SILVICULTURE'S IMPACT ON THE HISTORICAL SHORTLEAF COMPONENT OF PINE FORESTS IN THE UPPER WEST GULF COASTAL PLAIN

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Abstract—Silvicultural practices and human-induced alterations to natural disturbance regimes have contributed to a dramatic decline in shortleaf pine (*Pinus echinata*) across most of the Upper West Gulf Coastal Plain (UWGCP). The increased preference for faster-growing loblolly pine (*Pinus taeda*) in natural-origin stands, coupled with the spread of loblolly plantations and less fire on the landscape, have selected against shortleaf pine. While many are interested in reversing shortleaf's decline, remarkably little is known about the composition and structure of historical UWGCP natural-origin pine stands, and this lack of knowledge constrains our ability to establish restoration goals. As a first step, this review first contrasts the shortleaf composition of the virgin forest with that of well-stocked second-growth in the first half of the 20th century using a variety of sources. For instance, two extensive inventories conducted by the Forest Service, U.S. Department of Agriculture in the early 1930s in northeastern Louisiana and southeastern Arkansas surveyed cutover pinelands. Shortleaf pine was a prominent component in both inventories across all size classes, accounting for 20 to 40 percent of the pine sawtimber volume in many second-growth forests. These statistics are supported by later regional inventories as well as other UWGCP-based studies on wood decay, selective logging, site quality, pulpwood thinning, and seed tree management. Such examples can help identify the silvicultural contributions to this decline, thereby laying the foundation for conservation options.

INTRODUCTION

From southern Pennsylvania and New Jersey to eastern Oklahoma and Texas across to northern Florida, shortleaf pine (*Pinus echinata*) covers the widest geographic extent of any southern pine (Lawson 1990). However, a recent analysis of rangewide abundance using Forest Inventory and Analysis (FIA) data noted that shortleaf pine-dominated forests declined from 12.6 million acres in 1980 to 6.1 million acres in 2010—a decrease of 52 percent (Oswalt 2012). Although some regions (for example, the Ouachita Mountains in Arkansas and Oklahoma) have been less affected, others including the coastal plains across the southeastern U.S. have witnessed dramatic decreases across all size classes (Moser and others 2007, Oswalt 2012). Historically, the Upper West Gulf Coastal Plain (UWGCP) has been considered the pinnacle of shortleaf pine's distribution, with the biggest individual trees and highest stand volumes (Mohr and Roth 1897, Mattoon 1915). According to Mohr and Roth (1897, p. 94): "[w]est of the Mississippi River the Shortleaf pine finds its region of greatest profusion, forming forests of vast extent on the uplands of the undulating plain and table-lands of the hill country, which in their timber wealth and economic importance rival the great lumbering regions farther south." Yet, across the UWGCP today, shortleaf pine has become an increasingly minor species. According to the most recent FIA data, the previously codominant shortleaf now comprises only 11.7 percent of the region's 56 billion board feet of pine sawtimber, and has particularly declined in southwestern Arkansas and northern Louisiana.[1]

As with virtually all declines of once prominent species, the diminishment of shortleaf pine has its roots in both natural and anthropogenic causes. During the forest exploitation period of the southeastern U.S. (from 1880 to 1930), all of the major southern pines were heavily lumbered and untold billions of board feet of shortleaf were felled. Traditionally, shortleaf pine was preferred over loblolly pine (*Pinus taeda*) for lumber. Bray (1904, p. 52) described the wood of shortleaf pine as "…heavy, hard, strong, and generally coarse-grained…as lumber it is inferior only to longleaf pine," while loblolly wood was considered "…light, not strong, brittle, very coarse grained, and not durable." However, when grown under

[1] Gross sawtimber in terms of board feet, International ¼-inch rule. Includes data from all pine species for 2013 for Bailey's Ecological Subregion 231E (Mid-coastal plains, western region) for Arkansas, Louisiana, Oklahoma, and Texas from the U.S. Forest Service's Forest Inventory Data Online (FIDO) website (http://apps.fs.fed.us/fia/fido/index.html), accessed 12 February 2015. Note that other board foot reports in this paper could be in terms of International ¼ inch, Doyle, Scribner, or other log rules (some sources are not specific).

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Citation for proceedings: Schweitzer, Callie J.; Clatterbuck, Wayne K.; Oswalt, Christopher M., eds. 2016. Proceedings of the 18th biennial southern silvicultural research conference. e–Gen. Tech. Rep. SRS–212. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 614 p.

comparable circumstances, the wood quality between old-growth loblolly and shortleaf pine probably differed less than that noted by Bray. Commercially, there was little distinction between these species, especially when contrasted to old-growth longleaf (*Pinus palustris*) and slash pine (*Pinus elliottii*). The label "shortleaf" was applied when marketing the lumber of both *Pinus echinata* and *Pinus taeda* (Davis 1931) and was often used interchangeably to describe either species in the field.

