, adding the acreage estimates from Mohr and Roth (1896) in the western part of the range and estimating the potential acreage in two physiographic regions in the eastern portion of the range. The estimate is better stated as a range, with between 70 and 80 million acres of shortleaf dominant or co-dominant forests in the Southeast U.S.

The 6 million acres remaining today (Oswalt 2015) is between 7.5 and 8.5% of the historic range. Thus, the current acreage of shortleaf pine is less than 10% of the historic range.

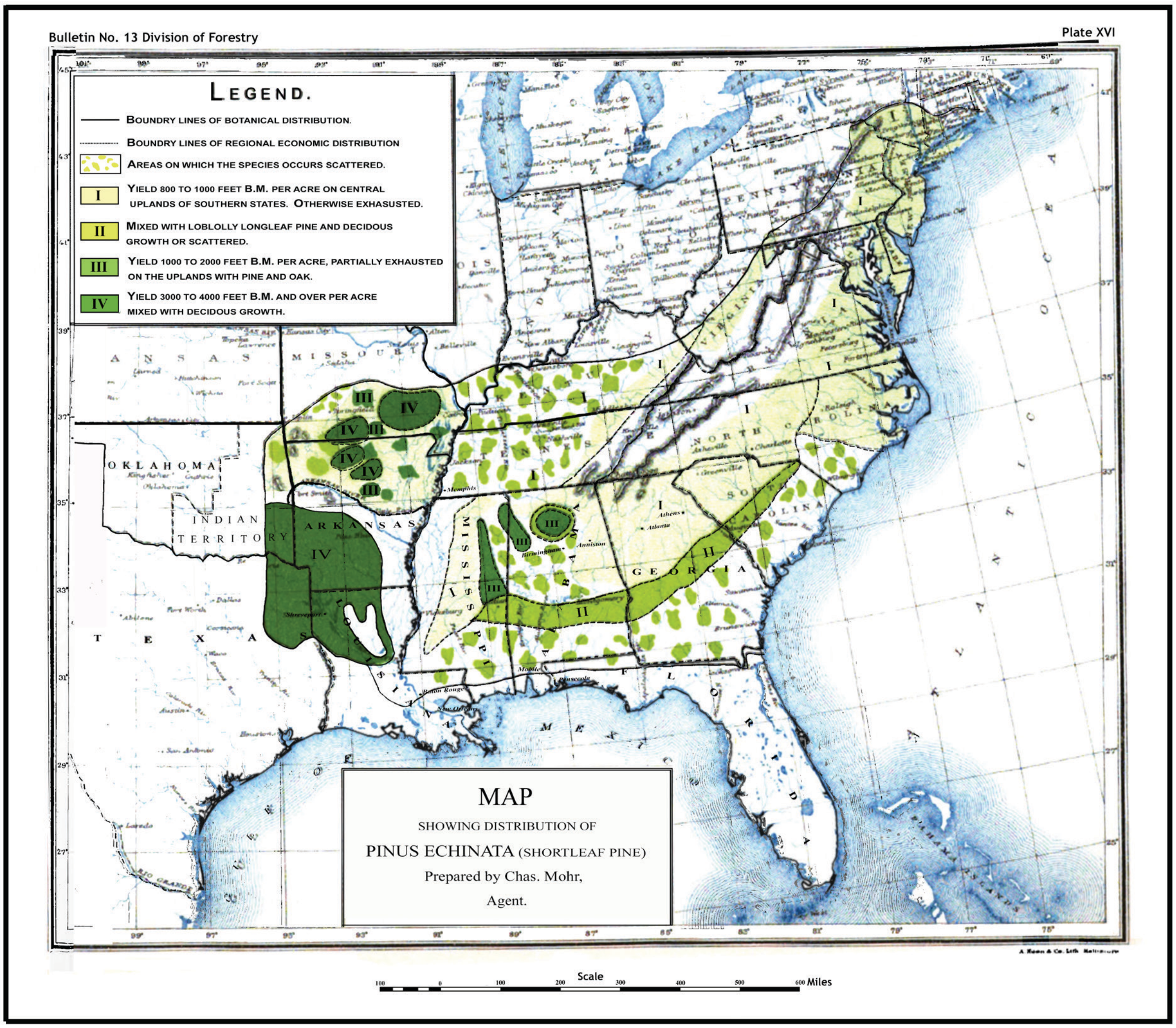


*Figure B.1.* Map of the range of shortleaf pine from Mohr and Roth (1896).

## APPENDIX C: SHORTLEAF PINE ASSOCIATED FOREST COVER TYPES FROM SOCIETY OF AMERICAN FORESTERS

- Eastern white pine (*Pinus strobus*)
- Post oak (*Quercus stellate*) - blackjack oak (*Q. marilandica*)
- Bear oak (*Q. ilicifolia*)
- Chestnut oak (*Q. montana*)
- Pitch pine (*P. rigida*)
- Eastern red-cedar (*Juniperus virginiana*)
- White pine (*P. strobus*) - chestnut oak (*Q. montana*)
- White oak (*Q. alba*) - black oak (*Q. velutina*) - northern red oak (*Q. rubra*)
- Yellow-poplar (*Liriodendron tulipifera*)
- Longleaf pine (*P. palustris*)
- Shortleaf pine (*P. echinata*)
- Shortleaf pine (*P. echinata*) – oak (*Q. spp.*)
- Virginia pine (*P. virginiana*) – oak (*Q. spp.*)
- Virginia pine (*P. virginiana*)
- Loblolly pine (*P. taeda*) - shortleaf pine (*P. echinata*)
- Loblolly pine (*P. taeda*)
- Loblolly pine (*P. taeda*) - hardwood
- Black oak (*Q. velutina*)

## APPENDIX D: SHORTLEAF PINE PLANT COMMUNITY ASSOCIATIONS FROM NATURESERVE

States where shortleaf pine associations are or could occur, and current status of the associations (Critically Imperiled, Imperiled, Vulnerable, Apparently Secure, Demonstrably Secure) (http://explorer.natureserve.org)

| Associations | States | Status |
|---|---|---|
| **Appalachian Mafic Glade** | | |
| *Pinus echinata - Quercus velutina - Quercus marilandica / Piptochaetium avenaceum* | NC | Critically Imperiled |
| **Central and Southern Appalachian Rocky Outcrop** | | |
| *Quercus prinus - Quercus stellata - (Pinus virginiana, Pinus echinata) / Vaccinium pallidum / Schizachyrium scoparium* | GA, NC, SC | Imperiled |
| **Central Acidic Open Glade and Barren** | | |
| *Quercus stellata - (Pinus echinata) / Vaccinium arboreum / Andropogon gerardii - Symphyotrichum patens var. patentissimum* | AR | Imperiled |
| **Dry-Mesic Loamy Longleaf Pine Woodland** | | |
| *Pinus palustris - Pinus (echinata, taeda) - Quercus (incana, margarettiae, falcata, laevis)* | AL, FL, GA, MS, NC, SC | Apparently Secure |
| *Pinus palustris - Pinus (echinata, taeda) / Schizachyrium tenerum - Vernonia angustifolia* | MS | Imperiled |
| *Pinus palustris - Pinus (echinata, taeda)* | LA, TX | Critically Imperiled |
| **Loblolly and Shortleaf Pine - Oak Forest and Woodland** | | |
| *Pinus echinata - Pinus taeda - Quercus (alba, falcata, stellata)* | AR, LA, OK, TX | Imperiled |
| *Pinus echinata - (Pinus taeda) - Quercus falcata / Dichanthelium sphaerocarpon* | AR, LA, TX | Imperiled |
| *Pinus echinata - (Pinus taeda) - Quercus (margarettiae, stellata, falcata) - Carya texana* | AR, LA, OK, TX | Imperiled |
| *Pinus echinata - Pinus taeda - Quercus stellata - Carya texana / Vaccinium arboreum* | AR, LA, OK, TX | Vulnerable |
| *Pinus echinata - Pinus taeda - Quercus stellata / Juniperus virginiana var. virginiana / Cornus drummondii* | LA, TX | Critically Imperiled |
| *Pinus echinata - Quercus alba / Viburnum (dentatum, acerifolium)* | AR, LA, OK, TX | Imperiled |
| *Pinus echinata / Quercus incana / Selaginella arenicola ssp. riddellii* | AR, LA, TX | Imperiled |
| *Pinus echinata - Quercus (incana, stellata, margarettiae) / Cnidoscolus texanus* | AR, LA, OK, TX | Imperiled |
| *Pinus echinata - Quercus stellata - Quercus falcata - Carya texana* | LA, TX | Critically Imperiled |
| *Pinus (echinata, taeda) / Symplocos tinctoria - Morella cerifera - Vaccinium elliottii* | AR, LA, OK, TX | Vulnerable |
| *Pinus taeda - (Pinus echinata) - Quercus alba - Carya alba / Acer barbatum - (Acer leucoderme)* | AR, LA, OK, TX | Imperiled |
| *Pinus taeda - (Pinus echinata) - Quercus falcata - Carya texana / Vaccinium arboreum* | AR, LA, OK, TX | Apparently Secure |
| *Pinus taeda - (Pinus echinata) / Quercus michauxii / Thaspium barbinode* | TX | Critically Imperiled |
| *Quercus (incana, margarettiae, arkansana) - (Pinus echinata) / Schizachyrium scoparium* | AR, LA, OK, TX | Imperiled |

