Shortleaf Pine: Guidance for Seed Transfer Within the Eastern United States

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Abstract

Shortleaf pine (*Pinus echinata* Mill.) is a shade-intolerant conifer tree native to forests across the Eastern United States, extending from east Texas to New Jersey. Shortleaf pine has declined sharply in abundance during the last several decades due to species conversion, reduced fire frequency, and competition with encroaching broadleaf trees. Genetic diversity of the species is high due to high seed dispersal and long-distance pollen dispersals maintaining low population structure across the species' range. Shortleaf pine can hybridize with loblolly pine (*P. taeda* L.), which could increase if climatic shifts begin to synchronize pollen dispersal and receptivity of the two species. Fire is an important component of shortleaf pine ecosystems and helps to reduce hardwood and pine competition, including loblolly pine hybrids. Local seed sources are generally best in far northern and southern areas of the species' range. In central and northern areas, seed transfer from sites that are warmer by 7 and 5 °F (3.9 and 2.8 °C) average annual minimum temperature, respectively, may have increased growth relative to local sources. Shortleaf pine is highly susceptible to southern pine beetle but is relatively resistant to fusiform rust disease. Shortleaf pine is likely to persist, or expand northward, in the future because of its high tolerance to drought and fire.

Introduction

Shortleaf pine (*Pinus echinata* Mill.) is a long-lived, shade-intolerant conifer that grows on relatively dry, infertile sites across the Southern United States. It has the largest range of any southern pine, growing across 22 States and as far north as New York's Long Island (Lawson 1990). Shortleaf pine may occur as pure stands (figure 1) or as a component of pine/oak and loblolly/shortleaf pine forests (Lawson 1990), driven in large part by past disturbance regimes (Guyette et al. 2007). Sharp declines in abundance over the last 50 years are attributed to a combination of overharvesting, fire suppression, and stand replacement by loblolly pine (*P. taeda* L.), which is a preferred commercial species (McWilliams et al. 1986). Shortleaf pine wood is relatively dense and is used for building construction, railroad ties, and plywood (Alden 1997). In pine/oak stands, shortleaf pine is sympatric with black oak (*Quercus velutina* Lam.), white oak (*Quercus alba* L.), and hickory (*Carya* spp.), but it may be out competed in the absence of disturbances that increase available light (Stambaugh et al. 2002) or bare mineral soil for natural regeneration (Guyette et al. 2007). Efforts to reduce competition are often required if hardwoods are dominant in the understory (figure 2). Low recruitment, along with the decline in abundance, has led to increased restoration and tree planting efforts (figure 3) such as the Shortleaf Pine Initiative (https://shortleafpine.org). Compared with other southern pines, shortleaf pine is slower growing in its early years, but is relatively cold tolerant and fusiform rust resistant. Cold injury may appear as winter burn on needles and frost heave (Pickens and Crate 2018).

Shortleaf pine is moderately fire tolerant because of its thick, platy bark and its ability to resprout after light- to moderate-intensity fires (figure 4). Mature stands can tolerate exceptionally hot fires if crowns are not burned (figure 5). The presence of a basal crook at the root collar protects dormant buds during fires, allowing the species to resprout (Bradley et al. 2016, Lilly et al. 2012, Little and Somes 1956, Stewart et

Figure 1. Shortleaf pine is commonly associated with oaks (*Quercus* spp.), since both require high light environments and similar temperature and moisture regimes. (Photo by C. Pike, 2019)

Figure 2. Competition, especially from hardwoods, should be managed to facilitate regeneration of shortleaf pine, which is otherwise shade intolerant. In this photo, goats were brought in to help control competing vegetation from hardwood trees and shrubs. (Photo by C. Pike, 2019)

Figure 3. Restoration with tree planting is necessary to restore shortleaf pine in stands that have converted to hardwoods or other vegetation. Trees growing in this container will be outplanted in a few months. (Photo by C. Pike, 2018)

Figure 4. The lower boles of shortleaf pine trees have very thick, platy bark that can survive light- to moderate-intensity wildfires. (Photo by C. Pike, 2019)

