Composition and Structure of a 1930s-Era Pine-Hardwood Stand in Arkansas

DON C. BRAGG[1]

Abstract This paper describes an unmanaged 1930s-era pine-hardwood stand on a minor stream terrace in Ashley County, AR. Probably inventoried as a part of an early growth and yield study, the sample plot was approximately 3.2 ha in size and contained at least 21 tree species. Loblolly pine comprised 39.1 % of all stems, followed by willow oak (12.7%), winged elm (9.6%), sweetgum (7.8%), water oak (6.7%), white oak (6.2%), red oak (4.9%), and hickory (4.6%). Pine, sweetgum, and oak dominated the midcanopy and overstory, with few late successional species. Stand basal area averaged 32 m^2/ha, with 409 live trees/ha. The dominance of shade intolerant species, the lack of very big trees, and a scarcity of snags suggested that this stand was second-growth and likely arose from a disturbance in the mid-19" Century. Because this forest was sampled in the 1930s, its composition and structure should better reflect mature presettlement pine-hardwoods on minor stream terrace sites than modern examples.

Introduction

Restoration ecology has traditionally focused on the reproduction and maintenance of a desired environmental state and developmental trajectory (SER 2002). In the highly modified landscapes of eastern North America, much of the emphasis has been placed on creating communities visually similar to those of presettlement times. This is especially true on public lands, where some degree of restoration has become general policy and practice (e.g., Tyrrell 1996). Reliable reference conditions must therefore be acquired if the effort is to be successful.

Centuries of human intervention, including logging, agriculture, urbanization, fire control, and the introduction of exotic species have impacted the southeastern United States. This makes it almost certain that any contemporary examples of old forests are significantly different than presettlement conditions (Kennedy and Nowacki 1997) and, hence, poor models for restoration. Very few technical assessments of ecosystem condition date back to before 1900. Qualitative descriptions of virgin landscapes can be developed from the narratives of early explorers (e.g., Grimmett 1989, Hammett 1992) or historical photographs (Fig. I), but these typically lack sufficient detail to gauge restoration

[1]USDA Forest Service, Southern Research Station, PO Box 3516 UAM, Monticello. AR 7 1656; dbragg@fs.fed.us

effectiveness. Public land survey records have limited quantitative elements in them, including tree diameter, taxonomic abundance, and stem location. Even though survey notes have been extensively studied (e.g., Bourdo 1956, Delcourt and Delcourt 1974, Jackson et al. 2000, Lutz 1930), there are some problems with their interpretation and use in ecological research (e.g., Bragg 2003, Manies et al. 200 1, Mladenoff et al. 2002. Noss 1985).

It is highly improbable that most presettlement natural communities will ever be thoroughly described. However, some records from early studies conducted by the USDA Forest Service (USFS) date back to the early 20"' Century and thus are decades closer to presettlement conditions. One such data set from a mature pine-hardwood forest along a minor stream terrace was recently discovered in the files of the USFS's Crossett Experimental Forest and will be detailed in this paper.

Field Site Location and Sample Period

The rectangular sample plot was located in Ashley County, AR, most likely within the Chemin-A-Haut Creek drainage (Fig. 2). The stand seems to have been inventoried between 1933 and 1935, probably by foresters Russ Reynolds and/or A.E. Wackerman for a joint project between the Crossett Lumber Company and the USFS Southern Forest Experiment Station. Unfortunately, the exact location of this plot has been lost, so the area defined in Figure 2 is as precise as currently available. The following lines of evidence support the aforementioned sampling location and time frame.

The data were recovered from a large mailing envelope simply marked "Sample Plot #I East Block" in a study file originally denoted as "Industrial Forestry Arkansas #4" and later renumbered "CR-2.3." Presumably, this envelope was placed with this study file because it was part of this project. Study CR-2.3 was an investigation of the growth and reproduction in forest cover types common to a holding called the "Crossett East Block" (CEB), which at that time was owned by the Crossett Lumber Company (Anonymous 1940). The 10,500-ha CEB

Figure I. Virgin overcup oak-dominated bottomlands in the Ouachita River drainage of southern Arkansas and northern Louisiana. Photograph by Russ Reynolds (USFS# FS350894).

was located approximately 24 km east of the city of Crossett, AR, and consisted of a mixture of old fields, cut-over stands, second-growth forest, and virgin timber, including pine-hardwood stands on minor stream terraces (Reynolds 1934, 1980). Numerous streams bisect this portion of Ashley County, but few have extensive floodplains. Chemin-A-Haut Creek drains much of central Ashley County and has a sufficiently broad floodplain to accommodate a multi-hectare stand.

This file also included a letter reviewing the timber marking protocols for the CEB from Burt Kirkland, an economist with the USFS Southern Forest Experiment Station (Kirkland 1934). In his correspondence, Kirkland suggested that Reynolds (the study's principal investigator) continue the 100% inventory of the Crossett Lumber Company because of its low cost (about 5 cents per thousand board feet). Kirkland also advised the extension of the inventory to trees less than 33 cm in diameter at breast height (DBH), even to stems as small as 5 cm in DBH.

