EVALUATING STEM AND BRANCH CHARACTERISTICS OF 5-YEAR-OLD SONDEREGGER PINE SAPLINGS

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ABSTRACT

Sonderegger pine (*Pinus* x *sondereggeri*), the natural hybrid of longleaf (*P. palustris*) and loblolly pine (*P. taeda*), is often described as having stem and branch deformities at maturity that may lead to poor wood quality. For this reason, Sonderegger pine seedlings are traditionally culled from southern forest tree nurseries to ensure only pure longleaf pine seedlings are outplanted to meet landowner objectives. The general acceptance of Sonderegger pine as an inferior tree has led to an absence of research to determine its morphological development from the seedling to mature stand management phases. In 2018, 400 Sonderegger pine seedlings were operationally detected in the nursery and outplanted on the Catahoula Ranger District of the Kisatchie National Forest (Pollock, LA) with the main objective of evaluating and describing their morphological development over time. Before planting, seedling height to the terminal bud and root collar diameter were measured. In the field, tree height and diameter at breast height measurements were recorded, and evaluations for stem straightness, forking defects, ramicorn branches, and disease occurrence were made. These observations along with ongoing assessments of branch angle, diameter, and height along the bole may provide insight into Sonderegger pine morphology at age five as it relates to long-term wood quality and utilization.

INTRODUCTION

In the Southeastern United States, longleaf (*Pinus palustris*) and loblolly (*P. taeda*) pines are most widely known for providing highly diverse forest ecosystems and a fast-growing, reliable supply of timber for wood products, respectively. Of the major southern pines, longleaf pine is considered the most valuable in terms of wood-product quality, aesthetics, and tolerance to fire, insects, and diseases (Barnett 2002). Longleaf pine is also a good choice for sawtimber and pole production, and its needles are ideal for pine straw raking, which offers an alternative source of income for landowners (Susaeta and Gong 2019). Loblolly pine is the leading commercial timber species in the United States (Edwards 1987, Hepting 1971, Schultz 1997, Xiong and others 2010) and has even been referred to as one of the most important timber species in the world (Wahlenberg 1960). For more than 60 years, loblolly pine has been the primary focus of many southern forest tree improvement programs (Cumbie and others 2012, Xiong and others 2010), and significant improvements in growth rate, wood volume, stem straightness, and disease tolerance have been made.

During pollen flight in early spring, longleaf and loblolly pine can cross-pollinate and produce a natural hybrid known as Sonderegger pine (*Pinus* x *sondereggeri*). Sonderegger pine usually occurs in nature as single specimens or in small groups where both parent species co-exist (Saucier and others 1979). Cones collected for longleaf pine seedling propagation in the nursery usually contain some hybrid seeds. Longleaf and Sonderegger pine seeds cannot be distinguished by visual inspection alone (Bolner and others 2019), causing many hybrids to be sown in the nursery. According to Wahlenberg (1946), Sonderegger pine seedlings can make up

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0.5–6.0 percent of a longleaf pine seedlot, and this range may vary substantially across temporal and spatial scales (Dorman 1976). However, for decades Sonderegger pine has been considered less desirable than longleaf and loblolly pine due to reports of poor stem form, irregular branching, and susceptibility to brown-spot needle blight (*Lecanostica acicula*) and fusiform rust (*Cronartium quercuum* f. sp. *fusiforme*) (Saucier and others 1979, Schoenike and others 1975). Because of this, seedlings that exhibit hybrid characteristics in the nursery are usually culled before being packaged and shipped to landowners for outplanting. In the nursery, stem elongation of longleaf pine seedlings is the traditional indicator that hybridization between longleaf and loblolly pine has occurred (Barnett and others 2020, Jackson and others 2020).

Sonderegger pine's reputation as an unmerchantable species has prevailed for more than 100 years since its description by Chapman (1922) with virtually no support from empirical research. Furthermore, the few studies available comparing Sonderegger to loblolly or longleaf pine are now over 40 years old. For example, van Buijtenen (1969) reported that Sonderegger pine was prone to forking defects and heavy branches on an east Texas site, but presented no data to draw comparisons with longleaf or loblolly pine at the same site with similar silvicultural management. Henderson and Schoenike (1981) found no significant difference between height, diameter at breast height (d.b.h.), volume, branch diameter, stem form, or fusiform rust damage in two mixed stands of 20-year-old Sonderegger and loblolly pines. They concluded that discriminating against Sonderegger pine in stand thinnings and other management practices is unnecessary. While Henderson and Schoenike (1981) did not promote growing Sonderegger pine for such purposes, they stated that hybrid seedlings occurring naturally in southern pine nurseries could be planted satisfactorily along with loblolly pine on many sites in the coastal plain. Schoenike and others (1975) and Saucier and others (1979) believed Sonderegger pine might be suitable for pulpwood production and supported its use in southern forest tree breeding programs that select for rapid growth.

