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An Age, Size, and Climate Response Study of Old Growth Shortleaf Pine in the McCurtain County Wilderness Area, Oklahoma

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Pine in the McCurtain County Wilderness Area, Oklahoma

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Abstract

Increment cores were extracted from 483 trees distributed over 21 semi-randomly sampled 0.1-hectare plots on three distinct landscape positions in the McCurtain County Wilderness Area (MCWA), a 57 square kilometer tract of uncut shortleaf pine in southeastern Oklahoma. Forty additional cores were taken off plot from older-appearing trees. All sampled trees were shortleaf pine (*Pinus echinata*) with a diameter at breast height (DBH) of at least 10 cm. Hardwoods were not included in the size and age analyses. The study site chosen for the sampling was made up of four parallel east-west trending ridges near North Linson Creek, making up about 1.3 square kilometers in area. The cores and diameter measurements were used to examine the age, size, basal area, density, and growth rate of the sampled pine stands. All core samples were dated dendrochronologically using the Douglass method of cross dating (Douglass, 1941) and measured for the development of earlywood (EW), latewood (LW), and total ring width (RW) chronologies. The average diameter for all randomly sampled trees at Linson Creek was 31.3 cm at breast height, and the average age was 100.3 years (i.e., the minimum age, based on core sampling at breast height). The size-age correlation was found to be stronger for the pines with a diameter of over 40 cm. A major pulse of shortleaf pine recruitment to breast height was detected from 1920-1940, when a sizable group of sampled trees reached ~1.4 m. Cumulative radial growth curves showed a wide variety of growth rates. When the effect of topographic position was tested, south-facing plots were found to have both the oldest and slowest-growing trees on average, and the youngest and smallest were found on the north-facing plots. Ridgetop plots had both the largest and fastest growing pines. The final chronology for Linson Creek dates from 1743 to 2020, and includes some individual trees cored outside of the randomly sampled plots due to their old appearance. These off-plot samples were not used for the dendroecological

analyses, which were based only on the randomly sampled trees. Data from Stahle et al. (1985) were subsequently added to the Linson Creek samples to construct final, fully replicated chronologies of EW, LW, and RW, which extend from 1688 to 2020. The measured EW, LW, and RW chronologies were correlated with gridded instrumental Palmer Drought Severity Indices (PDSI) for the United States from 1895-2005. Results showed a significant positive correlation between latewood width and August PDSI in the same year as ring formation, not just in McCurtain County but also the surrounding states. Earlywood growth, by contrast, was only weakly correlated with June-July PDSI in the summer one year prior to EW formation.

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1. Introduction

Shortleaf pine (*Pinus echinata*) is the most widespread of the southern pines (Lawson, 1990; Mattoon, 1915) with a native range extending from New York to eastern Texas. The species is particularly dominant in the Ouachita Mountains and Ozark uplands of Arkansas and Oklahoma, where it has historically made up the pine-bluestem *(Pinus echinata; Andropogon gerardii)* habitat, characterized by a pine-dominated woodland with a rich herbaceous grassy understory (Little, 1971; Hedrick et al., 2007; Figure 1). A valuable timber species, *P. echinata* has been heavily logged since the late 19^{th} century, most notably from 1880-1920 (Smith, 1986). Oswalt (2015) and Anderson et al. (2016) estimate less than 2.5 million hectares of shortleaf pine-dominated forests remain in North America, representing less than 10% of its original extent. Commercial timber harvesting of old growth shortleaf pine forests continued well into the 1980s (Smith, 1986; Bragg, 2021). The few remaining pristine examples of old growth shortleaf pine are mostly small tracts, ranging from only 4-40 hectares in extent, likely making up less than 1% of the species' original distribution (Cerny et al., 2016).

Even accounting for recovery efforts starting in the 1990s, *P. echinata* experienced a net decline from 1970-2013 (Guldin, 2019). The planting and consequent expansion of, and hybridization with the related loblolly pine (*Pinus taeda*) are also factors in the species' decline, as are southern pine beetle *(dendroctonus frontalis)* outbreaks and littleleaf disease (caused by the fungus *phytopthora cinnamomic*) (Coyle et al., 2015). Even so, the bulk of this decline has been observed east of the Mississippi. Arkansas and Oklahoma's *P. echinata* forest cover has remained relatively intact, especially in the Ouachitas (Oswalt, 2013; Guldin, 2019).

It is difficult to accurately describe the nature of pre-settlement old growth in the shortleaf pine-bluestem ecosystem. The reasons for this lack of clarity include exploitation of the species for timber, the collapse of the Aboriginal population, as well as the suppression of fire in more recent decades (Bragg, 2002; Cerny et al., 2016). Early European travelers to the region described vast woodlands of pure pine stands, mixed pine-oak communities, as well as some pure oak stands. These were underlain by a vibrant understory of fire-dependent grasses and forbs, which served as rich fodder for herbivores like bison (*bison bison)*, elk *(cervus candensis)*, and white-tailed deer *(odocoileus virginianus)*, the former two having since been extirpated from the region (Du Pratz, 1774; Nuttall 1821; Featherstonhaugh 1844; Smith and Neal, 1991). Much of the area had a fire return interval of less than 10 years, according to Masters (1995). The historical landscape also appeared to be sparsely wooded, perhaps due to the frequent fire. According to Kreiter (1995), total tree density in the McCurtain County Wilderness Area (MCWA) was about 70 trees per hectare in 1896. This number had increased to 615 trees per hectare by 1994, which is almost certainly related to fire suppression after the Second World War.

The loss of regular surface fires resulted in the encroachment of hardwoods in the midstory and a homogenization of the landscape into a denser mix of hardwoods and pine (Masters et al., 2007; Foti and Glenn, 1991). Even by 1915, pure shortleaf pine stands had already been greatly depleted (Mattoon, 1915). This suggests that these phenomena of hardwood encroachment and homogenization may have started earlier than the post-war fire suppression era, perhaps at least in part as a result of logging and development in some parts of its native range (Mattoon, 1915).

Interest in rehabilitating this ecosystem has increased in recent decades. In particular, the United States Forest Service (USFS) and other institutions (e.g., America's Longleaf Restoration Initiative) have begun ambitious, range-wide efforts to restore some of the southern pine species. The first major effort, arresting the decline of longleaf pine (*pinus palustris*), which occupies a niche on the more low-lying coastal plains of the southeast and has been greatly exploited and reduced in its native range, has been fairly successful (Oswalt and Guldin, 2021). The relative success of longleaf pine restoration efforts has sparked interest in similarly ambitious goals for shortleaf pine (Hedrick et al., 2007; Guldin, 2019; Oswalt and Guldin, 2021). Starting in the early 1990s, over 100,000 hectares have been dedicated to this effort to restore the shortleaf pine-bluestem woodlands in the Ouachita National Forest (Hedrick et al., 2007). Most shortleaf pine-bluestem restoration treatments involve mechanical thinning of the midstory followed by burns in 3–5-year intervals, which usually results in three controlled burns over about 10 years (Hedrick et al., 2007). More recently, USFS efforts have been supported by programs like Western Woodland Restoration project and the Shortleaf Pine Initiative, among others (Walkenhorst, 2016). The former was established in 2014 and aims to assist the revitalization of forest communities in 29 counties in western Arkansas on both public and private land through direct funding and technical support. The latter program similarly promotes cooperation between the public and private sector on restoring the species within its entire native range. These programs have continued until at least 2021 (Walkenhorst, 2016; 2019).

Despite the interest in restoration and revitalization of the species, relatively little is known about the dendroecological characteristics of unlogged *P. echinata*. This thesis seeks to supplement the existing literature by documenting the age and size distribution, growth rate, and climate response of a randomly sampled selection of the species within an old growth setting. Such knowledge could help inform how these ecosystems can best be restored and managed by describing the dendroecological characteristics of one of the few examples of ancient shortleaf pine left in existence.

2. Research Objectives

Despite the extent of the intact ancient forests in the MCWA, very little dendroecological research has been conducted within the reserve. Hence, this study was designed to obtain data on the age, size, and stand structure of *P. echinata* within the MCWA based on trees from three distinct geomorphic positions, and to derive tree-ring width chronologies for the analysis of climate response of the species in southeastern Oklahoma and surrounding states. Another goal of the project was to locate and core the oldest pine trees possible in order to lengthen the existing chronology, or at least supplement it.

3. Methods

a. Study Area

Ouachita Mountains and McCurtain County Wilderness Area descriptions. The study area is located in the Ouachita Mountains, a series of roughly east-west trending escarpments and u-shaped valleys stretching for approximately 360 km across western Arkansas and southeastern Oklahoma, with elevations ranging from 100 to 900 meters (Stone, 1994). Soils are thin and rocky, especially at higher elevations. The lithology is dominated by shale, sandstone, siltstone, chert-novaculite, conglomerate, tuff, and limestone, in order of decreasing abundance, and strata have been dated from the late Cambrian to the Pennsylvanian periods (Stone, 1994). Local formations were intensely folded and faulted in the Appalachian-Ouachita orogeny associated with the formation of the Pangea supercontinent (Croneis, 1930; Viele, 1979; Kreiter, 1995). The abundance of east-west striking hills makes for a relatively predictable topography. South-facing slopes tend to be more xeric due to higher insolation, which makes them more likely to support more dry-adapted species like shortleaf pine and post oak (*Quercus stellata*) (Foti and Glenn, 1991; Guldin, 2006).

Most of the old growth forests Ouachita Mountains were exploited for commercial timber well into the 20th century (Lynn, 1996; Smith, 1986). A notable exception to this is the McCurtain County Wilderness Area (MCWA). The MCWA is located in extreme southeastern Oklahoma, near the Arkansas and Texas borders. It covers roughly 57 square kilometers of rugged backcountry, part of the broader Kiamichi uplands at the western margin of the Ouachita Mountains. Elevations range from 183 to 415 meters, and annual rainfall averages 121 cm, with average temperatures ranging from 34°C in July to -2°C in January (Masters et al., 1989; Kreiter, 1995; Figure 2). The MCWA is near the western edge of the natural distribution of *P.*

echinata, close to the border with the Cross Timbers ecoregion dominated by *Quercus stellata* (Diggs et al., 1999). The MCWA contains the largest remaining tract of uncut old growth shortleaf pine (Stahle et al., 1985). Other old stands of shortleaf pine in the Ouachita ecoregion are generally small and sparsely distributed, such as can be found at Hot Springs National Park and Lake Winona Research Natural Area on the Ouachita National Forest (Cerny et al., 2016, Flatley et al. In press).

Today, the MCWA is managed by the Oklahoma Department of Wildlife and Conservation (ODWC), in part as a refuge for endangered species **(**Thill et al., 2004; Masters et al., 2007). These endangered species include the red-cockaded woodpecker (*Leuconotopicus borealis*), which depends on mature, open pine woodlands and the leopard darter (*Percina pantherine*), a small fish found in the waterways within the reserve. The property that makes up the modern-day MCWA was historically part of Caddo territory, though it later was ceded to the Choctaw Nation in 1820 under the Treaty of Doak's Stand, which traded the Choctaw's ancestral lands in Mississippi for over 5 million hectares in southeastern Oklahoma (Kidwell, n.d). Widespread Choctaw relocations started after 1830 following passage of the Indian Removal Act (Kidwell, n.d.). The MCWA was purchased by the State of Oklahoma from the Choctaw and Chickasaw Nations in 1918 for $6.13 an acre, primarily to develop a game reserve for the state's rapidly dwindling population of white-tailed deer *(Odocoileus virginianus)* to be operated by the ODWC (Jackson, n.d.).

During the Great Depression, the Works Progress Administration and Civilian Conservation Corps maintained a presence in the MCWA. During this time, they undertook numerous projects, including a low-water bridge over the Mountain Fork and a 39-km-long boundary fence (Jackson, n.d.). The preserve earned an official wilderness area designation by the state legislature in 1951, thereby prohibiting timber and mining operations (Edmondson and Zumalt Smith, 2004). The US Army Corps of Engineers constructed the Broken Bow Reservoir in the mid-1960s, and that agency still maintains ownership of the abutting shoreline (Kreiter, 1995). The lake bisects the wilderness, with most of the MCWA's area is to the east of the reservoir (Kreiter, 1995). The wilderness later gained more federal recognition when it was named a National Natural Landmark in 1975 by the National Park Service (Edmondson and Zumalt Smith, 2004; Jackson, n.d.).

Despite some opposition from state legislators, the ODWC developed a management plan in 1992 that called for controlled burns and small-scale thinning of hardwoods from 2.5-30.5 cm in diameter in an attempt to make up for decades of fire suppression and restore habitat for the red-cockaded woodpecker *(Leuconotopicus borealis),* among other species (Edmondson and Zumalt Smith, 2004). This system of ecosystem treatment was implemented in the 1990s, following the lead of the USDA Forest Service's shortleaf pine-bluestem restoration plan, and aims to restore the open woodlands that could be observed before the era of post-war fire suppression (Hedrick et al., 2007; Skeen, 2016). This lack of fire has resulted in the development of a more homogenized and dense pine-hardwood mixed forest from 1955-1990 (Masters, 1997; Master et al., 2007). Large areas have been treated with controlled burns and midstory thinning since 1992 (Skeen, 2016).

The MCWA's vegetation cover is currently characterized by a mixed pine-hardwood assembly with a grassy and herbaceous understory (Smith et al., 1997). Shortleaf pine is dominant in most areas of the wilderness, but some sites are more evenly mixed pine-hardwood, including areas of relatively open pine-oak woodland and denser pine-hardwood communities. In fact, shortleaf pine is known to occupy some of the most marginal of the southern pine habitats, so its prevalence in the rugged MCWA is unsurprising ecologically (Blizzard et al., 2007). There are some localized areas of virtually pure hardwood in other parts of the wilderness (Stahle et al., 1985).

North Linson Creek study site.

For the experimental design, a compact area of four parallel east-west trending ridges was chosen as the specific study area, directly north of North Linson Creek (the MCWA's largest drainage), near its confluence with Mountain Fork and the Broken Bow reservoir (Kreiter, 1995).

This study site covers approximately 75 hectares of the southwestern corner of the wilderness (Figure 2). It consists of four roughly east-west trending ridge lines of about 1 km in length. They are essentially spurs coming off a broader upland to the west, and they gradually taper off to meet North Linson Creek, a tributary of Mountain Fork, and the largest of the five perennial streams draining the interior of the MCWA (Kreiter, 1995). The study site consists of mature to old growth shortleaf pine and hardwoods on various aspect positions, which provide interesting points of comparison. In the southeastern quadrant of Figure 3a, North Linson Creek meets the Broken Bow Reservoir. Figure 3b shows the same area but with topographic imagery, with color-coded circles approximating the location of each randomly sampled plot. The satellite image shown in Figure 3a demonstrates the preponderance of pine on the ridgetops and slopes, as opposed to the riparian areas, where hardwoods are more dominant. Evidence of mechanical thinning is present throughout on the ground, though it appeared to be mainly concentrated on the ridgetops and north-facing aspects.

Pines with a dendrochronologically observed minimum age of over 150 years old can be found in the wilderness area, some being well beyond 200 years (Figures 4ab). Figures 5 and 6 shows the density and species composition of the forest changing from pine-dominated on the slope to hardwood-dominated in the adjacent gulley, demonstrating the dynamic nature of the forest composition within a relatively compact area. The North Linson Creek study area is slightly more densely wooded on slopes than on ridgetops, though not enough to be statistically significant (Table 1; Table 2). The ridgetops in the study site north of Linson Creek were observed to be mostly pine-dominant, perhaps as a result of recent mechanical thinning of midstory hardwoods by the ODWC (Skeen, 2016). Even so, numerous large hardwoods were still noted on the ridgetops during fieldwork, especially post oak (*Q. stellata*) (Figure 7). *Quercus* spp. might dominate in areas with a more shaley substrate and more level terrain, as was observed by Foti and Glenn (1991) in Hot Springs National Park.

Despite its relatively pristine condition, numerous invasive species were observed at the study site, most notably feral hogs. Cattle from surrounding farms also inevitably roam into the MCWA in search of grasses and forbs. Evidence of their presence was obvious throughout the reserve. The extent of the ODWC's ongoing habitat restoration efforts in the MCWA (including at the North Linson Creek Study area) as of 2016 can be seen in Figure 8. Indeed, we found some evidence of human disturbance at the site, including numerous cut hardwood stumps, almost certainly a result of the hardwood thinning and ecosystem restoration efforts started by the ODWC in 1992 (Skeen, 2016; Figure 8).

b. Field sampling design

Productivity for the species on other sites in the Ouachitas has been shown to be dependent on topography and aspect, with the ridge tops and xeric south-facing slopes usually being the least productive (Guldin, 2007). Consequently, the shortleaf pine data from MCWA were randomly sampled according to the landscape position in which they were collected (north-facing, ridge-top, or south-facing), which would make it possible to investigate the local effects of this variable (i.e., a stratified random sampling of age, size, and stand structure according to topographic position). A series of 21 study plots were deliberately located on three distinct landscape positions: north-facing (7 plots), ridgetop (7 plots), and south-facing (7 plots), respectively, using a stratified random sampling technique to place the plots. All plots were placed within a compact area of four east-west trending ridges (Figure 3). Each of these aspects held roughly a third of the total study plots. Gradients were between approximately 10-50% on the north- and south-facing slopes. Ridgetop sites generally were not perfectly flat, and usually had a gentle grade to the north or south.

Each 0.1 ha study plot was marked with reflective field tape and diameter at breast height (DBH) was measured for each sampled pine with a diameter-calibrated tape at 1.37 m above the ground surface (Speer, 2010). Hardwoods were not included in any of the analyses; pine were sampled exclusively. Increment cores were extracted using Swedish increment borers. Cores were taken from all *P. echinata* ≥10 cm DBH within a series of 21 circular plots spread equally over three topographic aspects. The dataset also includes some trees that were cored off-plot; these were assessed to be old by their appearances (heavy limbs, flattened crowns with dieback, exposure of the root collar, torsion and sinuosity of the trunk, smooth bark, evidence of disturbances, etc.; (Mattoon, 1915; Pederson, 2010; Figure 4), and were cored in order to supplement the chronology and gain further insights into the age distribution of *P. echinata* at the study site. Trees cored off-plot were not used in the dendroclimatic or dendroecological analyses, in order to not bias the results towards older-appearing trees.

Data including DBH and observed minimum age were subsequently recorded in an Excel file (Appendix 1). From these data, a series of graphs display the age and size distributions, as well as the correlation between age and size, both for all randomly sampled trees in the MCWA, and separately for each of the three topographic aspects. T-tests (Kim, 2015) were then performed using the Excel spreadsheet to investigate the statistical significance of any differences in the data with respect to topographic position: north-facing, south-facing, and ridgetop. Resultant *p*-values under 0.05 were considered significant.

c. Dendrochronological analysis

After collection in the field, cores were mounted and polished so they could be dated dendrochronologically using the Douglass method (Douglass, 1941). All core samples were assigned an accession number (21-210) and are permanently curated with the University of Arkansas Museum. A master dating chronology was established for the site using the skeleton plot technique, and all cores were subsequently dendrochronologically cross-dated with the help of this master (Douglass, 1941). A Velmex stage micrometer (0.001 mm precision) was then used to measure earlywood, latewood, and total ring width on cores with at least 25 dated rings. Quality control was performed on the measurement data with the COFECHA computer program. The program ARTSAN was used to produce the detrended and standardized EW, LW, and RW chronologies (Cook and Pederson, 2011; Holmes, 1983). Numerical chronologies of earlywood, latewood, and total ring width were produced from these measurement data. The North Linson Creek measurement data were later combined with earlier data collected by Stahle et al. (1982).

To further document the climate signal in the earlywood and latewood width chronologies derived from the Linson Creek study area, the chronologies were correlated with the instrumental Palmer Drought Severity Index (PDSI) from 1895-2005, using the North American Drought Atlas (Cook et al., 2010; Burnette 2021; Palmer; 1965). The PDSI measures soil moisture balance (Palmer, 1965; Torbensen and Stahle, 2018). The climate analysis was not separated by aspect and included all sampled trees. Cumulative growth curves by topographic position were also developed for the Linson Creek study site using the total ring-width data for trees cored to the pith or near it.