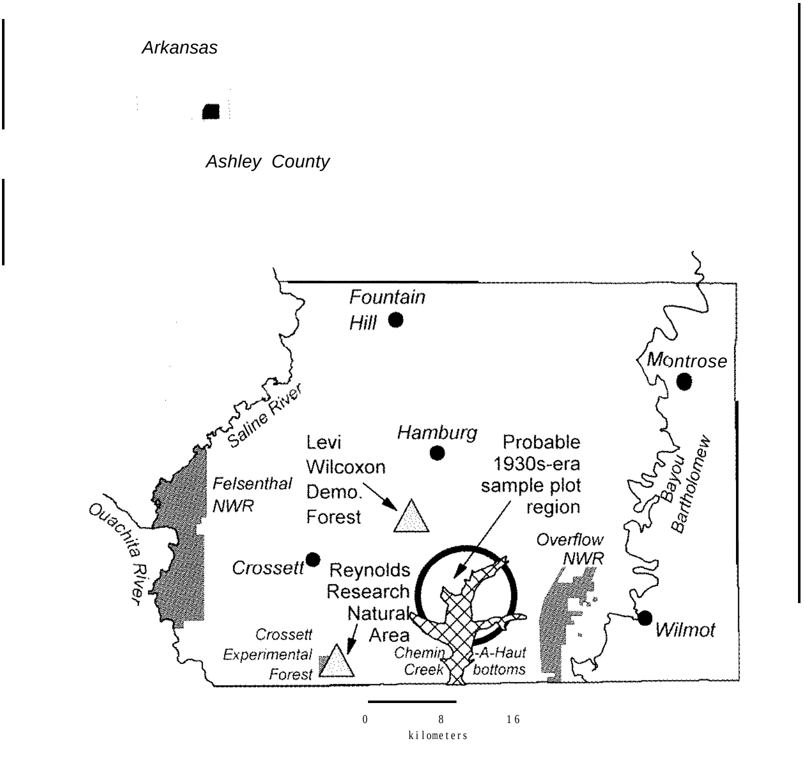

Figure 2. Probable location of the 1930s-era pine-hardwood sample plot in the Chemin-A-Haut Creek bottoms (cross-hatched), including the locations of the Reynolds Research Natural Area (RRNA) and the Levi Wilcoxon Demonstration Forest (LWDF).

This sample plot may have been a pilot study on the efficiency of Kirkland's suggestions. Work on the CR-2.3 inventory and timber marking of the CEB began in 1933 and was completed later that year (Reynolds 1934).

One final line of evidence suggested that this plot was sampled before 1935. Study CR-2.3 was one of a very few USFS studies established in the area that included minor terrace forests. As early as 1935, research and demonstration projects had started on the newly established Crossett Experimental Forest 10 km south of Crossett (Reynolds 1980), which lacks blocks of mature terrace pine-hardwood timber large enough to encompass a 3.2 ha sample plot. Over the next few years, USFS research in southern Arkansas focused on the upland pine forests of the Crossett Experimental Forest.

Methods

Original sampling design

The study plot measured 220 m by 146 m. All living and standing dead trees greater than 3.5 cm DBH had their species and DBH (to the nearest 0.25 cm) recorded. Live trees also received a relative crown class (dominant, codominant, intermediate, and suppressed) and status (live, cull, or dead) rating. Trees that were at least 33 cm DBH had their merchantable height (to the nearest 0.3 m) and number of graded sawlogs recorded. Measurements of bark thickness and 20 yr radial growth (in 5 yr increments) were collected from loblolly (*Pinus taeda* L.) and shortleaf (*Pinus echinata* Mill.) pines. The file contained no information on non-arboreal species or site conditions.

Data analysis

For diameter and crown position distributions, I condensed species into the following groups to reduce the number of sparsely populated taxa: pines (loblolly + shortleaf); hickories (*Carya* spp.); sweetgum (*Liquidambar styraciflua* L.); white oak (*Quercus alba* L.); red oaks (*Quercus falcata* Michx. and probably *Quercus pagoda* Raf.); water oak (*Quercus nigra* L.); willow oak (*Quercus phellos* L.); post oak (*Quercus stellata* Wang.); elms (*Ulmus* sp. + *Ulmus alata* Michx.); and other hardwoods (*Acer* spp. + *Cornus florida* L. + *Fagus grandifolia* Ehrh. + *Fraxinus* sp. + *Ilex opaca* Ait. + *Nyssa sylvatica* Marsh. + *Ostrya virginiana* (Mill.) K. Koch. + *Oxydendrum arboreum* (L.) DC + *Prunus serotina* Ehrh. + *Quercus velutina* Lam.). Diameter distributions follow 5 cm DBH classes, starting at O-S cm DBH.

Radial increment and bark thickness equations were developed for the pines using ordinary least squares regression. For all pines ≥ 14 cm DBH, tree- and stand-level sawtimber volumes were calculated using equations for "average" sites in Ashley County (Farrar et al. 1984). No comparable hardwood sawtimber equations with DBH as the sole independent variable were available, so a polynomial equation based on a local hardwood stand table (Table 25 in Reynolds (1959)) was used to predict volume. Sawtimber volume was calculated using the Doyle log scale to permit comparison with historical growth and yield information. To convert board feet Doyle per acre to cubic meters per hectare, I assumed 5.5 board feet Doyle = 1 cubic foot = 0.02832 cubic meters and 1 acre = 0.4047 ha, thus 1 m^3/ha = 79 board feet Doyle/acre.

Results

Species composition and stocking

At least 21 taxa were found in the 3.2 ha study plot (Table 1), although only 17 were identified definitively enough to assign species.

Table 1. Species composition of the 1930s-era pine-hardwood sample plot

Species[a]	Live trees per ha	Live basal area (m^2/ha)	Dead trees per ha	Dead basal area (m^2/ha)
Maple (*Acer* spp.)	4.983	0.067	0.000	0.000
Hickory (*Carya* spp.)	18.997	0.349	0.311	0.002
flowering dogwood (*Cornus florida* L.)	5.606	0.054	0.311	0.013
American beech (*Fagus grandifolia* Ehrh.)	0.311	0.020	0.000	0.000
Ash (*Fraxinus* sp.)	0.311	0.009	0.000	0.000
American holly (*Ilex opaca* Ait.)	0.311	0.006	0.000	0.000
Sweetgum (*Liquidambar styraciflua* L.)	32.389	1.211	0.000	0.000
Blackgum (*Nyssa sylvatica* Marsh.)	3.426	0.150	0.000	0.000
Eastern hophornbeam (*Ostrya virginiana* (Mill.) Koch.)	0.311	0.003	0.000	0.000
Sourwood (*Oxydendrum arboreum* (L.) DC.)	0.623	0.004	0.000	0.000
Shortleaf pine (*Pinus echinata* Mill.)	1.869	0.14X	0.000	0.000
Loblolly pine (*Pinus taeda* L.)	158.829	22.244	3.737	0.136
Black cherry (*Prunus serotina* Ehrh.)	0.311	0.007	0.000	0.000
White oak (*Quercus alba* L.)	25.849	1.159	0.000	0.000
Red oak[b] (*Quercus falcata* Michx.)	10.309	1.362	0.934	0.040
Water oak (*Quercus nigra* L.)	27.094	1.656	0.934	0.081
Willow oak[c] (*Quercus phellos* L.)	52.632	2.233	0.000	0.000
Post oak (*Quercus stellata* Wang.)	15.883	0.890	0.000	0.000
Black oak (*Quercus velutina* Lam.)	0.000	0.000	0.311	0.071
Elm (*Ulmus* sp.)	0.311	0.045	0.000	0.000
Winged elm (*Ulmus alata* Michx.)	39.552	0.528	0.311	0.005
TOTALS:	408.907	32.145	6.849	0.348

[a] Nomenclature from Smith (1988) and Moore (1999).