Understanding the economic and ecological values of longleaf and loblolly pine is important in developing a framework to research their hybrid. However, due to an absence of research, heritability of morphological features, wood properties, disease tolerance, and subsequent commercial value of Sonderegger pine remains unknown. Evaluating Sonderegger pine development from the seedling phase throughout maturity may lead to information that provides economic returns from stand management and improved seed efficiency for nurseries. The primary objective of this research was to document Sonderegger pine growth and morphology at age five as it relates to wood quality standards at maturity.

MATERIALS AND METHODS

On March 27, 2018, 400 container-grown Sonderegger pine seedlings were outplanted on the Catahoula Ranger District of the Kisatchie National Forest (near Pollock, LA) on an open field site with a silt-loam soil. These seedlings were operationally culled from longleaf pine container stock grown at the International Forest Company nursery (Evans, LA) during the 2017–2018 production season. Before planting, seedling height and root collar diameter were measured, and each seedling was numbered for future data reference. Seedlings were planted in eight plots, and each plot was planted with 50 seedlings on an 8-foot by 8-foot spacing with a 16-foot spacing between each plot (Jackson and others 2020).

One-year height measurements were conducted on March 1, 2019. In 2022, 4 years after outplanting, total height, d.b.h., and branch angle and diameter were measured on 109 saplings (table 1). Occurrence of stem crooks, forks, ramicorn branches, brown spot needle blight, and fusiform rust were also recorded (table 1). Twenty-four border trees in each plot (120 trees total) were excluded from the study to reduce potential bias caused by increased height and diameter growth compared to interior trees (Cancino 2005, Oliver and Larson 1996).

Correlations between seedling height at planting and height at age two, height at planting and

Table 1—Variables used in this study to measure growth and evaluate defects of 5-year-old Sonderegger pines

Variable	Unit of measure	Description and measurement method	Reference
Height	Feet	Distance from ground-line to tip of terminal bud	Schultz 1997
d.b.h.	Inches	Diameter of bole at 4.5 feet from groundline	Helms 1998
Branch diameter	Inches	Diameter of branches in the stabilization zone (2 to 7 whorls below the canopy) measured 1 inch from the bole. Branch diameter was not evaluated for branches <0.25 inches in diameter and <6 inches long.	Dorman 1976 Snyder 1961
Branch angle	Nearest degree	Angle of branches in the stabilization zone. Branch angle was not evaluated for branches <0.25 inches in diameter and <6 inches long.	Dorman 1976 Snyder 1961
Crook	Binary trait	An abrupt bend in the main bole	Helms 1998
Fork	Binary trait	A separation of the bole into two or more stems of similar sizes	Schermann and others 1997 Xiong and others 2010
Ramicorn branch	Binary trait	A steeply angled branch oriented at <30 degrees with the main stem and having a diameter distinctly less than the main bole	Schermann and others 1997 Xiong and others 2010
Brown-spot needle blight	Binary trait	Necrotic lesions on needles or premature defoliation	Enebak and Starkey 2012a
Fusiform rust	Binary trait	One or more fusoid galls on the bole or branches	Enebak and Starkey 2012b

height at age four, and height and d.b.h. at age five were calculated using Excel (Microsoft, Redmond, WA).

RESULTS

At outplanting, the average seedling height was 6.2 inches. After one growing season, the average seedling height was 10.0 inches. Taller seedlings at time of planting had a growth advantage 1 year after outplanting (r = 0.76, *P* <0.001) (fig. 1), but after 4 years in the field, the correlation between initial seedling height and subsequent height growth had weakened (r = 0.11, *P* = 0.248) (fig. 2). At age five, the trees averaged 7.7 feet tall and 1.6 inches d.b.h. (table 2). At this age, d.b.h. and total height were positively correlated (r = 0.89, *P* <0.001) (fig. 3). Of the 109 study trees, 15 (13 percent) had at least one crook or sinusoidal bole, and another 15 trees had a ramicorn branch or stem fork.