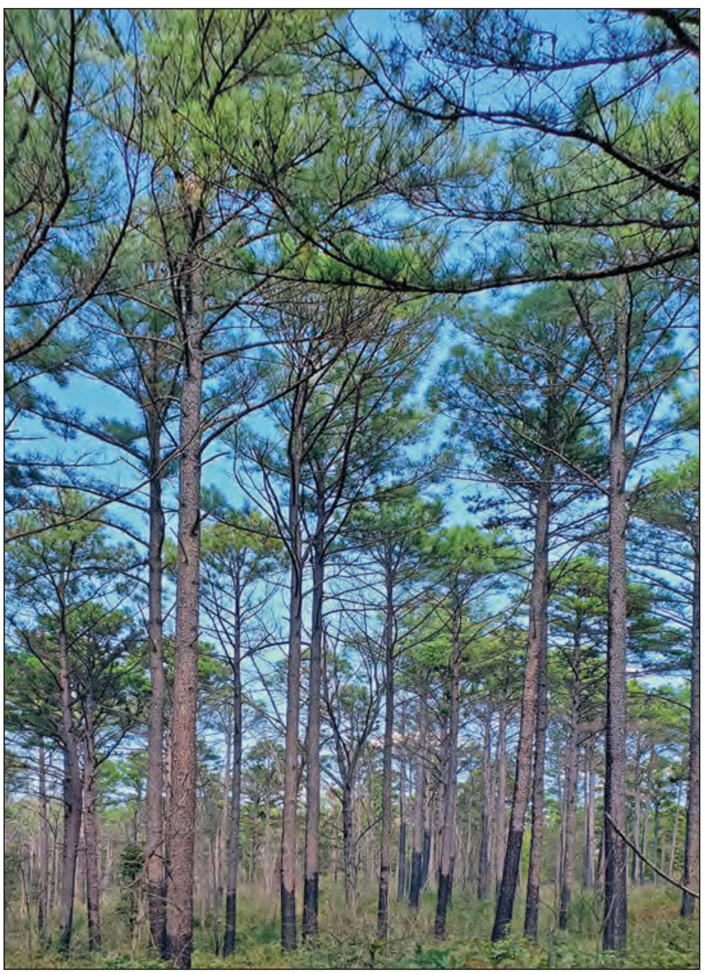

Figure 5. This stand sustained an extremely hot fire that destroyed most of the understory, while the mature shortleaf pines survived. (Photo by C. Pike, 2019)

Figure 6. Shortleaf pine seedlings form a basal crook that is an adaptive trait to protect against fire damage. (Photo courtesy of Southern Research Extension Forestry)

al. 2015) (figure 6). This characteristic is absent in loblolly pine and loblolly-shortleaf pine hybrids. In addition, shortleaf pine may allocate more resources to coarse roots than stem mass compared with loblolly pine (Bradley and Will 2017), which may enhance its drought tolerance. High drought and fire tolerance contribute to its likely persistence in a drier and warmer future climate (Peters et al. 2020). Warmer temperatures in the winter months, as has been observed in the Ozarks (Stambaugh and Guyette 2004), may confer a competitive advantage to shortleaf pine because photosynthesis can take place while competing hardwoods are dormant (Guyette et al. 2007). Shortleaf pine regenerates from seed if conditions, such as bare mineral soil created through fire or scarification, prevail during seed crops (Yocom and Lawson 1977).

Genetics

Shortleaf pine is a monoecious diploid species with wind-dispersed pollen and cones requiring 2 years to mature (figure 7) (table 1). Trees do not produce seed until 5 to 20 years of age, which can hinder

Figure 7. Shortleaf pine cones open to release seed with or without fire. (Photo by C. Pike, 2019)

Table 1. Summary of silvics, biology, and transfer considerations for shortleaf pine.

Shortleaf pine, *Pinus echinata* Mill.	
Genetics	• Genetic diversity: high • Gene flow: high
Cone and seed traits	• 2 to 73 cleaned seeds per pound (71 to 161 per kg) (Krugman and Jenkinson 2008)
Insect and disease	• Southern pine beetle • Pales and eastern tip weevil • Various cone and seed insects
Palatability to browse	• Few browse issues in its current range • Northward movement to areas with different herbivores may alter its susceptibility
Maximum transfer distances	• In northern locations, local sources are best, but consider conservative application of the general rule (using seed from up to 5 o F (2.8 °C) warmer average annual minimum temperature • In central locations sources should be moved northward no more than 7° F (3.9 °C) average annual minimum temperature • In southern locations, it is best to use local seed zones latitudinally and conservatively diversify longitudinally
Species range-expansion potential	• Shortleaf pine is a good candidate for northward expansion due to drought tolerance, but insects may become problematic

natural regeneration (Krugman and Jenkinson 2008). Seed is typically released from cone bracts in October and November. Hybridization with loblolly pine, with which it is sympatric across much of its range, is a concern because of potential losses to the genetic integrity of naturally regenerating forests or seed orchards (Stewart et al. 2010, 2013; Tauer et al. 2012). Regular burn intervals of 3 years or less can effectively select against hybrids and loblolly pine in mixed species stands (Stewart et al. 2015). Additional genetics research to improve marker-based identification of hybrids is needed to identify and remove advanced-generation hybrids from established seed orchards and restoration seed reserves (Stewart et al. 2016). The proportion of hybrids recruiting into regenerating stands is likely to increase with continued fire suppression (Stewart et al. 2015, Tauer et al. 2012). Climate change may also increase hybridization if phenology of flower production in loblolly and shortleaf pines become more synchronized (Tauer et al. 2012).