[b] Probably also includes cherrybark oak (*Quercus pagoda* Raf.).

[c] Labeled "pin oak," but was almost certainly *Quercus phellos* rather than southern pin oak (*Quercus palustris* Muenchh.) since *Quercus palustris* is not native to this part of Arkansas (Smith 1988).

The diversity of individuals in the 1930s-era pine-hardwood stand was not even, with nine species accounting for > 95% of all stems. Loblolly pine was the most frequently measured of the 1,335 trees sampled, encompassing 39. I % of all living and dead stems (Table 1). Oaks were common, especially willow oak, water oak, white oak, red oak, and post oak. Winged elm, sweetgum, and hickory were also relatively abundant. The remaining 12 taxa accounted for only 4.57% of the live and dead stems. For example, shortleaf pine was represented by only six individuals (0.45%). Basal area from the 409 live trees per hectare exceeded 32 m^2/ha (Table 1). Loblolly pine also dominated stocking, contributing 158.8 live trees/ha and almost 70% of live basal area. Willow oak produced the next highest proportion of living basal area (6.9%), and no other single species exceeded 6%.

Less than 7 standing dead trees per hectare were tallied (≈ 1% of total basal area) (Table 1). Loblolly pine dominated the snag population, comprising almost 55% of the standing dead individuals and 39% of total snag basal area. Other species with snags included hickory, flowering dogwood, red oak, water oak, black oak, and winged elm, but none contributed more than a single standing dead tree per hectare. The only black oak reported in this plot was a large snag.

Diameter and canopy position distributions

The 1930s-era sample plot had a distinctly stratified size class distribution (Fig. 3), with pines comprising the majority of the large diameter individuals and hardwoods dominating the smallest classes. Over three

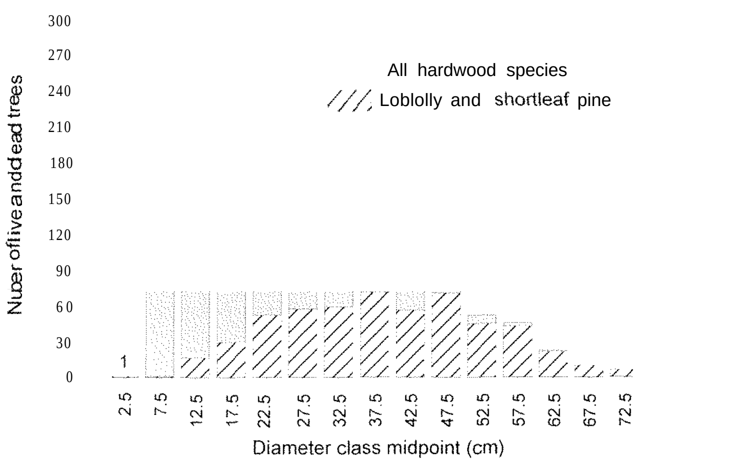

Figure 3. The stratified structure of the 1930s-era pine-hardwood sample plot is apparent when the diameter distribution of all trees is graphed.

dozen loblolly pines surpassed 60 cm DBH, including a 74.7 cm DBH specimen that was the largest tree on the plot. Only one individual (a 65 cm DBH willow oak) of the other taxa exceeded 60 cm (Table 2, Figure 4). The oaks were found in all size classes, but rarely had more than 5 individuals in the largest classes. Black oak (53.8 cm DBH) and *Ulmus* sp. (42.7 cm DBH) had the largest mean diameters, but were represented by a single individual each (Table 2). Most other hardwoods averaged 25 cm DBH or less, with maple, hickory, flowering dogwood, sourwood, and elm averaging < 1.5 cm. Both loblolly and shortleaf pine had mean DBH > 30 cm.

Canopy position data by species group for the 1930s-era sample plot followed patterns consistent with the presumed developmental stage of this stand (Fig. 5). Every species group occurred in each canopy position, although some were better represented than others. For example, the pines largely occupied dominant (45.0%) and codominant (22.2%) canopy positions, with fewer individuals classified as intermediate (13.3%) or suppressed (19.5%). Water oak and red oak also had their greatest presence in the dominant and codominant classes. Hickory, sweetgum, white oak, willow oak, post oak, elm, and the other hardwoods group were most prominent in suppressed and intermediate positions.

Table 2. Diameter attributes of all live and dead trees in the 1930s-era pine-hardwood plot.

Species	Number of live and dead	Minimum DBH (cm)	Maximum DBH (cm)	Mean DBH (cm)	Standard deviation (cm)
Maple spp.	16	X.1	20.3	12.7	3.3x
Hickory spp.	62	3.8	37.1	14.1	5.77
Flowering dogwood	19	7.0	22.0	11.5	3.51
American beech				28.7	
Ash sp.		—		19.3	
American holly		—		15.5	
Sweetgum	I 04	7.6	42.2	20.4	7.84
Blackgum	11	Il.9	43.9	22.0	9.14
Eastern hophornbeam				10.2	—
Sourwood	2	8.1	9.4	8.X	0.90
Shortleaf pine	6	17.8	37.3	30.9	8.01
Loblolly pine	522	6.6	74.7	39.4	14.1 I
Black cherry				17.0	
White oak	83	7.6	53.1	22.0	9.32
Red oak	65	7.4	57.9	26.6	13.35
Water oak	90	7.9	49.5	26.0	10.63
Willow oak	169	6.6	65.0	20.6	IO.80
Post oak	51	10.2	53.3	24.7	IO.23
Black oak				53.8	
Elm sp.	1			42.7	
Winged elm	128	5.3	33.5	12.3	4.49

Pine growth and yield

Twenty year pine increment was highly variable (Fig. 6). Of the 479 pines with radial measurements, annual growth ranged from 0.04 to 0.30 cm, with a slightly increasing trend related to diameter. Most pines averaged 0.05 to 0.15 cm of growth annually, or 2 to 6 cm of DBH increment in 20 yr. The linear regression fit to the data had a very low coefficient of determination ($R^2 = 0.03$) because of considerable variation in the radial increment of the sample (Fig. 6).