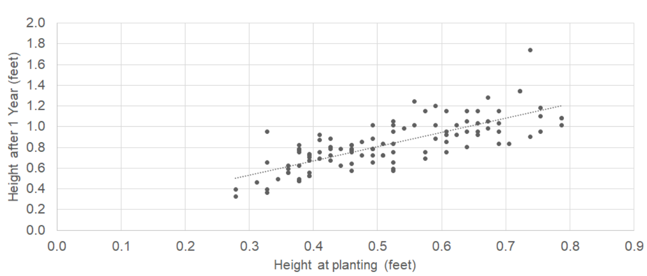

Figure 1—Correlation between seedling height at planting and height after 1 year in the field (r = 0.76).

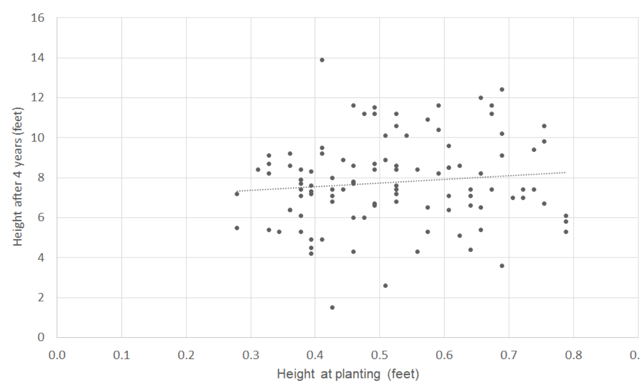

Figure 2—Correlation between seedling height at planting and height after 4 years in the field (r = 0.11).

Table 2—Summary of growth and branch characteristics reported for 5-, 9-, and 20-year-old Sonderegger pines across three study sites in the Southeast

Age	Site	Soil type	Spacing	d.b.h.	Height	Branch diameter	Branch angle
			feet	*inches*	*feet*	*inches*	*degrees*
5	Pollock, LA	Silt loam	8 by 8	1.6	7.7	0.54	72.4
9	Clemson, SC[1]	Clay loam	9 by 9	4.5	24.6	–	70.0
20	Upper coastal plain, South Carolina[2]	Sandy loam	6 by 9	11.5	58.0	2.20	67.4

[1] Source: Schoenike and others (1975).
[2] Source: Henderson and Schoenike (1981).

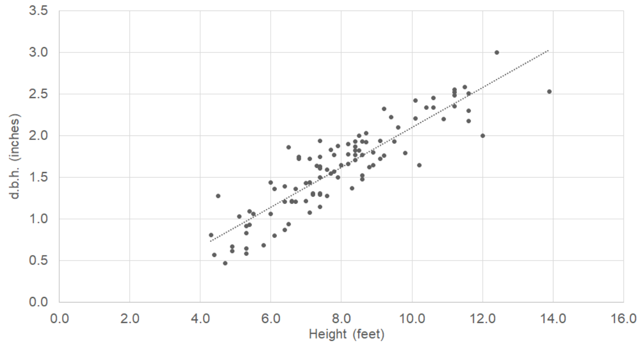

Figure 3—Correlation between height at age five and diameter at breast height (d.b.h.) (r = 0.89).

Branch angle was highly variable, ranging from 40 to 110 degrees, with a site average of 72.4 degrees. Branch diameter was also variable, ranging from 0.25 to 1.50 inches, with a site average of 0.52 inch. To our knowledge, branch diameter has never been reported for Sonderegger pines at age five.

Although fusiform rust has been reported as a primary disease for Sonderegger pine, only six trees (5 percent) had stem or branch cankers. Brown-spot needle blight incidence was noted on all trees, but most infections were minor and did not appear to affect tree vigor.

DISCUSSION

Past observations that indicated Sonderegger pine as having large branches or poor form (Dorman 1976, van Buijtenen 1969) did not account for the silvicultural components that may have influenced these poor growth responses. Philip Wakeley, in a personal communication with Schoemike and others (1975), stated that the large diameter branches of Sonderegger pine made it less desirable than the pure species. However, the crown morphology he observed may have been influenced by the open-grown environment created in a stand of slower growing longleaf pine (Schoenike and others 1975).

