Determining Seed Transfer Guidelines for Southern Pines

Ron C. Schmidtling

Ron C. Schmidtling is Chief Geneticist, USDA Forest Service, Southern Research Station, Southern Institute of Forest Genetics, 23332 Hwy 67, Saucier, MS 39574; telephone: 228.832.2747 ext 212; email: rschmidtling@fs.fed.us

Schmidtling R.C. 2003. Determining seed transfer guidelines for southern pines. In: Riley L.E., Dumroese R.K., Landis T.D., technical coordinators. National Proceedings: Forest and Conservation Nursery Associations-2002. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28: 8–11. Available at: http://www.fcnanet.org/ proceedings/2002/schmidtling.pdf

Abstract

The selection of an appropriate seed source is critical for successful southern pine plantations. Seed movement guidelines are described which are based on climatic similarities between the seed source origin and the planting site. Because yearly average minimum temperature is the most important climatic variable related to growth and survival, it has been used to define the rules of seed movement. This variable, which defines "plant hardiness zones", has been used for many years by horticulturists to guide the transfer of plant materials. East-west movement to areas of similar climate is permissible, with the exception of loblolly pine.

Key Words

Pinus taeda, *Pinus palustris*, geographic variation, tree breeding

Choosing Seed Sources for Southern Pine Plantations

The source of seeds used to establish forest tree plantations is very important. Many years of scientific study show that the seed source can strongly affect survival and subsequent growth of southern pines. Perhaps the most important early study of pine seed sources was Philip C Wakeley's Bogalusa, Louisiana, planting of 1927. There, loblolly pines (*Pinus taeda* L.) grown from local seeds (Livingston Parish) produced about twice the wood volume through age 22 as did trees of the same species grown from Arkansas, Georgia, and Texas seeds (fig. 1). These differences persisted through age 35 (Wakeley and Bercaw 1965). Since Wakeley's pioneering study, a great deal has been learned about geographic variation in southern pines. The Southwide Southern Pine Seed Source Study (SSPSSS) was a cooperative effort initiated in 1951 by the Southern Forest Tree Improvement Committee. Federal, state, university, and industry foresters throughout the South worked together to discover the patterns of geographic variation in the southern pines. The results of this work are summarized in publications by Dorman (1976), Wakeley (1961), Wells (1969, 1983), Wells and Wakeley (1966), Schmidtling (1995), and Schmidtling and White (1990).

Figure 1. Wakeley's 1927 Bogalusa, Louisiana, loblolly pine provenance test at age 35. The sources, from left to right, are southeast Louisiana, east Texas, central Georgia, and central Arkansas. The planting was thinned at age 35; the resulting pulpwood is shown beneath each seed source. Adapted from Wakeley and Bercaw (1965).

These studies show that most southern pine species have reacted to differences in environmental conditions by developing different traits in different places through the process of natural selection. Therefore, there are races of southern pines that grow faster in certain areas than in others. Some of these races are more resistant to disease or more tolerant of cold than other pines of the same species. The recognition of these patterns of geographic variation was the first step in the process of genetic improvement of the southern pines. All successful southern pine breeding programs first take into account geographic variation before utilizing within-population genetic variation. Important gains in growth and disease resistance can often be made simply by selecting the best seed source for a given planting location. With most species, additional gains can be obtained by using the improved stock developed by tree breeding programs.

Planting seedlings from a seed source that is poorly adapted to the site and climatic conditions can cause devastating losses. Even if the trees survive, their reduced growth will adversely affect yields throughout the timber rotation. It is better to postpone planting for a year rather than to risk the unfortunate results of planting ill-adapted seedlings.

In general, the natural distribution of the southern pines is limited to the north by low temperature, and to the west by low rainfall. Within these limits, native races have developed that are adapted to the local climate. This adaptation to local climatic variation is generally referred to as geographic variation.

Geographic variation of the major southern pine species has been well studied. Seed collected from different geographic areas vary greatly in their potential for growth and survival, depending upon where they are planted. Although a good conservative approach would be to only plant seedlings from locally obtained seed, native sources are not always the best, especially for economically important traits. For instance, it is often observed in seed source studies of forest tree species that sources from warmer climates tend to grow faster than local sources, if these sources are not moved to greatly differing climates. In loblolly pine, this is at least partly due to the warm-climate sources growing longer in the fall than the sources from colder climates (Jayawickrama and others 1998).

Climatic modeling of data from many southern pine seed source studies has shown that the most important factor influencing growth and survival within their natural ranges is average yearly minimum temperature at the seed source (Schmidtling 1997). This climatic variable has been used, not coincidentally, by horticulturists to determine plant hardiness zones (USDA 1990). These zones are used to predict the probable success of plantings of ornamentals. They are also the most important consideration in formulating the seed transfer guidelines for southern pines.