Stand-level pine sawtimber yield in the 1930s-era pine-hardwood stand was calculated to be 149.9 m^3/ha. Using the increment data to back-calculate pine diameter of 20 years earlier (merchantable pines that died and fell during this period were not tallied), the stand appar-

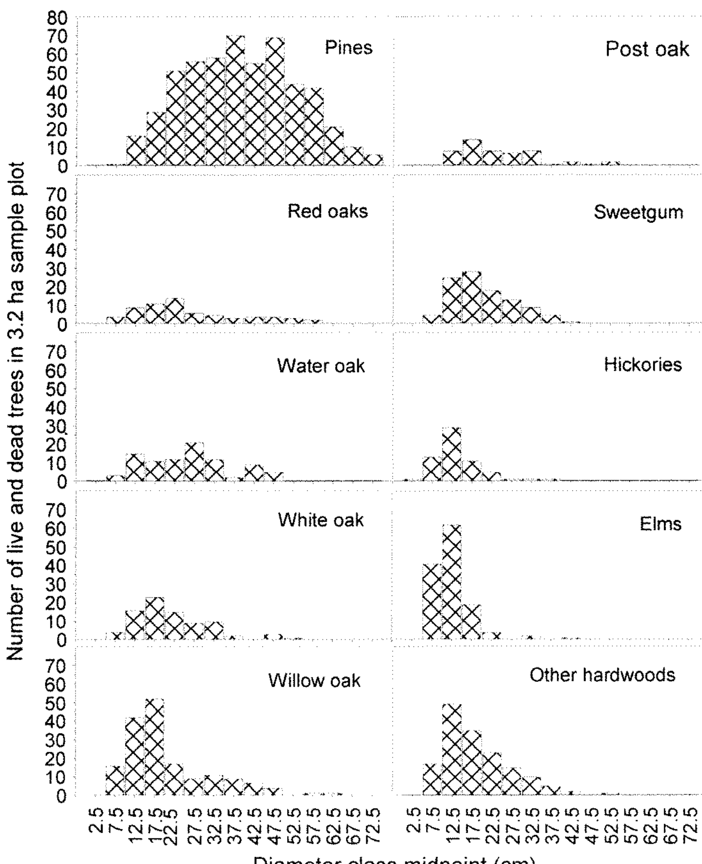

Figure 4. Diameter class distributions by species groups for the 1930s-era pine-hardwood sample plot.

ently increased from 116.9 m^3 of pine per hectare, or an average stand-level sawtimber growth of 1.65 m^3/ha/yr.

Similar growth calculations were not possible for the hardwoods since they lacked increment information. Hardwoods contributed 54.6 m^3/ha in merchantable sawtimber at the time the plot was measured, making the total yield of this pine-hardwood stand in the 1930s of approximately 204 m^3/ha.

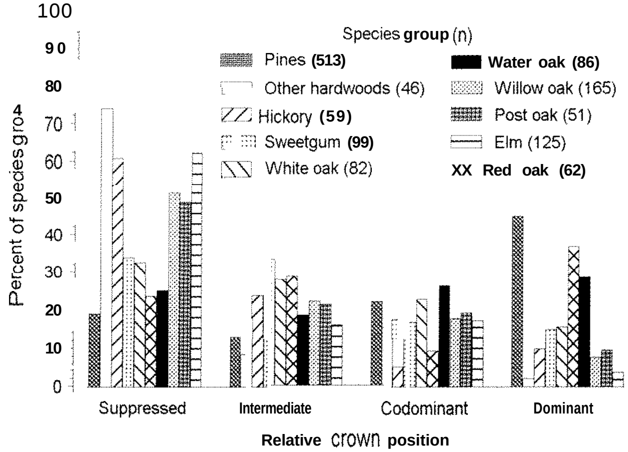

Figure 5. Crown position frequency by species groups for the 1930s-era pine-hardwood sample plot.

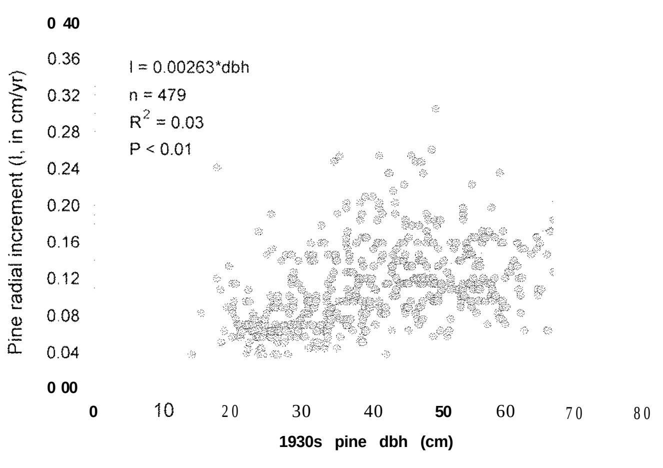

Figure 6. Plot of 1930s pine DBH against average annual increment over the previous 20 yr period for the 1930s-era pine-hardwood sample plot.

Bark thickness

Bark thickness data was also collected for 471 of the loblolly and shortleaf pines sampled in the 1930s-era pine-hardwood stand. Pine bark thickness ranged from 0.4 to 5.6 cm. although most trees averaged 1 to 3 cm. Bark thickness was positively correlated to tree DBH, and a regression equation explained almost 56% of the variance in the data (Fig. 7).

Discussion

Compositional patterns

The composition and relative abundance of pine and hardwoods reported in this file suggests that the 1930s-era pine-hardwood stand occurred along a minor stream terrace (Hodges 1997). Pine-oak terrace flats are frequent in this part of Arkansas (Record 1910, Vanatta et al. 1916), and mature stands of this type were common during the 1930s (Reynolds 1980). Vanatta et al. (1916, p. 1201) described a poorly drained phase of the abundant loessal soils found in Ashley County as "... forested with pin [willow] oak, black gum, water oak, and pine . ..". This soil type dominated the Chemin-A-Haut Creek drainage (Vanatta et al. 1916), further corroborating the location of the 1930s-era pine-hardwood stand.

