RESTORATION OF SHORTLEAF PINE IN THE SOUTHERN UNITED STATES—STRATEGIES AND TACTICS

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Abstract—Shortleaf pine (*Pinus echinata* Mill.) is the most widely distributed and poorly understood of the four major species of southern yellow pine. The area of southern forests dominated by shortleaf pine forest types has declined by more than 50 percent since 1980, with the most dramatic declines found in states east of the Mississippi River. To counteract this decline, the Shortleaf Pine Initiative was launched in the spring of 2013 by a host of partners including the U.S. Department of Agriculture Forest Service, other Federal and State agencies, universities, major conservation organizations, and other private partners in the region. The release of the Shortleaf Pine Restoration Plan in the summer of 2016 outlines a series of optimum restoration strategies, opportunities for coordination among proponents interested in shortleaf pine, and ways for partners to work together. However, geographic conditions and forest types are highly variable across the 23 States where shortleaf pine is found, and as a result, different approaches to restoration will be required in different regions. The management strategies and silvicultural tactics that managers should consider in application to the restoration and management of shortleaf pine in pure and mixed stands across the native range of the species are discussed.

INTRODUCTION

The dominant frequent-fire-adapted southern yellow pine ecosystems in the Southern United States are iconic places that have declined in area and are at risk of further decline. Assessments under two of the Southern Forest Futures forecasts of forest type change from 1950 to 2060 (Wear and Greis 2013) show the scale and scope of the decline. One forecast was built using assumptions of high urbanization, high timber prices, and accelerated rates of pine plantation management. Under those assumptions, the natural pine forest type declines by 59 million acres, the oak-pine forest type declines by 14.5 million acres, and the planted pine type increases by 66 million acres (table 1A). A second forecast was built using assumptions of low urbanization, low timber prices, and decelerating rates of pine plantation establishment. Under those assumptions, the natural pine forest type declines by 48.5 million acres, the oak-pine forest type declines by 9 million acres, and the planted pine type increases by 47 million acres (table 1B). By way of perspective, the draft 2017 Forest Resources report for the 2020 Resources Planning Act reports slightly more than 208 million acres of timberland in the Southern United States (Oswalt and others, In press). In round numbers, by the year 2060, 25 percent of the South's forests will be planted pine stands, and less than 10 percent will be in naturally regenerated pine-dominated stands.

The most substantial declines in acreage of native fire-adapted southern yellow pine ecosystems occurred prior to the 1950 date used in the Forest Futures analysis. The archetypal example of this decline is found in the decline of longleaf pine (*Pinus palustris* Mill.) ecosystems. Estimates are that, prior to European colonization of North America, stands dominated by longleaf pine or mixed pine-oak stands occupied roughly 91 million acres (Frost 1993). Current estimates from Forest Inventory and Analysis show that longleaf-dominant stands occupy 4.3 million acres (Oswalt and others 2012), a decline of 95 percent in its historic area. Since 1970, there has been no net loss of longleaf pine, though there was a slight decline into the 1990s and a recovery since that time. In essence, most of the loss of longleaf pine occurred prior to 1970.

By way of comparison, shortleaf pine (*P. echinata* Mill.) is more widely distributed than longleaf pine, but not as widely dominant historically. Estimates are that, prior to European colonization, stands dominated by shortleaf pine or pine-oak stands covered roughly 70–80 million acres. Today, shortleaf pine or pine-oak stands are dominant on only 6.1 million acres, a decline also of more than 90 percent (Anderson and others 2016). However, unlike the decline in longleaf pine, the decline in shortleaf pine has been more recent; currently, the area of stands dominated by shortleaf pine

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Table 1—Forecast of forest type based on analysis conducted by the Forest Futures Project (Wear and Greis 2013)

(A) Cornerstone Future E.
Assumptions: high rate of urbanization, high timber prices, high rate of planting

Year	Natural pine	Oak-pine	Planted pine
	--million acres--	*--million acres--*	*--million acres--*
1950	72.5	28.0	1.0
1980	50.0	30.0	15.0
2010	31.5	22.0	40.0
2060	13.5	13.5	67.0
Net, 1950–2060	-59.0	-14.5	66.0

(B) Cornerstone Future F.
Assumptions: low rate of urbanization, low timber prices, low rate of planting

Year	Natural pine	Oak-pine	Planted pine
	--million acres--	*--million acres--*	*--million acres--*
1950	72.5	28.0	1.0
1980	50.0	30.0	15.0
2010	31.5	22.0	40.0
2060	24.0	19.0	48.0
Net, 1950–2060	-48.5	-9.0	47.0

or pine-oak stands have declined by 52 percent since 1980 (Anderson and others 2016). From 1980–2012, a decrease in shortleaf pine and pine-oak types exceeding 500,000 acres has been reported for Alabama, Mississippi, Texas, Arkansas, and Georgia; three other States (Louisiana, Tennessee, and Oklahoma) have had declines between 400,000 and 500,000 acres over that same time period (Anderson and others 2016).