Minimum age was determined for every core using the innermost visible annual ring on each core (dated with dendrochronology and/or ring counted inside of the innermost dated ring). The resultant inner ring date was noted as the estimated year of recruitment to breast height, since coring and diameter measurement were both performed at this level on the trees, defined here as 1.4 meters from the ground (Speer, 2010). “Age” in this paper refers to minimum age at breast height, unless otherwise noted. Note that for this estimate of recruitment year, only those cores that were cored to pith or close to pith were included. These data were all used to make observations and inferences about age and size structure, growth rate, and climate response of *P. echinata* found within the study plots. Age, size, growth rate, density, and basal area were computed for the site overall, as well as for each of the topographic positions.

5. Results

a. Size distribution

The age, diameter, and recruitment results for the randomly sampled trees on all 21 plots are shown in Figure 9. The analysis of the size data for all randomly sampled pines from all 21 plots produced a mean diameter at breast height (DBH) of 31.3 cm (Table 1). Note that “diameter” and “size” refer to DBH in this paper, unless otherwise noted. Most sampled trees had an observed DBH of between 15 and 40 cm (Figure 9). The largest randomly sampled trees ranged from 50-75 cm, while the largest sampled off-plot was 83.5 cm (Figure 9; Appendix 2). Meanwhile, the average diameter values for trees from the ridgetop, north-, and south-facing aspects were 35.2, 29.8, and 30.4 cm, respectively (Table 1). Indeed, the ridgetop plots had the greatest number of trees over 40 cm with 47, compared to 37 and 30 for the north- and south-facing plots, respectively (Figure 10). This is borne out by t-tests that showed ridgetop plots to have significantly greater diameters than any other topographic aspect (Kim, 2015; Table 2). The two remaining topographic positions had insignificant differences in average diameter (Table 2). The north- and south-facing plots do have slightly greater average values for stem density (Table 1; Table 2). However, trees on ridgetop plots have significantly higher average basal area than the trees on north- and south-facing plots (Table 2).

b. Age distribution

A total of 523 trees were sampled for age at the North Linson Creek study area, which included 483 trees within 21 sample plots and the remaining 40 chosen from old-looking trees outside of these plots. Average minimum age for the randomly sampled pines was 100.3 years (Table 1). Most trees had a minimum age of 60-100 years, with under 10% exceeding 150 years (Figure 9). The oldest randomly sampled pine at North Linson Creek was observed to be at least 252 years old. Meanwhile, the oldest tree cored off-plot had a minimum age of 278 years, and the oldest pine yet found at the MCWA had a minimum observed age of 295 years when it was cored about 40 years ago (Stahle et al., 1982; Appendix 2).

After cross dating the cores and separating out those that at least came close to reaching the pith, the randomly sampled Linson Creek data show an average recruitment-to-breast-height year of 1919, and a median of 1928 (Figure 9). By far the most prominent pulse of recruitment occurs from approximately 1920-1940, perhaps corresponding to some disturbance around this time. There also appears to be a lesser increase in recruitment from 1905-1910. There is no recruitment visible after 1955 among pines with at least a 10 cm DBH (Figure 9).

The age of shortleaf pine appears to be influenced to a degree by topographic aspect in the Linson Creek study area. For instance, average minimum age for south-facing trees was greatest on average, being 106.9 years. The north-facing trees were youngest, having an average age of 93.6 years, and the ridgetop trees split the difference at 102.7 years (Table 1). The south-facing plots had the greatest number of trees with a minimum age of over 150 years, at 26, while the ridgetop and north-facing slopes had 14 and 8 trees over this threshold, respectively (Figure 11). The mean age of shortleaf pine on the north-facing plots was significantly below that of trees on the two other aspects, based on t-tests (Kim, 2015). The greater average age for south-facing trees was not enough to be statistically significant when compared to the ridgetop plots (Table 2).

15. **Age-size relationships**

The relationship between age and diameter for all randomly sampled pines that were dated to pith or near pith is illustrated in a series of three scatterplots in Figure 12, depicted in three panels. Panel 12a shows includes all randomly sampled pines that had a recorded diameter and age. Panels 12b and 12c separate this group out by size at a 40 cm diameter threshold (Figure 12). There appears to be a weak positive correlation between the diameter and age of the randomly sampled pines overall ($r = 0.59$; Figure 12a). However, this correlation appears to be most influenced by the larger trees. The positive correlation is very weak for trees with a diameter under 40 cm ($r = 0.26$), and moderate for trees over this threshold ($r = 0.52$; Figures 12bc). However, this should be qualified by the fact that the smaller group has a larger sample size.

d. Growth rate performance

When compared by aspect, there is also a significant difference in the correlation between size and age of shortleaf pine from the Linson Creek study site. The ridgetop and north-facing trees had the weakest correlation, with R-values of 0.57 and 0.51, respectively (Figures 13a and 13b). The south-facing trees have the strongest correlation between size and age (r = 0.72; Figure 13c). Even so, after dividing diameter by age to estimate yearly growth rate, pines on south-facing slopes were shown to be significantly slower-growing than both other aspects, with ridgetop pines appearing to be meaningfully faster-growing than those from either south- or north-facing plots (Table 2). This may be attributed to the generally more xeric conditions found on southerly aspects that may result in generally slower-growing and older trees (Guyette et al, 2007; Schulman, 1954).

Figure 14 shows the cumulative radial growth of each tree that was cored to the pith or near it, plotted for each of the three topographic positions, and for all aspects combined (radial growth is the length in mm of the dated core radius; radial growth times two approximates diameter inside the bark). Figures 14a and 14b represent the trees from ridgetop and north-facing plots, and they show remarkable variance in their cumulative radial growth rates. For example, after 40 years, cumulative radial growth ranges from 20 to over 130 mm on ridgetop plots, and 15 to 120 mm on north-facing slopes (Figure 14a; Figure 14b).

After 150 years, cumulative radial growth is roughly 190, 180, and 155 mm for trees from the ridgetop, north-, and south-facing plots, respectively (Figure 14). Trees from all aspects combined have a cumulative growth of approximately 175 mm after 150 years of growth (Figure 14d). This translates to approximately 1.26, 1.20, and 1.03 mm of cumulative radial growth per year for the aforementioned topographic aspects, and roughly 1.17 mm per year for all aspects combined (Figure 14).

e. Annual ring production and climate response

The earlywood (EW), latewood (LW), and total ring-width (RW) measurements are plotted for the shortleaf pine cored and dated at Linson Creek in Figure 15. These so-called "spaghetti plots" do not indicate strong coherence of inter-annual variability among the sampled trees, particularly for the earlywood width data. The average correlation among all individual cores (RBAR; Cook and Pederson 2011) are 0.35 for EW, 0.49 for LW, and 0.43 for total RW (the mean ring widths were 0.82, 0.51, and 0.133 mm for EW, LW, and RW, respectively). Note that the data plotted in Figures 16, 17, and 18 are based on a sub-sample of the dated cores that passed screening designed to remove series that were not well correlated with the other trees (n = 442, 446, and 443 for EW, LW, and RW, respectively). The cores removed are believed to have been correctly dated (or ring counted) but were simply not well correlated with the other trees and therefore were not included in the numerical tree-ring chronologies.

The agreement in the inter-annual variability of EW, LW, and RW for shortleaf pine from Linson Creek visibly improve once the individual measurement time series have been detrended and low-order autocorrelation has been removed (the detrended and autoregressively modeled white noise residuals, Cook 1985; Figure 16). This is especially evident for the LW series (Figure 16). The average correlation among all individual "residual" time series (RBAR; Cook and Pederson, 2011) are 0.31 for EW, 0.56 for LW, and 0.43 for total RW. Note that the RBAR statistic actually declined for the EW residuals.

The North Linson Creek study area PDSI correlation revealed distinct climate signals for the earlywood and latewood chronologies, respectively. The earlywood measurements have a weaker climactic signal than the latewood, and they correlate best with the previous-year June-July PDSI in the general vicinity of the McCurtain County Wilderness Area (Figure 18).

However, the highest earlywood width correlation with prior summer PDSI is only r = 0.3 (Figure 18). The latewood, by contrast, correlated very strongly with same year August PDSI, with a maximum correlation of r = 0.7. The highest values again centered around southeastern Oklahoma and western Arkansas (Figure 18). The data from Stahle et al. (1982) was used to compute the detrended and standardized mean index chronologies for earlywood, latewood, and total ring-width based on all trees sampled from the McCurtain County Wilderness area (Figure 19). It also supplements and lengthens the chronology, given that at least one shortleaf pine found in that earlier study would be about 340 years old today, which is considerably older than anything sampled at the Linson Creek site. Perhaps the most notable additional finding provided by these extra data is the low growth of earlywood, latewood, and total ring width in the 1730s. This appears be indicative of another period of severe drought in the region (Figure 19).

6. Discussion

Shortleaf pine has been shown to achieve ages of up to 400 years while growing to a maximum diameter of 120 cm, although such observations were rare even in previous centuries (Mattoon, 1915). More recently, the expected life span and maximum size for the species have been suggested to be 200 years and 60-90 cm, respectively (Lawson, 1990; Pickens, 2018).

This further suggests that the species may have lived longer and attained greater size when its natural distribution was more intact. The widespread and thorough lumbering of shortleaf pine might have left only the more marginal sites, possibly skewing these metrics lower on average (Oswalt, 2016).

a. Size distribution patterns and processes

The randomly sampled pines from the Linson Creek study site within the wilderness are not large, with a mean diameter of 31.3 cm (Table 1). There is evidence that shortleaf pine tends to reach greater size in the more southern and eastern zones of its range. One of the largest known diameters recorded for the species was recorded at Myrtle, Mississippi, at 108 cm, significantly higher than any tree observed at the MCWA (American Forests, 1996).

It has been shown that diameters over 100 cm are possible for shortleaf pine (Bragg and Riddle, 2014). A survey of overstory shortleaf pines at the LWDF yielded an average size of 52.4 cm, though from a relatively small sample size (Bragg, 2004). Other examples of extraordinarily large *P. echinata* include the current national champion in eastern Texas, with a diameter of roughly 124 cm; and the Missouri state record of just under 120 cm (American Forests, 2022; Sheeley, 2019). Note again the largest shortleaf pine measured at the Linson Creek area was 83.5 cm DBH (off plot) and the oldest yet found in the same study area was at least 278 years old (also off plot). Mattoon (1915) found an average diameter of about 45 cm in a survey of shortleaf pine throughout its native range, with a maximum of over 86 cm.

b. Age patterns and stand dynamics

The randomly sampled pines from the Linson Creek study site are not especially old, either, with an observed average minimum age of 100.3 years (Table 1). Moreover, only about 8.5% of randomly sampled trees, or just 41 individuals, have a minimum age of over 150 years, (Appendix 2). However, this is apparently not uncommon for the species. In fact, Cerny et al. (2016), found a mean age of only 79 years for overstory shortleaf pine at Shortleaf Canyon in eastern Oklahoma, with only 6.9% of sampled pines being over 150 years at breast height. However, Shortleaf Canyon was a marginal site for the species, outside of its continuous range (Cerny et al., 2016). Stambaugh et al. (2002) found a larger average diameter of 36.9 cm and a greater average age of 230 years with a range of 120-325, though only among trees in the overstory. Flatley et al. (In press) showed shortleaf pine over 150 years old to be similarly rare at Lake Winona RNA, another old growth site in the Ouachita Mountains. Examining remnant old growth in the Uwharrie Mountains of North Carolina, Cline (2021) found an age range of 54-206 years for shortleaf pine, with an average of 142.6 years in age.

Mattoon (1915) also notes that 200-300 years in age and 60-90 cm DBH were more common maximum values for shortleaf pine. Ages of over 300 years for the species appear to be exceedingly rare in any old growth setting (Bragg, 2004; Cerny et al., 2016; Cline, 2021; Guyette et al., 2007; Flatley et al, In press; Matoon, 1915; Stahle et al., 1985). In fact, from the randomly sampled Linson Creek data, only 12 trees had a minimum age of between 200 and 250 years (Figure 9a). Even among older-appearing trees cored off-plot, the oldest observed minimum age was 278 years (Appendix 2). In fact, only one shortleaf pine with an observed age of at least 295 years has been documented in the McCurtain County Wilderness Area (Stahle et al., 1982).

Stahle et al. (1982) found one shortleaf pine tree near the Linson Creek study site with a minimum age of 295 years. Even throughout *P. echinata's* entire native range, the oldest known dendrochronologically determined minimum age was 324, as of 2007. It was found in the Great Smoky Mountains National Park of Tennessee (Earle, 2022). Another extraordinary pine dubbed "Tree LAW38" was dated to 314 years as of 1980 by D. Stahle and G. Hawks at the Lake Winona Natural Area (Earle, 2022). Guyette et al., (2007) also documented a 315-year-old shortleaf pine at the Eck Conservation Area in Missouri. Note that these are only minimum ages at breast height. Guyette et al. (2007) and Mattoon (1915) have stated the species can live up to 350 and 400 years, respectively. Meanwhile he longest known shortleaf pine chronology (including living trees, stumps, and remnant wood) was documented in Shannon County, Missouri; it extends for 434 years, from 1558 to 1996 (Guyette, 1996).

The oldest examples of shortleaf pine could have succumbed to logging or other disturbances since the early 20th century because the most productive sites were largely cut by the end of the 20th century (Guldin, 2007; Little, 1971; Oswalt, 2016; Smith, 1986). Most remaining tracts of uncut shortleaf pine like the MCWA are marginal sites that may not have been ideal for logging. The relatively poor soils and steep terrain at a location like the MCWA might limit the life span and maximum diameter of local *P. echinata* (Kreiter, 1995). The paucity of quantitative data on shortleaf pine from the precolonial period makes this hard to comment on with certainty, however (Bragg, 2002). Regardless, more extensive dendroecological surveys of all remaining uncut shortleaf pine throughout its range would be useful to determine any spatial variations in average age and size.

c. Relationships between age and size in the study area

There is a weak positive correlation between size and age in the Linson Creek study area (Figure 12). Diameter has been shown to be a poor predictor of age in shortleaf pine and other species, given how confounding factors arise with varying site conditions (Black et al., 2008; Bragg, 2004; Brown et al., 2019; Cline, 2021; Patterson and Knapp, 2016; Stambaugh et al., 2002; Sumida, 2012). However, the threshold at 40 cm with respect to the age-size correlation shown in Figures 12b and 12c has less precedence. This phenomenon might be due at least partially to varying degrees of suppression in the understory. In other words, there could be marked variations in growth rate depending on the availability of light for pine seedlings and saplings throughout a given site. Other factors like slope, soil fertility, and soil moisture could also play a role in this regard (Adhikari et al., 2021; Guyette et al., 2007).

In fact, some studies have shown that younger shortleaf pine have a more robust size-age relationship than their older counterparts (Brown et al., 2019; Cline, 2021; Guyette et al., 2007). This appears to contradict the findings depicted in Figure 12, wherein the older trees have a greater size-age correlation. This might be explained by a relatively intact and homogenous canopy in the uncut shortleaf pine habitat of the McCurtain County Wilderness area (MCWA), as opposed to the successional forests of southern Missouri and the more hardwood dominated Appalachian Mountains (Cline, 2021; Guyette et al., 2007). In other words, the MCWA could have a more predictable pattern of suppression in the understory, followed by a release of growth once established in the overstory. Indeed, Stambaugh et al. (2002) has shown that *P. echinata* can tolerate 80 years or more of suppression in a shaded understory.

In any case, these findings underscore the importance of varying site conditions and disturbance histories and their effect on inter-tree competition and aging characteristics, both amongst individuals and neighborhoods (Aakala et al., 2013; Sumida, 2012). In fact, the greater insolation and generally more xeric conditions on south-facing slopes might make the size-age correlation more robust on these aspects, given their relatively predictable and homogenous conditions (Guyette et al., 2007). However, as Cline (2021) points out, the shortage of age-diameter studies for old growth forests can make this relationship hard to assess.

d. Topographic position and age/density relationships

All three topographic aspects have a dominant age class of roughly 80-100 years. Even so, trees on the south-facing slopes were shown to have significantly greater ages than their north-facing counterparts (Table 2; Figure 11). The primary reason for this is a greater number of trees with a minimum age of 100 years or more on the southerly aspects (Figure 11). This may be attributed to the concept of “longevity under adversity” first proposed by Schulman

(1954). Specifically, the generally hotter, drier, and more insolated south-facing slopes may result in slower growth and greater average age (Guyette et al., 2007).

Although topographic aspect had a statistically meaningful effect on average basal area, a t-test could not determine a significant difference in stem density. Even so, stem density of shortleaf pine was on average lowest on ridgetop plots (Table 1; Table 2). However, basal area was shown to be greater on the ridgetop plots by a statistically significant margin (Table 2). This apparently inverse relationship might be at least partially attributed to a reduction in pine germination following an increase in understory shade brought on by larger trees. This concept has precedent in studies of forest succession (Adhikari et al., 2021; Drew and Downes, 2018; Neumann and Hasenhauer, 2021).

In any case, shortleaf pine appears to be more productive on the ridgetop plots in the study area, with greater growth rates, basal area, and average diameter observed from this group (Table 2). The low density of shortleaf pine on ridgetops might help explain these higher growth rates.

Shortleaf pine was also surprisingly dense on the north-facing slopes, despite pines being more likely to occur south and west-facing sites, which are subject to more frequent fire and higher insolation (Table 1; Guyette et al., 2007; Walker et al., 1966). This may speak to the xeric nature of the site overall, as well as the well-drained rocky soils that dominate the region, both of which seem to favor *P. echinata* and to a lesser extent, *Q. stellata*. The Linson Creek site may be unusual in this respect, since Smith et al. (1997) reported north-facing slopes to be dominated by *Quercus* spp. *and Carya* spp. However, since a quantitative species count was not performed for this paper, these results are merely speculative. Numerous hardwood stumps were observed on north-facing slopes as well, suggesting ecosystem treatment might have been focused on these areas, given their probable denser mix of hardwoods and pines (Masters et al., 1995).

e. Shortleaf pine recruitment trends

Years of recruitment were also established, wherever possible, for all pines randomly sampled at Linson Creek. It should be stressed that recruitment is distinct from germination. In other words, a dendrochronologically observed inner ring date is not necessarily equivalent to tree age from germination (Li FR et al., 2005; Gutsell and Johnson, 2002). The trees that showed the recruitment pulse(s) discussed above were sampled at breast height. To carefully estimate the germination date, cores would have to be taken from the root collar as well as at breast height to estimate the time it took for the tree to reach that height, which was not performed in this study (Cerny et al., 2016; Fraver et al., 2011; Gutsell and Johnson, 2002). An age analysis of pine saplings also would have been helpful in this regard. Although there are few studies on the typical time needed for a shortleaf pine to reach breast height, they have been shown to start producing flowers after about 10-12 years, and cone production usually begins after about 20 years (Lawson, 1990; Mohr, 1896).

The absence of any trees with a recruitment date after 1955 on Figure 9c suggests a lengthy period of growth before a 10 cm diameter is reached. The cumulative growth curves in Figure 14 also show an average age of about 40 years for trees at the 10 cm diameter threshold. Indeed, even the youngest tree from the total dataset, including trees cored far from the pith, had an observed inner ring date of 1982 (Appendix 2). This is perhaps unsurprising, given the species' ability to survive in the understory for up to 80 years, or possibly more, in a suppressed state (Stambaugh et al., 2002). The wide range of growth rates also has precedence for the species, with rates having been shown to range from as little as 1 cambial growth ring per cm to as much as 20 per cm (Guyette et al., 2007). Even so, it’s difficult to draw any conclusions on the typical age at which a shortleaf pine reaches a height of 1.4 m from the cumulative growth curves or recruitment data.