For the 3 species of southern pines that occur naturally on both sides of the Mississippi River, only in loblolly pine are there important differences between eastern and western sources. This difference between loblolly pine and other species is probably rooted in the Pleistocene geologic era. During the height of the Wisconsin Ice Age, 14,000 years before present, the South was occupied by a boreal forest. Patterns of genetic variation in allozymes indicate that longleaf pine (*Pinus palustris* Mill.) resided in 1 refugium in south Texas/north Mexico and migrated northward and eastward when the ice retreated (Schmidtling and Hipkins 1998). It is probable that loblolly pine originated from 2 isolated refugia, one in southwest Texas/northeast Mexico, and one in south Florida/Caribbean (Schmidtling and others 1999). The 100,000-year isolation of the 2 populations, in differing environments, resulted in the differences we see today.

There is little soil-related ecotypic differentiation in the southern pines. For instance, longleaf stands from deep sand sites do not differ in adaptive traits from nearby stands on heavier soils (Schmidtling and White 1990). Similarly, “wet site” ecotypes in loblolly pine do not seem to exist, although there are individual genotypes that are well-adapted to wet sites. This is not surprising considering extensive long-distance pollen flow that has been found in studies of pollen contamination in southern pine seed orchards (Friedman and Adams 1985).

The lack of soil-related ecotypic differences in southern pines simplifies seed transfer guidelines. The guidelines are as follows (with exceptions for loblolly pine noted below):

As a general guideline, seedlings can be used from any area having a minimum temperature within 5 °F (-15 °C) of the planting site (fig. 2). Obtaining seedlings from an area with a higher minimum temperature (warmer winter) will result in an increase in growth over local sources; obtaining seedlings from an area with a lower minimum temperature will result in a decrease in growth (Schmidtling 1994). Seedlings can be moved as far as 10 °F (-12 °C), but risk of cold damage increases in northward transfers, and loss of growth in

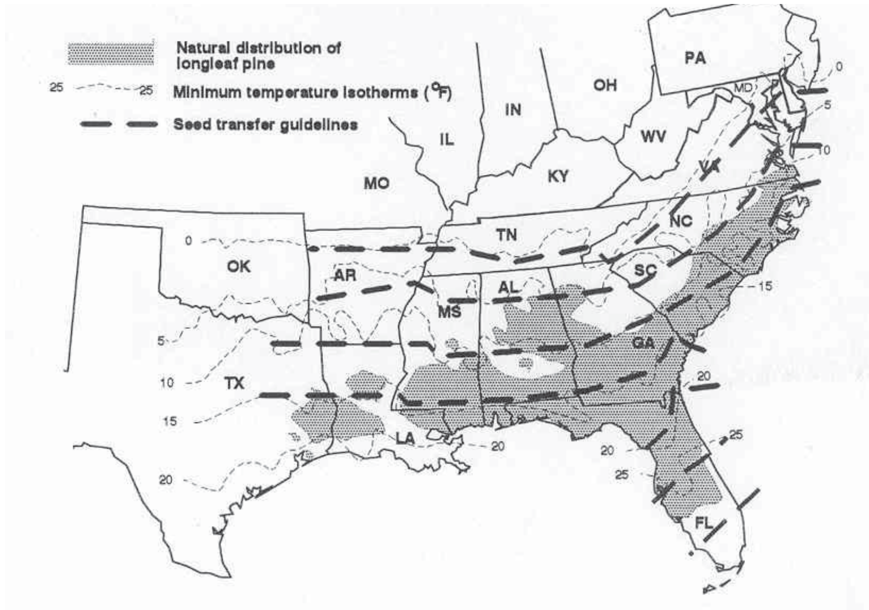

Figure 2. Map of southeastern US showing the natural distribution of longleaf pine with 5 °F (-15 °C) minimum temperature isotherms (Schmidtling 2001).

southward transfers is larger. East-west transfers within the temperature guidelines are generally permissible, and in some instances may be desirable if improved stock is available.

The loblolly pine planting areas have been divided into districts because of the complex nature of geographic variation in the species (fig. 3). The eastern district is east of the Mississippi River, and the western and far-western districts are west of the