| | | |
|---|---|---|
| **Quercus alba - Quercus falcata - Quercus nigra forest group** | | |
| *Pinus echinata / Quercus (falcata, nigra) / Vaccinium pallidum* | DE, MD, NJ | Vulnerable |
| *Quercus stellata - (Pinus echinata) / Schizachyrium scoparium - Echinacea laevigata - Oligoneuron album* | NC | Critically Imperiled |
| *Quercus stellata - (Pinus echinata) / Schizachyrium scoparium - Symphyotrichum georgianum* | NC, SC | Critically Imperiled |
| **Pitch Pine Barrens** | | |
| *Pinus rigida - (Pinus echinata) / Quercus (marilandica, ilicifolia) / Vaccinium pallidum* | NJ, NY | Imperiled |
| *Pinus (rigida, echinata) - Quercus coccinea / Ilex opaca* | NJ | Not Yet Ranked |
| **Shortleaf Pine - Oak Forest** | | |
| *Pinus echinata - Pinus taeda - Quercus (alba, stellata) - Carya alba / Oxydendrum arboreum* | AL, FL, GA, LA, MS | Imperiled |
| *Pinus echinata - Quercus alba - Carya alba* | AL, FL, GA, MS, TN | Imperiled |
| *Pinus echinata - Quercus alba - Quercus falcata* | AR | Vulnerable |
| *Pinus echinata - Quercus alba / Schizachyrium scoparium* | AR, MO, OK | Vulnerable |
| *Pinus echinata - Quercus alba / Vaccinium pallidum / Hexastylis arifolia - Chimaphila maculata* | AL, GA, KY, NC, SC, TN | Vulnerable |
| *Pinus echinata - Quercus (alba, rubra) / Vaccinium (arboreum, pallidum) / Schizachyrium scoparium - Chasmanthium sessiliflorum - Solidago ulmifolia* | AR, MO, OK | Vulnerable |
| *Pinus echinata - Quercus falcata* | AL, FL, GA, LA, MS, TN | Imperiled |
| *Pinus echinata - Quercus marilandica / Kalmia latifolia - Symplocos tinctoria* | NC | Imperiled |
| *Pinus echinata - Quercus prinus - Quercus stellata / Vaccinium pallidum / Pityopsis graminifolia var. latifolia* | KY, VA, WV | Imperiled |
| *Pinus echinata - Quercus prinus / Rhododendron minus / Vaccinium pallidum* | GA, NC, SC | Imperiled |
| *Pinus echinata - Quercus prinus* | TN | Imperiled |
| *Pinus echinata - Quercus (prinus, falcata) / Oxydendrum arboreum / Vaccinium pallidum* | AL, GA, KY, NC, SC, TN | Vulnerable |
| *Pinus echinata - Quercus stellata - Quercus marilandica / Andropogon gyrans - Chrysopsis mariana* | NC | Critically Imperiled |
| *Pinus echinata - Quercus stellata - Quercus marilandica / Schizachyrium scoparium* | AR, MO, OK | Imperiled |
| *Pinus echinata - Quercus stellata - Quercus marilandica / Vaccinium pallidum* | GA, KY, NC, SC, TN | Apparently Secure |
| *Pinus echinata - Quercus stellata - (Quercus marilandica)* | AL, FL, GA, MS, TN | Critically Imperiled |
| *Pinus echinata - Quercus stellata - Quercus prinus - Carya glabra / (Danthonia spicata, Piptochaetium avenaceum)* | AL, GA, KY, TN | Vulnerable |
| *Pinus echinata - (Quercus stellata, Quercus marilandica) / Schizachyrium scoparium - Salvia urticifolia* | GA | Imperiled |
| *Pinus echinata - Quercus velutina - Quercus stellata / Vaccinium* spp. | AR, IL, OK, MO | Vulnerable |

| | | |
|---|---|---|
| *Pinus echinata* | AR, MO, OK | Imperiled |
| *Pinus echinata / Schizachyrium scoparium - Solidago ulmifolia - Monarda russeliana - Echinacea pallida* | AR, MO, OK | Critically Imperiled |
| *Pinus echinata / Schizachyrium scoparium* | AL, GA, KY, NC, TN | Imperiled |
| *Pinus echinata / Vaccinium (arboreum, pallidum, stamineum)* | AR, MO, OK | Vulnerable |
| *Pinus echinata / Vaccinium (pallidum, stamineum)* | GA, KY, MD, NC, SC, TN | Apparently Secure |
| *Pinus (echinata, taeda)* | MS | Not Yet Ranked |
| *Pinus palustris - Pinus echinata - (Pinus virginiana) / Quercus marilandica - (Quercus prinus) / Vaccinium pallidum* | AL, GA, NC, SC | Imperiled |
| *Pinus palustris - Pinus echinata / Quercus coccinea - Quercus georgiana* | GA | Critically Imperiled |
| *Pinus palustris - Pinus echinata - Quercus prinus / Kalmia latifolia - Rhododendron minus* | AL, GA | Imperiled |
| *Pinus palustris - Pinus echinata / Schizachyrium scoparium - Manfreda virginica* | GA | Critically Imperiled |
| *Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum* | AL, GA, IN, KY, MD, NC, OH, PA, SC, TN, WV | Vulnerable |

**South-Central Interior Oak Forest and Woodland**

| | | |
|---|---|---|
| *Quercus velutina - Carya pallida - (Pinus echinata) / Vaccinium arboreum / Yucca filamentosa* | AL, GA, MS, SC | Vulnerable |

**South-Central Interior Oak Savanna and Barrens**

| | | |
|---|---|---|
| *Pinus echinata - Quercus (marilandica, stellata) / Schizachyrium scoparium - Silphium terebinthinaceum - Oligoneuron album* | AL, GA | Imperiled |

**Xeric Longleaf Pine Woodland**

| | | |
|---|---|---|
| *Pinus palustris - Pinus (echinata, taeda) - Quercus falcata - Carya texana* | LA, TX | Imperiled |
| *Pinus palustris - Pinus (echinata, taeda) - Quercus (incana, margarettiae) / Schizachyrium scoparium* | LA, TX | Critically Imperiled |
| *Pinus palustris - Pinus (echinata, taeda) / Quercus (marilandica, laevis) / Schizachyrium scoparium* | AL, GA, MS | Vulnerable |