Based on the samples collected, the bulk of the recruitment to breast height occurs from 1915 to the end of the 1950s, with recruitment appearing to plateau in the late 1920s and early 1930s (Figure 9c). This is the only major recruitment pulse, with the only other two clusters around 1905 and 1810 being very small by comparison. Other than these clusters, the record of recruitment is muted and sparse with numerous gaps and small pulses of recruitment stretching back 250 years.

The recruitment data of the randomly sampled pines are comparable to a few other studies. Stambaugh et al. (2002) documented a similar roughly bell-shaped curve centered around 1935 to 1950 at the Eck Conservation Area in southeast Missouri. This period coincided with a sudden reduction of wildfire ignition and followed an extensive regional drought (Cook et al., 1999; Klockow et al., 2020; Torbenesen and Stahle, 2018). Wildfire frequency and intensity tend to increase with drought, and these conditions might have favored the overstory recruitment of shortleaf pine that had already been established in the understory in previous decades, since it is more tolerant of drought and fire than other species in the region (Bradley et al., 2016; Littell et al., 2016; Mattoon, 1915). Indeed, shortleaf pine regeneration and recruitment patterns have been shown to be influenced by decadal fluctuations in precipitation in addition to localized disturbances like fire and ice storms (Fountain and Sweeney, 1987; Jones and Bowles, 2012).

Stambaugh et al. (2002) postulates that these commonly observed bell-shaped curves for shortleaf pine are also a result of recent hardwood encroachment, which is another possible explanation for the relative paucity of pine recruitment in the latter decades of the 20th century documented in Figure 9c. In fact, Kreiter (1995) and Masters et al. (2007) observed a transition to a relatively dense forest community in the MCWA, with an increased component of more shade-tolerant hardwoods. This is further corroborated by several other studies in Arkansas and Texas (Glitzenstein et al. 1986; Fountain and Sweeney 1987; Shelton and Cain 1999). In other words, the era of fire suppression could have muted pine germination recruitment in more recent decades and favored more fire-intolerant hardwoods (Flatley et al., In press; Masters, 2007; Masters et al., 1995). Nevertheless, there appeared to be a healthy contingent of pine seedlings and saplings on most study plots at the Linson Creek site, likely the result of the recent mechanical thinning of hardwoods by the Oklahoma Department of Wildlife and Conservation (Masters et al., 1995; Skeen, 2016).

f. Fire history at North Linson Creek study area

Masters et al. (2007) demonstrated a loss of open woodlands since 1956, when the practice of fire suppression took hold in the wilderness. This reduction in burning almost certainly contributed to the mean fire interval skyrocketing to nearly 550 years from its value of 30 years before 1956 (Masters et al., 2007). This hypothesis is supported by the unique ability of *P. echinata* to sprout from the base even after the stem is severely damaged, a survival mechanism which may lead to its dominance over other species during periods of regular fire (Mattoon, 1915).

The frequent regionwide fires before 1900 likely would have been conducive to *P. echinata* germination, if not recruitment and establishment into the overstory (Flatley et al., In press; Stambaugh et al., 2007). A possible explanation for the paucity of trees older than 100 years in the Linson Creek study area could be the frequent anthropogenic burning that occurred in the region throughout the 19th century, which might have transformed the landscape into a more open grassy woodland compared to its previous condition (Flatley et al., In press; Masters, 1995). This is supported by the assertion that prolonged period of frequent burning in 2–4-year intervals may be detrimental to the long-term survival of the species, and longer 8–15-year intervals might be more ideal for the retention of already recruited pines (Stambaugh et al., 2007). This frequent human ignition could have caused the increase in densities found by Kreiter (1995) and Masters et al. (2007) to be more drastic than they might have been if compared to their pre-European condition. However, the characteristics of the pre-18th century Ouachitas is hard to accurately describe, given the paucity of quantitative accounts (Bragg, 2002).

There is a well-documented history of fire at the MWCA, at least some of which was likely the result of human ignition (Masters, 1995). The oldest documented fire in the MCWA is from 1710; by this time, North America's Native American populations had already been decimated by the introduction of novel diseases by the Spanish (Masters, 1995; Taylor, 2003). Even so, there was still likely a Caddo presence in the vicinity of the MCWA until at least the late 1700s (Trubitt et al., 2019). The Choctaw people were later forcibly relocated to the region in the 1830s and assumed ownership of what is now the MCWA. Early waves of Euro-American settlers had also been moving to the broader Oucahita region in the 19th century. This influx brought with it an increase in human ignition, although it is unclear what effect this had on the MCWA, if any, given its remoteness (Edmondson and Zumwalt-Smith, 2004; Flatley et al., In press; Kreiter et al., 1995; Masters et al. 1995; Sabo 2001; Trubitt 2019).

g. Climate response of shortleaf pine at North Linson Creek

Lastly, the difference in the climate response of earlywood and latewood in shortleaf pine is well documented (Cleveland, 1975; Schulman 1942), as is the greater variability of the latewood compared to earlywood and total ring width in other species of yellow pine (Meko and Baisan, 2001; Griffin et al. 2013). The latewood series of *P. echinata* was also shown by Torbensen and Stahle (2018) to be the strongest proxy for same-year atmospheric moisture balance during summer out of multiple species, demonstrating its utility for reconstructing summer climate in the past. However, the length and replication of latewood width chronologies of shortleaf pine both need to be improved in the 18^{th} and 17^{th} century to maximize the paleoclimate value of this proxy. Potential sources of old shortleaf pine wood include old cut stumps and remnant dead wood still found sufficiently preserved on the landscape (e.g., Flatley et al., In press; Stambaugh et al., 2020), as well as building timbers preserved in early historic structures (e.g., Stahle, 1979).

Schulman (1942) noted that the strongest crossdating and climate signal in his study of shortleaf pine in Arkansas was found in the latewood width data. This strong climate signal in latewood has been confirmed by Torbenson and Stahle (2018) who calibrated 74% of the variance in the atmospheric moisture balance for the summer season using a network of four shortleaf pine chronologies from Arkansas and Oklahoma, including latewood width data from earlier collections of shortleaf pine in the McCurtain County Wilderness Area by Stahle et al., (1985). For comparison, the latewood width data that passed screening are plotted in Figure 17 (mean LW width, top panel; the detrended and standardized chronology, middle panel; and the sample size, bottom panel). Note the episodes of low latewood growth near 1800, 1830, 1840, 1880, 1950, and 1980, and the periods of above average latewood growth near 1760, 1810, 1860, 1900, 1960, and 2020 (Figure 17, middle panel; note that the sample size of cores falls below 20 before 1805 and below 10 before 1771). Based on the work of Schulman (1942) and Torbenson and Stahle (2018) these episodes of low and high latewood growth likely represent intense drought and wet intervals in southeastern Oklahoma.

7. Conclusions

This study of the age and size distribution of shortleaf pine was undertaken in the North Linson Creek area of the MCWA. This study also includes an investigation of the climate response of earlywood and latewood width and is one of the few dendrochronological studies of an old growth *P. echinata* forest that has yet been conducted. The main results of this study are:

1. Three ring width datasets and derived mean index chronologies were developed for the MCWA using the new collections from Linson Creek and the existing data collected elsewhere in the MCWA by Stahle et al., (1982). All these data are to be contributed to the International Tree Ring Database (ITRDB) available at the National Centers for Environmental Information at the National Oceanic and Atmospheric Administration (NOAA; https://www.ncei.noaa.gov/products/paleoclimatology/tree-ring).
2. The randomly sampled pine ≥10cm Diameter at Breast Height (DBH) were on average at least 100.3 years old and 31.3 cm in diameter. The minimum age of the oldest pine yet found in the MCWA was 295 years old when cored in 1982 (Stahle et al., 1982). The largest pine measured in the Linson Creek area was 83.5 cm DBH (found off plot), and the oldest found in the same study area was a minimum of 278 years old at breast height (also off plot).
3. Most of the recruitment to breast height occurred from 1920-1940, with the mean year of recruitment being 1918, and the median 1928. Note that this is distinct from

the year of germination, which could have occurred anywhere from 10-100 years before recruitment to breast height, based on the cumulative growth curves for the Linson Creek samples.

4. Diameter was a better predictor of age in randomly sampled pine ≥40 cm DBH ($r = 0.52$) compared to those under this size threshold ($r = 0.26$).
5. The oldest and slowest-growing trees were found on south-facing slopes, and the largest and fastest-growing were found on the ridgetop position. North-facing plots had the smallest and youngest trees on average.
6. The cumulative growth data suggests that 10 cm DBH shortleaf pine may average approximately 40 years old, meaning that the average germination age of the pine trees ≥10 cm DBH at Linson Creek may be 140 years old, and the oldest pine yet cored in the MCWA may have been at least 335 years old from germination when it was cored (Stahle et al., 1982).
7. The latewood width chronology is very well correlated with the August PDSI over a broad area of the south-central United States. The earlywood series has a weak correlation with previous year June-July PDSI over roughly the same area. The total ring width chronology roughly splits the difference between these two correlations.

Extending the Linson Creek chronologies of shortleaf pine further back in time could have valuable paleoclimatic applications. Studies of remnant wood found on the forest floor in the MCWA or in historic buildings of southeastern Oklahoma might help extend the living tree chronology from Linson Creek back to the 17th century. The Linson Creek study area makes up just a small fraction of the roughly 57 square kilometers of uncut shortleaf pine habitat that is the MCWA. The rest of the vast reserve is ripe for further exploration and sampling.

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9. Tables

Table 1: Average size and age data for randomly sampled *P. echinata* with >10 cm DBH by topographic aspect and for the total dataset are displayed here.

DBH: Diameter at Breast Height (cm)
AGE: Dendrochronologically dated minimum age
GROWTH: Average cambial growth rate per year
DENSITY: Stems per hectare of *P. echinata* >10 cm DBH
BASAL AREA: Average cumulative basal area of all 7 plots from each topographic aspect in square meters per hectare of *P. echinata* ≥10 cm DBH

	DBH	AGE	GROWTH	DENSITY	BASAL AREA
South Slope	30.4	106.9	0.28	240	18.8
North Slope	29.8	93.6	0.32	270	19.5
Ridgetop	35.2	102.7	0.34	206	21.8
Total	31.3	100.3	0.32	239	20.1

Table 2: This table illustrates p-values for t-test performed on the indicated data, compared between all plot aspects. Note that values under 0.05 indicate a statistically significant difference, and the lower the p-value, the more significant the difference. There are exponents on each statistically significant difference. The value of the exponent signifies which topographic aspect had comparatively greater values, listed below. Note that for comparisons where no significant difference was found, no exponent is present. See Table 1 for definitions of each category of comparison.

[1] Ridgetop samples have greater values
[2] South-facing samples have greater values

	North vs. Ridge	**North vs. South**	**Ridge vs. South**
DBH	0.0001[1]	0.6597	0.0006[1]
AGE	0.0161[1]	0.0004[2]	0.3437
GROWTH	0.0384[1]	0.0001[3]	0.0001[1]
DENSITY	0.2335	0.5761	0.5408
BASAL AREA	0.0002[1]	0.4154	0.0046[1]

10. Figures

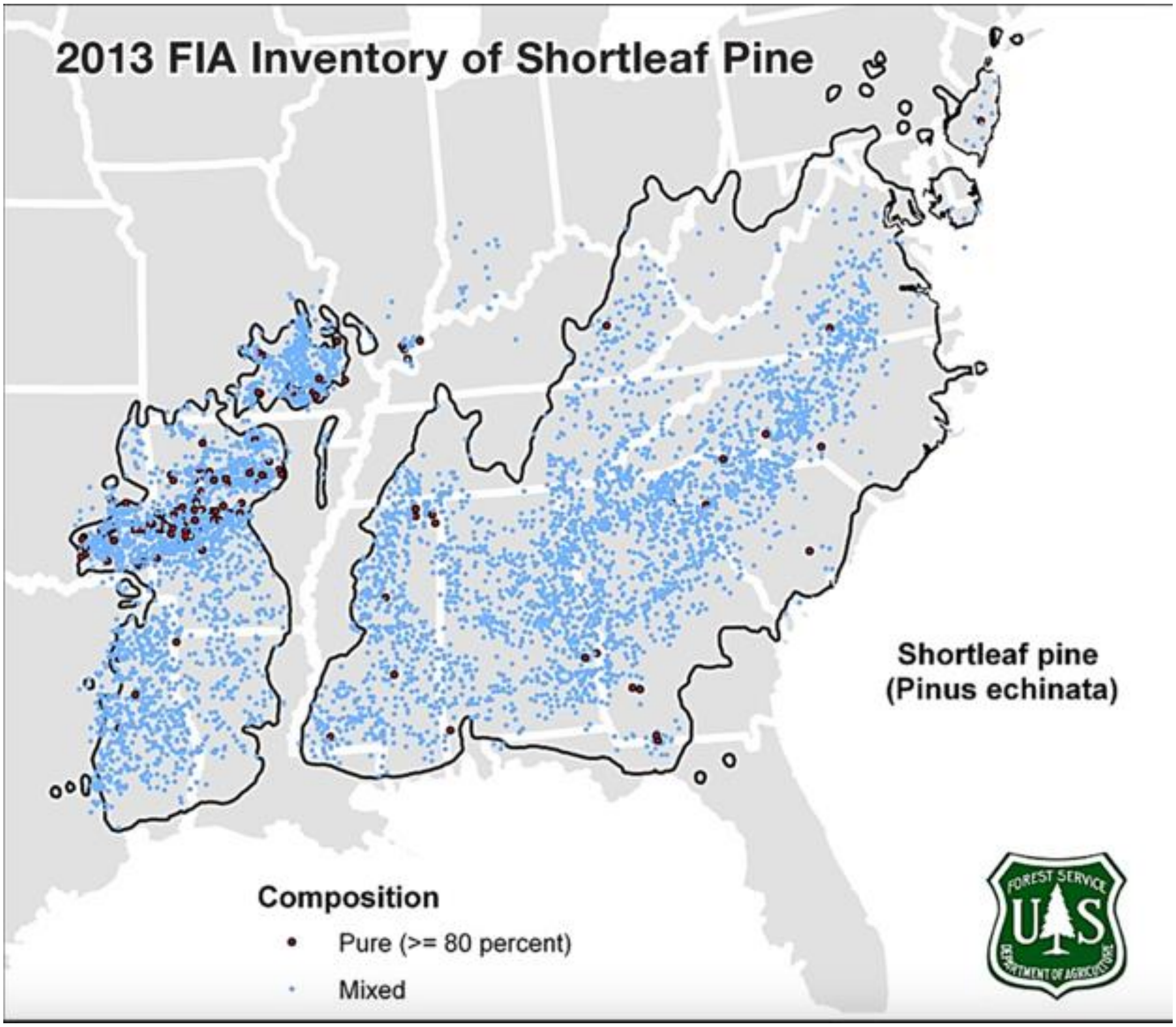

Figure 1. Pictured is a map of mixed stands of shortleaf pine *(P. echinata)*, defined as stands with less than 80% relative frequency of shortleaf pine (blue dots), and "pure" stands, defined as containing at least an 80% component of shortleaf pine stems (red dots) (Oswalt, 2015). Note the high concentration of pure shortleaf pine stands in Arkansas and eastern Oklahoma, especially the Ouachita mountains. The black outline that encompasses most of these stands is *P. echinata* range data from Little (1971).

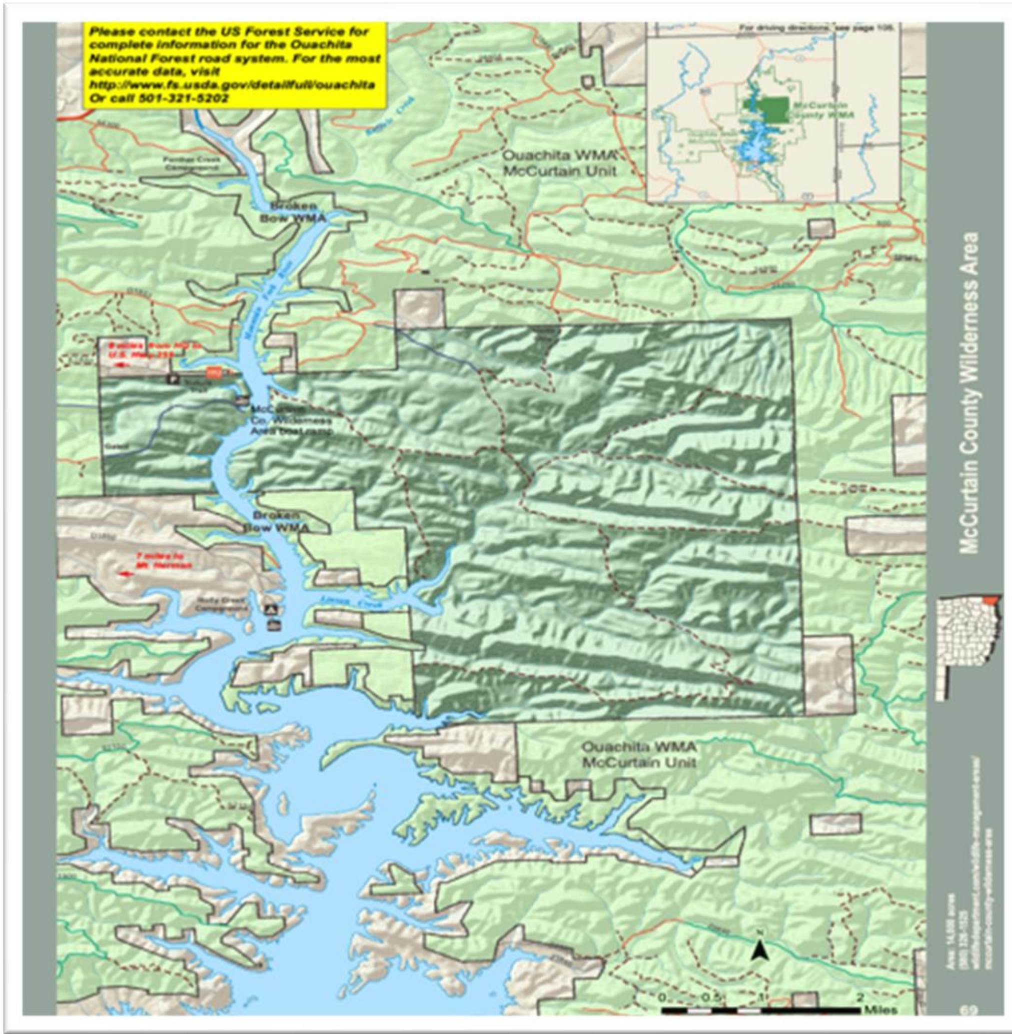

Figure 2. The McCurtain County Wilderness Area (MCWA) in southeastern Oklahoma is indicated by the dark green shading, adjacent to the Broken Bow reservoir indicted by the light blue shading. The study area is in the MCWA, just north of North Linson Creek. The MCWA preserves a sizable remnant of a characteristic pine-bluestem habitat that was once widespread in the southeastern and south-central United States (Kreiter, 1995; ODWC, 2022).

