FIELD OBSERVATIONS OF LONGLEAF PINE SEEDLINGS TO EXAMINE POSSIBLE HYBRIDIZATION

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Abstract—Stem elongation in the nursery is the traditional and accepted indicator that hybridization between longleaf pine (*Pinus palustris*) and loblolly pine (*P. taeda*) has occurred. These hybrids, known as Sonderegger pines (*P*. x *sondereggeri*), are reported to have distorted limb structure and low-quality wood. As a result, landowners avoid using them. Recently, a large number of longleaf pine seedlings grown in a nursery from particular seedlots displayed unusual stem elongation and were assumed to be Sonderegger pines. It was determined that long-term observations of their development were necessary. Seedlings that displayed true longleaf pine morphology, stem elongation but with atypical longleaf or Sonderegger pine morphology (suspected hybrids), and true Sonderegger pine morphology were outplanted in arranged plots. After assessing the current measurement data, there is no indication that the suspected hybrids are Sonderegger pines. The trees will continue to be monitored for many years to see if their development corresponds to what is known about true longleaf pine or true Sonderegger pine morphology.

INTRODUCTION

Land managers plant longleaf pine (*Pinus palustris*) for many reasons, including high-value forest products and to help restore its diverse ecosystem (Jose and others 2006). Hence, longleaf pine seedling quality is important. During lifting and processing of longleaf pine seedlings in the nursery, seedlings are sometimes detected that have characteristics associated with Sonderegger pine (*P*. x *sondereggeri*), an undesirable hybrid produced from the cross-pollination of longleaf and loblolly pine (*P*. *taeda*) (Chapman 1922). Wakeley (1954) described mature Sonderegger pines as having bole and limb distortion and non-merchantable-quality timber. The hybrid may develop heavier branches connected at weaker limb unions (more forked) leading to increased breakage in adverse weather conditions (Dorman 1976). From a management perspective, prescribed fires used to control herbaceous and woody competition in the first few years following longleaf pine plantings can cause mortality to Sonderegger pines, as this hybrid has terminal buds at heights vulnerable to flames. There is also concern that, if planted, genes from Sonderegger pine will backcross into the longleaf pine population influencing future seed crops.

It is important to understand the developmental differences between longleaf pine and Sonderegger pine in order to understand why the latter species has been traditionally undesirable. True longleaf pine seedlings form buds that remain near the soil line surrounded by fascicle needles, and they do not extend or bolt until they begin growing out of this “grass stage” (Wahlenberg 1946). It is during the grass stage when prescribed fire is used to eliminate competitive vegetation near longleaf pine seedlings to allow them to begin height growth (Jose and others 2006). Longleaf pine is considered out of the grass stage when either height growth reaches about 12 cm or ground-line diameters reach 25 mm (Wahlenberg 1946). Sonderegger pine hybrids exhibit stem elongation and have heightened terminal buds that stand above true longleaf pine seedlings in the nursery. Once observed, these putative Sonderegger pines are culled before being packaged and shipped for outplanting. This culling limits the chance of planting a seedling that is not a true longleaf pine, and it ensures the purity of future stands.

In 2015, there were reports from a Georgia tree seedling nursery that longleaf pine seeds from a Louisiana (LA) source and a Mississippi (MS) source produced

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Citation for proceedings: Bragg, Don C.; Koerth, Nancy E.; Holley, A. Gordon, eds. 2020. 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. 338 p.

seedlings that exhibited significant stem elongation (Barnett and others 2020). Because land managers avoid planting Sonderegger pine, the nursery disposed of millions of the suspect seedlings. In response, a team of researchers interested in evaluating seedling development established observational plots comprised true longleaf pine, true Sonderegger pine, and samples of these suspected Sonderegger pine from the Louisiana and Mississippi sources, over a 3-year span (Barnett and others 2020).

These "suspect" seedlings were evaluated morphologically and molecularly to determine if they were Sonderegger pines or if they had possibly developed abnormally for another reason (Barnett and others 2020). Plans are to monitor growth and development of the trees for many years. The plots containing known Sonderegger pine may also shed light on whether the hybrid develops as described in the past (Wakeley 1954) or if it develops into a tree that could be a timber resource.

FIELD ESTABLISHMENT

Field plots were established on the Catahoula Ranger District of the Kisatchie National Forest near Pollock, LA, in an open field site. Grass and forb species made up the major component of seedling competition. All plots consisted of 50 seedlings on 2.4- by 2.4-m spacing. Plots were arranged 4.8 m apart, and each plot represented a particular seedlot. Within each plot, randomization of seedlings for seedlots that produced suspected hybrids was done by sorting seedlings by their stem elongation measurements (recorded at Louisiana Tech University) and then numbering them sequentially. A random sequence of numbers was generated from 1 to the maximum number. Seedlings were then arranged in trays by their sequence number, brought to the field, and outplanted in that sequence. Treatments were not employed on the seedlings prior to outplanting as their growth and morphology will be monitored for development to compare among seedlots.