Over time, opinions of loblolly pine timber changed, aided by a fast growth rate and the comparative ease of regenerating this species. Loblolly took advantage of favorable old-field sites and cutover timberlands now protected from fire to rapidly expand its distribution across the UWGCP, becoming the dominant pine species across the region by the mid-20th century. This dominance has only increased in recent years, as many natural-origin pine, pine-hardwood, and hardwood forests have been replaced by loblolly pine plantations (Klepzig and others 2014). A concurrent decline of shortleaf pine went largely unheralded until recently (Moser and others 2007, Oswalt 2012). Growing concern helped prompt the formation of the "Shortleaf Pine Initiative" (http://www.shortleafpine.net/) to educate landowners and foresters about the decline of shortleaf and promote silviculture to help this species.

While many are interested in reversing the wane of shortleaf, little is known about its role in historical UWGCP natural-origin forests and the contributions of silviculture to its decline. This lack of knowledge constrains our ability to establish restoration goals for shortleaf pine. Fundamentally, there is no expectation that this timber-producing region will ever revert back to pre-Euroamerican dynamics sufficiently to return to an extensive shortleaf pine-dominated forest. However, a review of historical pine forest conditions across the UWGCP should provide valuable insights into what management options may be most effective in restoring shortleaf.

METHODS

The literature reviewed here is not intended to be an exhaustive list of the material available, but rather was chosen to help illustrate the role of silviculture in the decline of the shortleaf pine resource across the UWGCP. The UWGCP covers over 22 million acres of southern Arkansas, northern Louisiana, eastern Texas, and extreme southeastern Oklahoma and was chosen to highlight a portion of the range of shortleaf pine in which land ownership patterns, management practices, and site conditions remain potentially favorable for restoration. The UWGCP is still dominated by pine, although most is now loblolly and virtually no old growth remains (Klepzig and others 2014).

A large number of historical maps, photographs, inventory reports, scientific papers, and other documents were consulted; those that featured descriptions of well-stocked, second-growth pine and pine-hardwood UWGCP forests were chosen for further analysis. This resulted in most sources coming from after 1930. Before this time, there was little quantifiable information on relative shortleaf pine abundance and only sparse photographic evidence of stand composition and structure. Most references also came from before 1970, when naturally regenerated silviculture of second-growth stands dominated UWGCP landscapes. As the 20th century progressed, loblolly pine plantation management became the prevailing practice, and interest in natural-origin pine silviculture dropped greatly.

RESULTS AND DISCUSSION

Virgin Shortleaf Pine in the UWGCP

Almost without exception, the earliest reliable documentation indicates that upland pine-dominated forests across the UWGCP were heavily shortleaf pine. For example, Sargent's (1884) census report for the UWGCP in Arkansas, Louisiana, and Texas showed shortleaf as the most prominent pine of this region. Mohr and Roth (1897) provided semi-quantitative maps of the distribution of the major southern pine species, and from these (fig. 1) it is clear that shortleaf pine was dominant or codominant with loblolly pine (and, to a lesser degree, longleaf) across nearly the entire UWGCP. Olmsted (1902) noted that in some uncut lands near Pine Bluff, Arkansas, the "pine ridge" type averaged 5,945 board feet of merchantable pine sawtimber per acre, of which 64.2 percent was shortleaf and the remaining 35.8 percent was loblolly. His less common "pine flat" type on small stream terraces was better stocked (6,646 board feet per acre in pine) and was composed of 67.3 percent loblolly and 32.7 percent shortleaf. Parts of the UWGCP were even more shortleaf-dominant: a selective logging study in virgin pine timber from eastern Texas reported only a few hardwoods and a small fraction (about 7.5 percent) of loblolly (Garver and Miller 1933). The 1930s-vintage Forest Service, U.S. Department of Agriculture inventories for the UWGCP reported a major (25 to 50 percent) shortleaf component in the remaining old-growth pine-dominated forests (table 1).

Most other early UWGCP descriptions agree with these assessments, although they tend to be more qualitative (for example, Mattoon 1915). Bray (1904) mapped most of northeastern Texas as shortleaf pine forest (he called it the only important timber species in this region), with loblolly pine and longleaf pine more prominent in southeastern Texas. Foster (1912, p. 9) noted similar dominance of shortleaf pine across much of northern Louisiana—his "shortleaf pine uplands"