The recent decline for shortleaf pine could be an artifact of the changes in forest management on private lands in the region, especially where the distribution of loblolly pine (*P. taeda* L.) and shortleaf pine are sympatric and management has displaced shortleaf pine with loblolly pine. For example, in the upper west Gulf Coastal Plain of southern Arkansas in the 1980s, woodlands managers with Georgia-Pacific Corporation managed mixed stands of loblolly pine and shortleaf pine of natural origin using the seed tree method, precommercial and commercial thinning, and prescribed fire to rotations of 45 years. That silvicultural system produced an expected mean annual increment of roughly 4 tons per acre annually (Zeide and Sharer 2001). Conversely, Fox and others (2007) describe advances in loblolly pine plantation silviculture that yield roughly 10 tons per acre or more from planted loblolly pine stands on similar sites over a 25-year rotation. It's easy to see why productive forest lands across the South are converted from naturally regenerated stands to planted stands—especially on lands managed primarily for returns on investment, in areas where the natural range of loblolly and shortleaf pine is sympatric, and by landowners that can afford to make the substantial initial investment in plantation establishment.

Not only are shortleaf pine-dominated stands less prominent on the landscape, but the character of stands that remain has changed because of changing fire regimes. In 1935, U.S. Department of Agriculture (USDA) Forest Service Chief V.A. "Gus" Silcox codified a new agency policy that all forest fires were to be extinguished by 10 a.m. on the day after they were detected (Long 2016). This, in conjunction with the rise in capacity for State forestry agencies after World War II, set the standard for control of wildfires on public and private forest lands nationwide. The message was driven home by the Smokey Bear Wildfire Prevention Program, established in 1944; Smokey's classic message, "Remember… Only YOU Can Prevent Forest Fires," was established in 1947 (cf. smokeybear.com). But in application to fire-adapted southern yellow pine ecosystems, the message was confusing and impeded resource managers and the public. In addition, the transition from open range to fence laws for domestic livestock during the 20th century played a role in the reduction of surface fires set by farmers and ranchers to improve forage. The result has been a general withdrawal of effective controlled burning to maintain

habitat in mature native stands of southern yellow pines, including shortleaf pine, and replacement of the pine component to a prominent midstory and overstory component of less fire-tolerant hardwoods through succession. Smokey's message was revised in 2001 to say, "Only You Can Prevent Wildfires," in part to reflect the value of controlled burning in southern pine forest types (cf. smokeybear.com).

These two factors, the decline in area of shortleaf pine and pine-hardwood forest types and the exclusion of fire across the landscape, combine to form the crux of the issue—that mature fire-maintained shortleaf pine stands are dramatically underrepresented on the landscape today relative to 200 years ago. Moreover, while 200 years constitute multiple generations in human timeframe, it's within the span of a single generation in shortleaf pine. And when that habitat is underrepresented on the landscape especially within a short ecological timeframe, the species of flora and fauna that are specifically adapted to that habitat become underrepresented as well. For example, west of the Mississippi River and east of the Great Plains, American bison (*Bison bison*) and elk (*Cervus canadensis*) have been largely extirpated in woodlands; species such as northern bobwhite (*Colinus virginianus*), Bachman's sparrow (*Peucaea aestivalis*), and the Diana fritillary butterfly (*Speyeria diana*) have limited distribution; and the red-cockaded woodpecker (*Picoides borealis*) is officially endangered.

THE SHORTLEAF PINE INITIATIVE

In 2010, agencies and conservation leaders across the region convened a Shortleaf Pine Working Group. Two regional meetings were hosted, one in Raleigh, NC, in 2010 and the other in Huntsville, AL, in 2011, which built impetus for a more formal region-wide program on restoration of shortleaf pine. That led to the establishment of the Shortleaf Pine Initiative in 2013; an Advisory Committee was formed consisting of representatives from a dozen public and private organizations including Federal agencies (USDA Forest Service, USDA Natural Resource Conservation Service, and U.S. Department of the Interior Fish and Wildlife Service), State agencies, nongovernmental conservation organizations, universities, forest management organizations, and conservation-based foundations. The Initiative was funded by the Forest Service Region 8, State and Private Forestry, through the University of Tennessee-Knoxville. After a number of regionally based organizational and implementation meetings, the goals and objectives of the Initiative were codified in the Shortleaf Pine Restoration Plan in 2016 (Anderson and others 2016).