## APPENDIX E: WILDLIFE OF CONSERVATION CONCERN AND MANAGEMENT INTEREST IN SHORTLEAF PINE ECOSYSTEMS

*Compiled by the U.S. Fish and Wildlife Service, Division of Migratory Birds, Atlanta, GA 30345*

| Broad Ecosystem Type | Shortleaf Pine–Oak Forest & Woodland | Shortleaf Pine–Bluestem Woodland & Savanna |
|---|---|---|
| **Federally Threatened or Endangered (Endangered Species Act)**<br><br>(Status under ESA may differ across shortleaf pine range) | • American Burying Beetle (*Nicrophorus americanus*)<br>• Eastern Indigo Snake (*Drymarchon couperi*)<br>• Gopher Frog (*Rana capito*)<br>• Gopher Tortoise (*Gopherus polyphemus*)<br>• Red-cockaded Woodpecker (*Picoides borealis*) | • American Burying Beetle (*Nicrophorus americanus*)<br>• Eastern Indigo Snake (*Drymarchon couperi*)<br>• Gopher Frog (*Rana capito*)<br>• Gopher Tortoise (*Gopherus polyphemus*)<br>• Red-cockaded Woodpecker (*Picoides borealis*) |
| **Special Conservation Interest (USFWS)**<br><br>(Not including species in previous category) | • Baird's Pocket Gopher (*Geomys breviceps*)<br>• (Black) Pine Snake (*Pituophis melanoleucus lodingi*)<br>• (Louisiana) Pine Snake (*Pituophis melanoleucus ruthveni*)<br>• Southern Hognose Snake (*Heterodon simus*)<br>• Striped newt (*Notophthalamus perstriatus*) | • Baird's Pocket Gopher (*Geomys breviceps*)<br>• (Black) Pine Snake (*Pituophis melanoleucus lodingi*)<br>• (Louisiana) Pine Snake (*Pituophis melanoleucus ruthveni*)<br>• Southern Hognose Snake (*Heterodon simus*)<br>• Striped newt (*Notophthalamus perstriatus*) |
| **Birds of High Conservation Concern or Management Interest**<br>**(USFWS & Joint Ventures - Birds of Conservation Concern, USFWS, 2008)**<br><br>(Not including species in previous two entries) | • (Southeast) American Kestrel (*Falco sparverius paulus*)<br>• American Woodcock (*Scolopax minor*)<br>• Bachman's Sparrow (*Peucaea aestivalis*)<br>• Brown-headed Nuthatch (*Sitta pusilla*)<br>• Chuck-will's-widow (*Antrostomus carolinensis*)<br>• Eastern Whip-poor-will (*Antrostomus vociferus*)<br>• Field Sparrow (*Spizella pusilla*)<br>• Loggerhead Shrike (*Lanius ludovicianus*)<br>• Northern Bobwhite (*Colinus virginianus*)<br>• Prairie Warbler (*Setophaga discolor*)<br>• Red-headed Woodpecker (*Melanerpes erythrocephalus*)<br>• (Eastern) Wild Turkey (*Meleagris gallopavo silvestris*) | • (Southeast) American Kestrel (*Falco sparverius paulus*)<br>• American Woodcock (*Scolopax minor*)<br>• Bachman's Sparrow (*Peucaea aestivalis*)<br>• Brown-headed Nuthatch (*Sitta pusilla*)<br>• Chuck-will's-widow (*Antrostomus carolinensis*)<br>• Common Ground-Dove (*Columbina passerina*)<br>• Field Sparrow (*Spizella pusilla*)<br>• Henslow's Sparrow (*Ammodramus henslowii*)<br>• LeConte's Sparrow (*Ammodramus leconteii*)<br>• Loggerhead Shrike (*Lanius ludovicianus*)<br>• Northern Bobwhite (*Colinus virginianus*)<br>• Prairie Warbler (*Setophaga discolor*)<br>• Red-headed Woodpecker (*Melanerpes erythrocephalus*)<br>• Sedge Wren (*Cistothorus platensis*)<br>• (Eastern) Wild Turkey (*Meleagris gallopavo silvestris*) |

## APPENDIX F: SCIENTIFIC AND COMMON NAMES OF GRASS AND HERBACEOUS SPECIES TYPICALLY FOUND IN SHORTLEAF PINE WOODLAND UNDERSTORY

| **Ferns** | |
|---|---|
| *Polystichum acrostichoides* | Christmas fern |
| *Pteridium aquilinum* | bracken |

| **Graminiods** | |
|---|---|
| *Carex annectens* | yellowfruit caric sedge |
| *Carex carolinaina* | Carolina caric sedge |
| *Carex complanata* | caric sedge |
| *Carex glaucodea* | blue caric sedge |
| *Carex latebracteata* | Watterfall's caric sedge |
| *Carex muehlenbergii* | Muhlenberg's caric sedge |
| *Eleocharis tenuis var. verrucosa* | slender spike rush |
| *Scleria oligantha* | littleflower nutsedge |
| *Scleria triglomerata* | nutsedge |
| *Agrostis perennans* | fall bentgrass |
| *Andropogon gerardii* | big bluestem |
| *Andropogon gyrans* | Elliott's bluestem |
| *Andropogon ternarius* | splitbeard bluestem |
| *Andropogon virginicus* | broomsedge bluestem |
| *Aristida dichotoma* | churchmouse three-awngrass |
| *Aristida oligantha* | prairie three-awngrass |
| *Aristida purpurea* | purple three-awngrass |
| *Chasmanthium latifolium* | lax woodoats |
| *Chasmanthium sessilifolium* | spanglegrass |
| *Danthonia spicata* | poverty oatgrass |
| *Dichanthelium acuminatum* | hairy rosettegrass |
| *Dichanthelium boscii* | Bosc's rosettegrass |
| *Dichanthelium commutatum* | variable rosettegrass |
| *Dichanthelium dichotomum* | cypress rosettegrass |
| *Dichanthelium laxiflorum* | soft-tufted panicgrass |
| *Dichanthelium linearifolium* | slimleaf rosettegrass |
| *Elymus glabriflorus* | southeastern wild rye |
| *Eragrostis hirsuta* | bigtop lovegrass |
| *Eragrostis spectabile* | purple lovegrass |
| *Festuca subverticellata* | nodding fescue |
| *Gymnopogon ambiguous* | bearded skeleton grass |
| *Muhlenbergia tenuiflora* | slender muhly |
| *Muhlenbergia scherberi* | nimblewill |
| *Muhlenbergia sobolifera* | rock muhly |
| *Panicum anceps* | beaked panicgrass |
| *Panicum dichotomiflorum* | fall panicgrass |
| *Panicum rigidulum* | rigid panicgrass |

| | |
|---|---|
| *Paspalum leave* | smooth crowngrass |
| *Piptochaetium avenaceum* | blackseed speargrass |
| *Schizachyrium scoparium* | little bluestem |
| *Sorghastrum nutans* | Indian grass |
| *Sporobolus clandestinus* | dropseed |
| *Sporobolus compositus* | tall dropseed |
| *Tridens flavus* | tall purpletop |
| *Tridens strictus* | narrow redtop |

| **Legumes** | |
|---|---|
| *Amphicarpaea bracteata* | American hog peanut |
| *Apios americana* | groundnut |
| *Baptisia alba var. macrophylla* | largeleaf wild indigo |
| *Baptisia bracteata* var. *leucophaea* | longbract wild indigo |
| *Baptisia sphaerocarpa* | yellow wild indigo |
| *Chamaecrista fasciculata* | partridge pea |
| *Chamaecrista nicitans* | sensitive partridge pea |
| *Clitoria mariana* | butterfly pea |
| *Dalea candida* | white prairie clover |
| *Desmodium canescens* | tick trefoil |
| *Desmodium ciliare* | tick trefoil |
| *Desmodium cuspidatum* | tick trefoil |
| *Desmodium laevigatum* | tick trefoil |
| *Desmodium marilandicum* | Maryland tick trefoil |
| *Desmodium nudiflorum* | naked-flower tick trefoil |
| *Desmodium paniculatum* | panicled-flower tick trefoil |
| *Desmodium sessilifolium* | sessile-leaf tick trefoil |
| *Galactia volubus* | milk pea |
| *Lathyrus venosus* | veiny peavine |
| *Lespedeza capitata* | round-head bushclover |
| *Lespedeza frutescens* | purple bushclover |
| *Lespedeza hirta* | hairy bushclover |
| *Lespedeza intermedia* | pink bushclover |
| *Lespedeza procumbens* | trailing bushclover |
| *Lespedeza repens* | creeping bushclover |
| *Lespedeza virginica* | slender bushclover |
| *Mimosa quadrivalis var nuttallii* | sensitive briar |
| *Orbexilum pedunculatum* | Sampson's snakeroot |
| *Rhynchosia latifolia* | snout bean |
| *Senna marilandica* | wild senna |
| *Strophostyles unbellata* | wild bean |
| *Stylosanthes biflora* | sidebeak pencilflower |
| *Tephrosia virginiana* | Virginia goatsrue |