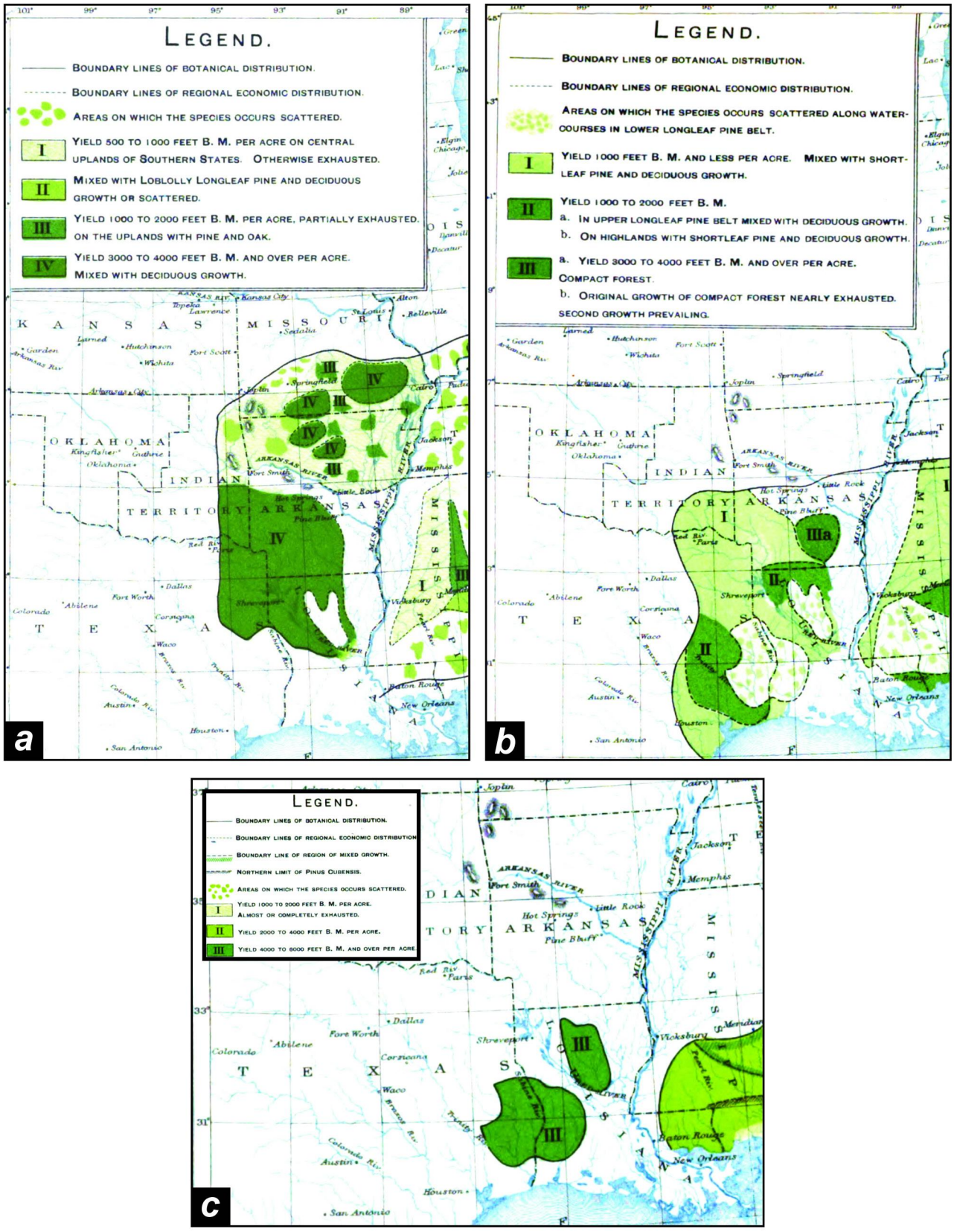

Figure 1—Historical distribution of the pine forests of the Upper West Gulf Coastal Plain, as drawn by Mohr and Roth (1897) and excerpted from their original maps of (*a*) shortleaf pine, (*b*) loblolly pine, and (*c*) longleaf pine (including slash pine east of the Mississippi River).

Table 1—Coverage, estimated pine sawtimber volume (foot, board measure (fbm)), and fractions of this sawtimber volume by species in uncut old-growth pine-dominated forests of the Upper West Gulf Coastal Plain as identified by U.S. Forest Service regional inventories in the mid-1930s

Region/State	Year of survey	Uncut old-growth area	Sawtimber volume	Pine species			Source
				Short-leaf	Loblolly	Long-leaf	
		-- acres --	*-- 1000s fbm --*	*-- percent of sawtimber --*			
SW Arkansas	1936	48,300	628,000	30.8	69.2	0.0	Eldredge (1937)
NW Louisiana	1935	61,100	387,800	39.9	60.1	0.0	Eldredge (1938a)
NE Texas	1935	33,600	341,700	49	46-50	1-5	Cruikshank (1938)
SE Texas	1935	180,900	1,177,800	24.7	58.8	16.5	Cruikshank and Eldredge (1939)

region had "pure" stands of shortleaf on the dry ridges and a mixture of hardwoods, shortleaf, and loblolly in the "intermediate" lands. Even in the better soils of northeastern Louisiana, Foster (1912) only mentioned shortleaf pine mixed with the hardwoods. Chapman (1913, p. 4) reported the virgin forests of a 27,000-acre tract in southeastern Arkansas and northeastern Louisiana were "…shortleaf and loblolly pine in almost equal mixture... [loblolly] gradually gives place to shortleaf on drier soils and on the driest the shortleaf grows pure." Russell R. Reynolds, the first scientist at the Crossett Experimental Forest, later described the virgin timber in this same area as 50 percent loblolly, 25 percent shortleaf, and 25 percent hardwoods (Reynolds and others 1984).