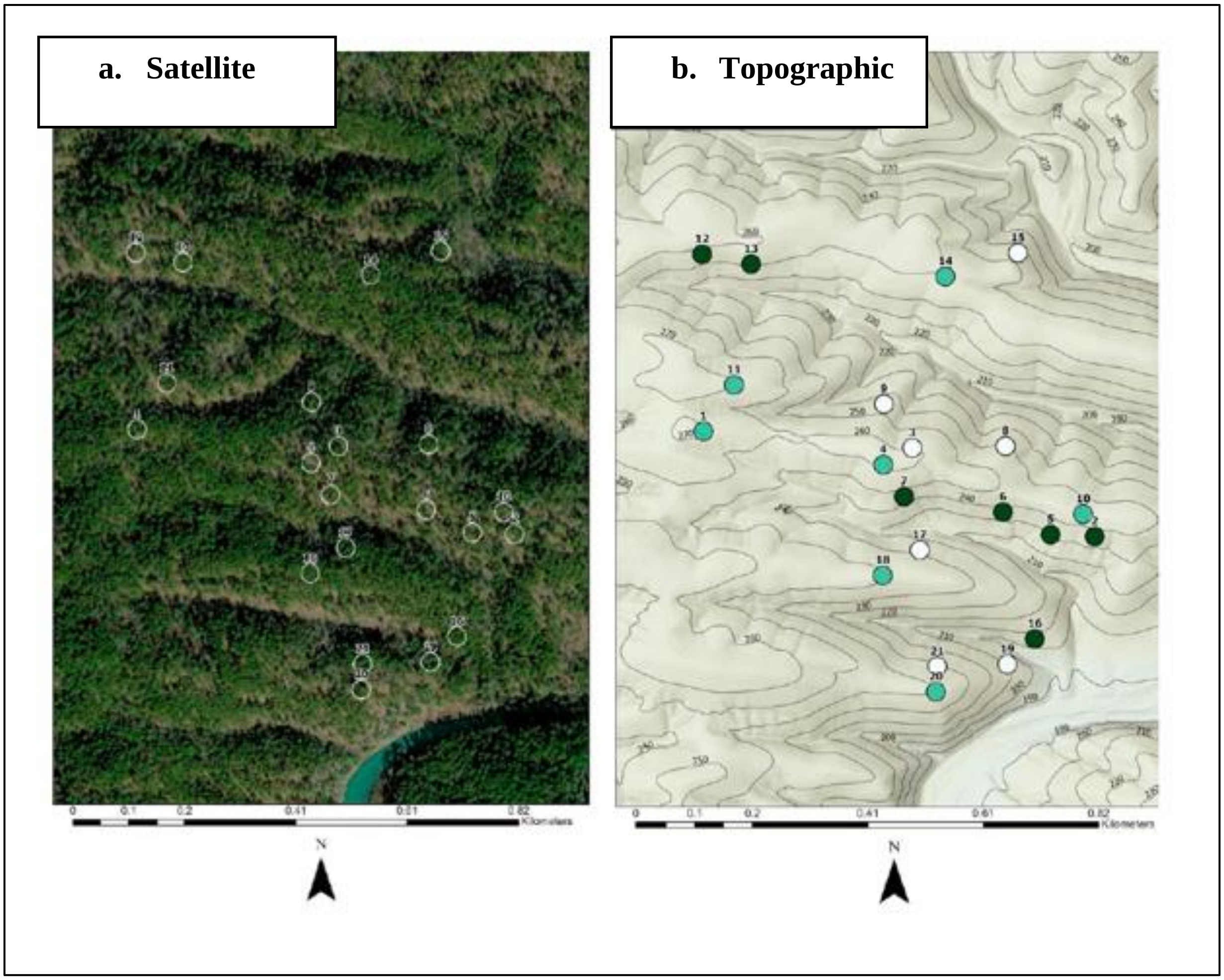

Figure 3. (a) Shown on the left panel is a multispectral image of the study area from a Maxar satellite, including the locations of the sample plots. Note that the diameter of the study plots is approximately 35 meters for an area of roughly 0.1 hectares**.** This image was obtained from the ESRI ArcGIS application and was last accessed in June 2022. (b) A map is shown on the right panel with plot locations superimposed on a USGS topographic map with elevation shown in meters. It centers on the four parallel ridges which make up the study site. The 21 sample plots are also shown and are labelled by topographic position: white (north-facing), light green (ridgetop), and dark green (south-facing). North Linson Creek is visible in the southeast portion of both maps. Topographic imagery was obtained from GaiaGPS.com and was last accessed in August 2022.

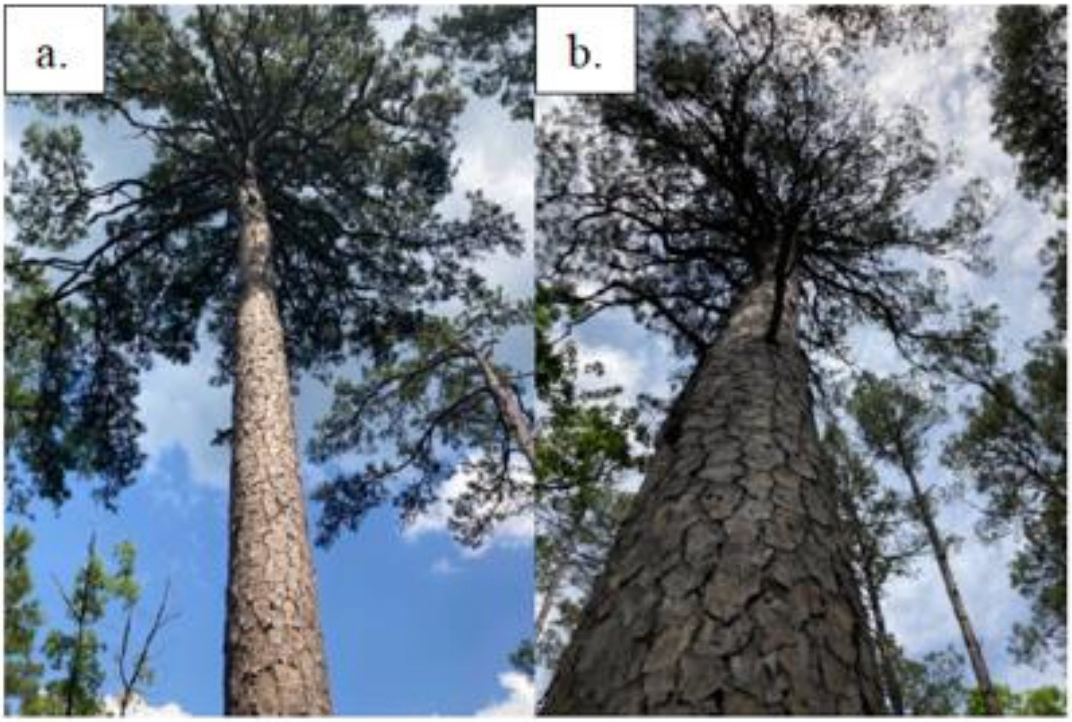

Figure 4. (a) The tree pictured on the left panel is least 228 years old, based on a dendrochronologically observed inner ring date taken from breast height. (b) The pine on the right panel is a mature tree of at least 177 years, based on the same dating criteria. Note the similar appearances of the two trees; despite an age difference of 51 years, both have similar outward characteristics.

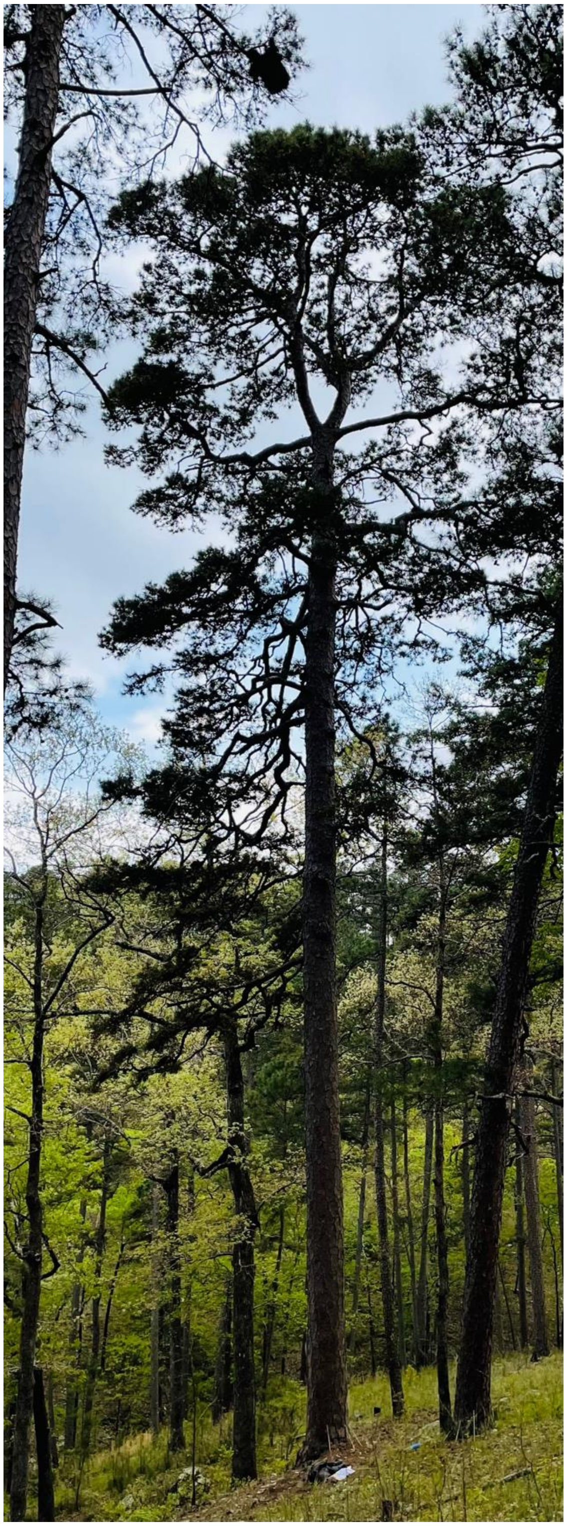

Figure 5. An old growth *P. echinata* is illustrated in the Linson Creek study area is pictured in this figure.

Figure 6. Pictured here is a view northeast into the interior of the wilderness area from one of the sample plots. Note the grassy bluestem-dominated understory in the foreground, the oaks in the middle distance, and the pine-oak woodlands on the distant ridge. The four pines on the foreground are typical of the mature shortleaf pine found in the study area.

Figure 7. This is a view of a typical ridgetop within the study site, with a relatively open pine-oak woodland and a grassy understory where the hardwoods have been mechanically thinned in an attempt to reproduce historic pine-bluestem conditions. Some large post oaks were left uncut.

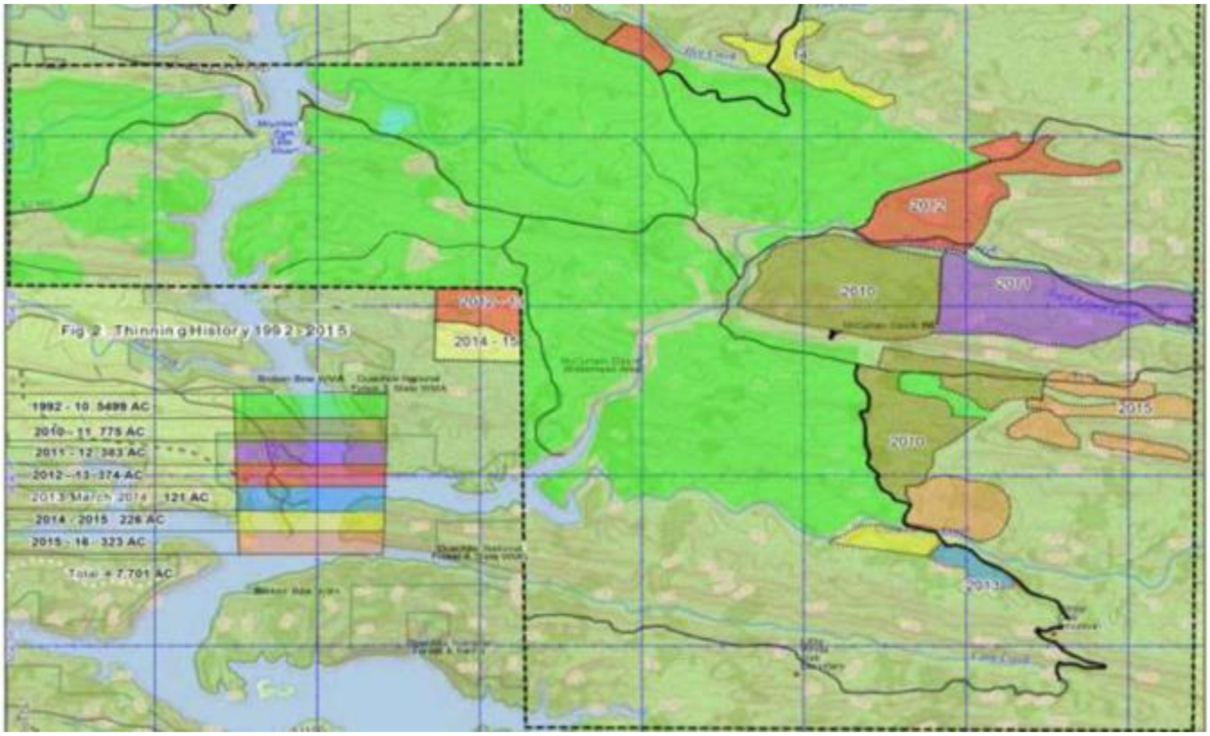

Figure 8. This is an overview of areas burned and mechanically thinned in the MCWA from 1992-2015. These restoration efforts are ongoing. Note that the Linson Creek study area is within the light-green polygon, indicating treatment began in 1992 (Skeen, 2016). However, more recent thinning and burning on some of the study plots were noted during fieldwork.

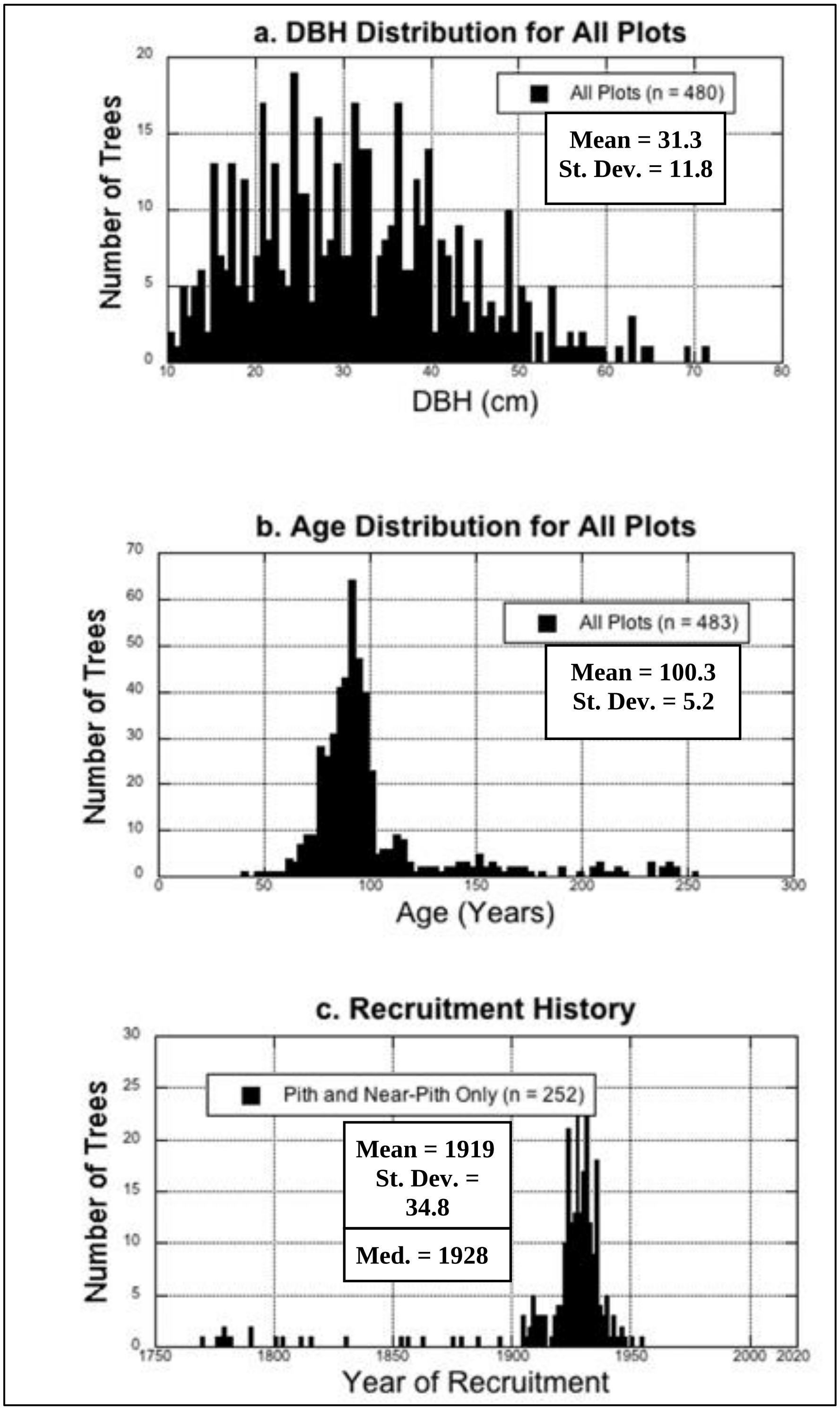

Figure 9. Pictured above are the diameter distribution (a), age distribution (b), and recruitment history (c) of randomly sampled shortleaf pine >10 cm in diameter, regardlessof aspect. For the recruitment history (c), only trees that were cored to the pith or close to the pith were included. DBH (cm), minimum age in years, and year of recruitment are shown on the x-axes, and number of trees on the y-axes.

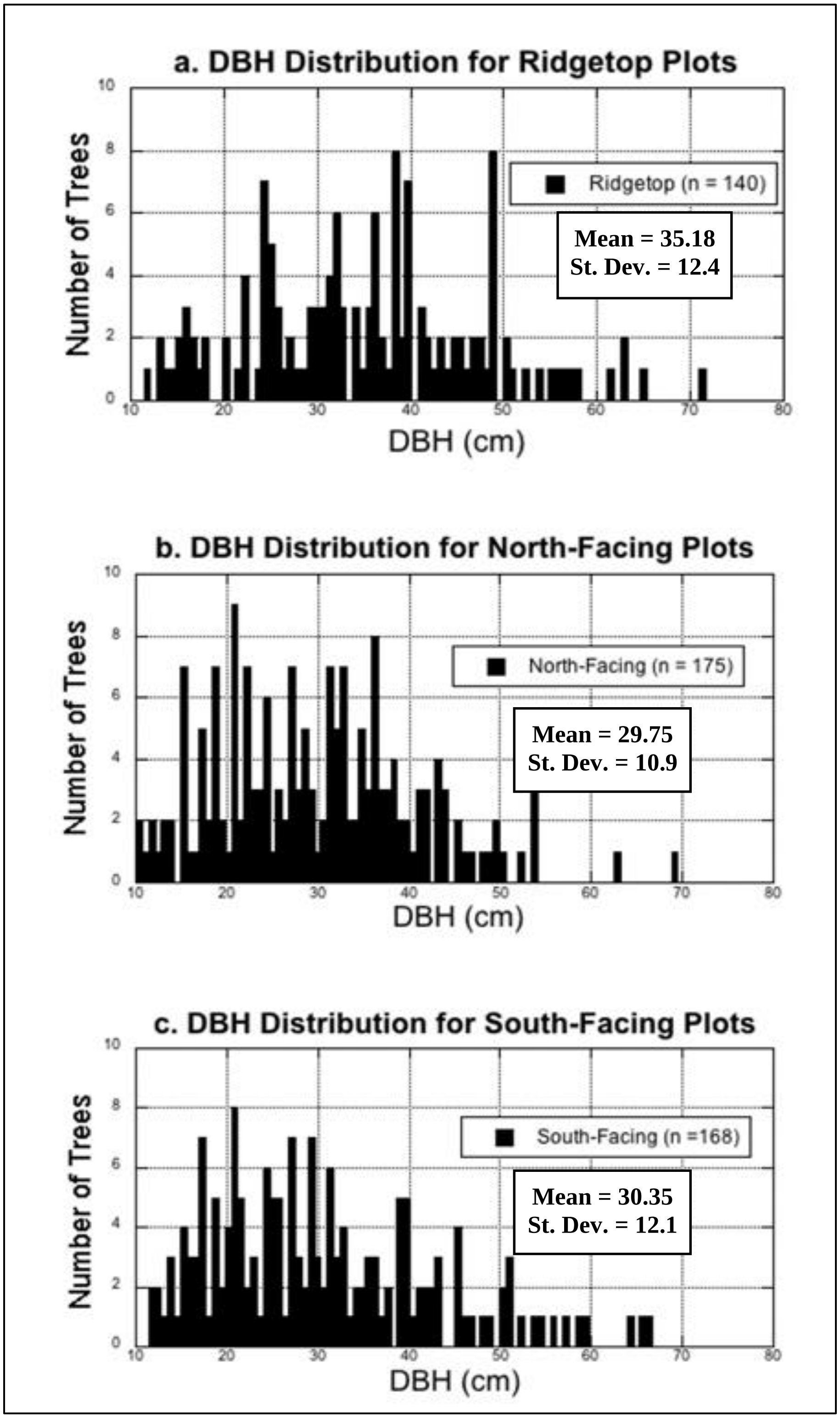

Figure 10. Diameter distributions for all randomly sampled pines are shown here, separated by topographic aspect, with diameter at breast height (DBH) on the x-axes, and number of trees on the y-axes.