| **Forbs** | |
|---|---|
| *Acalypha graciliens* | three-seeded mercury |
| *Acalphya monococca* | one-seeded mercury |
| *Agalinis fasciculata* | false foxglove |
| *Agrimony rostellata* | agrimony |
| *Allium canadense* | wild onion |
| *Ageratum altissima* | white snakeroot |
| *Ambrosia artemisiifolia* | annual ragweed |
| *Ambrosia bidentata* | lanceleaf ragweed |
| *Ambrosia psilostachya* | western ragweed |
| *Antennaria plantaginifolia* | woman's tobacco |
| *Apocynum cannabinum* | hemp dogbane |
| *Aristolochia serpentaria* | Virginia snakeroot |
| *Asclepias hirtella* | green milkweed |
| *Asclepias quadrifolia* | fourleaf milkweed |
| *Asclepias tuberosa* | butterflyweed |
| *Asclepias variegata* | redring milkweed |
| *Aureolaria grandiflora* | western false foxglove |
| *Bradburia pilosa* | golden aster |
| *Chaerophyllum tainturieri* | hairyfruit chervil |
| *Cirsium altissimum* | tall thistle |
| *Cirsium caroliniana* | thistle |
| *Cocculus carolinusa* | Carolina moonseed |
| *Conyza canadensis* | Canada horseweed |
| *Coreopsis grandiflora* | largeflower tickseed |
| *Coreopsis lanceolata* | lanceleaf tickseed |
| *Coreopsis tinctoria* | black-eyed tickseed |
| *Croton capitatus* | wholly croton |
| *Croton monanthogynus* | prairie tea |
| *Croton willdenowii* | Willdenow's croton |
| *Cunila origanoides* | common dittany |
| *Delphinium carolinianum* | Carolina larkspur |
| *Diodia teres* | rough buttonweed |
| *Dioscorea villosa* | wild yam |
| *Echinacea pallida* | pale purple coneflower |
| *Echinacea purpurea* | purple coneflower |
| *Elephantopus carolinianus* | Carolina elephant's foot |
| *Erechtites hieraciifolia* | American burnweed |
| *Erigeron philadelphicus* | Philadelphia fleabane |
| *Erigeron strigosus* | rough fleabane |
| *Eryngium yuccifolium* | rattlesnake master |
| *Eupatorium altissimum* | tall thoroughwort |
| *Eupatorium capillifolium* | dog-fennel |
| *Eupatorium perfoliatum* | clasping boneset |

| | |
|---|---|
| *Eupatorium rotundifolium* | round-leaf boneset |
| *Eupatorium serotinum* | late boneset |
| *Eutrochium fistulosum* | Joe Pye weed |
| *Euphorbia corollata* | flowering spurge |
| *Euphorbia cyathophora* | flowering spurge |
| *Eurybia hemisphericus* | southern prairie aster |
| *Fragaria virginiana* | wild strawberry |
| *Galium arkansanum* var. *pubiflorum* | Ouachita bedstraw |
| *Galium circaezans* | licorice bedstraw |
| *Galium obtusum* | bluntleaf bedstraw |
| *Galium pilosum* | hairy bedstraw |
| *Geranium carolinianum* | Carolina cranesbill |
| *Geranium maculatum* | spotted cranesbill |
| *Geum canadense* | white avens |
| *Glandularia canadensis* | rose vervain |
| *Gaura demareei* | Demaree's beeblossum |
| *Hedyotis longifolia* | longleaf bluets |
| *Helenium flexuosum* | purple sneezeweed |
| *Helianthus hirsutus* | woodland sunflower |
| *Helianthus grossiserratus* | sawtooth sunflower |
| *Helianthus hirsutus* | hairy sunflower |
| *Helianthus mollis* | ashy sunflower |
| *Heterotheca subaxillaris* | camphorweed |
| *Hieracium gronovii* | Gronovius' hawkweed |
| *Hieracium longipilum* | hairy hawkweed |
| *Hypericum gentianoides* | pine-weed |
| *Hypericum drummondii* | nit-and-lice |
| *Ipomoea pandurata* | wild potato vine |
| *Krigia dandelion* | potato dandelion |
| *Krigia virginica* | dwarf dandelion |
| *Lactuca canadensis* | Canada wild lettuce |
| *Lactuca floridana* | Florida wild lettuce |
| *Liatris aspera* | tall blazingstar |
| *Liatris hirsuta* | hairy blazing star |
| *Liatris squarrosa* | blazing star |
| *Lobelia apependiculata* | lobelia |
| *Lobelia spicata* | highbelia |
| *Lonicera sempervirens* | honeysuckle |
| *Ludwigia alternifolia* | primrose-willow |
| *Maianthemum paniculatum* | false Solomon's seal |
| *Manfreda virginica* | false aloe |
| *Menispermum canadense* | Canada moonseed |
| *Monarda bradburiana* | Bradbury's beebalm |
| *Monarda fistulosa* var. *stipitatoglandulosa* | beebalm |

| | |
|---|---|
| *Monarda russeliana* | Russell's horsemint |
| *Nothoscrodium bivalve* | false garlic |
| *Oenothera linifolia* | threadleaf evening primrose |
| *Opuntia humifusa* | eastern prickly pear |
| *Oxalis dillenii* | yellow wood sorrel |
| *Oxalis violacea* | violet wood sorrel |
| *Pakera tomentosa* | woolly ragwort |
| *Passiflora incarnataa* | purple passionflower |
| *Passiflora lutea* | yellow passionflower |
| *Parthenium integrifolium* | wild quinine |
| *Pedicularis canadensis* | Canada lousewort |
| *Penstemon arkansanus* | Arkansas beard-tongue |
| *Phlox pilosa* | downy phlox |
| *Physalis virginiana* | ground cherry |
| *Pityopsis graminifolia* | grass-leaved golden aster |
| *Phytolacca americana* | American pokeweed |
| *Plantago aristata* | bracted plantain |
| *Polygala verticillata* | whorled milkwort |
| *Porteranthus stipulatus* | Indian physic |
| *Potentilla simplex* | old-field cinquefoil |
| *Prunella vulgaris* subsp. *lanceolata* | heal-all |
| *Pseudognaphalium obtusifolium* | fragrant cudweed |
| *Pseudognaphalium purpureum* | purple cudweed |
| *Pycnanthemum albescens* | whiteleaf mountain mint |
| *Pycnanthemum tenuifolium* | slender mountain mint |
| *Rudbeckia grandiflora* | large coneflower |
| *Rudbeckia hirta* | black-eyed Susan |
| *Ruellia humilis* | wild petunia |
| *Ruellia strepens* | limestone wild petunia |
| *Sbatia angularis* | rose pink |
| *Salvia lyrata* | lyre-leaf sage |
| *Sanicula canadensis* | Canada black snakeroot |
| *Scutellaria elliptica* | elliptic skullcap |
| *Scutellaria ovata* | skullcap |
| *Scutellaria parvula* | skullcap |
| *Silphium integrifolium* | rosin-weed |
| *Silphium laciniatum* | compass plant |
| *Solanum carolinense* | Carolina nightshade |
| *Solidago altissima* | tall goldenrod |
| *Solidago caesia* | blue-stem goldenrod |
| *Solidago hispida* | hairy goldenrod |
| *Solidago nemoralis* | old field goldenrod |
| *Solidago odora* | fragrant goldenrod |
| *Solidago radula* | rough goldenrod |