There are other qualitative accounts of the historical dominance of shortleaf pine across the UWGCP, including some photographs taken by U.S. Forest Service staff (fig. 2). Other historical photographs of the piney woods of the UWGCP are often labeled as showing "shortleaf" pine, although it is often not clear if the pines shown are *Pinus echinata*, *Pinus taeda*, or some mixture of these species. This taxonomic uncertainty is an unfortunate consequence of some early reports failing to distinguish between loblolly and shortleaf pine—many were only interested in differentiating between longleaf pine and other southern pines (Davis 1931, Bragg 2002, Bragg 2008). For instance, Morbeck (1915) described the uncut pine-hardwood forests of the Fordyce Lumber Company exclusively as shortleaf pine, even though loblolly was present in most of the upland virgin forests across southern Arkansas, particularly along the smaller stream bottoms (Mohr and Roth 1897, Olmsted 1902, Mattoon 1915, Chapman 1942).

Historical Accounts of Shortleaf in Second-Growth Pine Forests

Shortleaf's prominence on most upland sites in the UWGCP waned as the old growth was cleared or otherwise disrupted by widespread Euroamerican settlement. Regrettably, most data on the abundance and size-class distribution of second-growth shortleaf pine in the UWGCP came decades after most of the virgin timber had been cleared. During the first decades of the 20th century, the nascent forestry profession had yet to offer meaningful management options for second-growth forests, and very few publications considered the prospects for shortleaf pine silviculture. For example, Bray (1904, p. 39) dedicated only one small paragraph on "conservative lumbering" in shortleaf pine forests of northeastern Texas, as he was convinced that "…the [second-growth shortleaf] forests of this region will find their chief usefulness as protective forests and woodlots."

Early U.S. Forest Service inventories—During their early years, U.S. Forest Service experiment stations often aided private landowners and government agencies interested in sustainable forestry by inventorying their cutover timberlands. In 1931, the Southern Forest Experiment Station assessed the lands of the Union Saw Mill Company in northern Louisiana and southern Arkansas. Union Saw Mill was trying to determine if their uncut second-growth and recently

Figure 2—Photograph from the fall of 1937 of a stand of young and old shortleaf pine-dominated timber near Hamburg, Arkansas. U.S. Forest Service image from the files of the Crossett Experimental Forest.

cutover pine lands could sustain their mill in Huttig, Arkansas, and Forest Service forester A.E. Wackerman cruised their approximately 152,000 acres of uncut second-growth timber. Wackerman estimated these lands averaged 5,210 board feet (International ¼-rule log scale) per acre of pine, of which 1,574 board feet were shortleaf (just over 30 percent of the pine; fig. 3) (Unpublished 1936 report to Mr. F.W. Scott, President, Union Saw Mill Company, Huttig, Arkansas, on a management plan for sustained yield. On file with D.C. Bragg). Most of the shortleaf pine sawtimber volume was less than 15 inches diameter at breast height, suggesting that shortleaf had robustly regenerated following the clearing of the virgin pine. Similarly, Russell R. Reynolds provided the data and analysis for second-growth upland forests in UWGCP for the National Plan for American Forestry (also known as the "Copeland Report"; USDA Forest Service 1933). According to Reynolds' work (pages 945-946 in the Copeland Report), an "average-stocked" acre of pine-hardwood (inventoried across 345,000 acres and thought to be "typical of conditions on 7 million acres of this type" across southern Arkansas, northern Louisiana, and eastern Texas) had 1,000 board feet of shortleaf pine, 1,768 board feet of loblolly pine, and 1,920 board feet of hardwoods in sound trees (fig. 4a). Although the extent of "better-stocked shortleaf-loblolly-hardwood stands" was not specifically given (it was probably in the hundreds of thousands of acres), this stand condition likewise had a substantial amount of shortleaf pine sawtimber (4,371 board feet per acre, or 37.6 percent of all pine sawtimber; fig. 4b). In both stand types, shortleaf pine was well distributed across the range of tree diameters.