Similarly, the natural pruning ability of any tree species is influenced by silvicultural practices such as planting density and fire frequency as well as genetic and environmental interactions (Wright 1976). For example, longleaf pine is one of the best natural pruners of all the southern pines (Wahlenberg 1946), but branch size and angle of orientation can vary substantially in open-pollinated families (Dorman 1976). In loblolly pine, natural pruning may be delayed in under-stocked stands and can subsequently reduce the merchantable volume of wood produced at harvest (Dorman 1976, Schultz 1997). While the genetic and environmental interactions that influence natural pruning ability and knot development in Sonderegger pine are still unknown, Chapman (1922) predicted that the limbs of Sonderegger pine would be less persistent and grow less vigorously than loblolly pine, most likely resulting in the self-pruning of branches as the tree matures in a fashion similar to longleaf pine.

Although conclusions cannot be drawn at this time, mean branch angle at this site was similar to findings from previous studies involving 9- and 20-year-old Sonderegger pines in South Carolina, which may indicate that branch orientation is less dependent on tree age than other factors (table 2). Henderson and Schoenike (1981) found that 20-year-old Sonderegger pine had a branch angle of 67.4 degrees when grown in mixed stands of loblolly pine in South Carolina. In the same study, mean branch angle was found to be less acute in Sonderegger pine than loblolly pine, indicating that Sonderegger pine had the more desirable branch attribute (table 2).

Further research is needed to draw conclusions on branch characteristics and their impacts on woody quality of Sonderegger pine. Studies that evaluate Sonderegger pine's outplanting performance, fire tolerance, wood quality, and potential nontimber values will also add to our understanding of this naturally occurring hybrid.

CONCLUSIONS

It was surmised decades ago that Sonderegger pine was not commercially viable. Despite the lack of research to support this conclusion, Sonderegger pine seedlings have traditionally been culled from the nursery to prevent them from being planted in southern forest plantations.

Studies have reported that Sonderegger pine's growth and morphology is similar to loblolly pine (Henderson and Schoenike 1981, Schoenike and others 1975), but the consensus surrounding the hybrid's reputation has not changed for more than a century. Although conclusions on branch diameter and knot development cannot be drawn at this time, this study showed that branch orientation at age five was similar to findings for 20-year-old Sonderegger and loblolly pine on a South Carolina site (Schoenike and others 1975). Furthermore, while Sonderegger pine has historically been considered highly susceptible to brown-spot needle blight and fusiform rust (Saucier and others 1979), disease incidence was low at our site.

If Sonderegger pine has commercial value, economic returns for nursery owners may be possible with improved seed efficiency. However, financial gains may not be fully realized unless Sonderegger pine development is examined across various sites and compared with the performance of longleaf and loblolly pine.

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LITERATURE CITED

Barnett, J.P. 2002. Longleaf pine: why plant it? Why use containers? In: Barnett, J.P.; Dumroese, R.K.; Moorhead, D.J., eds. Proceedings of workshops on growing longleaf pine in containers—1999 and 2001. Gen. Tech. Rep. SRS-56. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 5–7. https://doi.org/10.2737/SRS-GTR-56.

Barnett, J.P.; Olatinwo, R.; Jackson, D.P.; Blomquist, S. 2020. Longleaf pine hybridization: is there a growing problem? In: Bragg, D.C.; Koerth, N.E.; Holley, A.G., eds. Proceedings of the 20th biennial southern silvicultural research conference. e-Gen. Tech. Rep. SRS-253. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 128–134. https://www.fs.usda.gov/research/treesearch/60908.

Bolner, N.G.; Jackson, D.P.; Olatinwo, R.; Barnett, J.P. 2019. Evaluation of sowing methods to determine the role of hypocotyl lift in longleaf pine seedling development. Tree Planters' Notes. 62(1&2): 88–94. https://www.fs.usda.gov/research/treesearch/59713.

Cancino, J. 2005. Modelling the edge effect in even-aged Monterey pine (*Pinus radiata* D. Don) stands. Forest Ecology and Management. 210: 159–172. https://doi.org/10.1016/j.foreco.2005.02.021.

Chapman, H. H. 1922. A new hybrid pine (*Pinus palustris* × *Pinus taeda*). Journal of Forestry. 20: 729–734. https://doi.org/10.1093/jof/20.7.729.

Cumbie, W.P.; Isik, F; McKeand, S.E. 2012. Genetic improvement of sawtimber potential in loblolly pine. Forest Science. 58(2): 168–177. https://doi.org/10.5849/forsci.09-060.