| | |
|---|---|
| *Solidago rugosa* | rough-leaved goldenrod |
| *Solidago ulmifolia* | goldenrod |
| *Spiranthes cernua* | nodding ladies' tresses |
| *Symphyotrichum anomalum* | manray aster |
| *Symphyotrichum laeve* | smooth blue aster |
| *Symphyotrichum lanceolatum* | aster |
| *Symphyotrichum oolentangiense* | azure aster |
| *Symphyotrichum patens* | late purple aster |
| *Symphyotrichum pilosum* | hairy white oldfield aster |
| *Taenidia integerrima* | yellow pimpernel |
| *Thalictrum thalictroides* | rue anemone |
| *Tradescantia ohiensis* | smooth spiderwort |
| *Triodanis perfoliata* | clasping Venus' looking glass |
| *Valerianella radiata* | corn salad |
| *Verbena urticifolia* | white vervain |
| *Verbesina alternifolia* | yellow ironwood |
| *Vernonia baldwinii* | Baldwin's ironweed |
| *Viola palmata* | early blue violet |
| *Viola pedata* | bird's-foot violet |
| *Viola sagittata* | arrow-leaved violet |
| *Viola sororia* | wholly violet |
| *Yucca arkansana* | Arkansas yucca |
| *Zizia aurea* | golden Alexander |

| **Woody species** | |
|---|---|
| *Acer rubrum* | red maple |
| *Amelanchier arborea* | serviceberry |
| *Ampelopsis arborea* | peppervine |
| *Aralia spinosa* | devil's walking stick |
| *Berchemia scandens* | Alabama supplejack |
| *Callicarpa americana* | American beautyberry |
| *Carpinus caroliniana* | blue beech |
| *Carya glabra* | pignut hickory |
| *Carya texana* | black hickory |
| *Carya tomentosa* | mockernut hickory |
| *Ceanothus americanus* | New Jersey tea |
| *Celtis tenuifolia* | dwarf hackberry |
| *Cercis canadensis* | eastern redbud |
| *Chionanthus virginicus* | fringe tree |
| *Cornus drumondii* | rough-leaved dogwood |
| *Cornus florida* | flowering dogwood |
| *Cotinus obovatus* | American smoketree |
| *Crataegus crusgalli* | cockspur hawthorn |
| *Crataegus marshallii* | parsley hawthorn |

| | |
|---|---|
| *Crataegus spathulata* | pasture hawthorn |
| *Crataegus uniflora* | one-seed hawthorn |
| *Diospyros virginiana* | American persimmon |
| *Eounymus americana* | strawberry bush |
| *Frangula caroliniana* | Carolina buckthorn |
| *Fraxinus americana* | white ash |
| *Hypericum hypericoides* | St. Andrew's cross |
| *Hypericum punctatum* | spotted St. John's wort |
| *Ilex decidua* | deciduous holly |
| *Juniperus virginiana* | eastern redcedar |
| *Liquidambar styraciflua* | sweetgum |
| *Morus rubra* | red mulberry |
| *Nyssa sylvatica* | blackgum |
| *Ostrya virginiana* | hop hornbeam |
| *Parthenocissus quinquefolia* | Virginia creeper |
| *Pinus echinata* | shortleaf pine |
| *Prunus mexicana* | Mexican plum |
| *Prunus serotina* | black cherry |
| *Quercus alba* | white oak |
| *Quercus falcata* | southern red oak |
| *Quercus marilandica* | blackjack oak |
| *Quercus rubra* | northern red oak |
| *Quercus stellata* | post oak |
| *Quercus velutina* | black oak |
| *Rhus aromatica* | fragrant sumac |
| *Rhus copallinum* | winged sumac |
| *Rhus glabra* | smooth sumac |
| *Ribes missouriense* | Missouri gooseberry |
| *Robinia pseudoacacia* | black locust |
| *Rosa carolina* | Carolina rose |
| *Rubus allegheniensis* | Allegheny blackberry |
| *Rubus trivialis* | southern dewberry |
| *Sassafras albidum* | sassafras |
| *Sideroxylon lanuginosum* | chittimwood |
| *Smilax bona-nox* | saw greenbrier |
| *Smilax glauca* | cat greenbrier |
| *Smilax rotundifolia* | roundleaf greenbrier |
| *Symphoricarpos orbiculatus* | coralberry |
| *Toxicodendron radicans* | eastern poison ivy |
| *Ulmus alata* | winged elm |
| *Vaccinium arboreum* | farkleberry |
| *Vaccinium pallidum* | blueberry |
| *Vaccinium stamineum* | deerberry |
| *Viburnum rufidulum* | rusty blackhaw |

| | |
|---|---|
| *Vitis aestivalis* | summer grape |
| *Vitis cinerea* | grayback grape |
| *Vitis palmata* | cat grape |
| *Vitis rotundifolia* | muscadine |

## APPENDIX G: DESIRED FUTURE CONDITIONS FOR RESTORED SHORTLEAF PINE ECOSYSTEM IN THE INTERIOR HIGHLANDS OF ARKANSAS AND MISSOURI

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Ouachita National Forest, 1920, photo courtesy of the Forest History Society

***Purpose:***

The purpose of this report is to provide descriptions, definitions, and assign metrics to structural and compositional variables characterizing desired future conditions (DFCs) for shortleaf pine–bluestem and pine–oak natural community restoration in the Interior Highlands (Ozark/Ouachita region). The emphasis of this document is to help define goals of management rather than management approaches. The purpose of natural community restoration is to recover the biodiversity associated with these shortleaf community types, especially the highly diverse grass/forb component of the groundcover (Masters 2007). Natural communities with a shortleaf pine (SLP) component are listed and metrics for desired conditions provided, along with management guidelines and decision-making criteria. These are not given as absolutes, but rather as guidelines for use in adaptive management; while much has been documented regarding methods for and effects of pine–woodland restoration on the Ouachita National Forest, comparably little has been formally evaluated with regards to the restoration of pine–bluestem in the Ozarks or pine–oak natural communities throughout the region. The intended audience is resource managers that have influence over forest management plans, private land consultants and federal assistance agency, researchers, academia, and wildlife professionals. The subcommittee also recognizes that there are other approaches to growing pine for forest products, but describing those was beyond the scope of the task with which they were charged.

***Shortleaf Pine Natural Communities in the Ozark/Ouachita (AR/MO) region:***

*Natural Community Definition:* Natural communities are distinct assemblages of native plants, animals and microorganisms that occur in repeatable and often mappable patterns across the landscape. Natural communities in which SLP is dominant or important are the result of specific combinations of factors related to soils, bedrock and disturbance patterns (e.g. drought, fire, wind and ice storms). SLP occurs primarily within dry and dry-mesic chert, sandstone and igneous woodlands across Missouri, but also occupies igneous and sandstone glades and igneous, chert and sandstone cliff tops. It occurs in similar sites in the Arkansas Ozarks, except that igneous substrates are lacking, and novaculite provides a unique substrate. In the Ouachitas, it is typically on south-facing aspects of extensive east-west trending ridges, and pine–dominated areas are typically larger than in the Ozarks. Mixed hardwood-pine communities are relatively more common in the Ozarks than in the Ouachitas (Guldin 2007).

While drought, wind and ice storms influenced SLP ecosystems, fire is the most consistent disturbance. Fire regimes are affected by site conditions described above and involve variability in intensity, seasonality (time of year), and frequency (time between fires). Large-scale fires occurred over portions of the landscape roughly every 20-40 years, in conjunction with severe droughts.