The MS-2014 and LA-2014 seedlots represented suspect seedlings that showed a high percentage of stem elongation in the nursery (Barnett and others 2020). Seedlings from the MS-2015 seedlot did not exhibit stem elongation in the nursery and had morphology consistent with longleaf pine, and they served as a comparison to the suspect seedlings grown from the MS-2014 and LA-2014 seedlots. Sonderegger pine seedlings being evaluated were culls from the International Forest Company (IFCO) nursery in Evans, LA. In total, 1,250 seedlings were planted in 25 plots. Seedlings were outplanted in December 2016 and March 2018.

Outplanting: December 16, 2016—Nine plots were planted with a total of 450 seedlings. Four plots (200 seedlings) were planted with seedlings from the MS-2014 seedlot and five plots (250 seedlings) were planted with seedlings from the MS-2015 seedlot. One-year height measurements were conducted on January 25, 2018, and 2-year height measurements were conducted on March 1, 2019. Only seedlings with height measurements of ≥5 cm were recorded. The plots were prescribed burned on May 14, 2018, and survival data were recorded.

Outplanting: March 27, 2018—Eight plots were planted with a total of 400 seedlings. Four plots (200 seedlings) were planted with seedlings from the MS-2014 seedlot, and four plots (200 seedlings) were planted with seedlings from the LA-2014 seedlot. The seedlings evaluated in these plots were grown from seed per operational practices at the IFCO nursery in Evans, LA, during the 2017 growing season. One-year height measurements were conducted on March 1, 2019. Only seedlings with height measurements of ≥5 cm were recorded.

Adjacent to these plots were another 8 plots planted with a total of 400 Sonderegger pine seedlings. These hybrid seedlings were culled at the IFCO nursery in Evans, LA, and saved for field evaluations. One-year height measurements of these seedlings were also conducted on March 1, 2019.

RESULTS AND DISCUSSION

Outplanting: December 16, 2016—After one growing season, the average height of seedlings per plot was similar between both seedlots (table 1). Overall, of those measured, the MS-2014 suspected hybrid seedlings and the MS-2015 true longleaf pine seedlings averaged 5.50 cm and 5.27 cm in height, respectively, after one growing

Table 1—Mean seedling heights after one (Year 1) and two growing seasons (Year 2) for each plot of the Mississippi 2014 (MS-2014) seedlot (suspected hybrids) compared to each plot of the Mississippi 2015 (MS-2015) seedlot (true longleaf pine)

	MS-2014 Suspected hybrid		MS-2015 True longleaf pine	
Plot	Year 1	Year 2	Year 1	Year 2
	cm			
1	5.62	9.20	5.16	9.53
2	5.31	8.94	5.10	9.89
3	5.45	8.25	5.10	8.60
4	5.64	9.47	6.00	8.59
5	-	-	5.00	7.03

season. About 14 percent of the MS-2015 longleaf seedlings and 42 percent of the MS-2014 suspected hybrid seedlings had reached measurable height after 1 year (table 2). The MS-2014 seedlings displayed some level of stem elongation at planting which may have contributed to that seedlot having more measurable seedlings compared to the MS-2015 true longleaf pine seedlings after 1 year.

During the first year of growth, longleaf pine seedlings typically remain in the grass stage and allocate energy into building a more robust root system (Wahlenberg 1946). After a longleaf pine seedling's second growing season, grass stage emergence is possible (Jackson and others 2012). After two growing seasons, the MS-2015 longleaf pine seedlings and MS-2014 suspected hybrid seedlings remained similar in height, averaging 8.96 cm for the MS-2014 seedlings and 8.72 cm for the MS-2015 seedlings (table 1). In addition, the number of measurable MS-2015 longleaf pine seedlings increased 59 percentage points to 73 percent, while the number of measurable MS-2014 suspected hybrids increased 23 percentage points to 65 percent (table 3). The average heights of all seedlings per plot did not reach the 12-cm threshold for grass stage emergence published by Wahlenberg (1946). Also, the MS-2014 suspected hybrid seedlings lacked terminal growth that is typically associated with Sonderegger pine seedlings. These observations indicate that the suspected hybrids are responding more like true longleaf pine seedlings.

Seedling survival was 97 percent for all plots combined after one growing season with the loss of four MS-2014 seedlings and seven MS-2015 seedlings (table 2). The prescribed fire occurred during the second growing season, and overall survival was reduced to 92 percent

Table 2—The number of seedlings that measured above or below the 5-cm threshold and survival for each plot after one growing season for the Mississippi 2014 (MS-2014) seedlot (suspected hybrids) compared to the Mississippi 2015 (MS-2015) seedlot (true longleaf pine)

	MS-2014 Suspected hybrid			MS-2015 True longleaf pine		
Plot	<5 cm	≥5 cm	Dead	< 5 cm	≥ 5 cm	Dead
	number of seedlings					
1	28	20	2	37	12	1
2	28	22	0	36	14	0
3	28	20	2	38	5	5
4	27	23	0	47	2	1
5	-	-	-	48	2	0

Two true Sonderegger pines planted in MS-2015 plot 3 were not included in the reported data.