The U.S. Forest Service's Southern Forest Survey conducted the first formal inventories of the UWGCP in the 1930s. These inventories found shortleaf to be a prominent component of uncut second-growth stands, both young and old. With the notable exception of northeastern Texas, shortleaf averaged between 18.6 and 24.1 percent of all sawtimber, and 26.4 to 47.6 percent of pine sawtimber (table 2). As mentioned earlier, northeastern Texas was even more shortleaf dominated, with between 30.4 and 44.2 percent of all sawtimber and 65.7 to 70.8 percent of pine sawtimber. Unfortunately, these inventories do not detail relative pine abundance in the corner of the UWGCP that occurs in extreme southeastern Oklahoma (the southern half of McCurtain County). However, both loblolly and shortleaf are known to have been common in this small (less than 80,000 acres) enclave of pine-hardwood (Little and Olmsted 1936, Blair and Hubbell 1938, Eldredge 1938b, Duck and Fletcher 1945).

Other technical forestry reports—By the mid-20th century, technical forestry reports had increased substantially, but many authors did not distinguish between loblolly and shortleaf pine, limiting their utility for this paper. Hence, this section focuses on papers that detail species abundance. For example, Garver and Miller's (1933, p. 10) evaluation of selective logging in UWGCP forests noted that a 17-acre tract of somewhat understocked, approximately 60-year-old second-growth pine stand in southern Arkansas was "…about equally divided between shortleaf and loblolly pine…." This was considerably less than the over 90 percent shortleaf sawtimber from some companion virgin stands in eastern Texas, but far exceeded the roughly 6 percent they noted in a 13-acre old-field stand in northern Louisiana (Garver and Miller 1933). Old-field stands that arose following the abandonment of agriculture across the UWGCP are usually considered loblolly pine habitat. However, shortleaf pine can also dominate old fields, assuming an adequate seed source was present (Mattoon 1915). For instance, Forbes and Stuart (1930, p. 10) noted old-field stands "containing 80 per cent or more" of shortleaf pine commonly occurred in the UWGCP. Likewise, Turner's (1936) site index study of mature (greater than 50 years old), mostly old-field pine stands across southern Arkansas sampled shortleaf as often as loblolly pine, suggesting these species occurred in approximately equal frequencies. Representation was not always equivalent—Guttenberg (1954) noted that a dense, 44-year-old old-field pine stand on the Crossett Experimental Forest was 80 percent loblolly pine and 20 percent shortleaf pine in 1937—but still a much higher proportion of shortleaf than assumed today.

Other studies can be used to infer shortleaf abundance. In the 18 soils series Turner (1936) compared for site index, shortleaf pine was absent from the two most poorly drained soils considered, and was less commonly sampled than loblolly in only one other soil series. A later, large-scale study of non-randomly chosen stands across southern Arkansas and northern Louisiana placed 9 percent of their sites in "pure" shortleaf pine stands and another 24 percent in stands classified as mixed loblolly and shortleaf pine (Zahner 1958). In an assessment of wind firmness in shortleaf and loblolly seed trees on the Crossett Experimental Forest (Grano 1953), harvests were done on two 40-acre compartments in 1949, retaining 13 to 21 seed trees per acre. Of these seed trees, 55 percent were loblolly and 45 percent were shortleaf pine (Grano 1953). While shortleaf pines may have been disproportionately retained, Grano (1953, p. 116) noted that "…only the best individuals were selected for seed trees" and at that time the Crossett Experimental Forest did not prefer one pine over the other, suggesting that almost half of the pines were probably shortleaf prior to cutting. This assertion is supported by Reynolds (1959, p. 5), who stated that the second-growth forests of southern Arkansas and northern Louisiana were "… often half loblolly and half shortleaf…." Stephenson