***Shortleaf Pine Community Types:***

While the "natural community" can be defined in various ways and levels of detail in distinguishing distinctive plant species assemblages associated with chert, sandstone and igneous woodlands in which SLP is important, the most widely used classification system has been developed by NatureServe. Nelson's classifications (Nelson 2005) are listed because they often are used for the Ozarks as well. NatureServe recognizes the following Plant Community Associations in Ozark/Ouachita in which SLP is important:

1. Shortleaf Pine / blueberry Forest
   Recognized in Nelson 2005 as community variant on dry chert/sandstone/igneous woodland
2. Shortleaf Pine - (White Oak, Northern Red Oak) / (Farkleberry, Hillside Blueberry) / Little Bluestem - Longleaf Woodoats - Elmleaf Goldenrod Forest
   Nelson 2005 typical of dry-mesic woodland types
3. Shortleaf Pine - Black Oak - Post Oak / Blueberry species Forest
   Nelson 2005 as dry woodland type in more dissected landscapes (Salem/Potosi Ranger Districts)
4. Shortleaf Pine / Rock Outcrop Interior Highland Woodland
   Variant of woodland types where excessive exposure on rock and cliff is prominent
5. Shortleaf Pine / Little Bluestem - Elmleaf Goldenrod - Red-purple Beebalm - Pale Purple Coneflower Woodland
   Nelson 2005; variant of chert and sandstone distinguished on gentle dissected plains: Pineknot
   Unit in Missouri for example
6. Shortleaf Pine - White Oak / Little Bluestem Woodland
   Nelson 2005 similar to above but white oak increases with landscape dissection on dry mesic slopes
7. Shortleaf Pine - Post Oak - Blackjack Oak / Little Bluestem Woodland
   Nelson 2005. More prominent near the Central Plateau in Missouri
8. A shortleaf pine component is associated with igneous and sandstone glade/rock outcrops where SLP is within the range
9. Delta Post Oak-Willow Oak Flatwoods Forest (includes shortleaf pine)

Although this list demonstrates the diversity of plant communities in the region in which SLP is important, the subcommittee felt that the list could be simplified for the purpose of defining DFCs for the region. The DFCs will therefore be described for the following three landscape and community types:

1. *Pine–bluestem:* SLP communities in which warm season grasses/forbs are prominent on dissected plains (includes plant community associations 6 and 7 above).
2. *Dry-Mesic Pine–Oak:* SLP mixes with oak species (either can be dominant) on more deeply dissected hills, even on upper north-facing slopes (includes plant community associations 1, 2, 3, and 9 above).
3. *Dry Pine–Oak:* SLP mixes with oak species (Black and Post Oak) on steep, south-facing upper slopes and ridgetops (includes plant community associations 1, 3, 4, 5, and 8 above).

***Desired Future Conditions for Shortleaf Pine Communities in the Ozark/Ouachita (AR/MO) region:***

Shortleaf pine ecosystem restoration should occur at the landscape scale and therefore the DFCs presented below provide both landscape and stand level guidelines. Landscape scale DFCs were adapted from the Landfire project developed by USFS and DOI, with cooperators. Landscape conditions were developed by Landfire using state-transition computer models with input parameters provided by expert groups along with literature sources. Full documentation of the methodology has been published and reviewed (http://www.landfire.gov/). Under this process, disturbance type and frequency that would lead from each state such as mid-seral mature open to every other state such as mature closed are input into the computer. A computer then simulates a long period of community change such as 1,000 years, to determine what proportion of the landscape would be occupied by each state. Disturbances include weather, within-stand competition, insect and disease outbreaks, ice, and fire, with varying severity (partial or stand-replacing disturbance or no disturbance). Landfire states or classes are based on stand age and openness. Both open and closed seral states are described as woodland conditions, that is, less than full canopy cover, with an understory dominated by native herbaceous species. The following DFCs apply only to the mature open seral stage.

These are presented only as guidelines. They are presented because the assumptions and methodology have been published and provide guidance on the spatial diversity of structural conditions that might occur within a community in landscapes (10,000 acres or more). When researchers and managers on the team have information indicating that local percentages differ from those calculated by Landfire, these can be updated. Note also that Landfire used a slightly different classification from what is used in this document in that Landfire has only Shortleaf Pine Oak Forest and Woodland type, along with a pine–bluestem model, whereas the classification used here distinguishes dry pine–oak from dry-mesic pine–oak woodlands. Also, the team that developed this document felt an old growth closed class was needed, but it has not been added below. This diversity of structural conditions would have occurred in a mosaic of various patch sizes across these landscapes.

Stand level conditions were developed by the DFCs committee using historic data, research literature, and managers' collective experience. Research has shown that both natural and anthropogenic fires influenced historic vegetation. Fire scar research from the Interior Highlands provides the most detailed fire frequency information, however, it is widely understood that many low intensity fires do not leave fire scar evidence. Therefore, fire frequencies recorded by this method likely underestimate the actual frequencies, so ranges are provided below. Some areas within the Interior Highlands have more detailed data and DFCs could be modified based on their findings.

***<u>Desired Future Conditions for Shortleaf Pine–Bluestem:</u>***

*Site Types:* This shortleaf association exhibits the most open canopy condition of the three described here, as a result of frequent fires of varying intensity and seasonality that serve to control most other woody growth. The herbaceous ground cover is abundant. These communities occur on less dissected landscapes where larger areas of relatively gentle topography allowed for greater and more frequent disturbances, especially from fire.

*Desired Age and Structural Characteristics:* landscape level

- Early seral open – 15%
- Mid-seral open – 35%
- Mature open – 45%
- Mid-seral closed – 3%
- Mature closed – 2%

(With about 85% pines across the landscape)

*Canopy Closure:* Range of 30-60% overall, but could be much sparser or denser in certain locales depending on small-scale ecological factors.

*Basal Area:* 40-70 sq. ft./ac with an average diameter of 16 inches DBH. Refer to Table G.2. for stocking ratios.

*Midstory:* Coverage should be less than 10%.

*Understory:* Coverage should be less than 10%.

*Ground Layer:* Coverage should be extensive in restored sites, 80-100% cover and made up of at least 80% graminoid-forbs in composition.

*Disturbance Regimes:* Since this community occurred over larger geographic areas with great connectivity, natural and anthropogenic ignitions would burn larger units and therefore fire return intervals would be shorter, 3-5 years.

***<u>Desired Future Conditions for Dry Pine–Oak Woodland:</u>***

*Site Types:* In Missouri, these community types typically occur on south and west-facing slopes and ridge tops and approximately the upper third of their backslopes. In the southern Ozarks, they occur on upper south and west-facing slopes. In the Ouachitas, dry pine–oak is more prevalent in the central regions on upper south and west-facing slopes. These systems are more edaphically controlled than the other community types, although fire is still important. These sites are more dissected and therefore have more variability in fire regimes. In the Ozarks Highlands, the extent and frequency of fires often was less compared to the large connected landscapes of the Ouachitas and Boston Mountains.

*Desired Age and Structural Characteristics:* landscape level

- Early seral open – 5%
- Mid-seral open – 25%
- Mature open – 45%
- Mid-seral closed – 5%
- Mature closed – 20%

*Canopy Closure:* Range of 30-50%. Use Table G.2. to determine relationship among average stand DBH and canopy closure.

*Basal Area:* Range of 30-60 sq. ft./ac. In the northern Ozark Breaks, BA would be higher due to large numbers of old growth stands with larger diameters.

*Midstory:* Coverage should be approximately 15%, with common plants like farkleberry, dogwood, hickories, etc.

*Understory:* Coverage can be 20-80% in the northern Ozark Breaks and Hills. In the southern Ozarks/Ouachitas coverage is less than 30%. Coverage may increase with restoration.

*Ground Layer:* Range of 40-60% in coverage with at least 80% graminoid-forbs in composition.

*Disturbance Regimes:* Fire is likely to occur on these drier sites (at least the larger sites) but drought is the primary disturbance. Typical fire return intervals were 5-10 years in the Ozark and 3-7 years in the Ouachita and Boston Mountains because of relatively smaller units.

***Desired Future Conditions for Dry-Mesic Pine–Oak Woodland:***

*Site Types:* In MO, typically occurs on mid-to-low, moderately steep north and east-facing slopes where fire frequency was less than pine–bluestem systems. In the southern range (Ozarks and Ouachitas), occurs on low-to-mid south and mid-north slopes and toe slopes. Percent of pine varies inversely with steepness. Shortleaf pine with white oak is typical with a red oak component increasing farther south. Oaks may dominate many sites, with shortleaf pine as a secondary component because oaks have a competitive advantage on moist sites.

*Desired Age and Structural Characteristics:* landscape level

- Early seral open – 5%
- Mid-seral open – 25%
- Mature open – 45%
- Mid-seral closed – 5%
- Mature closed – 20%

*Canopy Closure:* Range of 50-80%. Use Table G.1. to determine relationship among average stand DBH and canopy closure.