Loblolly pine was often a prominent component of stands on terrace soils following severe disturbances like windthrow, fire, logging,

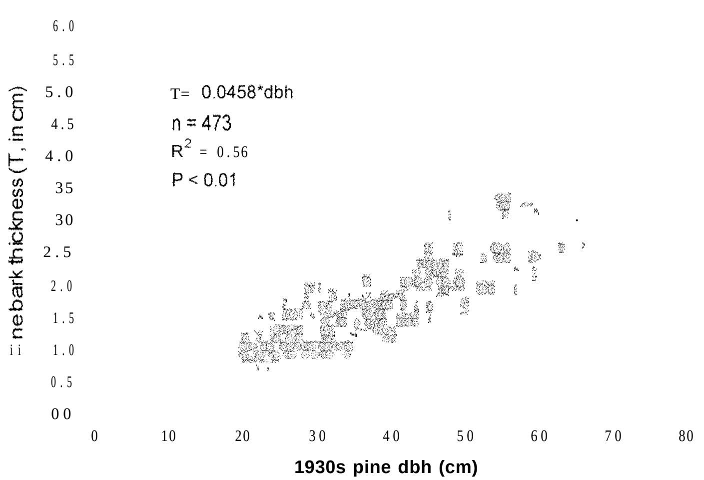

Figure 7. Plot of 1930s pine DBH against hark thickness for the 1930s-era pine-hardwood sample plot.

and failed agriculture, but shortleaf pine occurred only sparingly (Record 1910, Turner 1937). Shortleaf pine does not tolerate saturated soils as well as loblolly, but can sprout following top-killing fires when young (Mattoon 1915). Hence, loblolly pine was more frequent in sheltered bottoms, while shortleaf pine dominated fire-prone upland sites (Bragg 2002, Mattoon 1915, Record 1910, Turner 1937). These autecological attributes help differentiate pine species between landforms in prcsettlement forests of the Upper Gulf Coastal Plain.

The arboreal richness found in this sample plot is considerable but not unusual for streamside forests of the southeastern United States (e.g., Fountain 1980, Harcombe et al. 2002, Jones et al. 1981, Pederson et al. 1997, White and Skojac 2002). Fountain (1980) described similar diversity patterns in unmanaged terrace hardwoods in southern Arkansas. In his plots in the Chemin-A-Haut Creek bottom, sweetgum was most abundant, followed by American hornbeam (*Carpinus caroliniana* Walt.), mockernut hickory (*Carya tomentosa* Nutt.), white oak, and blackgum. An abundance of shade tolerant, fire intolerant understory hardwoods like American holly and winged elm were also found. Fountain (1980) did not report any pine in his sample, but his plots were chosen to reflect hardwood-dominated stands, not pine-hardwood mixtures.

Notable for their absence in this stand are species commonly found in wetter Arkansas bottomlands like sycamore (*Platanus occidentalis* L.), river birch (*Betula nigra* L.), baldcypress (*Taxodium distichum* (L.) Rich.), water tupelo (*Nyssa aquatica* L.), swamp privet (*Forestiera acuminata* (Michx.) Poir.), overcup oak (*Quercus lyrata* Walt.), waterlocust (*Gleditsia aquatica* Marsh.), black willow (*Salix nigra* Marsh.), sugarberry (*Celtis laevigata* Willd.), and planertree (*Planera aquatica* (Walk.) Gmelin). Coupled with the presence of other taxa not known for their success on wet terraces (e.g., shortleaf pine, American beech), the sample plot likely received only periodic inundation.

An unexpected species appeared in the 1930s-era plot inventory. Sourwood, a common understory tree in other parts of the southeastern US, is relatively rare west of the Mississippi River (Overton 1990). Sourwood can be found in northeastern Louisiana and apparently extends into southeastern Arkansas, although no herbarium collections have been made in the state (Smith 1988).

Stand origin from tree size, age, and species inferences

Two nearby contemporary examples of pine-hardwood stands with similar landforms, stand structures, and species composition have larger pines and hardwoods. The proposed Reynolds Research Natural Area (RRNA) on the Crossett Experimental Forest (Fig. 2) was reserved as an uncut control in 1935 after the USFS acquired the property (Shelton and Cain 1999). When sampled in the winter of 1992-93, loblolly and shortleaf pine in the RRNA had reached maximum diameters of 9.5 and 74 cm, respectively, and the largest hardwoods ranged from 75 to 112 cm DBH (Cain and Shelton 1994). By 1990, the maximum age of the overstory in the RRNA exceeded 140 yr, although most pines were recruited in the early 20"' Century (and, hence, were 70 to 80 yr old). The oldest trees survived the initial high-grading around 1915, when only pines > 30 cm DBH were logged (Reynolds 1980). The Levi Wilcoxon Demonstration Forest (LWDF), a nearby industrially-owned old forest remnant (Fig. 2), has been periodically salvaged since being established in 1939. The largest pines and hardwoods in this stand are > 200 yr old and many have diameters from 80 to 120 cm (D.C. Bragg, unpubl. data).

With the dimensions and ages of the dominants in these stands, it appears that the oldest trees in the 1930s-era sample plot are probably 70 to 80 yr old, suggesting the overstory initiated between 1855 and 1865. Another stand of similar dimensions was briefly described in the CR-2.3 study file. A 1940 letter from Ike W. Rawls (superintendent of the Crossett Experimental Forest) reported a trip to the CEB to visit Professor H.H. Chapman of Yale University. Chapman was measuring an old field pine stand that was "... 75 to 77 years old and had an average d.b.h. of 20" [51 cm] and was from 100 to 125 feet [30.5 to 38.1 m] high . . . [t]he diameter ran as high as 28" (71 cm]. These figures do not include small suppressed trees." (Rawls 1940). This would place the old field stand's origin in 1863-65, possibly following Civil War-era agricultural abandonment, logging, or natural disturbance (Carver and Miller 1933, Vanatta et al. 1916). Jones et al. (1981) and Pederson et al. (1997) postulated similar origins for "old-growth" loblolly pine-hardwood stands in some South Carolina floodplains.