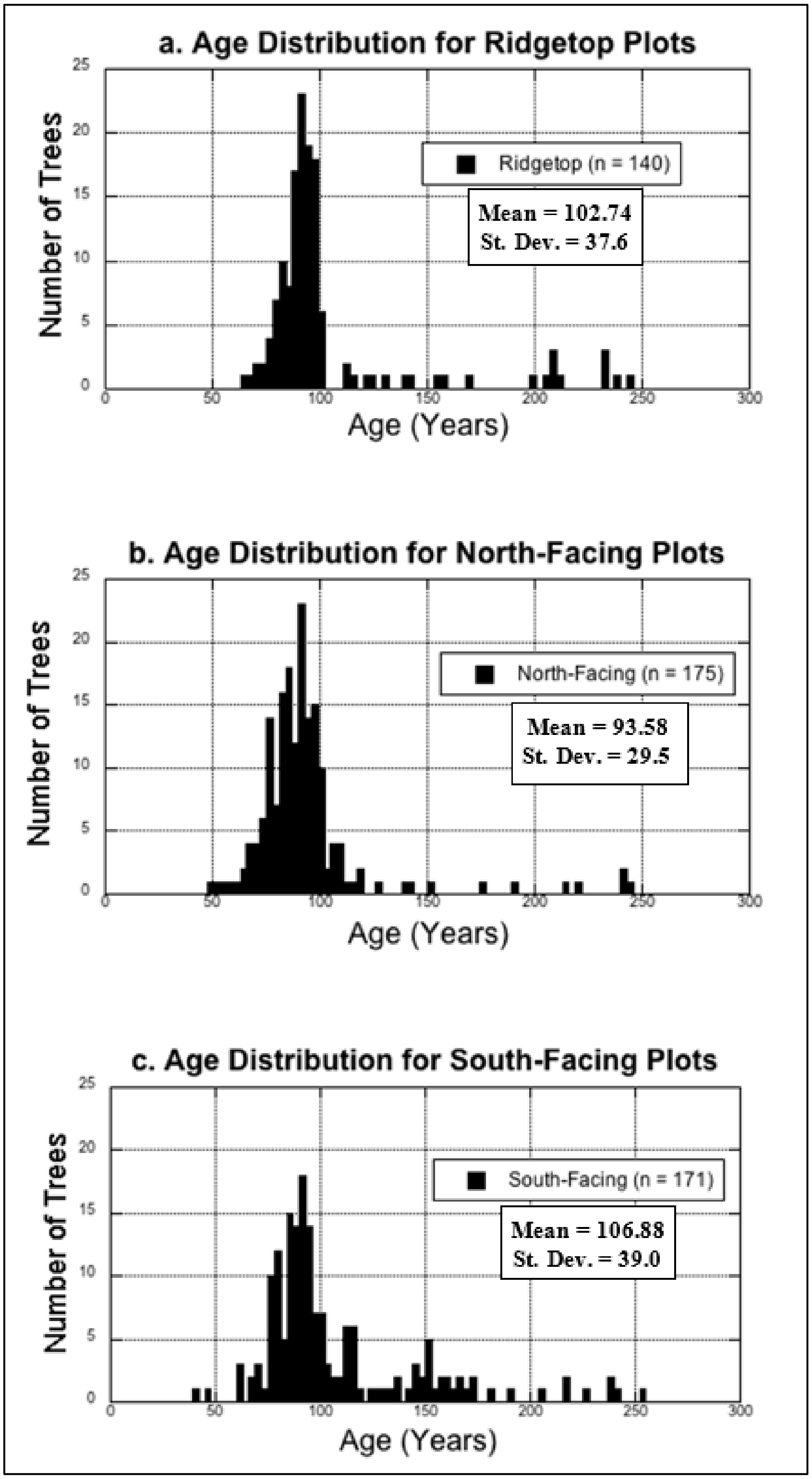

Figure 11. Diameter distributions for all randomly sampled pines are shown here, separated by topographic aspect, with minimum age in years on the x-axes, and number of trees on the y-axes.

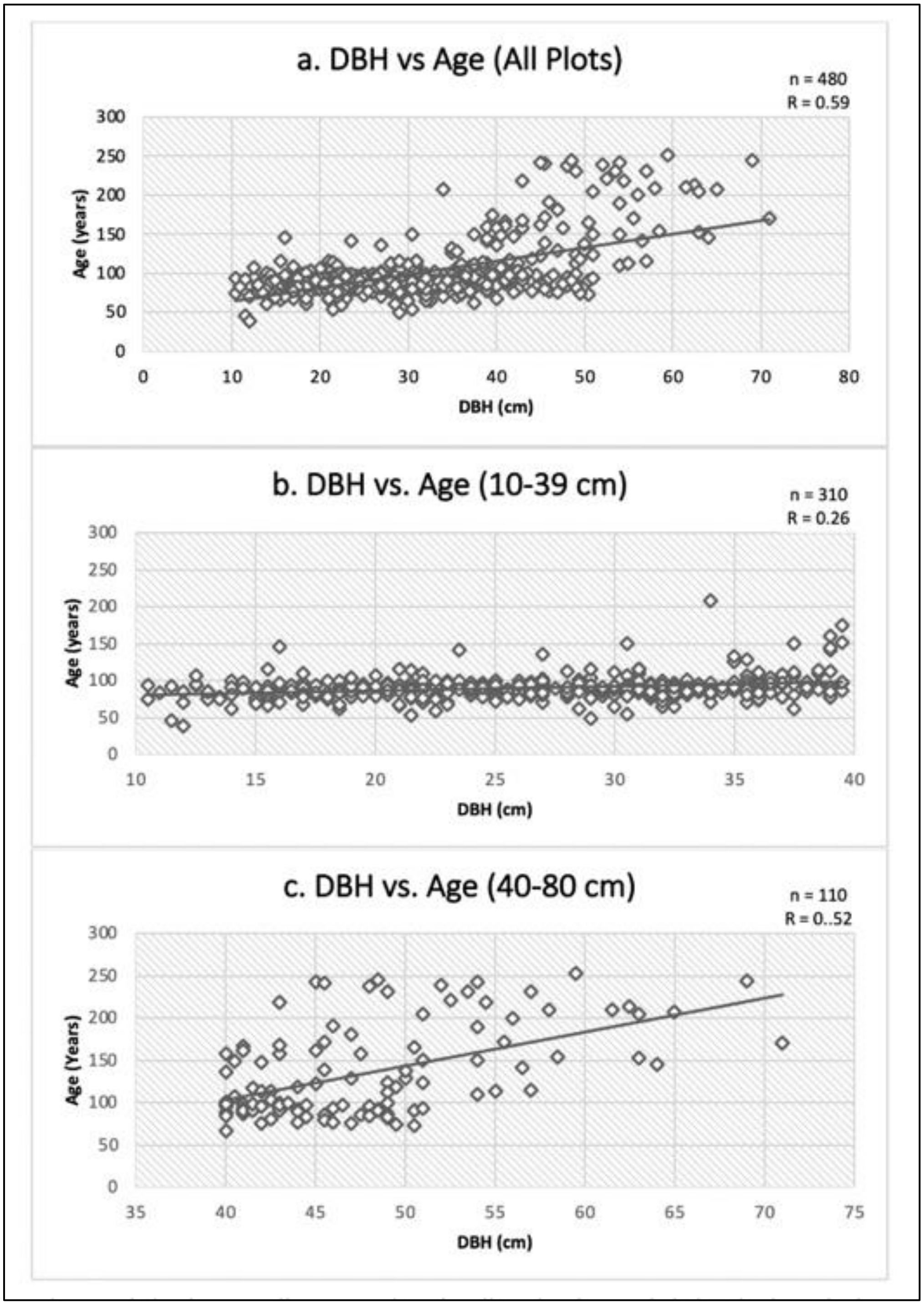

Figure 12. The correlation between diameter and age for all randomly sampled pines is shown in the top panel (a). The two lower panels demonstrate a comparison of the age/size relationship separated at the 40 cm-diameter threshold. Note the far higher correlation in the larger group. All three panels show diameter at breast height (DBH) on the x-axis, and minimum age in years on the y-axis. Note the high variation of age and size overall.

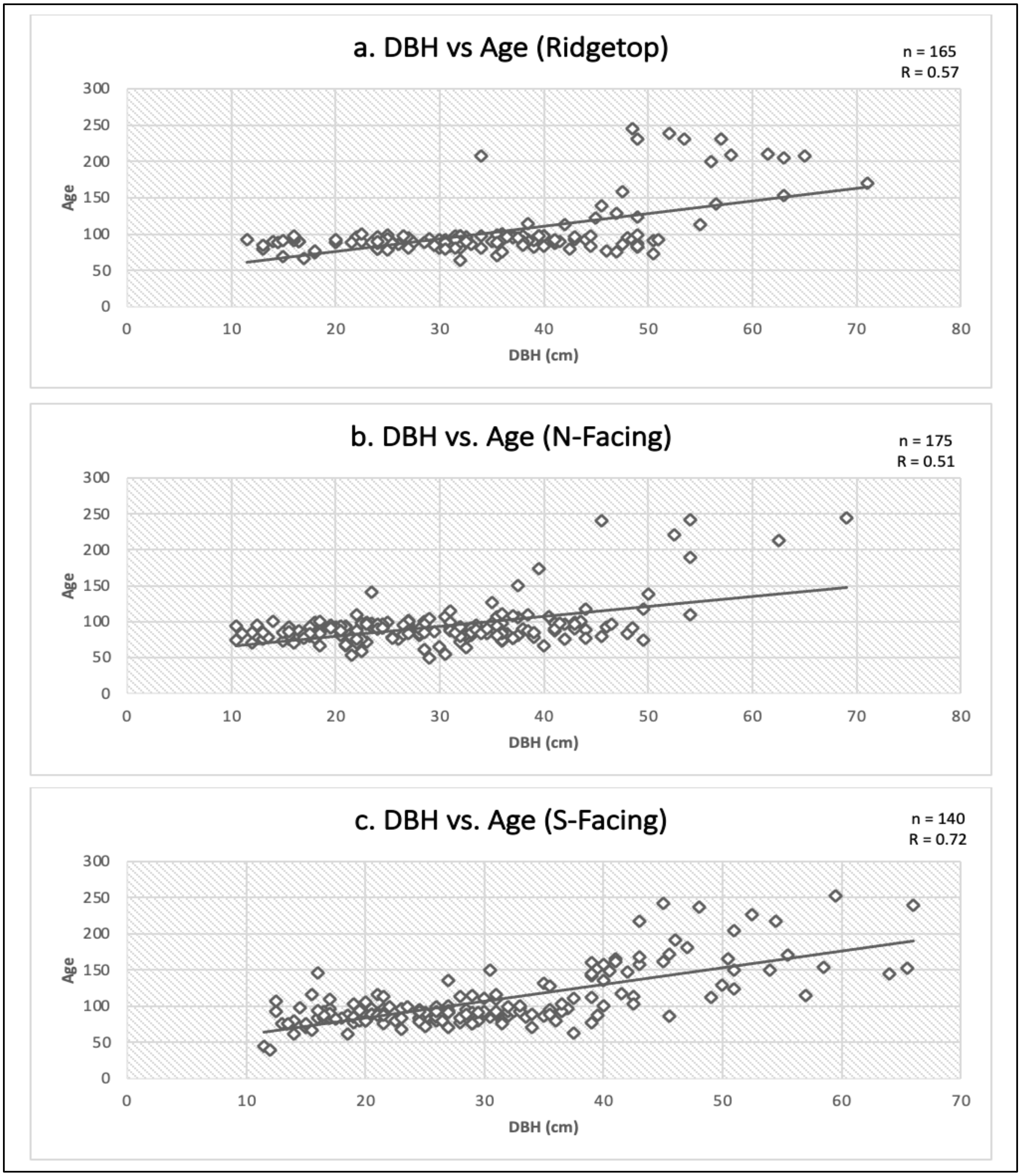

Figure 13. Shown here are scatterplots for diameter and minimum age for all randomly sampled pines, separated by topographic aspect. For all three panels, diameter at breast height (DBH) is shown on the x-axis, and age in years is measured on the y-axis.

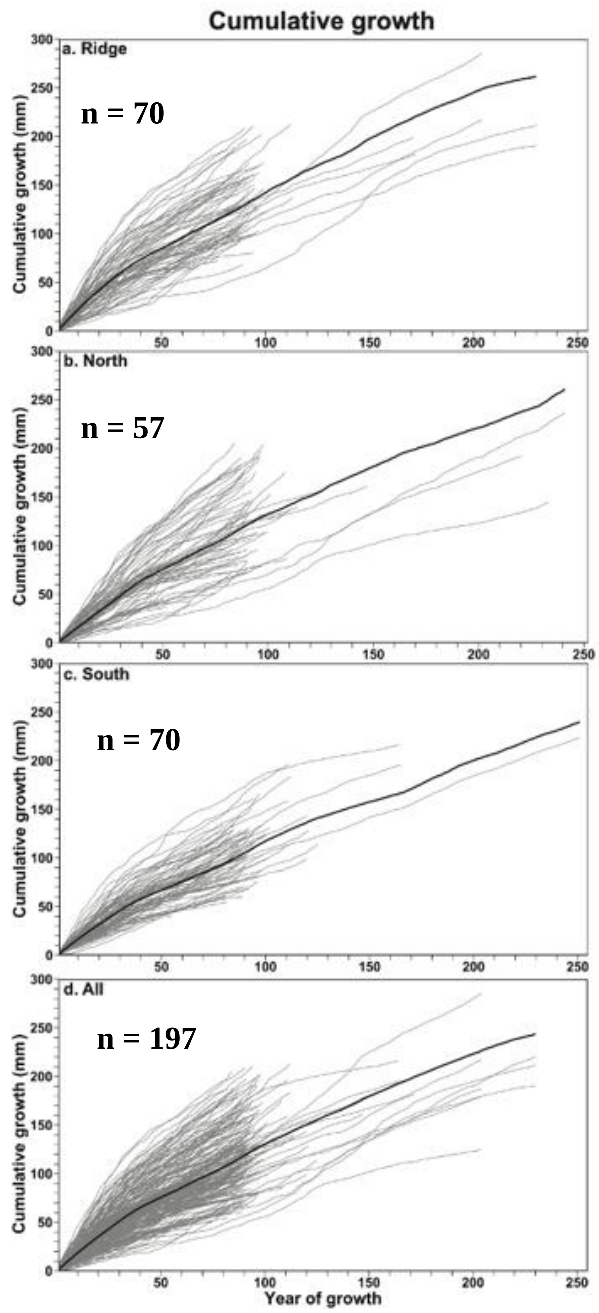

Figure 14. Cumulative radial growth curves are illustrated for each topographic position (a-c), and for trees from all plots (d). Only trees which were cored to the pith or near the pith were used for this analysis. The bold middle line represents average radial growth; the surrounding grey lines represent radial growth for individual trees. Note the high variation in cumulative growth among individual trees on all aspects, as well as the lower spread and relatively suppressed growth of trees on south-facing plots. Years of growth are shown on the x-axes; cumulative radial growth is enumerated on the y-axis.

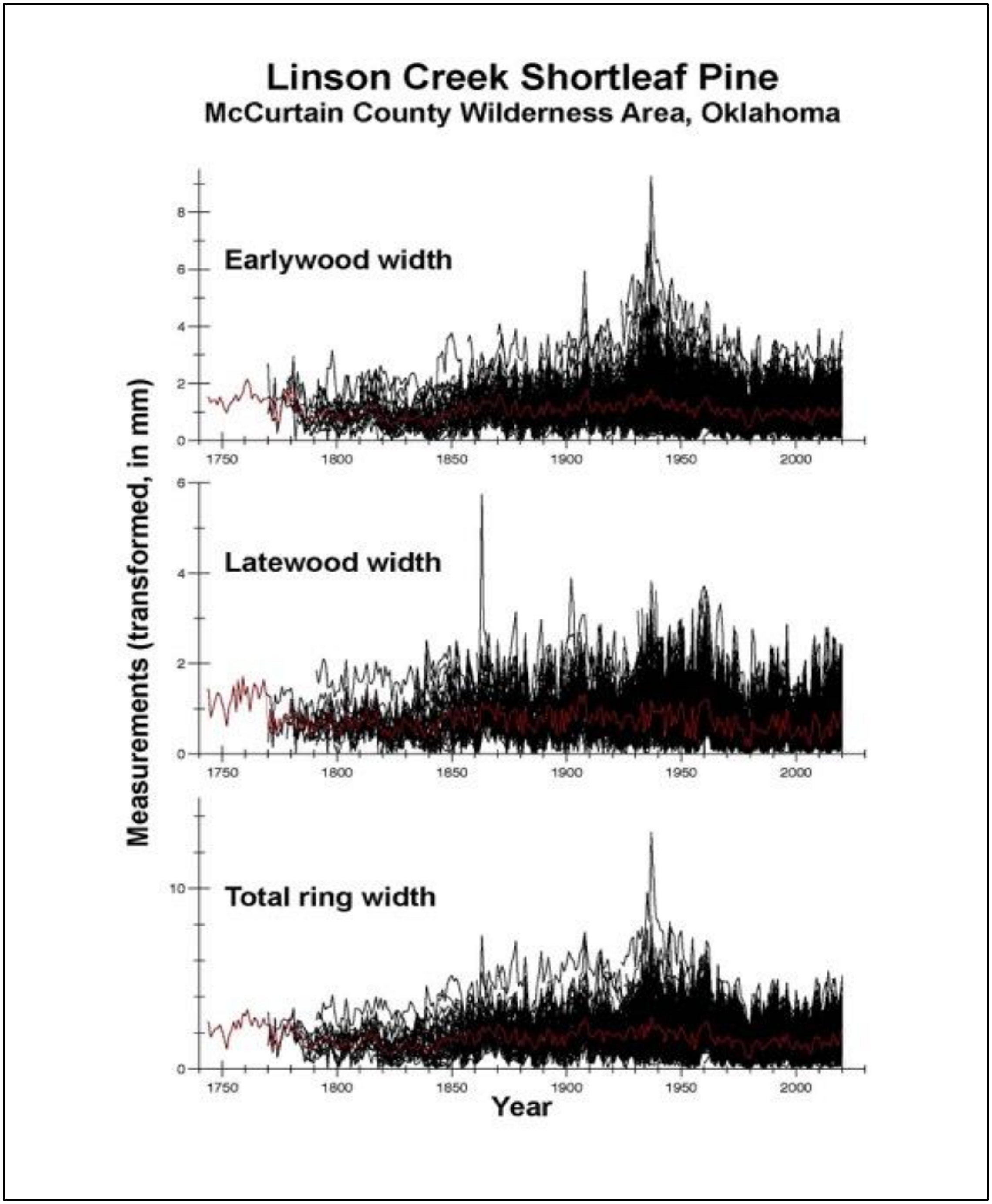

Figure 15. The earlywood, latewood, and total ring-width raw measurement data are plotted for all shortleaf pine cored at Linson Creek, with year of growth on the x-axes and measurements in mm on the y-axes. The red line represents the mean annual ring-width value, and the surrounding black lines show the fluctuations in annual growth for each individual core. Note the more marked fluctuations in the latewood series (Watkins et al., 2018).