*Basal Area:* Range of 50-90 sq. ft./ac with an average diameter of 16 inches DBH.

*Midstory:* Coverage should be less than 30%.

*Understory:* Coverage should be less than 30%.

*Ground Layer:* The committee could not reach a consensus range of percent coverage from the wide variation experienced by those who have been engaged in restoration throughout the range. It is agreed it should be over 20% and 80- 100% is desirable but may not be feasible. The ground layer should be made up of at least 80% graminoid-forbs in composition.

*Disturbance Regimes:* Fire is likely to occur on these sites, depending on size, but other disturbances like windthrow, drought and insect outbreaks are also common disturbances. Typical fire return intervals were 5-10 years in the Ozark and 3-7 years in the Ouachita and Boston Mountains.

***Herbaceous site indicator species for the three identified SLP communities:***

Managers have found some sites to be resistant to restoration due to past management activities. Species that should be present may have been lost, even in the seed bank, through past management. Species uncharacteristic of the community may have become abundant, and may not be easily controlled through fire or other available management practices. The presence of species appropriate to the site and community is an important component to judge the restorability of a particular site. Using a Floristic Quality Index (Swink and Wilhelm, 1994) that considers all species present on the site is the best way to evaluate restoration potential, but below is a short list of indicator species. Presence of herbaceous species that require open canopy and frequent fire provide valuable indications of the functioning of shortleaf pine ecosystems.

Characteristic and Desired Indicators:

- Little bluestem (*Schizachyrium scoparium*)
- Big bluestem (*Andropogon gerardii*)
- Tick trefoil (*Desmodium marilandicum*)
- Sensitive briar (*Mimosa quadrivalvis var. nuttallii*)
- Cream wild indigo (*Baptisia bracteata*)
- Stiff-leaved aster (*Ionactis linariifolia*)
- Spreading aster (*Symphyotrichum patens*)
- Turbinate aster (*Symphyotrichum turbinellum*)

- Goldenrod (*Solidago odora*)
- Bristly sunflower (*Helianthus hirsutus*)

In addition these species can be used in Arkansas

- Pale purple coneflower (*Echinacea pallida*)
- Large coneflower (*Rudbeckia grandiflora*)

For more specifics on identifying these, refer to Common Indicator plants of Missouri (Farrington 2010).

| Community Type | Canopy Closure (%) | Basal Area* ($ft^2$/ac) | Trees Per Acre* | Midstory Density (%) | Understory Cover (%) | Ground Cover (%) |
|---|---|---|---|---|---|---|
| Shortleaf Pine–Bluestem | 30-60 | 35-70 | 26-52 | <10 | <10 | 80-100 |
| Dry Mesic Shortleaf Pine–Oak Woodland | 50-80 | 60-95 | 44-70 | <30 | <30 | 50-80 |
| Dry Shortleaf Pine–Oak | 30-50 | 35-60 | 26-44 | 15 | 20-80 North<br><30 South | 40-60 |
| *Calculated Based on an average DBH of 16”, will vary with average stand DBH see table 1 A | | | | | | |

***Table G.1.*** *Summary of DFCs for mature, open condition shortleaf pine communities.*

***<u>Management:</u>***

*General Considerations:* Natural community restoration cannot be accomplished on every site formally occupied by shortleaf pine, especially in those areas with a lot of damage from overgrazing and other abuses. Initial inventory should identify landscape-scale areas with a preponderance of restorable sites. Based on the collective experience of the subcommittee, the guidelines below could help to determine whether or not restoration is practical on a given site. Practicality of restoration can be influenced by economics, invasive species, native seed bank, or other factors.

*Pretreatment Decision Making:* The initial step is to determine the feasibility of restoration with managers' limited resources: efforts should focus on sites with the best chance of success. Using Floristic Quality Index plots is expensive, but the use of indicators and quick herbaceous layer monitoring (rapid ecological assessment based on the indicator species listed above) will also help to determine whether the site is a good candidate for restoration. Without a good indication of a response of herbaceous indicator plants, the stand may simply need a prescribed light thinning and/or creation of opening followed by dormant/growing season fires as a pretreatment to determine whether the indicator species' seedbank is present. This would be a good path forward if in doubt. Conducting an intermediate thinning under a forest management plan would leave the tract available for reaching alternative goals. Invasive species should be aggressively controlled. Opening the canopy and applying one burn will increase the probability that characteristic sun-loving perennial forbs will remain for the next burn treatment (Guldin 2007). If the site is determined to be restorable, continued treatment will be needed to achieve the DFCs. (SLP ecosystems are fire adapted, so it is imperative that restoration sites and landscapes be burnable). Herbicides and mechanical treatments are likely to be necessary in the restoration prescription due to the invasion of plants that were historically absent.

Managers must also decide whether to focus on getting pine back in the system first or to work to restore the grass/forb component of the understory first. Different management approaches are required to accomplish each of these. If the landscape to be restored is dominated by maturing or seed-producing pine, then managers may concentrate on thinning and applying fire to restore groundcover diversity and begin to bank SLP reproduction. If SLP is essentially missing from the landscape where formerly dominant, then the site should be converted to planted SLP stand and managed as such until a commercial thinning is viable. Again, managers and planners must consider what personnel and financial resources will continue to be available when determining the scale of restoration projects they can sustain over time.

*Fire:* Maintaining a fire regime in these landscapes is critical to successful ecosystem restoration. Initial high fuel loading or those that develop following management or natural disturbances need to be managed carefully to avoid undesirable overstory mortality or other adverse effects. Fire intervals will need to be kept to 1-3 years apart during the restoration process with thinning occurring early in the process. While historic fire intervals were more variable (Guyette et al. 2002, Guyette et al. 2006), current conditions resulting from decades of fire suppression and other land use have been found to require more frequent controlled burns in order to recover the ground flora and reduce competition by oaks and other hardwoods (Sparks et al. 1998). Missing scheduled management treatments can actually result in converting the system to non-pine forest types. Fire return intervals in restoration areas tend to be shorter than the historical intervals in order to remove large amounts of accumulated fuels, kill undesirable hardwood resprouts, and remove fire-intolerant invasive species. Fire adapted exotic species such as *Sericea lespedeza* should be controlled before burning. Herbicides are an effective control treatment depending on the species. Once the vegetation community has stabilized, fire intervals can be lengthened.

*Hardwood Control:* Restored sites are two layered for the most part, consisting open canopy and groundlayer with some understory. A common need in restoration is to reduce the density of hardwood species in the midstory and understory. This can be achieved a number of ways, (1) applying herbicides as a pretreatment (2) increasing fire frequency and maintaining a higher overstory density to reduce hardwood sprout growth or (3) using hotter fires in the growing season to remove midstory and understory hardwood species and accepting greater overstory mortality. On mesic mixed sites, hardwood species have a competitive advantage over SLP because of reduced fire intensity and frequency. Management strategies should focus on increasing SLP in these stands.

*Herbicide:* Herbicide, while having the potential for adverse effects, may be the most effective way to reduce dense hardwoods and invasive species that have increased in a site over decades of prior or no management and should be in the managers "toolbox". Invasive species and hardwoods (including oak) may be fire-resistant or too large to be effectively reduced by fire and/or may resprout after cutting, resulting in a degree of shading that will hamper the desired herbaceous response. Evaluation and implementation of herbicide treatments should be undertaken carefully, following all approved uses and cautions when mixing according to label recommendations.

*Thinning:* Numerous studies have demonstrated that existing forests and woodlands are much denser and with more shade on the ground than a century ago (Foti 2004, Nowacki and Abrams, 2008). The resulting shaded conditions reduce overall species diversity and especially the species characteristic of SLP dominated communities. Restoration of these areas will often require mechanical removals to increase light resources to the herbaceous layer. The restoration process requires multiple silvicultural entries and burns in order to reach specified conditions. Thinning toward recommended DFCs should be kept at a slightly higher level (10-20 BA) than DFCs to account for potential loss of overstory trees from fire damage, windthrow, lighting, insects and natural mortality.