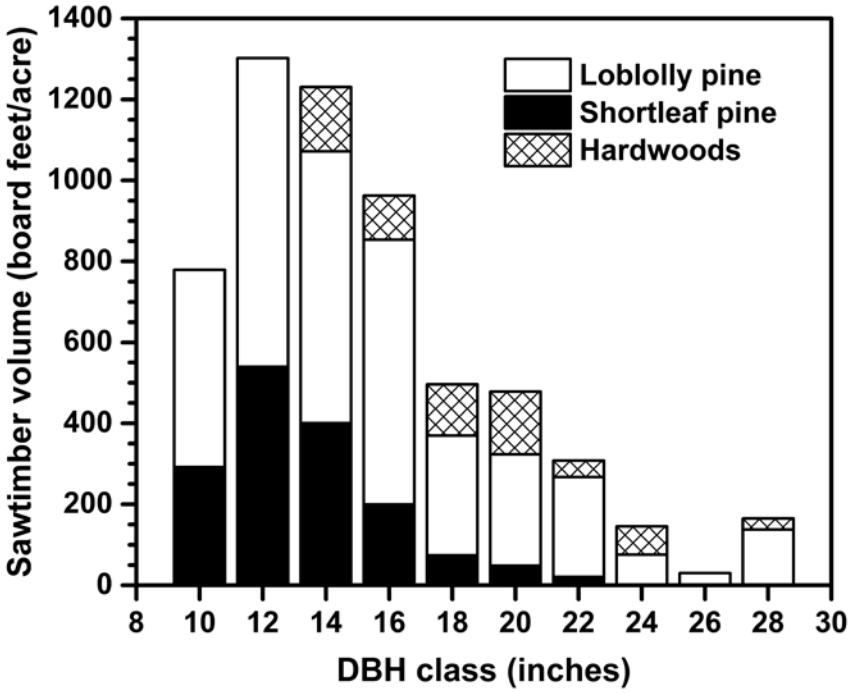

Figure 3—Size and sawtimber volume distribution by species for 152,000 acres of second-growth pine-dominated forests in Union County, Arkansas and Union Parish, Louisiana in the early 1930s adapted from A.E. Wackerman's unpublished 1936 report to the Union Saw Mill Company. Note: data did not include trees less than 10 inches DBH (diameter at breast height).

(1963) noted second-growth stands on the E.L. Kurth Experimental Forest in eastern Texas were at least 90 percent shortleaf pine, with only a few plots having more than 25 percent loblolly.

The Likely Impacts of Silvicultural Practices on Shortleaf's Decline

Undoubtedly, the application of silviculture in the UWGCP has contributed to the decline of shortleaf pine. This waning almost certainly began with the clearing of the virgin forest and was then continued by treatments that, either directly or indirectly, discriminated against shortleaf. Reynolds (1951, p. 4) noted as much in a guidebook he prepared: "Management [on the Crossett Experimental Forest] is gradually converting the original shortleaf-loblolly pine-hardwood stands to a shortleaf-loblolly pine type in which loblolly is increasingly dominant." This admission is significant because shortleaf was not treated differently from loblolly at Crossett, yet loblolly was being favored by the uneven-aged practices of Reynolds.

As silvics information swelled, foresters quickly realized that loblolly outgrew shortleaf pine on the same UWGCP sites, especially when protected from fire (for example, Record 1907, Chapman 1942). It is possible that the smaller size of shortleaf pine may have led to higher rates of removal during thinning operations, which were often done from below to remove what were thought to be intermediate or suppressed trees. Furthermore, although it was not necessarily appreciably different than loblolly pine, shortleaf developed a reputation for being a less prolific seed producer (Barnett and Haugen 1995) and more prone to certain forest health issues, including susceptibility to southern pine beetle (*Dendroctonus frontalis*) (Ku and others 1980), greater windthrow of seed trees (Grano 1953), and periodic unexplained declines (Williams and Tainter 1971). This perception often led to recommendations to select against shortleaf in natural-origin pine stands. For example, Grano (1953) advised managers that shortleaf seed trees either be retained in 'mutually protective' small groups or loblolly pine should be favored. With these concerns (deserved or not), it is not surprising that foresters increasingly selected against shortleaf pine in second-growth forests.

The recent success of loblolly pine across the UWGCP is not due solely to harvest practices. As cutover and agriculturally abandoned lands reforested, loblolly's proclivity to occupy favorable sites allowed it to rapidly expand. Concurrently, fire suppression in the UWGCP became widespread during the 1930s, with forest coverage increases being attributed in part to better