Given the vertical distribution of the stand and the overstory dominance of shade intolerant species like loblolly and shortleaf pine, willow oak, and sweetgum, similar events may have produced the 1930s-era stand. When initially settled, the minor stream pine-hardwood flats in Ashley County were considered good farmland (Vanatta ct al. 1916, Turner 1937) and hence attracted many early farmers. Howcvcr, these terrace soils often suffered from hardpan-related impeded drainage, leading to flooding in wet periods and drought and salt accumulation in the dry season (Vanatta et al. 1916). Such harsh growing conditions usually triggered their abandonment for cultivation. In addition to reclaiming old fields, pines, sweetgum, and some oak species also rapidly invade openings created by catastrophic disturbances on the coastal plain of Arkansas (Turner 1937).

Snag abundance

Some of the best evidence suggesting that this pine-hardwood stand was a mature, second-growth forest is the relative rarity of snags (< 7 per ha) and low average snag basal area (0.34 m^2/ha). Though the abundance of standing dead trees varies considerably from one stand to the next, these numbers correspond best with unmanaged second-growth forests (Harcombe et al. 2002, Spetich et al. 1999, Zhang 2000). Comparable old-growth forests typically have higher amounts of snags (Battaglia et al. 1999, Harcombe et al. 2002, Kennedy and Nowacki 1997). Old, dense, pine-dominated stands usually have many snags from southern pine beetle (*Dendroctonus frontalis* Zimm.) mortality (Belanger and Malac 1980, Ku et al. 1981, Turchin et al. 1999). For example, Cain and Shelton (1996) found an average of 32 snags/ha in the RRNA (23.5 pine snags/ha and 8.5 hardwood snags/ha).

Size class and basal area distributions

Further indication that this stand was second-growth can be seen from the size of the trees reported. The biggest individuals ranged from 60 to 7.5 cm DBH (Table 2), which is not particularly large, given the productivity of similar terrace sites in southern Arkansas. For instance, Bragg (2003) reported many oaks, gums, hickories, and pines greater than 100 cm DBH in Ashley County stream bottoms, including a 183 cm diameter pine in the flatwoods along the Ouachita River. Other sources have touted the impressive dimensions of the primeval forests of this region (e.g., Anonymous 1890, Record 19 10, Turner 1937).

The relatively high live tree density reported for the 1930s-era pine-hardwood sample is also consistent with mature, unmanaged forests (e.g., Batista and Platt 1997, Cain and Shelton 1996, Harcombe et al. 2002, Meier et al. 1999, Pederson et al. 1997, White and Skojac 2002). Upland virgin forests in the southeastern United States were often open, with sparse understories primarily maintained by frequent fire (e.g., Bragg 2002, Stanturf et al. 2002). However, terrace flats commonly supported many more trees in their moister, more protected environment.

Growth and yield

Mlodziansky (1896) and Mohr (1897) reported diameter growth of 0.3 to 0.4 cm annually in 70 to 90 yr old loblolly pines growing under relatively open conditions. This is somewhat higher than the 0.04 to 0.3 cm increment of the pines in the well-stocked1930s-era pine-hardwood stand. Stand-level growth of the sawtimber-sized pine in this 1930s-era sample plot (1.65 m^3/ha/yr) is consistent with other pine-dominated stands on good quality sites from this period. Bond (1939) reported growth of 1.4 m^3/ha/yr in the virgin pine forests of the Upper West Gulf Coastal Plain. Turner (1937) placed 60 to 80 yr old second-growth loblolly pine sawtimber increment on good Ashley County sites at 0.86 to 1.24 m^3/ha/yr. Chapman (1912, 1913) reported peak pine sawtimber growth of 0.71 to 0.73 m^3/ha/yr in unmanaged 80 to 100 yr old loblolly and shortleaf pine stands in Ashley County. However, Chapman's growth data came from stands much more poorly stocked than the one reported in this study. Second-growth stands under uneven-aged silviculture are capable of 2 to 3 m^3/ha/yr in this region, depending on their initial stocking (Baker and Murphy 1982, Williston 197X).

Chapman (19 12, 19 13) also determined that instantaneous yield peaked at 100 to 103 m^3/ha in 1.50 to 180 yr old understocked upland pine stands. Turner (1937) reported yields of 60 to 82 m^3/ha of loblolly pine in good quality, second-growth pine-hardwood sites similar to this study. A set of photograph point images from a "branch bottom type" was taken on the Crossett Experimental Forest in 1936. These second-growth pine-hardwoods are similar in composition and overall structure to the 1930s-era stand (Fig. 8), but sawtimber volume reported in the photograph caption was appreciably lower (50 to 60 m^3/ha versus 150 m^3/ha). The 1930s-era pine-hardwood stand is much higher than any of these values, suggesting a high amount of stocking and low disturbance rates.

Figure 8. A 1936 photograph of a "branch bottom" (a minor stream terrace) taken on the Crossett Experimental Forest, with approximately 1/3 of the sawtimber stocking of the 1930s-era stand. Photograph by Russ Reynolds (USFS# FS394375).

Conclusions

Even with uncertainty in the exact location and sample date of the 1930s-era pine-hardwood stand, considerable information was extracted from this data file. The information suggests that unmanaged second-growth forests along minor stream terraces in southern Arkansas early in the 20th Century often had a prominent if passing loblolly pine component. Unless impacted by catastrophic disturbance, this stand would have gradually developed an oak-gum-hickory overstory with only scattered pines and a midstory of dogwood, holly, and winged elm. This successional pattern is being witnessed in a number of old forest reserves in the area (e.g., Cain and Shelton 1995, Heitzman et al. in press).

Restoration is challenging in part because of how difficult it is to describe the community under consideration (Stanturf et al. 2001). Even for relatively abundant upland forests, we have only rudimentary descriptions of historical composition, structure, and dynamics. Thus, perhaps the greatest benefit from this information is the quantitative description of an unmanaged, mature stand of timber from a period much closer to presettlement (pre-1900) times. The data contained in this recently discovered file should assist restoration efforts in similar terrace pine-hardwood ecosystems in the Upper West Gulf Coastal Plain.