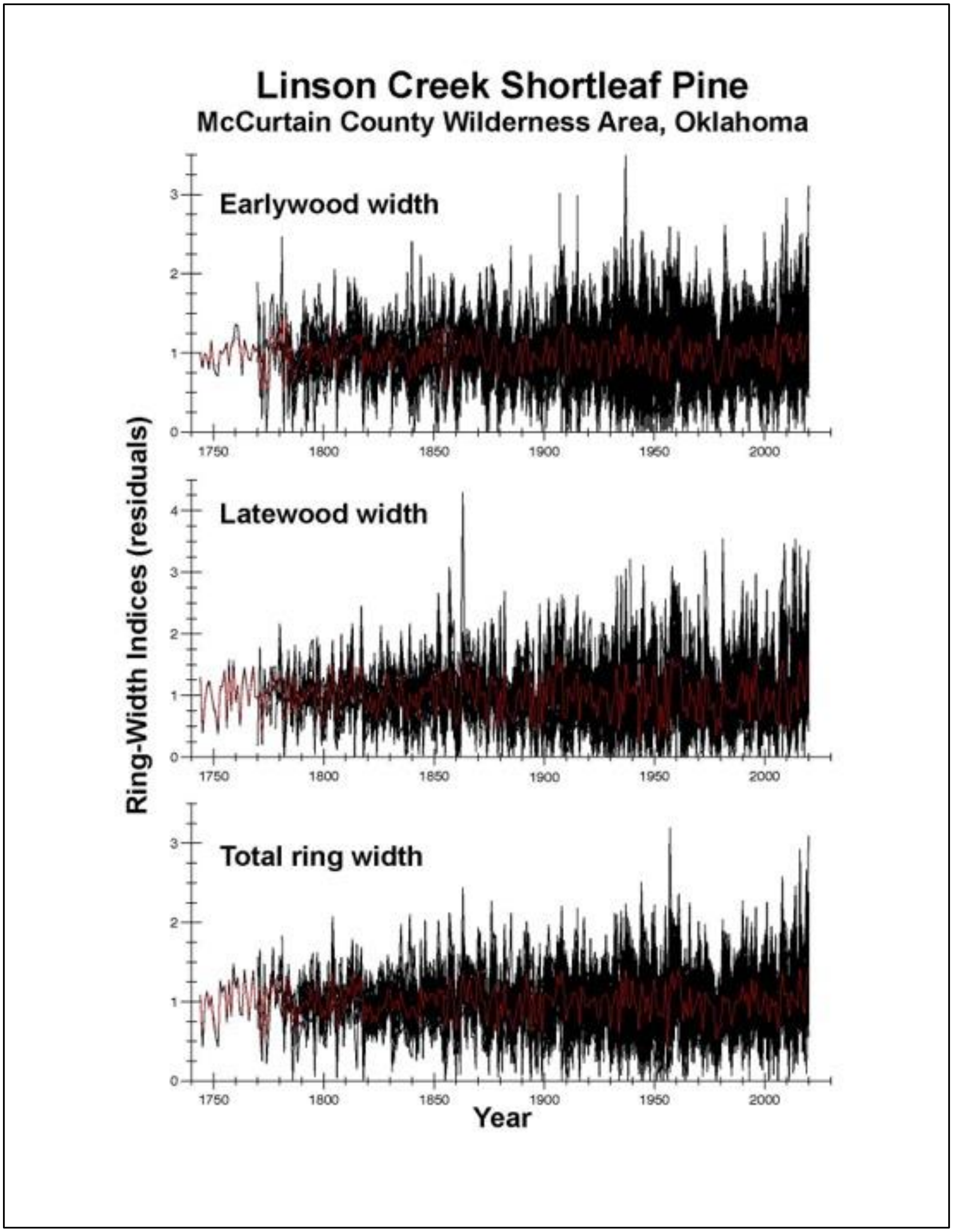

Figure 16. Same as Figure 15, but here, the detrended, standardized, and autoregressively modeled white noise residuals (Fritz, 1976; Cook, 1985) are plotted for each core (black), and for the mean (red).

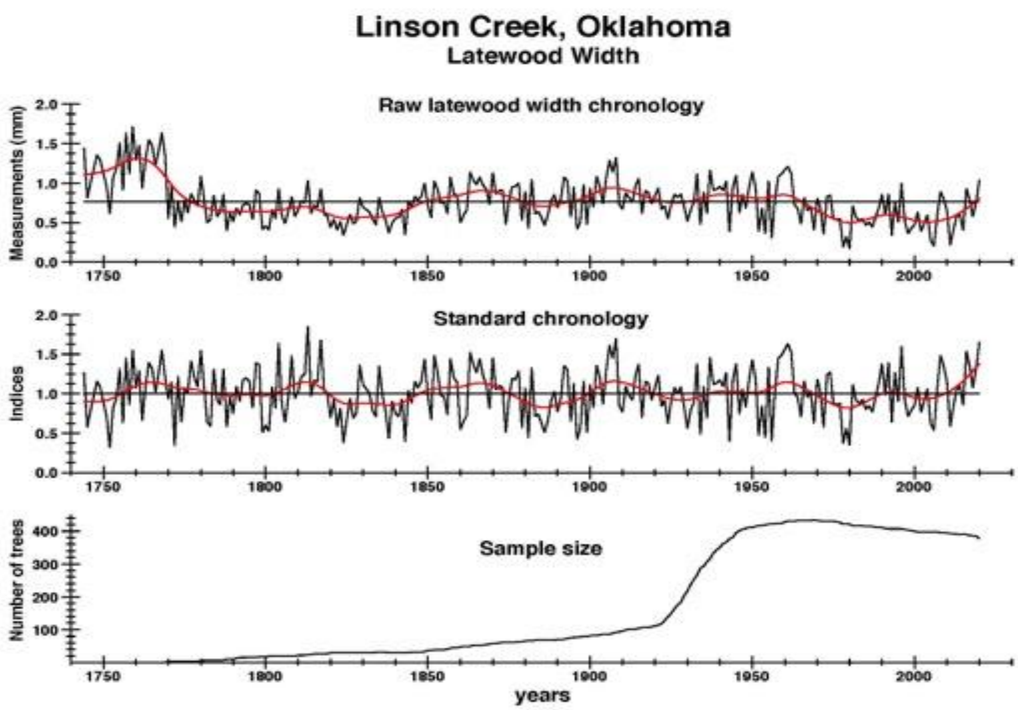

Figure 17. The latewood width data for Linson Creek are plotted for (a) the mean of the raw latewood width measurements (mm), (b) the detrended and standardized mean index chronology for latewood width (indices), and (c) the number of trees for each year in the time series. The red curves are smoothed versions of the annual values. Most sampled trees were recruited after 1920. For all three panels, year of growth is on the x-axis. Note the strong interannual variability of the standard latewood chronology. Years of notably low latewood growth include 1752, 1771, 1943 and 1980, among several others. Growth seems to peak in the 1810s, 1900s, and the 1950s to 1960s. These years coincide with droughts and pluvials, respectively (e.g., Cook et al., 2010; Torbensen and Stahle, 2018).

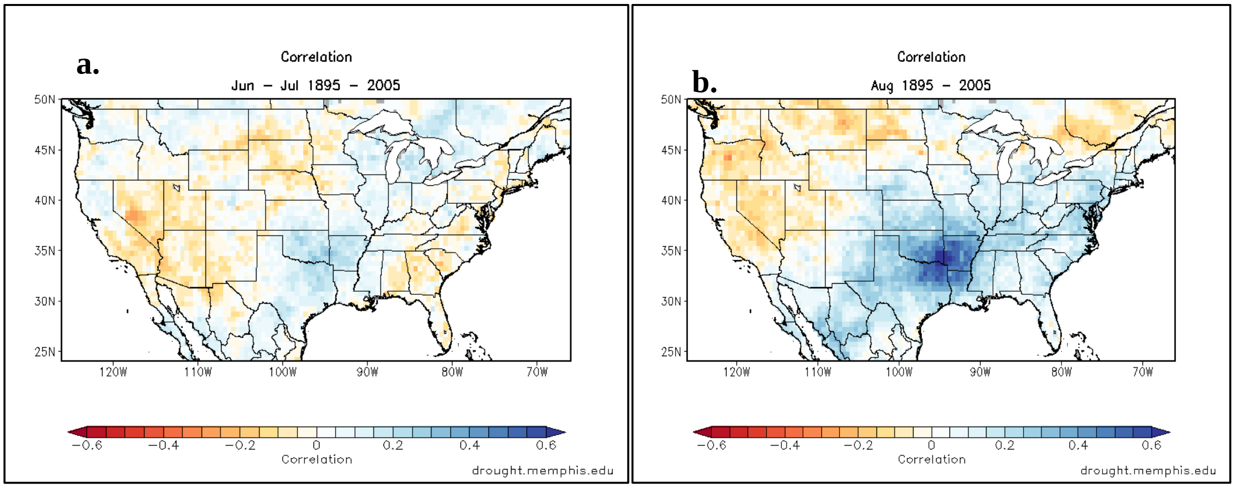

Figure 18. (a) The earlywood width chronology from Linson creek is correlated with the instrumental June-July PDSI for the year prior to earlywood formation. This is the highest PDSI signal detected in the earlywood width chronology from the study area, but the correlations only reach r = 0.3 and are confined to the vicinity of McCurtain County, Oklahoma. (b) The latewood width chronology from Linson Creek is correlated most strongly with August PDSI during the same year as latewood formation, reaching a maximum value of r = 0.7. The spatial pattern of significant correlation between the latewood chronology and August PDSI is much more extensive than that observed with the earlywood chronology and covers much of the south-central United States. The correlations are based on the period of 1895-2005. The PDSI data used in this analysis end in 2005 (Cook et al., 2010).

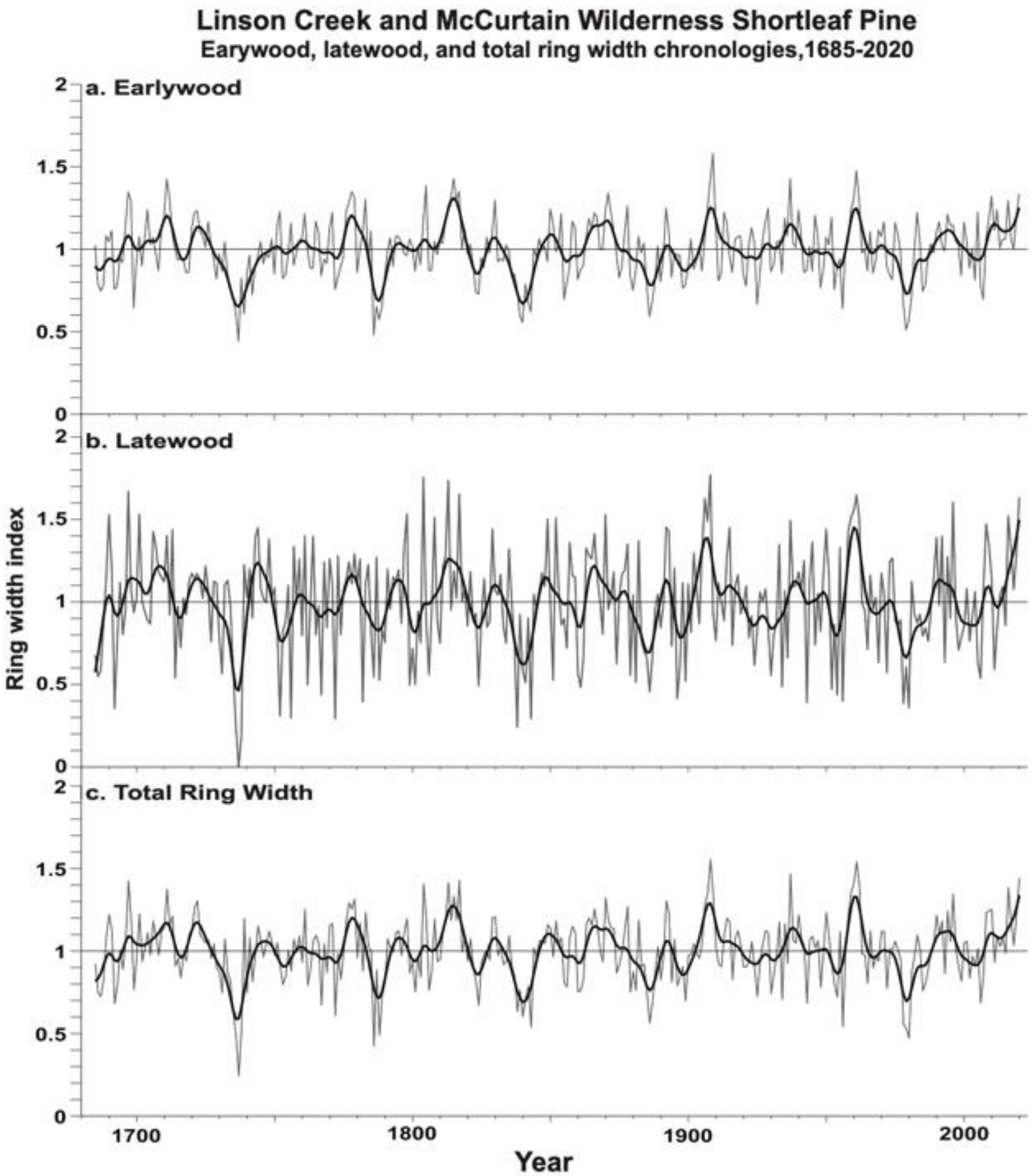

Figure 19. The detrended and standardized mean index chronologies for earlywood, latewood, and total ring-width based on all trees sampled from Linson Creek are combined with those collected nearby decades earlier in the MCWA (Stahle et al., 1985). The time series spans from 1688 to 2021. Years of growth are shown on the x-axes, and ring width indices are shown on the y-axes. A smoothed version, emphasizing decadal variability, is plotted for each chronology. Note that the correlation between the earlywood and latewood chronologies is high (R=.93). Moreover, the agreement between the smoothed versions of the earlywood and latewood chronologies, which reflects the long-term soil moisture signal detected in both the earlywood and latewood width chronologies, appears to be at least as robust, of not more so (See Figure 18).

11. Appendices

Appendix 1: Metadata and info on trees cored in each plot are displayed here.
PLOT: Plot number, labeled 1-21
POS.: Topographic aspect, N (north facing), S (south facing), R (ridgetop)
TREES: Interval of trees sampled from the given plot
DBH: Diameter at Breast Height (cm), averaged for all trees in the given plot
SD: Standard deviation for each preceding average.
AGE: Dendrochronologically dated minimum ages, averaged for each plot
DEN.: Density in stems per hectare of *P. echinata* for each plot
BA: Cumulative basal area in square meters per hectare of *P. echinata* ≥ 10 cm DBH in each plot.
AGE: Qualitative assessment of each plot's age structure made before sampling, Y (young), M (mature), O (old)
COORDINATES: Lat/Long Coordinates of each plot's centroid (+/- 10 m)

Plot	Pos.	Trees	DBH	SD	Age	SD	DEN.	BA	Age	Coordinates
1	R	Lin 4-31	36.9	9.4	104.8	40.6	280	29.6	Y/M	34.29588, -94.65873
2	S	Lin 32-47	35.9	8.9	108.4	31.8	160	18.4	M	34.29419, -94.65249
3	N	Lin 48-72	32.4	9.4	105.9	31.8	250	23.7	O	34.29561, -94.65540
4	R	Lin 73-102	35.5	9.6	108.3	29.6	300	32.2	O	34.29534, -94.65586
5	S	Lin 104-120	35.2	9.6	120.5	30.4	170	17.9	M	34.29426, -94.65308
6	S	Lin 121-138	25.7	9.2	87.9	13.5	180	10.6	Y	34.29458, -94.65395
7	S	Lin 142-171	28.8	9.4	116.6	14.0	300	23.2	O	34.29483, -94.65553
8	N	Lin 172-211	25.7	9.5	94.1	14.3	480	22.6	Y	34.29564, -94.65391
9	N	Lin 212-228	33.5	9.3	112.5	14.5	170	17.0	O	34.29632, -94.65585
10	R	Lin 229-243	30.0	9.4	96.1	14.4	150	12.6	M	34.29455, -94.65267
11	R	Lin 244-257	41.8	9.5	129.3	19.1	120	19.3	O	34.29663, -94.65824
12	S	Lin 261-274	39.0	10.1	144.7	18.7	140	18.3	M	34.29873, -94.65875
13	S	Lin 276-320	25.5	10.2	92.0	19.0	450	24.2	Y	34.29857, -94.65797
14	R	Lin 321-337	41.5	10.2	87.1	18.2	170	23.7	M	34.29837, -94.65487
15	N	Lin 339-362	28.0	10.3	88.0	18.6	240	15.7	Y	34.29875, -94.65371
16	S	Lin 367-396	28.7	10.1	93.8	17.9	280	18.8	M	34.29254, -94.65344
17	N	Lin 401-424	32.4	11.5	88.9	19.6	240	18.7	Y/M	34.29397, -94.65528
18	R	Lin 425-456	29.1	12.5	102.2	20.5	320	23.9	M	34.29356, -94.65587
19	N	Lin 457-479	27.7	12.9	89.9	20.6	230	15.5	O	34.29213, -94.65388
20	R	Lin 480-490	38.7	14.4	86.1	34.4	100	11.6	O	34.29169, -94.65502
21	N	Lin 491-518	32.3	14.4	82.6	34.3	280	24.7	M	34.29210, -94.65500

Appendix 2: Compiled data for all trees cored on and off plot are listed here. Average values for each column are present in the bottom row.
ID: Sample number, LIN01-n
PLOT: Plot number, 1-n, 0=off-plot
DATED: Inner-Outer Dated Rings, Including Ring Counts
MEASURED: Interval of dendrochronologically dated rings able to be measured; excludes ring counts. If n/a, the core in question could not be dated dendrochronologically for more than at least 20 years.
BY: Initials of Individual Recording Data
DBH: Diameter at Breast Height (cm)
RAD: Measurement from inner ring to outer ring on core (cm)
PITH: P (Pith), NP (Near Pith), Blank (Far from pith)
ASP: Aspect of the individual tree from which the core was taken
AGE: Date of innermost dendrochronologically dated ring (including ring count)
RC: Denotes whether the inner ring date is dendrochronologically dated, or just estimated based on the ring count, Y (estimate), Blank (dated).