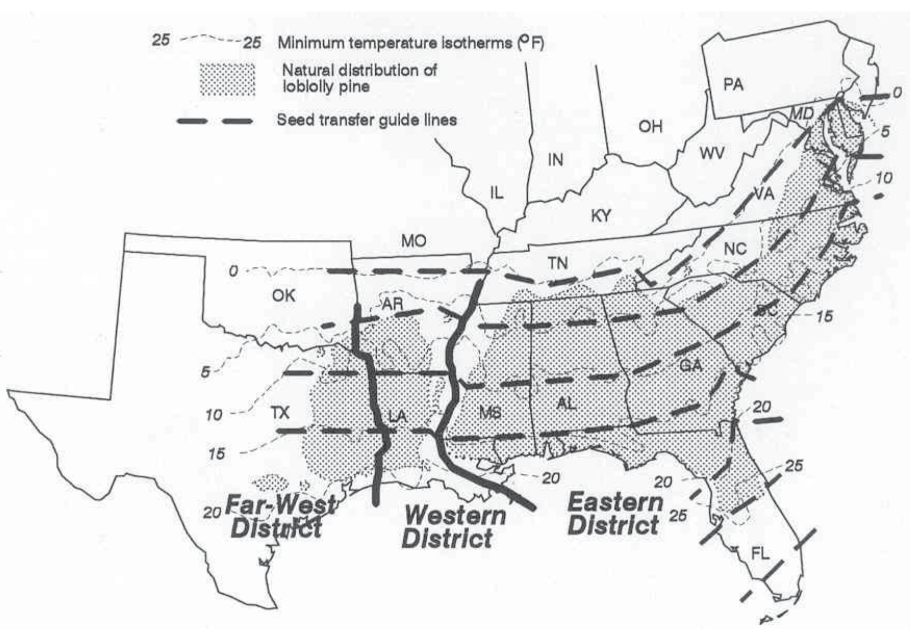

Figure 3. Map of southeastern US showing the natural distribution of loblolly pine with 5 °F (-15 °C) minimum temperature isotherms. In loblolly pine, east-west transfers should be made within districts (Schmidtling 2001).

Mississippi River. The far-western district is separated from the western district somewhat arbitrarily by the Texas/Louisiana-Arkansas border. Possible losses due to drought become much more probable in the far-western district, and local seed sources are more tolerant (Long 1980).

Generally, and especially for the non-industrial small land owner or others who may not practice intensive management, it is most prudent to use seed sources from within the same district. Seed sources originating in the eastern district should not be used in the western district because of danger of losses due to drought and fusiform rust. Sources from the western districts, however, can be used in the eastern districts. Transfer in the eastern direction may be warranted for use on droughty sites or areas with high fusiform rust incidence. The western sources generally can be expected to grow slower, however.

Improved seed should be used where possible. Tree improvement programs have been initiated all across the South for the major species, and have been successful in securing substantial genetic gains in growth and form. In many programs, second and third generation breeding cycles are in progress. Seed transfer guidelines for improved seed should be assumed to be the same as for unimproved seed; transfers of 5 °F (-15 °C) minimum temperature or less within districts are optimal, but transfers should not exceed 10 °F (-12 °C). In some cases, advanced generation selections may be derived from controlled crosses of superior trees from areas of different minimum temperature. The average of these 2 temperatures should be used in assessing the suitability of these sources.

More detailed guidelines can be found in "Southern Pine Seed Sources" (Schmidtling 2001). It is also available on the web at:
http://www.rngr.net/genetics/publications.html

References

Friedman ST, Adams WT. 1985. Estimation of gene flow into two seed orchards of loblolly pine (*Pinus taeda* L.). Theoretical and Applied Genetics 69:609-615.

Jayawickrama KJS, McKeand SE, Jett JB. 1998. Phenological variation in height and diameter growth in provenances and families of loblolly pine. New Forests 16:11-25.

Long EM. 1980. Texas and Louisiana loblolly pine study confirms importance of local seed sources. Southern Journal of Applied Forestry 4(3):127-132.

Schmidtling RC. 1994. Using provenance tests to predict response to climatic change: Loblolly pine and Norway spruce. Tree Physiology 14:805-817.

Schmidtling RC. 1995. Seed transfer and genecology in shortleaf pine. In: Proceedings of the 8th Biennial Southern Silvaculture Conference; 1994 Nov; Auburn, AL. Asheville (NC): USDA Forest Service, Southern Research Station. General Technical Report SRS-1. p 373-378.

Schmidtling RC. 2001. Southern pine seed sources. Asheville (NC): USDA Forest Service, Southern Research Station. General Technical Report SRS-44. 25 p.

Schmidtling RC, Hipkins V. 1998. Genetic diversity in longleaf pine (*Pinus palustris* Mill.): Influence of historical and prehistorical events. Canadian Journal of Forest Research 28:1135-1145.

Schmidtling RC, White T. 1990. Genetics and tree improvement of longleaf pine. In: Proceedings: Symposium on the management of longleaf pine. USDA Forest Service. General Technical Report SO-75. p 114-127.

USDA. 1990. USDA Plant hardiness zone map. USDA-Agricultural Research Service Misc. Pub. 1475.

Wakeley PC. 1961. Results of the southwide pine seed source study through 1960-61. In: Proceedings of the 6th Southern Conference on Forest Tree Improvement; 1961 June 7-8; Gainesville, FL. p 10-24.

Wakeley PC, Bercaw TE. 1965. Loblolly pine provenance test at age 35. Journal of Forestry 63:168-174.

Wells OO. 1969. Results of the southwide pine seed source study through 1968-69. In: Proceedings of the 10th Southern Conference on Forest Tree Improvement; 1969 June 17-19; Houston, TX. p 117-129.

Wells OO. 1983. Southwide pine seed source study-loblolly pine at 25 years. Southern Journal of Applied Forestry 7(2):63-71.

Wells OO, Wakeley PC. 1970. Variation in shortleaf pine from several geographic sources. Forest Science 16(4):415-423.