The vision and mission statements of the Initiative summarize the scale and complexity of work to be done. The vision is to expand the area of forests and woodlands dominated by shortleaf pine for the array of economic, ecological, and cultural benefits they provide, through a collaborative partnership effort across the historical range of the species. The mission is to provide the leadership and collaborative partnership framework for the restoration of shortleaf woodlands on a rangewide scale (Anderson and others 2016). Key elements of the restoration plan include 1) a series of optimum restoration strategies that are region-specific, 2) increased needs for coordination among proponents interested in shortleaf pine, and 3) ways for partners to work together.

Strategic Issues

The question of regional effect is important. The dominance of shortleaf pine varies widely across its natural range (fig. 1). The degree to which the species is found in mixture with other pines and hardwoods varies as well. As a result, the silvicultural prescriptions that are needed to manage for the species will be different, especially in the scale of activity across the landscape. A key to understanding the complexity of the challenge in shortleaf pine restoration is the question of managing mixed-species stands. There is a delicate balance in the establishment and development of seedling pines (or sprouts in the case of shortleaf pine) and vigorous sprouting hardwoods. Additional research is needed to develop the appropriate silvicultural prescriptions to ensure that the species desired in mixed stands will survive to the point of ingrowth into merchantable size classes.

Management of shortleaf pine stands in the Ouachita Mountains and Ozark Highlands will be relatively straightforward. In these Interior Highlands, shortleaf pine is the only native pine, and silvicultural systems devoted to managing pure shortleaf pine and pine-hardwood stands have been applied for 7 decades. Clearcutting has been commonly used to manage Ouachita shortleaf pine through the latter part of the 20th century; it's an effective silvicultural system provided that proper site preparation is conducted, especially ripping which markedly improves seedling survival in the very stony soils of the Ouachitas (Brissette and Barnett 2004, Walker 1992). Research from the latter part of the 20th century suggests that containerized shortleaf pine provides marginally better survival and growth than bare-root stock (Barnett and Brissette 2007, Brissette and Barnett 2003), and this appears to be supported by contemporary reports (Bell 2012, Schnake and others 2016). However, shortleaf pine lags far behind loblolly pine, slash pine (*P. elliottii* Engelm.), and even longleaf pine in area planted annually, and some degree of capacity improvement will be needed to broadly expand seed production and nursery propagation for a regional shortleaf pine planting program.

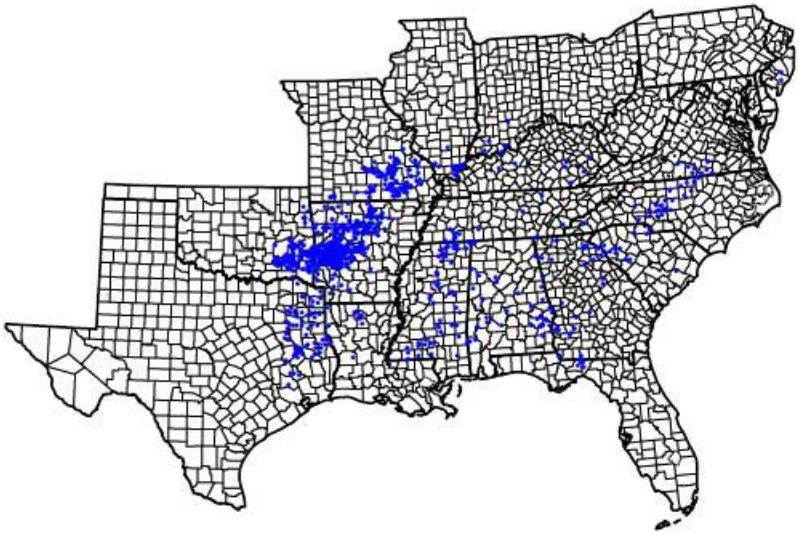

Figure 1—Forest Inventory and Analysis plot locations where shortleaf pine represents more than 50 percent of basal area, representing 3.453 million acres in this condition. Map projection: Lambert Continental. (Map created by J.F. Rosson, Jr., USDA Forest Service, Forest Inventory and Analysis, September 2015)