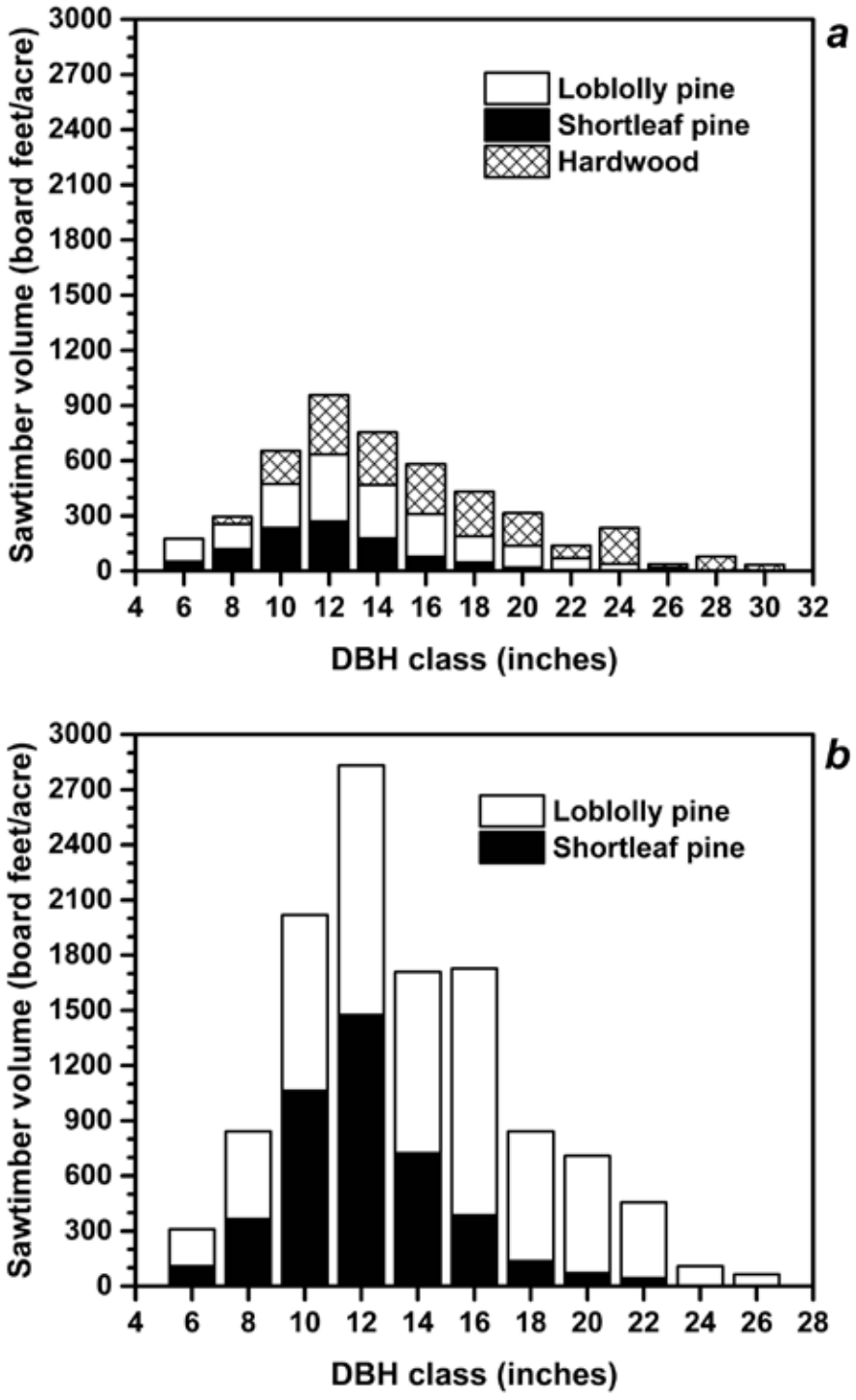

Figure 4—Size and sawtimber volume distributions by species for (*a*) average and (*b*) exceptionally well-stocked second-growth pine-dominated forests thought to be representative of hundreds of thousands to millions of acres across the Upper West Gulf Coastal Plain in southern Arkansas, northern Louisiana, and northeastern Texas in the early 1930s (USDA Forest Service 1933). (DBH = diameter at breast height).

Table 2—Quantity and proportion of sawtimber (foot, board measure (fbm)) in uncut second-growth pine-dominated forests in the Upper West Gulf Coastal Plain by different species or species groups estimated by U.S. Forest Service regional inventories in the mid-1930s

Region/State	Stand type [a]	Shortleaf	Loblolly/ longleaf [b]	All hardwood	All species	Pines only	Source
		---------- billions fbm ----------			----- percent -----		
SW Arkansas	sawlog	2.053	3.632	2.954	23.8	36.1	Eldredge (1937)
SW Arkansas	under	0.030	0.033	0.079	21.1	47.6	Eldredge (1937)
NW Louisiana	sawlog	1.240	2.054	1.855	24.1	37.6	Eldredge (1938a)
NW Louisiana	under	0.022	0.031	0.053	20.8	41.5	Eldredge (1938a)
NE Texas	sawlog	1.744	0.910	1.295	44.2	65.7	Cruikshank (1938)
NE Texas	under	0.034	0.014	0.064	30.4	70.8	Cruikshank (1938)
SE Texas	sawlog	1.134	3.155	1.793	18.6	26.4	Cruikshank and Eldredge (1939)
SE Texas	under	0.058	0.133	0.118	18.7	30.4	Cruikshank and Eldredge (1939)

[a] Stand types are either "sawlog size" or "under sawlog size"; under sawlog size includes reproducing stands.

[b] This combines loblolly and longleaf pine, when present--there is no longleaf pine in the Arkansas inventory. Longleaf is typically a minor component in the NW Louisiana and NE Texas inventories.

fire protection (for example, Eldredge 1937). Prior to this, much of the region burned frequently (for example, Bruner 1930), which helped shortleaf pine more than loblolly, given shortleaf's ability to sprout from the basal crook when young (Mattoon 1915). It is hard to overstate the impact of fire on the success of shortleaf pine regeneration. Mattoon (1915, p. 20) claimed that "…the majority of all standing shortleaf timber examined in various portions of Arkansas [including the UWGCP] was found to be of coppice origin." During the first few decades of the 20th century, fire suppression was often considered the only silvicultural option. As an example, Peters (1916) spent over three pages on fire in an assessment of forest conservation in southern pine, compared to only a half-page on forest management. After all, without effective fire control, it was thought to be impossible to get a properly stocked stand established (Bruner 1930).