Dorman, K.W. 1976. The genetics and breeding of southern pines. Agric. Handb. 471. Washington, DC: U.S. Department of Agriculture Forest Service. 407 p. https://naldc.nal.usda.gov/download/CAT87208699/pdf.

Edwards, M.B. 1987. Natural regeneration of loblolly pine: A loblolly pine management guide. Gen. Tech. Rep. SE-47. Asheville, NC: U.S. Department of Agriculture Forest Service, Southeastern Forest Experiment Station. 17 p. https://doi.org/10.2737/SE-GTR-47.

Enebak, S.A.; Starkey, T. 2012a. Brown spot needle blight. In: Cram, M.M.; Frank, M.S.; Mallams, K.M., tech. coords. Forest nursery pests. Agric. Handb. 680. Washington, DC: U.S. Department of Agriculture Forest Service: 28–30.

Enebak, S.A.; Starkey, T. 2012b. Fusiform rust. In: Cram, M.M.; Frank, M.S.; Mallams, K.M., tech. coords. Forest nursery pests. Agric. Handb. 680. Washington, DC: U.S. Department of Agriculture Forest Service: 41–43.

Helms, J.A. 1998. The dictionary of forestry. Bethseda, MD: Society of American Foresters. 210 p.

Henderson, L.T., Jr.; Schoenike, R.E. 1981. How good is Sonderegger pine? Southern Journal of Applied Forestry. 5(4): 183–186. https://doi.org/10.1093/sjaf/5.4.183.

Hepting, G.H. 1971. Diseases of forest and shade trees of the United States. Agric. Handb. 386. Washington, DC: U.S. Department of Agriculture Forest Service. 658 p.

Jackson, D.P.; Olatinwo, R.; Barnett, J.P. [and others]. 2020. Field observations of longleaf pine seedlings to examine possible hybridization. In: Bragg, D.C.; Koerth, N.E.; Holley, A.G., eds. Proceedings of the 20th biennial southern silvicultural research conference. e-Gen. Tech. Rep. SRS-253. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 137–141. https://www.fs.usda.gov/research/treesearch/60905

Oliver, C.D.; Larson, B.C. 1996. Forest stand dynamics. Update ed. New Haven, CT: Yale University. 520 p.

Saucier, J.R.; Henderson, L.T.; Schoenike, R.E. 1979. Wood properties of plantation-grown Sonderegger pine. Res. Note SE-272. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 4 p.

Schermann, W.T.; Adams, W.T.; Aitken, S.N.; Bastien, J.-Ch. 1997. Genetic parameters of stem form traits in 9-year-old coastal Douglas-fir progeny test in Washington. Silvae Genetica. 46(2): 166–170.

Schoenike, R.E.; Hart, J.D.; Gibson, M.D. 1975. Growth of a nine-year-old Sonderegger pine plantation in South Carolina. Silvae Genetica. 24(1): 10–11.

Schultz, R.P. 1997. Loblolly pine: The ecology and culture of loblolly pine (*Pinus taeda* L.) Agric. Handb. 713. Washington, DC: U.S. Department of Agriculture Forest Service. [irregular pagination].

Snyder, E.B. 1961. Measuring branch characters of longleaf pines. Occas. Pap. 184. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Susaeta, A; Gong, P. 2019. Economic viability of longleaf pine management in the southeastern United States. Forest Policy and Economics. 100: 14–23. https://doi.org/10.1016/j.forpol.2018.11.004.

van Buijtenen, J.P. 1969. Seventeenth progress report of the cooperative forest tree improvement program. Circ. 200. U.S. Department of Agriculture Forest Service. 14 p.

Wahlenberg, W.G. 1946. Longleaf pine: its use, ecology, regeneration, protection, growth, and management. Washington, DC: Charles Lathrop Pack Forestry Foundation in cooperation with U.S. Department of Agriculture Forest Service. 429 p.

Wahlenberg, W.G. 1960. Loblolly pine: its use, ecology, regeneration, protection, growth, and management. Durham, NC: Duke University, School of Forestry, in cooperation with forest industry and U.S. Department of Agriculture Forest Service. 603 p.

Wright, J.W. 1976. Introduction to forest genetics. New York: Academic Press. 480 p.

Xiong, J.S.; Isik, F.; McKeand, S.E.; Whetten, R.W. 2010. Genetic variation of stem forking in loblolly pine. Forest Science. 56(5): 429–436. https://doi.org/10.1093/forestscience/56.5.429.