Natural regeneration under even-aged rotations using the shelterwood method is known to be successful in shortleaf pine (Lawson 1990), especially when prescribed fire is used early in the life of the new age cohorts to stimulate shortleaf pine resprouting and re-establish native understory flora (Guldin 2007). Modifications of the seed tree and shelterwood methods that lead to two-aged stands are ideal for recovery of the endangered red-cockaded woodpecker (Conner and Rudolph 1991, Hedrick and others 1998, Rudolph and Conner 1996). A classic example of this is found in the Ouachita Mountains of western Arkansas and eastern Oklahoma (fig. 2). Active local timber markets allow the commercial sale of trees harvested during thinning in fully stocked sawtimber-sized pine stands. Receipts from that timber sale as well as other funding sources then support removal of the invading hardwood midstory, introduction of periodic prescribed burning at large scale, and even the insertion of artificial nest boxes in residual overstory pines for the endangered woodpecker. In essence, timber sales are the first step in the ecological restoration of extensive areas of shortleaf pine-dominated forests and woodlands, with attendant benefits for both the endangered woodpecker and the panoply of flora and fauna that rely upon open fire-maintained pine woodlands (Guldin 2007).

Restoration of shortleaf pine elsewhere throughout its range is complicated by a host of factors, the foremost of which is that shortleaf pine is not the only native conifer. Most of the silvicultural systems used to manage shortleaf pine in the western part of its range will also favor pitch pine (*P. rigida* Mill.), Virginia pine (*P. virginiana* Mill.), Table Mountain pine (*P. pungens* Lamb.), longleaf pine, and especially loblolly pine. Planting, whether as part of the clearcutting method, after other kinds of harvesting including high-grading, or to afforest abandoned agricultural lands, is an important part of the toolbox. However, differences in site preparation and release tailored to local conditions will obviously be required among these different kinds of conditions.

Fire is extraordinarily important in maintaining shortleaf pine ecosystems. Shortleaf pine is the only southern pine that will reliably sprout at young ages and small root-collar diameters when top-killed by fire (Lilly and others 2012a, 2012b), an adaptive trait noted more than a century ago (Mattoon 1915). Recent research suggests an increased incidence of hybridization between shortleaf and loblolly pine is, in part, a result of reduced temporal discontinuity between periods of loblolly pollination and shortleaf pine cone receptivity, and perhaps also the widespread planting of loblolly pine across the South (Tauer and others 2012). The importance of surface fires in young stands as an agent to trigger shortleaf pine resprouting while concurrently top-killing hybrids and also volunteer loblolly pine in new mixed-species age cohorts has been shown to be ecologically significant and silviculturally useful (Bradley and others 2016, Stewart and others 2015). However, as mixtures grow more diverse and more complex, another tool in the toolbox for those interested in managing for shortleaf pine is to select for retention of shortleaf preferentially and to remove other pine and hardwood species during the first entries associated with precommercial or commercial thinning.

Figure 2—Management of shortleaf pine on Federal lands in the Ouachita Mountains centers on overstory thinning, hardwood midstory removal, and cyclic prescribed burning; this leads to open fire-maintained shortleaf pine habitat suitable for the endangered red-cockaded woodpecker (cavity tree shown with metal flashing at the base) as well as many other species of flora and fauna that are adapted to these ecological conditions. (photo by James M. Guldin)

Tactics Appropriate for Restoration of Shortleaf Pine

In light of these issues and concerns, a subjective decision model can be developed that gives landowners some guidance about the feasibility and the likelihood of success for managing shortleaf pine. Because these elements depend on a host of factors with which foresters are more likely to be familiar than landowners, the first element is easily stated—landowners who decide to manage shortleaf pine should retain the services of a professional forester who can advise them about the opportunities and challenges that will arise.

The stand must be large enough to allow for cost-effective forest management activities. Two concerns seem paramount in this regard. First, a stand should be large enough to support operable harvests during thinning. Contracted services such as planting, site preparation, and release should be feasible, and the stand should be amenable to the safe execution of prescribed burning. Landowners should take advantage of natural regeneration with shortleaf pine especially if stands currently have mature shortleaf pine in the overstory. It's difficult to conduct many of these treatments if the stand is smaller than 25 acres in size, unless they are part of a larger landscape where treatments can be concurrently conducted.

Prescribed burning is critical for the successful management of new age cohorts of shortleaf pine to reduce the increasing frequency of shortleaf x loblolly pine hybrids (Bradley and others 2016, Stewart and others 2015, Will and others 2013), and perhaps also as a tool to convert offsite loblolly pine stands back to shortleaf pine. Controlled burning will be easier to implement if the site is characterized by homogeneous within-stand topography or lies within a larger landscape that can all be burned. Prescribed fire is more difficult to apply if the stand is isolated or is in terrain that has a high degree of topographic heterogeneity. Some Federal land management programs have a cooperative element that allows Federal fire crews to also burn private lands that are adjacent to Federal ownership as part of a larger landscape fire management plan. However, on private lands generally, the local availability of State or contract burning crews is certainly a constraint.