Acknowledgments

I would like to recognize the efforts of Russ Reynolds, A.E. Wackerman, the USDA Forest Service Southern Forest Experiment Station, and the Crossett Lumber Company for their work many decades ago. Special thanks also go to Tom Foti, Eric Heitzman, Brian Lockhart, Mike Shelton, Bruce Wilson, and an anonymous reviewer, all of whom helped improve the quality of this paper.

Literature Cited

Anonymous. 1890. Biographical and Historical Memoirs of Southern Arkansas. Goodspeed Publishing Co., Chicago, IL. 1088 pp.

Anonymous. 1940. Report on the growth and reproduction study in Unit I of the Crossett East Block. Unpublished report on file, study CR-2.3, Crossett Experimental Forest, 4472 Highway 133 South, Crossett, AR 71635. 16 pp.

Baker, J.B., and P.A. Murphy. 1982. Growth and yield following four reproduction cutting methods in loblolly-shortleaf pine stands: A case study. Southern Journal of Applied Forestry 6:66–74.

Batista, W.B., and W.J. Platt. 1997. An old-growth definition for southern mixed hardwood forests. USDA Forest Service General Technical Report SRS-9. 11 pp.

Battaglia, L.L., R.R. Sharitz, and P.R. Minchin. 1999. Patterns of seedling and overstory composition along a gradient of hurricane disturbance in an old-growth bottomland hardwood community. Canadian Journal of Forest Research 29: 144-156.

Belanger, R.P.. and B.F. Malac. 1980. Silviculture can reduce losses from the southern pine beetle. USDA Combined Forest Pest Research and Development Program Ag. Handbook #576. 17 pp.

Bond, W.E. 1939. Costs and returns of managing 100,000 acres of shortleaf and loblolly pine for sustained yield. USDA For. Serv. Occ. Paper SO-79. 15 pp.

Bourdo, E.A. 1956. A review of the General Land Office survey and its use in quantitative studies of former forests. Ecology 37:754–768.

Bragg, D.C. 2002. Reference conditions for old-growth pine forests in the Upper West Gulf Coastal Plain. Journal of the Torrey Botanical Society 129:261–288.

Bragg, D.C. 2003. Natural presettlement features of the Ashley County, Arkansas area. American Midland Naturalist 149: I-20.

Cain, M.D., and M.G. Shelton, 1994. Indigenous vegetation in a southern Arkansas pine-hardwood forest after a half century without catastrophic disturbances. Natural Areas Journal 14: 165-I 74.

Cain, M.D., and M.G. Shelton. 1995. Thirty-eight years of autogenic, woody understory dynamics in a mature, temperate pine-oak forest. Canadian Journal of Forest Research 25:1997–2009.

Cain, M.D., and M.G. Shelton. 1996. The R.R. Reynolds Research Natural Area in southeastern Arkansas: A 56-year case study in pine-hardwood overstory sustainability. Journal of Sustainable Forestry 3:59–73.

Chapman, H.H. 1912. A method of investigating yields per acre in many-aged stands. Forestry Quarterly 10:458–469.

Chapman, H.H. 1913. Prolonging the cut of southern pine. 1. Possibilities of a second cut. Yale University School of Forestry Bulletin 2: l-22.

Delcourt, H.R., and P.A. Delcourt. 1974. Primeval magnolia-holly-beech climax in Louisiana. Ecology 55:638–644.

Farrar, R.M., P.A. Murphy, and R.L. Willett. 1984. Tables for estimating growth and yield of uneven-aged stands of loblolly-shortleaf pine on average sites in the West Gulf area. Arkansas Agricultural Experiment Station Bulletin 874. 21 pp.

Fountain, M.S. 1980. Species composition of unmanaged stands of bottomland hardwoods in south Arkansas. Arkansas Farm Research 29:9.

Garver, R.D., and R.H. Miller. 1933. Selective logging in the shortleaf and loblolly pine forests of the Gulf States region. USDA Technical Bulletin 375.53 pp.

Grimmett, H.K. 1989. Early plant and animal communities of the Arkansas Delta. Arkansas Historical Quarterly 48: 10 l-1 07.

Hammett, J.E. 1992. The shapes of adaptation: Historical ecology of anthropogenic landscapes in the southeastern United States. Landscape Ecology 7:121–135.

Harcombe, P.A., C.J. Bill, M. Fulton, J.S. Glitzenstein, P.L. Marks, and I.S. Elsik. 2002. Stand dynamics over 18 years in a southern mixed hardwood forest, Texas, USA. Journal of Ecology 90:947–957.

Heitzman, E., M.G. Shelton, and A. Grell. in press. Species composition, size structure, and disturbance history of an old-growth bottomland hardwood-loblolly pine (*Pinus taeda* L.) forest in Arkansas. Natural Areas Journal.

Hodges, J.D. 1997. Development and ecology of bottomland hardwood sites. Forest Ecology and Management 90: 117-I 25.

Jackson, S.M., F. Pinto, J.R. Malcolm. and E.R. Wilson. 2000. A comparison of pre-European settlement (1857) and current (198 1-l 995) forest composition in central Ontario. Canadian Journal of Forest Research 30:605–6 12.

Jones, S.M., D.H. Van Lear, and S.K. Cox. 1981. Composition and density-diameter pattern of' an old-growth forest stand of the Boiling Springs Natural Area, South Carolina. Bulletin of the Torrey Botanical Club 108:347–353.

Kennedy, H.E., and G.J. Nowacki. 1997. An old-growth definition for seasonally wet oak-hardwood woodlands. USDA Forest Service General Technical Report SRS-8. 6 pp.

Kirkland, B.P. 1934. Comments on Reynold's report on marking for selective cutting Unit No. 1 Crossett East Block. Unpublished correspondence, Study CR-2.3. Crossett Experimental Forest, 4472 Highway 133 South, Crossett, AR 71635. 4 pp.

Ku, T.T., J.M. Sweeney, and V.B. Shelburne. 1981. Southern Arkansas. Pp. 16–22, *In* Site, Stand, and Host Characteristics of Southern Pine Beetle Infestations. USDA Combined Forest Pest Research and Development Program Technical Bulletin 161 2.