ID	PLOT	DATED	BY	MEASURED	BY	DBH	RAD	PITH	ASP	AGE	RC
LIN01A	0	1809-2020	DWS	1810-2020	NCD	65	29	NP	W	212	
LIN02A	0	1871-2020	DWS	1872-2020	NCD	49	14		E	150	
LIN03A	0	1809-2013	DWS	1810-2013	NCD	78	33	NP	NW	212	
LIN04A	1	1790-2021	DWS	1791-2020	NCD	57	22	NP	W	231	
LIN05A	1	1925-2012	DWS	1926-2012	NCD	32.5	14.5	NP	NW	96	
LIN06A	1	1863-2021	DWS	1864-1976	NCD	47.5	13.5		N	158	
LIN07A	1	1931-2019	DWS	1932-2018	NCD	38	14.5		NE	90	
LIN08A	1	1790-2021	DWS	1791-1850	NCD	49	20		NW	231	
LIN09A	1	1922-2021	DWS	1923-2011	NCD	25	10.5	NP	NW	99	
LIN10A	1	1924-2021	DWS	1926-2020	NCD	37	17	NP	NW	97	
LIN11A	1	1941-2021	DWS	n/a	NCD	24	13		NW	80	Y
LIN12A	1	1939-2020	DWS	1940-2020	NCD	39	16.5	NP	NW	82	
LIN13A	1	1926-2020	DWS	1927-1977	NCD	37	16.5	NP	N	95	
LIN14A	1	1897-2020	DWS	1917-2020	NCD	49	13.5		N	124	Y
LIN15A	1	1931-2020	DWS	1932-2010	NCD	24	11		N	90	
LIN16A	1	1951-2020	DWS	1964-2020	NCD	35.5	15.5		W	70	
LIN17A	1	1924-2021	NCD	1925-2020	NCD	34	14	NP	N	97	
LIN18A	1	1947-2021	NCD	n/a	NCD	18	10	NP	N	74	
LIN19A	1	1937-2021	NCD	1938-2020	NCD	30	14		S	84	
LIN20A	1	1930-2020	NCD	1940-2020	NCD	39	17	NP	NW	91	Y
LIN21A	1	1924-2020	DWS	1925-2020	NCD	31.5	14.5	NP	N	97	
LIN22A	1	1935-2020	NCD	1936-2020	NCD	33			NW	86	
LIN23A	1	1926-2020	NCD	1927-2020	NCD	48	21.5	NP	NW	95	
LIN24A	1				NCD						
LIN25A	1	1930-2020	NCD	1931-2020	NCD	50.5	22	NP	NW	91	
LIN26A	1				NCD						
LIN27A	1	1929-2020	NCD	1930-2020	NCD	44	18		E	92	

LIN28A	1	1938-2021	NCD	n/a	NCD	31	12.5		S	83	Y
LIN29A	1	1928-2020	NCD	1930-2020	NCD	38.5	17.5	NP	N	93	
LIN30A	1	1923-2020	NCD	1924-2020	NCD	32	13.5	NP	N	98	
LIN31A	1	1921-2020	NCD	1922-2020	NCD	36	15	P	N	100	
LIN32A	2	1897-2020	NCD	1898-2020	NCD	51	24.5		NW	124	
LIN33A	2	1925-2021	NCD	1925-1996	NCD	21.5	7.5	NP	W	96	
LIN34A	2	1924-2021	NCD	1925-2020	NCD	20.5	8.5	NP	W	97	
LIN35A	2	1959-2021	NCD	1960-2020	NCD	37.5	14.5		W	62	
LIN36A	2	1920-2021	NCD	n/a	NCD	40	18.5		W	101	Y
LIN37A	2	1909-2021	NCD	1910-2020	NCD	49	22	NP	NW	112	
LIN38A	2	1944-2021	NCD	1945-2020	NCD	28	11		W	77	
LIN39A	2	1911-2021	NCD	1920-2020	NCD	31	12.5	NP	W	110	Y
LIN40A	2	1920-2021	NCD	1921-2020	NCD	27	12.5	P	W	101	
LIN41A	2	1863-2020	NCD	1868-2020	NCD	43	16	NP	W	158	Y
LIN42A	2	1906-2020	NCD	1926-2020	NCD	57	23.5		NW	115	Y
LIN43A	2	1905-2021	NCD	1907-1977	NCD	21	9	NP	W	116	
LIN44A	2	1923-2021	NCD	1924-2020	NCD	33	17	NP	SW	98	
LIN45A	2	1905-2018	NCD	1907-2017	NCD	31	11.5	P	NW	116	
LIN46A	2	1915-2021	NCD	1916-1987	NCD	20	8.5		W	106	
LIN47A	2	1876-2021	NCD	1893-2020	NCD	64	27		W	145	Y
LIN48A	3	1951-2021	NCD	n/a	NCD	12	5		S	70	Y
LIN49A	3	1911-2020	NCD	1920-2020	NCD	54	17	NP	NW	110	Y
LIN50A	3	1777-2020	NCD	1778-1803	NCD	69	26	P	S	244	
LIN51A	3	1919-2020	NCD	1920-2020	NCD	27	13.5	P	NE	102	
LIN52A	3	1955-2020	NCD	1956-2020	NCD	21	6.5		W	66	
LIN53A	3	1935-2020	NCD	1936-2020	NCD	34	18	NP	W	86	
LIN54A	3	1929-2021	NCD	n/a	NCD	23.5	8		E	92	Y
LIN55A	3	1942-2020	NCD	1943-2019	NCD	17.5	9.5		E	79	
LIN56A	3	1779-2020	NCD	1780-2020	NCD	54	24	P	W	242	
LIN57A	3	1931-2021	NCD	1932-2020	NCD	27	14	NP	E	90	
LIN58A	3	1932-2020	NCD	1934-2020	NCD	38	17		E	89	
LIN59A	3		NCD		NCD						
LIN60A	3	1940-2021	NCD	1941-2020	NCD	28	14		E	81	
LIN61A	3	1932-2020	NCD	1934-2020	NCD	44	16.5		NW	89	
LIN62A	3	1927-2021	NCD	1929-2020	NCD	21	8.5	NP	W	94	
LIN63A	3	1929-2021	NCD	n/a	NCD	15.5	5	NP	NW	92	Y
LIN64A	3	1925-2021	NCD	1931-2020	NCD	42	14.5	NP	NW	96	Y
LIN65A	3	1937-2020	NCD	1938-2019	NCD	48	18		NW	84	
LIN66A	3		NCD		NCD						
LIN67A	3	1936-2021	NCD	n/a	NCD	12			W	85	Y

LIN68A	3	1929-2021	NCD	1930-2020	NCD	31	13	NP	NW	92	
LIN69A	3	1940-2021	NCD	1960-2020	NCD	33	12.5		W	81	Y
LIN70A	3	1808-2020	NCD	1820-2020	NCD	62.5	25		W	213	Y
LIN71A	3	1945-2021	NCD	n/a	NCD	15.5	6.5		S	76	Y
LIN72A	3	1938-2021	NCD	n/a	NCD	15.5	5		NW	83	Y
LIN73A	4	1926-2021	NCD	1927-2020	NCD	40	18.5		E	95	
LIN74A	4	1927-2020	NCD	1929-2020	NCD	32	12.5		W	94	
LIN75A	4	1929-2020	NCD	1930-2014	NCD	36	14		NW	92	
LIN76A	4	1935-2021	NCD	1936-2020	NCD	26	10.5	NP	W	86	
LIN77A	4	1908-2021	NCD	1920-2020	NCD	42	14	NP	NW	113	Y
LIN78A	4	1816-2020	NCD	1817-2020	NCD	63	29	NP	E	205	
LIN79A	4	1899-2020	NCD	1916-2020	NCD	45	13		E	122	Y
LIN80A	4	1813-2021	NCD	1814-1898	NCD	34	17		SW	208	
LIN81A	4	1933-2021	NCD	1934-2019	NCD	25.5	10.5	NP	NW	88	
LIN82A	4	1931-2021	NCD	1932-2020	NCD	16.5	7	NP	NW	90	
LIN83A	4	1933-2020	NCD	1934-2020	NCD	40	18		NW	88	
LIN84A	4	1924-2020	NCD	1925-2019	NCD	39.5	15.5	NP	W	97	
LIN85A	4	1811-2021	NCD	1813-2016	NCD	61.5	22	P	SW	210	
LIN86A	4		NCD		NCD						
LIN87A	4	1954-2020	NCD	1955-2020	NCD	17	7.5		W	67	
LIN88A	4	1812-2020	NCD	1813-2020	NCD	58	24		E	209	
LIN89A	4	1929-2021	NCD	1931-2020	NCD	30	14	P	NW	92	
LIN90A	4	1928-2021	NCD	1929-2021	NCD	29	13	NP	S	93	
LIN91A	4	1941-2021	NCD	n/a	NCD	13	4.5		SW	80	Y
LIN92A	4	1941-2021	NCD	1942-2020	NCD	24	8		S	80	
LIN93A	4	1934-2021	NCD	1935-2020	NCD	41	19		NW	87	
LIN94A	4	1926-2021	NCD	1927-2020	NCD	22	11	NP	N	95	
LIN95A	4	1921-2020	NCD	1922-2020	NCD	36	17	P	NE	100	
LIN96A	4	1924-2021	NCD	1925-2020	NCD	40	17.5		W	97	
LIN97A	4	1928-2020	NCD	1929-2020	NCD	43	16	P	NW	93	
LIN98A	4	1923-2021	NCD	1924-2020	NCD	32	13		SW	98	
LIN99A	4	1925-2020	NCD	1926-2020	NCD	24	9	NP	NW	96	
LIN100A	4	1940-2021	NCD	1941-2020	NCD	30	14		NW	81	
LIN101A	4	1928-2020	NCD	1929-2020	NCD	51	23.5		NW	93	
LIN102A	4	1928-2020	DWS	1929-2020	NCD	38	15	NP	NW	93	
LIN103A*	0	1797-2021	NCD	1798-1920	NCD	72	27		W	224	
LIN104A	5	1944-2020	NCD	1945-2020	NCD	19	7.5		S	77	
LIN105A	5	1879-2021	DWS	1901-2020	NCD	39	16.5	NP	NW	142	Y
LIN106A	5	1937-2021	LG	1938-2020	NCD	25	10.5	NP	N	84	
LIN107A	5	1937-2021	NCD	1938-1997	NCD	17	7.5	NP	NW	84	

LIN108A	5	1935-2020	LG	1936-2020	NCD	32	14.5	NP	N	86	
LIN109A	5	1892-2021	LG	1893-2020	NCD	50	23		SE	129	
LIN110A	5	1885-2021	LG	1892-2020	NCD	40	19.5		NW	136	Y
LIN111A	5	1976-2021	NCD	n/a	NCD	11.5	4		NW	45	Y
LIN112A	5	1927-2021	NCD	1928-2020	NCD		8.5		NW	94	
LIN113A	5	1855-2021	NCD	1856-2020	NCD	41	15.5		SE	166	
LIN114A	5	1945-2021	NCD	n/a	NCD	13	6	NP	W	76	Y
LIN115A	5	1867-2021	NCD	1868-2020	NCD	58.5	26		E	154	
LIN116A	5	1853-2021	NCD	1896-2020	NCD	43	18.5	NP	NW	168	Y
LIN117A	5	1871-2021	NCD	1872-1945	NCD	54	23.5		S	150	
LIN118A	5	1869-2021	NCD	1870-2020	NCD	39.5	18		S	152	
LIN119A	5	1877-2021	NCD	1878-1986	NCD	39	11.5		SE	144	
LIN120A	5	1860-2020	NCD	1861-2020	NCD	41	19.5		N	161	
LIN121A	6	1982-2021	NCD	1983-2021	NCD	12	4		NW	39	
LIN122A	6	1928-2021	NCD	n/a	NCD	12.5	8.5		NW	93	Y
LIN123A	6	1938-2021	NCD	n/a	NCD	16	6		W	83	Y
LIN124A	6	1943-2020	NCD	1944-2020	NCD	25	12		NW	78	
LIN125A	6	1936-2021	NCD	1937-2020	NCD	30.5	13	NP	E	85	
LIN126A	6	1937-2021	NCD	1938-2020	NCD	25	11.5	NP	E	84	
LIN127A	6	1942-2021	NCD	1943-2020	NCD	29.5	10		SW	79	
LIN128A	6	1929-2021	NCD	1930-2020	NCD	32	14	NP	NW	92	
LIN129A	6	1951-2021	NCD	n/a	NCD	15	4.5		SW	70	Y
LIN130A	6	1926-2021	NCD	1927-2020	NCD	35.5	16.5	NP	NW	95	
LIN131A	6	1939-2021	NCD	1940-2020	NCD	24.5	11.5		NW	82	
LIN132A	6	1933-2021	NCD	1934-2020	NCD	30	12.5		NW	88	
LIN133A	6	1942-2021	NCD	1945-2020	NCD	20	9.5		W	79	Y
LIN134A	6	1930-2021	NCD	1931-2020	NCD	27	11.5	P	NW	91	
LIN135A	6	1941-1997	NCD	1943-1997	NCD	26	7.5		NW	80	
LIN136A	6	1908-2021	NCD	1909-2020	NCD	42.5	18.5	NP	NW	113	
LIN137A	6	1960-2021	NCD	n/a	NCD	14			S	61	Y
LIN138A	6	1830-2021	NCD	1900-2020	NCD	46	20	P	NW	191	Y
LIN139A	**0**	1794-2021	NCD	1795-2020	NCD	52.5	24		NW	227	
LIN140A	0	1869-2020	NCD	1870-2020	NCD	65.5	29		NW	152	
LIN141A	0	1782-2020	NCD	1783-2020	NCD	66	24.5		NW	239	
LIN142A	7	1926-2021	NCD	1937-2020	NCD	24.5	11.5		NW	95	Y
LIN143A	7	1803-2020	NCD	1856-2020	NCD	54.5	23	NP	W	218	Y
LIN144A	7	1933-2020	NCD	1934-2020	NCD	20	8	NP	NW	88	
LIN145A	7	1925-2021	NCD	1926-1980	NCD	17	7.5	P	W	96	
LIN146A	7	1909-2020	NCD	1910-2020	NCD	39	16.5	NP	NW	112	
LIN147A	7	1908-2021	NCD	1909-2020	NCD	28	12.5		W	113	

LIN148A	7	1931-2021	NCD	1932-2020	NCD	21.5	9	NP	NW	90	
LIN149A	7	1907-2021	NCD	1916-2020	NCD	21.5	8.5	P	W	114	Y
LIN150A	7	1931-2021	NCD	1932-2020	NCD	21	7.5	P	NW	90	
LIN151A	7	1769-2020	NCD	1770-2020	NCD	59.5	23	NP	NW	252	
LIN152A	7	1784-2021	NCD	1785-2020	NCD	48	15.5		S	237	
LIN153A	7	1874-2020	NCD	1911-2020	NCD	42	21		NE	147	Y
LIN154A	7	1936-2021	NCD	1938-2020	NCD	26	12.5	P	NW	85	
LIN155A	7	1955-2021	NCD	1960-2020	NCD	15.5	5.5	NP	SW	66	Y
LIN156A	7	1861-2020	NCD	1862-2020	NCD	39	16		NW	160	
LIN157A	7	1935-2021	NCD	1936-2020	NCD	35	13	P	SW	86	
LIN158A	7	1863-2021	NCD	1864-2020	NCD	40	15		E	158	
LIN159A	7	1934-2020	NCD	1940-2020	NCD	18.5	8	P	W	87	Y
LIN160A	7	1875-2021	NCD	n/a	NCD	16	7	P	NW	146	Y
LIN161A	7	1945-2021	NCD	1946-2020	NCD	21.5	8		W	76	
LIN162A	7	1856-2021	NCD	1857-2020	NCD	50.5	22.5	NP	NE	165	
LIN163A	7	1937-2021	NCD	1938-1972	NCD	18	5.5	NP	SW	84	
LIN164A	7	1937-2021	NCD	1938-1972	NCD	16.5	6		W	84	
LIN165A	7	1942-2021	NCD	1943-2020	NCD	36	15		SW	79	
LIN166A	7	1931-2021	NCD	1940-2020	NCD	21	8.5	NP	W	90	Y
LIN167A	7	1936-2021	NCD	1937-1998	NCD	19	8	P	W	85	
LIN168A	7	1937-2021	NCD	1938-2020	NCD	28	10.5		SW	84	
LIN169A	7	1938-2021	NCD	1939-2020	NCD	17	6	NP	W	83	
LIN170A	7	1942-2021	NCD	1943-2020	NCD	19.5	7.5		W	79	
LIN171A	7	1871-2021	NCD	1890-2020	NCD	30.5	12		W	150	Y
LIN172A	8	1940-2021	NCD	1948-2020	NCD	37.5	13		NW	81	Y
LIN173A	8	1915-2021	NCD	1926-2020	NCD	37.5	17		NW	106	Y
LIN174A	8	1847-2021	NCD	1857-1980	NCD	39.5	13		NW	174	Y
LIN175A	8	1931-2021	NCD	1934-2020	NCD	24	10	NP	E	90	Y
LIN176A	8	1931-2021	NCD	1932-2020	NCD	31	12	NP	SE	90	
LIN177A	8	1930-2021	NCD	1931-2020	NCD	24.5	9.5	P	NW	91	
LIN178A	8	1940-2021	NCD	n/a	NCD	15.5	7.5	NP	NW	81	Y
LIN179A	8	1914-2021	NCD	1915-2020	NCD	35.5	14	NP	NW	107	
LIN180A	8	1927-2021	NCD	1928-2020	NCD	31	11.5		NW	94	
LIN181A	8	1929-2021	NCD	n/a	NCD	19	6	NP	NW	92	Y
LIN182A	8	1914-2021	NCD	1915-2020	NCD	30.5	12.5		NW	107	
LIN183A	8	1921-2021	NCD	n/a	NCD	14	4.5		SE	100	Y
LIN184A	8	1920-2021	NCD	1921-2020	NCD	28.5	11.5	P	NW	101	
LIN185A	8	1957-2021	NCD	1958-2020	NCD	32.5	15		NW	64	
LIN186A	8	1929-2021	NCD	1930-2020	NCD	27	10		SE	92	
LIN187A	8	1944-2021	NCD	1945-2020	NCD	32.5	15		SE	77	

LIN188A	8	1935-2021	NCD	1936-2020	NCD	21	8		SE	86	
LIN189A	8	1922-2021	NCD	1923-2020	NCD	25	12	NP	SE	99	
LIN190A	8	1925-2021	NCD	1926-2010	NCD	24.5	9.5	NP	NW	96	
LIN191A	8	1906-2021	NCD	1907-2020	NCD	31	14.5	NP	SE	115	
LIN192A	8	1895-2021	NCD	1896-2020	NCD	35	16	NP	SE	126	
LIN193A	8	1926-2021	NCD	n/a	NCD	12.5	4	NP	NW	95	Y
LIN194A	8	1928-2021	NCD	1929-1990	NCD	21	7.5	NP	NW	93	
LIN195A	8		NCD		NCD						
LIN196A	8	1951-2021	NCD	n/a	NCD	16	5	NP	W	70	Y
LIN197A	8	1950-2021	NCD	1951-2020	NCD	23	11.5		SE	71	
LIN198A	8	1944-2021	NCD	1945-1990	NCD	18	6	NP	NW	77	
LIN199A	8	1913-2021	NCD	1930-2020	NCD	37	16	P	SE	108	Y
LIN200A	8	1946-2021	NCD	n/a	NCD	13	6	NP	SE	75	Y
LIN201A	8	1948-2021	NCD	1949-1976	NCD	15	4.5	P	NW	73	
LIN202A	8	1934-2021	NCD	n/a	NCD	16.5	7.5	NP	SE	87	Y
LIN203A	8	1922-2021	NCD	1925-1980	NCD	18	8	P	NW	99	Y
LIN204A	8	1911-2021	NCD	1912-2020	NCD	22	9	NP	NW	110	
LIN205A	8	1947-2021	NCD	n/a	NCD	10.5	4		SE	74	Y
LIN206A	8	1943-2021	NCD	n/a	NCD	13.5	6	NP	NW	78	Y
LIN207A	8	1931-2021	NCD	1932-2020	NCD	32	12		NW	90	
LIN208A	8	1912-2021	NCD	1913-2020	NCD	38.5	18	NP	SE	109	
LIN209A	8	1923-2021	NCD	1924-2020	NCD	22.5	9	NP	NW	98	
LIN210A	8	1925-2021	NCD	1926-2020	NCD	35	17.5		SE	96	
LIN211A	8	1923-2021	NCD	1924-2020	NCD	41	20.5	NP	SE	98	
LIN212A	9	1832-2021	NCD	1833-2020	NCD	54	23.5		E	189	
LIN213A	9	1800-2020	NCD	1801-2020	NCD	52.5	19.5	NP	SE	221	
LIN214A	9	1944-2021	NCD	1971-2020	NCD	36	10		NW	77	Y
LIN215A	9	1927-2021	NCD	n/a	NCD	10.5	3.5	P	W	94	Y
LIN216A	9	1871-2021	NCD	1898-2020	NCD	37.5	16		SE	150	Y
LIN217A	9	1780-2021	NCD	1788-2020	NCD	45.5	15.5	NP	NE	241	Y
LIN218A	9	1883-2021	NCD	1912-2020	NCD	50	11		SW	138	Y
LIN219A	9	1880-2021	NCD	n/a	NCD	23.5	9		E	141	Y
LIN220A	9	1930-2021	NCD	n/a	NCD	18.5	6	NP	NW	91	Y
LIN221A	9	1935-2021	NCD	1936-1979	NCD	20.5	6.5	NP	W	86	
LIN222A	9	1967-2021	NCD	1968-2020	NCD	30.5	8.5		W	54	
LIN223A	9	1943-2021	NCD	1944-2020	NCD	25.5	9.5		NW	78	
LIN224A	9	1954-2021	NCD	1955-2020	NCD	40	15		W	67	
LIN225A	9	1956-2021	NCD	1957-2020	NCD	30	15		NW	65	
LIN226A	9	1903-2020	NCD	1904-2019	NCD	44	11.5		NW	118	
LIN227A	9	1972-2021	NCD	1973-2020	NCD	29	11		SW	49	