A key consideration is whether the sites where restoration is planned are within the woodshed of local mills, and whether there are local markets for pine timber. Knowing there is a market for trees harvested during thinning and ultimately for mature shortleaf will be critical to enable a cost-effective restoration program. One of the challenges in shortleaf pine restoration

activity in the northern part of its range, especially east of the Mississippi River and to the north of the natural range of loblolly pine, is the paucity of mills that utilize pine sawtimber and pulpwood.

On the other hand, if the stand is located within the sympatric range of shortleaf and loblolly pine, pine sawmills and pulp mills will be more common because of industrial management of loblolly pine, and shortleaf pine can be merchandised in those markets. But choosing to manage for shortleaf pine within the sympatric range of loblolly pine, especially the establishment of new planted stands, may be difficult for some landowners to justify because of the faster growth rates of loblolly pine, especially over the first 3 decades of stand establishment. Landowners will need other reasons to establish shortleaf pine in preference to loblolly pine—such as to provide landscape-scale species diversity, as part of a wildlife program involving prescribed burning at young ages, or as a hedge against changing climatic conditions especially in the western part of its range.

Obviously, stands with an existing shortleaf pine component are easier to manage than stands where shortleaf pine is rare or absent. But the potential to work with stands where shortleaf pine is a manageable minor component should not be overlooked by landowners and the foresters who advise them. In a study of the rehabilitation of understocked loblolly-shortleaf pine stands on the upper west Gulf Coastal Plain, Baker and Shelton (1998) reported that stands with 30 percent stocking recovered to full stocking in 15 years. Mixed stands where shortleaf is a minor component in the range of 20–50 square feet per acre are candidates for recovery by removing the non-shortleaf component through thinning, followed by judicious midstory treatment and initiation of cyclic prescribed burning. Among the resulting benefits of this approach is the development of new shortleaf pine seedlings and sprouts in the understory, which can develop into a new age cohort as opportunities allow. This could well be the best opportunity and highest priority rangewide to quickly restore shortleaf pine dominance in a stand.

Shortleaf pine can grow in a wide variety of soil types, but it may have a competitive advantage versus other conifers and hardwoods on dry, xeric soil types rather than wet and mesic soil types, especially in the western part of its range. Similarly, past land use is a consideration especially with respect to understory flora. If the site has a history of agricultural use, supplemental restoration will be needed to restore understory flora such as C4 grasses as well as the overstory shortleaf pine component. However, sites on eroded terrain or with a history of littleleaf disease in the Piedmont continue to be a challenge for restoration of shortleaf pine.

DISCUSSION

Shortleaf pine is an iconic southern yellow pine found in pure and mixed stands, but it is gradually being lost in stands and landscapes across the South. Planting will be required for its restoration, but not much shortleaf pine planting is currently done. Substantial effort will be needed by Federal and State agencies as well as the private sector to develop capacity for genetically improved shortleaf pine seed and to expand nursery production and planting of shortleaf pine seedlings. Restoration will be relatively straightforward in States west of the Mississippi, especially the Ouachitas of Arkansas and Oklahoma, where shortleaf is the only native pine, and where local markets for pine pulpwood and sawtimber are well developed. Efforts elsewhere are confounded by lack of markets, the complicated silviculture of mixed-species stands, and the professional preference for loblolly pine because of faster growth rates. Prescribed burning is critical for restoration of pure or mixed shortleaf pine stands, especially at young ages so as to help maintain pure shortleaf pine and to eliminate shortleaf x loblolly pine hybrids. Low-cost restoration should expand to include managing existing stands that have a shortleaf component, even a minor component that could be managed to accentuate its dominance in a given stand. Research is needed to better quantify the advantages of maintaining a dominant shortleaf pine component in mixed species stands, especially within the sympatric range shared by loblolly pine; advantages might include favorable elements of species diversity, distribution of risk in a management portfolio, ability to use cyclic prescribed burning to promote wildlife, and a possible hedge against mortality due to extended drought. Finally, although the strategies and tactics for restoration of shortleaf pine will differ from those used in longleaf pine, those two initiatives are united by a common goal—the restoration of fire-adapted southern pine ecosystems and the fauna and flora that depend upon them, which are underrepresented across the landscape of southern forests.

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