Table 3—The number of seedlings that measured above or below the 5-cm threshold and survival for each plot after two growing seasons for the Mississippi 2014 (MS-2014) seedlot (suspected hybrids) compared to the Mississippi 2015 (MS-2015) seedlot (true longleaf pine)

	MS-2014 Suspected hybrid			MS-2015 True longleaf pine		
Plot	<5 cm	≥5 cm	Dead	< 5 cm	≥ 5 cm	Dead
	number of seedlings					
1	15	27	8	7	43	0
2	12	34	4	6	44	0
3	13	29	8	12	29	7
4	6	41	3	11	36	3
5	-	-	-	16	32	2

Two true Sonderegger pines planted in MS-2015 plot 3 were not included in the reported data.

with a total of 23 MS-2014 seedlings and 12 MS-2015 seedlings lost (table 3). The elongated stems of the MS-2014 suspected hybrids may have contributed to their mortality by being at heights vulnerable to flames from a prescribed burn. Also, the herbaceous and sparse woody vegetation on the site may have contributed to some of the mortality.

Outplanting: March 27, 2018—The seedlings being evaluated in these plots included two seedlots (LA-2014 and MS-2014) that were suspected as being hybrid Sonderegger pine based on their abnormal morphology displayed in the nursery. After 1 year of growth in the field, 46 percent of the LA-2014 seedlings and 36 percent of the MS-2014 seedlings had reached the 5-cm threshold for height measurements (table 4), and neither seedlot produced stem elongation similar to what is typically expressed by Sonderegger pines. For those measured, the overall average height of the LA-2014 and MS-2014 seedlings was 6.05 cm and 5.98 cm, respectively (table 4). The seedling growth in these plots was similar to the 1-year seedling growth recorded in adjacent plots for the MS-2014 suspected hybrid seedlings and MS-2015 true longleaf pine seedlings planted in December 2016. Seedling survival was 96 percent for the LA-2014 seedlings and 99 percent for the MS-2014 seedlings (table 4).

The purpose behind planting Sonderegger pine seedlings in plots was to evaluate their morphology over time. Will the Sonderegger pine seedlings develop into unusable gnarly, weak trees (Dorman 1976, Wakeley 1954), or could they be useful as a timber resource? Schoenike and others (1975) reported that when Sonderegger pines were removed from a longleaf pine nursery and planted on a Piedmont site in South Carolina, they had similar limb and bole formation to that of loblolly pine after 9 years. To our knowledge, there has not been a comparative study to document the developmental differences between longleaf and Sonderegger pine when planted in plots side by side as seedlings from known sources on the same managed site. To make a true comparison of bole and scaffold limb formation with longleaf pine, it will take several more years of Sonderegger pine growth and development. After 1 year in the field, Sonderegger pine seedlings in each of the eight plots averaged about 25 cm in height with the shortest Sonderegger seedling measured being 10 cm and the tallest one measured being 55 cm. The MS-2014 and LA-2014 seedlings were only measured at the threshold of 5 cm. The tallest MS-2014 and LA-2014 seedlings measured were 24 and 20 cm, respectively, and those were most likely true Sonderegger pines that happened to be mixed in the seedlot. The heights of all other seedlings in both seedlots measured below 10 cm.

CONCLUSIONS

The suspected hybrids did not grow to heights displayed by the true Sonderegger pine. That information along with the suspected hybrids growing morphologically similarly to longleaf pine may indicate the MS-2014 and LA-2014 seedlots are, in fact, true longleaf pine. Furthermore, analyzing the deoxyribonucleic acid (DNA) from tissues of seedlings from each seedlot indicated there was no evidence of hybridization (Barnett and others 2020). At this time, the reason behind the abnormal stem elongation for the MS-2014 and LA-2014 seedlots cannot be explained. These observational plots will continue to be monitored for tree growth and development to gain a better understanding of their morphology.

Table 4—Mean seedling height, number of seedlings that measured above or below the 5-cm threshold, and survival for each plot after one growing season for the suspected hybrid seedlings from the Mississippi 2014 (MS-2014) seedlot compared to the suspected hybrid seedlings from the Louisiana 2014 (LA-2014) seedlot

	LA-2014				MS-2014			
		Abundance				Abundance		
Plot	Height	<5 cm	≥5 cm	Dead	Height	<5 cm	≥5 cm	Dead
	cm	----------*number*----------			*cm*	----------*number*----------		
1	7.03	35	13	2	7.20	35	15	0
2	5.83	10	37	3	5.73	35	15	0
3	5.58	24	24	2	5.48	21	27	2
4	5.78	30	19	1	5.53	34	16	0

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