In the Missouri Ozarks, genetic variation is high with little divergence among populations sampled and no evidence of a prior genetic bottleneck (Hendrickson et al. 2018). Stewart et al. (2016) summarized prior work on isozymes and DNA markers that all describe the species as highly outcrossing with little genetic structure, increased differentiation between sources west and east of the Mississippi River, and high genetic diversity throughout the range. Hybrids with loblolly pine were more common in the western part of the range than east of the Mississippi River (Edwards and Hamrick 1995, Stewart et al. 2010), although genetic diversity between east and west were similar. Genetic improvement in shortleaf pine is promising (Gwaze et al. 2005a, 2005b), and seed orchards with improved seed are in use (Hossain et al. 2021).

Seed-Transfer Considerations

In southern Illinois, shortleaf pine sources from Ohio, Mississippi, Missouri, Arkansas, Oklahoma, and Kentucky were similar in height, diameter, and survival after 27 years (Gilmore and Funk 1976). In New Jersey, local sources had the highest survival followed by those from northeast Tennessee and Missouri, which were 8 to 10 ft (2.4 to 3.6 m) shorter than the New Jersey source (Little 1969, Wells and Wakeley 1970).

Local sources were also best in Pennsylvania, but Tennessee sources were similar, followed by sources from Oklahoma and Georgia (Little 1969). Little (1969) attributed losses in survival and basal area in New Jersey and Pennsylvania sites to winter injury.

In southern range locations (Mississippi, southeast Louisiana, and southwest Georgia) southernmost sources were considerably taller than more northern sources (Wells and Wakeley 1970). Progeny tests in Arkansas revealed that shortleaf pine sources from the Ouachita National Forest had better growth than northerly sources from the Ozark National Forest (Hossain et al. 2021, Studyvin and Gwaze 2012). The same studies showed that eastern and western sources within the Ouachita National Forests did not differ significantly. North-south trends are complicated by the presence of loblolly pine hybrids in the south, which can alter the phenotype (Wells and Wakeley 1970). Local sources are best suited for areas along the northern range edge (Wells and Wakeley 1970). Seed sources originating from 5 to 7 °F (2.8 to 3.9 °C) warmer average annual minimum temperature have the fastest growth without sacrificing cold tolerance (Schmidtling 1994, 2001).

Insects and Diseases

Shortleaf pine is highly susceptible to southern pine beetle (*Dendroctonus frontalis* Zimmerman) and its fungal associate, *Ceratocystis minor* (Hedgecock) Hunt (Cook and Hain 1987). Southern pine beetle continues to expand its range northward and is likely to remain an impediment to southern pines into the future (Lesk et al. 2017). Cone and seed insects are often major pests in shortleaf pine seed orchards, including Nantucket pine tip moth (*Rhyacionia frustrana* [Comstock]), which infests conelets (Yates and Ebel 1972). The insect species *Dioryctria amatella* Hulst and *Eucosma cocana* Kearfott cause seed loss on second-year cones (Ebel and Yates 1974). Other insects associated with seed losses included seedbugs such as *Leptoglossus corculus* Say and *Tetyra bipunctata* Herrich-Schaeffer and the seed worm *Laspeyresia* spp. Sawflies (*Neodiprion* spp.) can also damage female strobili (Bramlett and Hutchinson 1965). Pales (*Hylobius pales* Herbst) and eastern pine weevil (*Pissodes nemorensis* [Germar 1824]) are known to feed on bark tissue of young, vigorous seedlings (Land and Rieske 2006).

Shortleaf pine is relatively resistant to fusiform rust, (*Cronartium quercuum* [f. sp. fusiforme]) (Powers et al. 1981), the most economically important pathogen of southern pines. Root rot pathogens associated with shortleaf pine include littleleaf disease (*Phytophthora cinnamomi* [Mistretta 1984]) and annosus root disease (*Heterobasidion annosum* (Fr.) Bref. [1888]) [formerly known as *Fomes annosus*]) (Berry 1968). Annosus root disease can spread onto freshly cut stumps, usually after thinning, infecting the stand for 50 years or more. Shortleaf pine can also be a host to Comandra blister rust (*Cronartium comandrae* Pk.), although this pathogen is more common in the Western United States (Johnson 1997).

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