Prescribed fire eventually returned as a means of competition control and as a habitat restoration tool. By the mid-1980s, some UWGCP landowners burned tens of thousands of acres annually (for example, Georgia-Pacific's Mid-Continent Division in Arkansas, Louisiana, and Mississippi; Williams 1985), a practice that is still common on public lands across the region. The use of fire to clear logging slash, prepare seedbeds, and restrict non-pine competition was implemented to have minimal impact on established loblolly or shortleaf pine, and it is likely that both species benefited from prescribed fire during this period. However, under these circumstances, fire no longer limits loblolly pine regeneration, with some important genetic consequences (described later). In recent years, increasingly effective mechanical and chemical site preparation techniques have largely replaced prescribed fire as the preferred stand establishment tools, particularly as investment-heavy loblolly pine plantations have become the norm. Restoration-focused prescribed fire use has increased as of late, but continued population growth and urbanization pressures are expected to further erode UWGCP forest cover over the next 50 years (Klepzig and others 2014), and this does not bode well for the large-scale use of fire to help restore shortleaf pine.

The rapid and large-scale expansion of loblolly pine plantations across the UWGCP over the last 30 years has probably had the biggest impact on the decline of shortleaf pine. Installing loblolly pine plantations on upland sites is now the industry standard and has also been adopted by many small private landowners. Decades of loblolly pine tree improvement programs, better herbicides, intensive site preparation methods (including bedding and fertilization), superior (often containerized) seedlings, and custom-tuned density management strategies have dramatically increased volume yields over increasingly shorter rotations (see reviews in Borders and Bailey 2001, Stanturf and others 2003, Allen and others 2005, Fox and others 2007, Jokela and others 2010). With the considerable investment required to achieve these gains, yield losses to competing vegetation (including natural-origin pine) are to be avoided, prompting many foresters to intensify silvicultural treatments over increasingly larger areas. The net result has been that many of the natural-origin pine and pine-hardwood forests, with their heretofore substantial shortleaf pine component, have been converted to loblolly plantations where prescribed fire is avoided.

The combination of more loblolly on the landscape and the loss of fire have yet other unanticipated consequences for shortleaf pine. There appears to be an increasing degree of introgression in the genetic integrity of shortleaf (Tauer and others 2012). Recent studies have documented that shortleaf and loblolly pines have been crossbreeding, suggesting that many of the putative shortleaf seedlings in naturally regenerated stands are, in fact, hybrids (Stewart and others 2012). One of the shortleaf pine traits that appears to be lost in these crosses is the strong basal crook and the concurrent ability to resprout following topkilling (Will and others 2013), which conveyed a distinct advantage over loblolly in fire-prone environments (Mattoon 1915, Walker and Wiant 1966, Stewart and others 2015). Frequent fire likely helped maintain the genetic distinctness of both shortleaf and loblolly by killing most fire-susceptible hybrid seedlings (Will and others 2013, Stewart and others 2015). In the absence of fire, the shortleaf-loblolly hybrids, with their enhanced growth rates, can outcompete genetically pure shortleaf pine seedlings, thereby further pressuring an already declining species (Tauer and others 2012, Will and others 2013).

IMPLICATIONS

This review presents a preliminary (and, admittedly, superficial) approximation of the challenges facing foresters and landowners interested in restoring shortleaf pine. The loss of natural-origin pine-dominated stands to loblolly pine plantations has contributed to a loss of genetic diversity in both shortleaf and loblolly pine. This trend, when coupled with fire suppression and the expansion of loblolly pine's range, suggests that returning significant amounts of shortleaf pine to the UWGCP may prove exceedingly difficult (Tauer and others 2012). However, modifications to a number of silvicultural practices (such as the retention of frequent prescribed fire) could help stem shortleaf's decline, even on a small scale. Further work will be needed to determine if even more effective strategies will be needed, but the rapidly changing genetics of shortleaf pine in the UWGCP, coupled with impending climate change, invasive species, and other landscape pressures, strongly favor quick action.

ACKNOWLEDGMENTS

I thank the following for their contributions to this work: O.H. "Doogie" Darling (retired Georgia-Pacific forester), Mike Shelton (retired U.S. Forest Service), and James M. Guldin (U.S. Forest Service). Andy Scott and Nancy Koerth (both of the U.S. Forest Service) and Andrew Nelson (UAM) graciously reviewed earlier drafts of this paper.

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