*Regeneration of Stands:* Stambaugh et al. (2007) suggest that while long-term frequent burning at 1-3 year intervals results in abundant SLP regeneration, fire-free intervals of eight to fifteen years likely are necessary to provide recruitment of cohorts into the stand. Given the long age span of SLP, and the desire to maintain relatively open stands, recruitment may only need to occur every several decades. There has been little experimentation to this end in restoration efforts currently underway, however, with the focus being on frequent burns to stimulate and maintain the overstory structure and ground flora. Experimentation, research and modeling are needed to find the most appropriate approach for different communities, conditions of stands, and sites.

***Decision Making Criteria:***

Each site contains its own unique challenges and complications that prevent a simple "recipe" for restoration. The tables on the following pages are provided to be a guide based on years of experience from managers.

| | Percent Canopy Closure for Forest Grown Shortleaf Pine Stands | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10% | | 20% | | 25% | | 30% | | 40% | | 50% | | 60% | | 70% | | 80% | | 90% | | 100% | |
| DBH | #/ac | BA | #/ac | BA | #/ac | BA | #/ac | BA | #/ac | BA | #/ac | BA | #/ac | BA | #/ac | BA | #/ac | BA | #/ac | BA | #/ac | BA |
| 10 | 30 | 16 | 59 | 32 | 74 | 40 | 89 | 49 | 119 | 65 | 148 | 81 | 178 | 97 | 208 | 113 | 237 | 129 | 267 | 146 | 297 | 162 |
| 12 | 14 | 11 | 28 | 22 | 35 | 28 | 42 | 33 | 57 | 44 | 71 | 56 | 85 | 67 | 99 | 78 | 113 | 89 | 127 | 100 | 142 | 111 |
| 14 | 10 | 11 | 21 | 22 | 26 | 27 | 31 | 33 | 41 | 44 | 51 | 55 | 62 | 66 | 72 | 77 | 82 | 88 | 92 | 99 | 103 | 110 |
| 16 | 9 | 12 | 17 | 24 | 22 | 30 | 26 | 36 | 35 | 49 | 44 | 61 | 52 | 73 | 61 | 85 | 70 | 97 | 78 | 109 | 87 | 122 |
| 18 | 7 | 12 | 14 | 25 | 17 | 31 | 21 | 37 | 28 | 49 | 35 | 62 | 42 | 74 | 49 | 86 | 56 | 99 | 63 | 111 | 70 | 123 |
| 20 | 7 | 15 | 14 | 30 | 17 | 37 | 20 | 45 | 27 | 59 | 34 | 74 | 41 | 89 | 48 | 104 | 55 | 119 | 61 | 134 | 68 | 149 |
| 22 | 6 | 17 | 13 | 34 | 16 | 42 | 19 | 51 | 26 | 68 | 32 | 84 | 38 | 101 | 45 | 118 | 51 | 135 | 58 | 152 | 64 | 169 |

***Table G.2.*** *Desired future conditions for Shortleaf Pine forests based on available growing space was adapted from Rogers (1983) using regionally-specific crown data collected from various forest grown shortleaf pine stands in Arkansas. Special considerations will need to be taken when working in small diameter stands (avg DBH of 10") where re-entry into the stand will be infrequent (<10 years). These typically younger trees respond well to thinnings and additional reductions in trees per acre may be required to prevent premature canopy closure. As tree diameter increases in the upper ranges of our dataset, the rate of crown growth slowed. The data ranged from 10-28" diameter classes (n=233), but only had a large enough sample size to include trees up to 22" in this table. If there is a significant proportion of hardwood species in the stand, the resulting basal areas and trees per acre may be too high due to their larger canopy sizes.*

DFCs Range for Pine–Bluestem Woodland
(for 16" average stand DBH)

DFCs Range for Dry SLP-Oak Woodland
(for 16" average stand DBH)

DFCs Range for Dry Mesic SLP-Oak Woodland
(for 16" average stand DBH)

| Forest Variables | Desired Stand Structure | Conditions that may warrant Management | If below desired | If above |
|---|---|---|---|---|
| Overstory Canopy Closure | 30-60 % | | Let regenerate | Thin/Burn |
| Midstory Cover | | | | |
| Hardwood encroachment | | | | |
| | | | | |
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***Table G.3.*** *This list of triggers should be completed but requires further data and input from the full committee*

***<u>Emerging Issues for the Future (challenges moving forward)</u>***

- Tools for private landowners, such as USDA Farm Bill incentives should be added.
- Develop commercial pine management blending restoration/economic feasibility.
- Effective reforestation/afforestation techniques need to be developed where we have lost SLP.
- Identify and map lands that historically supported SLP (thru GLO, soil maps, and historical records) and no longer do so.
- Increase the understanding and sustainability/economic feasibility of uneven-aged/even-aged management.
- Develop markets for SLP products.
- Smoke management with the restriction of national air quality standards.

**<u>Definitions</u>**

1. Forest, Woodland, Savanna:
   In the Interior Highlands, forests are communities characterized by layered woody species with a defined canopy, midstory, and understory. A woodland (25-70% woody canopy) and savanna (10%-25% woody canopy) are structurally two layered vegetative communities with a defined overstory and ground layer of native herbaceous plants and sparse midstory and understory. Forests and woodlands may be closed or open, but forests maintain a dominance of woody species through all the vertical layers. Woodlands may be open or closed but maintain a two-layered structure.

2. Basal Area:
   The cross-sectional area of a single stem, including the bark, measured at breast height (4.5 ft. or 1.37 m above the ground).

3. Midstory:
   The area 3 meters or more above the ground, but below the bottom of the canopy. This can be presented as a vertical percent cover or a horizontal percent cover ("as the crow flies" but is still indicative of light penetration thru the stand).

4. Understory: (Shrub layer/advanced regeneration layer)
   The percent cover of vegetation 1-3 meters above the ground.

5. Ground layer:
   The percent cover of vegetation that is less than 1 meter in height. It includes the grass-forb component (also could be sedge-forb).

6. Seral Conditions: (as defined by Landfire)

   Early seral open – Openings with herbaceous cover and/or seedling (young regeneration to 15 years old). Shrubs present and may provide up to 70% cover. Openings can be semi-persistent with regular fire. Scattered old or large trees may be present, basal area less than 14 square feet per acre. Large snags and downed woody debris present.

Mid-seral open – Overstory crown cover less than 70%, herbaceous cover greater than 70%, shrubs present but less than 30% cover. Pine and oak saplings to pole size trees less than 16” DBH. Ages range from 16 – 60 years old. Basal area between 15 - 80 square feet per acre. Oak component less than 35% of basal area. Scattered older/large trees may be present, less than 14 BA. Snags few, large woody debris 1 greater than 8” DBH per acre.

Mid-seral closed – Overstory cover greater than 70%, depauperate herbaceous layer, shrubs few, woody vines abundant. Pine and oak saplings to pole size trees less than 16” DBH. Ages range from 16 – 60 years old. Basal area greater than 80 square feet per acre. Scattered older/large trees may be present, less than 14 BA. Snags few, large woody debris less than 1 greater than 8” DBH per acre.

Mature open – Overstory crown cover less than 70%, herbaceous cover greater than 70%, shrubs present to 30% cover. Pine and oak trees greater than 16” DBH; 10% of stems greater than 20” DBH. Ages range from 61 - 200+. Basal area less than 80 square feet per acre. Oak component less than 35% of basal area. No midstory. Scattered older/large trees present (greater than 30” DBH and/or 250 years old). Large snags present; 1-10 greater than 8” DBH per acre. Large downed woody debris present.

Mature closed – Crown cover greater than 70%, herbaceous cover depauperate, shrubs few, woody vines abundant. Pine and oak trees greater than 16” DBH. 10% of stems greater than 20” DBH. Ages range from 61 - 200+. Basal area greater than 80 square feet per acre. Midstory present. Scattered older/large trees may be present (greater than 30” DBH and/or 250 years old). Large snags present; 1-10 greater than 8” DBH per acre. Large downed woody debris present.

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