Lutz, H.J. 1930. Original forest composition in northwestern Pennsylvania as indicated by early land surveyor notes. Journal of Forestry 2X: 1098-l 103.

Manies, K.L., D.J. Mladenoff, and E.V. Nordheim. 2001. Assessing large-scale surveyor variability in the historic forest data of the original U.S. Public Land Survey. Canadian Journal of Forest Research 3 1: 17 19–1730.

Mattoon, W.R. 1915. Life history of shortleaf pine. USDA Bulletin 244. 46 pp.

Meicr, C.E., J.A. Stanturi, E.S. Gardner, P.B. Hamel, and M.L. Warren. 1999. A quantitative assessment of the structure and function of a mature bottomland hardwood community: The Iatt Creek ecosystem site. Pp. 249-254, In J.D. Haywood (Ed.). Proceedings of the Tenth Biennial Southern Silvicultural Research Conference. USDA Forest Service General Technical Report SRS-30.

Mladenoff, D.J., S.E. Dahir, E.V. Nordheim, L.A. Schulte, and G.G. Guntenspergen. 2002. Narrowing historical uncertainty: Probabilistic classification of ambiguously identified tree species in historical forest survey data. Ecosystems 5:539–553.

Mlodziansky, A.K. 1896. Rate of growth of loblolly pine. Garden and Forest 9:92–93.

Mohr, C. 1897. The timber pines of the southern United States. USDA Division of Forestry Bulletin #I 3 (revised). 176 pp.

Moore, D.M. 1999. Trees of Arkansas. 5th Edition. Arkansas Forestry Commission, Little Rock, AR. 142 pp.

Noss, R.F. 1985. On characterizing presettlement vegetation: How and why. Natural Areas Journal 5:5–19.

Overton, R.P. 1990. Sourwood (*Oxydendrum arboreum* (L.) DC.). Pp. 497–500, *In* R.M. Burns and B.H. Honkala (Tech. Coords.). Silvics of North America: Volume 2, Hardwoods. USDA Forest Service Agricultural Handbook 654.

Pederson, N.A.. R.H. Jones, and R.R. Sharitz. 1997. Age structure and possible origins of old *Pinus taeda* stands in a floodplain forest. Journal of the Torrey Botanical Society 124: 1 1 I- 123.

Rawls, I.W. 1940. East block growth study. Unpublished letter from Rawls to R.R. Reynolds on file. study CR-2.3, Crossett Experimental Forest, 4472 Highway 133 South. Crossett. AR 7 1635. 2 pp.

Record, S.J. 19 10. The Forest Resources of Arkansas. Central Printing Co.. Little Rock. AR. 38 pp.

Reynolds, R.R. 1934. Report on marking for selective cutting unit no. 1: Crossett East Block. Unpublished report on file, study CR-2.3, Crossett Experimental Forest. 4472 Highway 133 South, Crossett. AR 71635. 18 pp.

Reynolds, R.R. 1959. Eighteen years of selection timber management on the Crossett Experimental Forest. USDA Technical Bulletin 1206. 68 pp.

Reynolds, R.R. 1980. The Crossett story: The heginning of forestry in southern Arkansas and northern Louisiana. USDA Forest Service General Technical Report SO-32. 40 pp.

SER (Society for Ecological Restoration). 2002. The SER primer on ecological restoration. Online (www.ser.org/) publication, Society for Ecological Restoration Science and Policy Working Group. 9 pp.

Shelton, M.G., and M.D. Cain. 1999. Structure and short-term dynamics of the tree component of a mature pine-oak forest in southeastern Arkansas. Journal of the Torrey Botanical Society 126:32–48.

Smith, E.B. 1988. An Atlas and Annotated List of the Vascular Plants of Arkansas. 2”” Edition. Department of Botany and Microbiology, University of Arkansas, Fayetteville. AR. 4X9 pp.

Spetich, M.A., S.R. Shifley, and G.R. Parker. 1999. Regional distribution and dynamics of coarse woody debris in midwestern old-growth forests. Forest Science 45:302–3 13.

Stanturf, J.A., S.H. Schoenholtz. C.J. Schweitzer, and J.P. Shepard. 2001. Achieving restoration success: Myths in bottomland hardwood forests. Restoration Ecology 9: 1X9-200.

Stanturf, J.A., D.D. Wade, T.A. Waldrop, D.K. Kennard, and G.L. Achtemeier. 2002. Fire in southern forest landscapes. Pp. 607-630, *In* D.N. Wear and J.G. Greis (Eds.). Southern Forest Resource Assessment. USDA Forest Service General Technical Report SRS-53.

Turchin, P., J. Davidson, and J.L. Hayes. 1999. Effects of thinning on development of southern pine beetle infestations in old growth stands. Southern Journal of Applied Forestry 23: 193–196.

Turner, L.M. 1937. Growth of second-growth pine on the coastal plain soils of Arkansas. University of Arkansas Agricultural Experiment Station Bulletin #342. 52 pp.

Tyrrell, L.E. 1996. National forests in the Eastern Region: Land allocation and planning for old growth. Pp. 245–273, *In* M.B. Davis (Ed.). Eastern Old-growth Forests: Prospects for Rediscovery and Recovery. Island Press, Washington, DC.

Vanatta, E.S., B.D. Gilbert, E.B. Watson. and A.H. Meyer. 1916. Soil survey of Ashley County, Arkansas. Pp. 11X5-1219, *In* M. Whitney (Comp.) Field Operations of the Bureau of Soils, 19 13. USDA Bureau of Soils, Government Printing Office, Washington, DC.

White. D.A., and S.A. Skojac. 2002. Remnant bottomland forests near the terminus of the Mississippi River in southeastern Louisiana. Castanea 67:134–145.

Williston, H.L. 1978. Uneven-aged management in the loblolly-shortleaf pine type. Southern Journal of Applied Forestry 2:7X-X2.

Zhang, M. 2000. Quantification of Snags and Downed Wood in the R.R. Reynolds Research Natural Area and Good Forty Demonstration Area in Southeastern Arkansas. M.S. Thesis, University of Arkansas. Monticello, AR. 47 pp.