LIN228A	9	1968-2021	NCD	1969-2020	NCD	21.5	9		SW	53	
LIN229A	10	1882-2021	NCD	1883-2020	NCD	45.5	22.5		NW	139	
LIN230A	10	1907-2021	NCD	1908-2020	NCD	38.5	14.5	NP	NW	114	
LIN231A	10	1925-2021	NCD	n/a	NCD	22	6	NP	NW	96	Y
LIN232A	10	1868-2021	NCD	1869-2020	NCD	63	25		NW	153	
LIN233A	10	1931-2201	NCD	n/a	NCD	16.5	7		E	90	Y
LIN234A	10	1932-2021	NCD	1934-1976	NCD	21.5	8.5	P	E	89	
LIN235A	10	1933-2021	NCD	1960-2020	NCD	20	7		NW	88	Y
LIN236A	10	1940-2021	NCD	1941-2020	NCD	32	14.5		NW	81	
LIN237A	10	1925-2021	NCD	1927-2020	NCD	43	20.5		NW	96	
LIN238A	10	1936-2021	NCD	1937-2020	NCD	29.5	11.5	NP	W	85	
LIN239A	10	1933-2021	NCD	1934-2020	NCD	25	11	NP	NW	88	
LIN240A	10	1932-2021	NCD	1947-2020	NCD	32	13.5	NP	NW	89	Y
LIN241A	10	1929-2021	NCD	n/a	NCD	11.5	5.5	NP	SW	92	Y
LIN242A	10	1944-2021	NCD	1945-2020	NCD	18	8		NW	77	
LIN243A	10	1957-2021	NCD	1960-2020	NCD	32	15.5		NW	64	Y
LIN244A	0	1802-2021	NCD	1803-2020	NCD	73.5	31.5	NP	N	219	
LIN245A	0	1864-2021	NCD	1865-2020	NCD	66.5	26	NP	SE	157	
LIN246A	11	1880-2020	NCD	1881-2020	NCD	56.5	29		NW	141	
LIN247A	11	1821-2021	NCD	1822-2020	NCD	56	17.5		SE	200	
LIN248A	11	1814-2021	NCD	1815-2020	NCD	65	28		N	207	
LIN249A	11	1851-2021	NCD	1852-2020	NCD	71	31		E	170	
LIN250A	11	1930-2021	NCD	1931-2020	NCD	38.5	16.5	NP	NW	91	
LIN251A	11	1923-2021	NCD	n/a	NCD	38	16	P	W	98	Y
LIN252A	11	1931-2021	NCD	1932-2020	NCD	22.5	10	NP	NW	90	
LIN253A	11	1931-2021	NCD	n/a	NCD	14	6	P	NE	90	Y
LIN254A	11	1941-2021	NCD	1942-2020	NCD	25	9		SW	80	
LIN255A	11	1790-2021	NCD	1791-2020	NCD	53.5	19.5	NP	W	231	
LIN256A	11	1943-2021	NCD	1944-2020	NCD	25	9.5	NP	SW	78	
LIN257A	11	1945-2021	NCD	1946-2020	NCD	36	14		NW	76	
LIN258A	0	1779-2021	NCD	1780-1804	NCD	69	13.5	P	NW	242	
LIN259A	0	1867-2021	NCD	1877-2020	NCD	62.5	26		S	154	Y
LIN260A	0	1879-2021	NCD	1880-2020	NCD	64	32		NW	142	
LIN261A	12	1803-2021	NCD	1860-2020	NCD	43	16.5		NE	218	Y
LIN262A	12	1941-2021	NCD	1942-1996	NCD	14	5	NP	NW	80	
LIN263A	12	1944-2021	NCD	1945-2020	NCD	39	14.5		W	77	
LIN264A	12	1953-2021	NCD	1954-2020	NCD	23	9		E	68	
LIN265A	12	1850-2021	NCD	1878-2020	NCD	55.5	20.5		E	171	Y
LIN266A	12	1889-2021	NCD	1900-2020	NCD	35	16.5		W	132	Y
LIN267A	12	1859-2021	NCD	1860-2020	NCD	45	21		W	162	

LIN268A	12	1905-2021	NCD	n/a	NCD	15.5	6	NP	NE	116	Y
LIN269A	12	1904-2021	NCD	n/a	NCD	41.5	9		W	117	Y
LIN270A	12	1935-2021	NCD	1936-2020	NCD	45.5	14		N	86	
LIN271A	12	1849-2021	NCD	1850-2020	NCD	45.5	17.5		N	172	
LIN272A	12	1840-2021	NCD	1845-2020	NCD	47	19.5		NW	181	Y
LIN273A	12	1779-2021	NCD	1781-1817	NCD	45	18	P	W	242	
LIN274A	12	1817-2021	NCD	1820-2020	NCD	51	26.5		W	204	Y
LIN275A	0	1815-2021	NCD	1841-2020	NCD	60	21.5		W	206	Y
LIN276A	13	1936-2021	NCD	n/a	NCD	33.5	10.5	NP	NW	85	Y
LIN277A	13	1930-2021	NCD	1931-1978	NCD	24.5	9	NP	W	91	
LIN278A	13	1910-2021	NCD	1930-2020	NCD	30	13	NP	NE	111	Y
LIN279A	13	1912-2021	NCD	n/a	NCD	17	8	P	W	109	Y
LIN280A	13	1930-2021	NCD	1931-2020	NCD	25	11.5	NP	W	91	
LIN281A	13	1946-2021	NCD	n/a	NCD	13.5			E	75	Y
LIN282A	13	1925-2021	NCD	1926-2020	NCD	37	13.5	NP	SW	96	
LIN283A	13	1926-2021	NCD	1927-2020	NCD	28.5	12.5	NP	W	95	
LIN284A	13	1926-2021	NCD	1927-2020	NCD	26	11.5	NP	NW	95	
LIN285A	13	1885-2021	NCD	1901-2020	NCD	27	12	NP	W	136	Y
LIN286A	13	1937-2021	NCD	1938-2020	NCD	24.5	9		E	84	
LIN287A	13	1922-2021	NCD	1923-2020	NCD	26	10.5	NP	W	99	
LIN288A	13	1929-2021	NCD	1930-2020	NCD	32.5	13	NP	SE	92	
LIN289A	13	1927-2021	NCD	1928-1993	NCD	19.5	8.5	NP	SE	94	
LIN290A	13	1922-2021	NCD	1923-2020	NCD	22	8.5	NP	SE	99	
LIN291A	13	1872-2021	NCD	1873-2020	NCD	40.5	18		NW	149	
LIN292A	13	1945-2021	NCD	1946-2020	NCD	29	8.5		W	76	
LIN293A	13	1945-2021	NCD	1946-2020	NCD	15	6.5		W	76	
LIN294A	13	1929-2021	NCD	1931-2020	NCD	27	9	P	SE	92	
LIN295A	13	1931-2021	NCD	1933-2020	NCD	31	13	P	NE	90	
LIN296A	13	1935-2021	NCD	1936-2020	NCD	29	12	NP	SW	86	
LIN297A	13	1928-2021	NCD	1929-2020	NCD	31	13	NP	W	93	
LIN298A	13	1941-2021	NCD	1942-2020	NCD	31.5	12.5		W	80	
LIN299A	13	1942-2021	NCD	1943-2020	NCD	22.5	9		NW	79	
LIN300A	13	1928-2021	NCD	1929-2020	NCD	16.5	7	NP	NW	93	
LIN301A	13	1930-2021	NCD	n/a	NCD		8	NP	NW	91	Y
LIN302A	13	1914-2021	NCD	n/a	NCD	12.5	5	NP	W	107	Y
LIN303A	13	1932-2021	NCD	1941-2020	NCD	17	7.5	P	W	89	Y
LIN304A	13	1928-2021	NCD	1929-2020	NCD	29	13	NP	NE	91	
LIN305A	13	1933-2021	NCD	1934-2020	NCD	21	9.5	P	NW	88	
LIN306A	13	1960-2021	NCD	1961-2020	NCD	18.5	7		NE	61	
LIN307A	13	1942-2021	NCD	1943-2020	NCD	26.5	11.5	NP	NW	79	

LIN308A	13	1942-2021	NCD	1943-2020	NCD	20	7.5		W	79	
LIN309A	13	1929-2021	NCD	1940-2020	NCD	36.5	15.5		NW	92	
LIN310A	13	1918-2021	NCD	1941-2020	NCD	42.5	19.5	NP	W	103	Y
LIN311A	13	1931-2021	NCD	n/a	NCD	17	6.5	NP	NW	90	Y
LIN312A	13	1928-2021	NCD	1930-2020	NCD	26	11	NP	E	93	
LIN313A	13	1934-2021	NCD	n/a	NCD	16.5	5.5	NP	NE	87	Y
LIN314A	13	1929-2021	NCD	1930-2020	NCD	30	13	NP	NW	92	
LIN315A	13	1933-2021	NCD	1934-2020	NCD	20.5	8	NP	NW	88	
LIN316A	13	1933-2021	NCD	1936-2020	NCD	28.5	12	NP	NW	88	Y
LIN317A	13	1918-2021	NCD	1919-1980	NCD	19	8.5	NP	NW	103	
LIN318A	13	1933-2021	NCD	1934-2020	NCD	20.5	8		NW	88	
LIN319A	13	1943-2021	NCD	1944-2020	NCD	24.5	10		W	78	
LIN320A	13	1932-2021	NCD	1933-2020	NCD	35.5	15	NP	SW	89	
LIN321A	14	1935-2021	NCD	1936-2020	NCD	47.5	20.5	NP	NW	86	
LIN322A	14	1934-2021	NCD	n/a	NCD	24	10	P	NW	87	Y
LIN323A	14	1944-2021	NCD	1945-2020	NCD	46	21		NE	77	
LIN324A	14	1928-2021	NCD	1929-2020	NCD	31.5	14	NP	NE	93	
LIN325A	14	1946-2021	NCD	1947-2020	NCD	47	18.5		NW	75	
LIN326A	14	1931-2021	NCD	1933-2020	NCD	38	15.5	P	NW	90	
LIN327A	14	1923-2021	NCD	1924-2020	NCD	40	17.5	NP	NW	98	
LIN328A	14	1922-2021	NCD	1931-2020	NCD	35.5	16.5		SE	99	Y
LIN329A	14	1924-2021	NCD	1925-2020	NCD	44.5	18	NP	NE	97	
LIN330A	14	1936-2021	NCD	1937-2020	NCD	38	18	NP	NW	85	
LIN331A	14	1929-2021	NCD	1930-2020	NCD	48.5	20.5	NP	NW	92	
LIN332A	14	1933-2021	NCD	1934-2020	NCD	41	17	NP	E	88	
LIN333A	14	1934-2021	NCD	1939-2020	NCD	49	20.5	P	NW	87	Y
LIN334A	14	1940-2021	NCD	1951-2020	NCD	34	12	NP	SW	81	Y
LIN335A	14	1948-2021	NCD	1949-2020	NCD	50.5	18.5		NW	73	
LIN336A	14	1931-2021	NCD	1936-2020	NCD	41.5	17	NP	NE	90	Y
LIN337A	14	1939-2021	NCD	1946-2020	NCD	49	21.5		E	82	Y
LIN338A	0	1844-2021	NCD	1845-2020	NCD	83.5	31.5	NP	SE	177	
LIN339A	15	1937-2021	NCD	1938-2020	NCD	36.5	15.5		NW	84	
LIN340A	15	1923-2021	NCD	n/a	NCD	23.5	8	NP	W	98	Y
LIN341A	15	1936-2021	NCD	n/a	NCD	15	5	NP	NW	85	Y
LIN342A	15	1935-2021	NCD	n/a	NCD	15.5	6.5	NP	E	86	Y
LIN343A	15	1938-2021	NCD	1939-2020	NCD	34.5	13		NW	83	
LIN344A	15	1960-2021	NCD	1961-2020	NCD	28.5	12.5		NE	61	
LIN345A	15	1926-2021	NCD	1928-2020	NCD	33.5	15	NP	NW	95	
LIN346A	15	1943-2021	NCD	n/a	NCD	39	13.5		NW	78	Y
LIN347A	15	1922-2021	NCD	n/a	NCD	31	14	NP	E	99	Y

LIN348A	15	1917-2021	NCD	n/a	NCD	29	11.5	P	W	104	Y
LIN349A	15	1927-2021	NCD	n/a	NCD	20.5	9	P	NW	94	Y
LIN350A	15	1923-2021	NCD	1924-2020	NCD	35	17		NE	98	
LIN351A	15	1935-2021	NCD	n/a	NCD	28.5	13		NW	86	Y
LIN352A	15	1938-2021	NCD	n/a	NCD	28	11.5		NW	83	Y
LIN353A	15	1934-2021	NCD	n/a	NCD	18.5	6.5	NP	SE	87	Y
LIN354A	15	1962-2021	NCD	1963-2020	NCD	22.5	7.5		W	59	
LIN355A	15	1948-2021	NCD	1949-2020	NCD	36	11.5		NE	73	
LIN356A	15	1931-2021	NCD	1932-2020	NCD	32.5	13		NW	90	
LIN357A	15	1935-2021	NCD	1936-2020	NCD	29.5	11		SW	86	
LIN358A	15	1914-2021	NCD	1927-2020	NCD	40.5	19.5	NP	E	107	Y
LIN359A	15	1933-2021	NCD	1934-2020	NCD	31	14.5		NE	88	
LIN360A	15	1921-2021	NCD	1922-1996	NCD	18.5	6.5	NP	NW	100	
LIN361A	15	1929-2021	NCD	n/a	NCD	20	9	NP	E	92	Y
LIN362A	15	1925-2021	NCD	1926-1999	NCD	24	10	NP	E	96	
LIN363A	0	1793-2021	NCD	1794-2020	NCD		34	P	S	228	
LIN364A	0	1791-2021	NCD	1792-2020	NCD		27	P	NE	230	
LIN365A	0	1743-2021	NCD	1744-2020	NCD		28		SE	278	
LIN366A	0	1880-2021	NCD	1881-1979	NCD	61.5	27.5		W	141	
LIN367A	0	1790-2021	NCD	1791-2020	NCD	57	27		E	231	
LIN368A	0	1860-2021	NCD	1861-2020	NCD	63	26.5	P	E	161	
LIN369A	16	1893-2021	NCD	1894-2020	NCD	35.5	14.5		SW	128	
LIN370A	16	1924-2021	NCD	1925-2020	NCD	23	11.5	P	SW	97	
LIN371A	16	1927-2021	NCD	1928-2020	NCD	27	11		W	94	
LIN372A	16	1922-2021	NCD	1923-2020	NCD	23.5	9	P	W	99	
LIN373A	16	1906-2021	NCD	1907-1984	NCD	29	12.5		NW	115	
LIN374A	16	1871-2021	NCD	1872-2020	NCD	51	21.5		E	150	
LIN375A	16	1945-2021	NCD	1946-2020	NCD	29	12.5		NE	76	
LIN376A	16	1923-1979	NCD	1924-1969	NCD	14.5	4.5	NP (inc)	NE	98	
LIN377A	16	1933-2021	NCD	1934-2020	NCD	34	12.5	NP	E	88	
LIN378A	16	1910-2021	NCD	1911-2020	NCD	37.5	18		NW	111	
LIN379A	16	1930-2021	NCD	1931-2020	NCD	29.5	15		NW	91	
LIN380A	16	1928-2021	NCD	1929-2020	NCD		15.5		E	93	
LIN381A	16	1918-2021	NCD	1919-2020	NCD	36.5	14.5	NP	W	103	
LIN382A	16	1934-2021	NCD	1935-1976	NCD	21	8	NP	NE	87	
LIN383A	16	1930-2021	NCD	1931-2020	NCD	27	11	NP	E	91	
LIN384A	16	1927-2021	NCD	n/a	NCD	16	7.5	NP	NW	94	Y
LIN385A	16	1934-2021	NCD	1935-2020	NCD	39.5	16.5		E	87	
LIN386A	16	1928-2021	NCD	1929-2020	NCD	33	13	NP	NW	93	
LIN387A	16	1945-2021	NCD	1946-2020	NCD	31.5	11.5		SW	76	

LIN388A	16	1939-2021	NCD	1941-2004	NCD	17.5	8		NW	82	
LIN389A	16	1938-2021	NCD	1939-2020	NCD	23	10.5		E	83	
LIN390A	16	1951-2021	NCD	1952-2020	NCD	34	14		E	70	
LIN391A	16	1951-2021	NCD	1952-2020	NCD	27	12		SE	70	
LIN392A	16	1949-2021	NCD	1950-2013	NCD	25	10.5		W	72	
LIN393A	16	1929-2021	NCD	1930-2020	NCD	24.5	8	NP	E	92	
LIN394A	16	1922-2021	NCD	1923-2020	NCD	32	13.5	P	NW	99	
LIN395A	16	1934-2021	NCD	1935-2020	NCD	21.5	7		W	87	
LIN396A	16	1920-2021	NCD	1921-2020	NCD	33	12.5	P	W	101	
LIN397A	0	1884-2021	NCD	1890-2020	NCD	52	22.5		SW	137	Y
LIN398A	0	1856-2021	NCD	1857-2020	NCD	61	29	NP	NW	165	
LIN399A	0	1801-2021	NCD	1802-2020	NCD	54	20.5	NP	SW	220	
LIN400A	0	1829-2021	NCD	1830-2020	NCD	78	30.5	NP	NW	192	
LIN401A	17	1923-2021	NCD	1924-2020	NCD	36	14	NP	NE	98	
LIN402A	17	1949-2021	NCD	1950-2020	NCD	32	12		NW	72	
LIN403A	17	1922-2021	NCD	1923-2020	NCD	43	21.5	NP	NW	99	
LIN404A	17	1939-2021	NCD	1940-2020	NCD	32.5	13.5		NE	82	
LIN405A	17	1925-2021	NCD	1926-2020	NCD	27	12.5	NP	NE	96	
LIN406A	17	1928-2021	NCD	1929-2020	NCD	32	12.5	NP	W	93	
LIN407A	17	1927-2021	NCD	1928-2020	NCD	35.5	16.5		E	94	
LIN408A	17	1926-2021	NCD	1927-1977	NCD	19.5	7.5	NP	NW	95	
LIN409A	17	1928-2021	NCD	1929-2020	NCD	46	17.5		NW	93	
LIN410A	17		NCD		NCD						
LIN411A	17		NCD		NCD						
LIN412A	17		NCD		NCD						
LIN413A	17	1931-2021	NCD	1936-2020	NCD	38	13		W	90	Y
LIN414A	17	1930-2021	NCD	1931-2020	NCD	33	11	NP	NW	91	
LIN415A	17	1936-2021	NCD	1937-2020	NCD	33	12		W	85	
LIN416A	17	1947-2021	NCD	1948-2020	NCD	49.5	19.5		W	74	
LIN417A	17	1933-2021	NCD	1934-2020	NCD	22	8		NW	88	
LIN418A	17	1944-2021	NCD	1945-2020	NCD	37	15		NE	77	
LIN419A	17	1924-2021	NCD	1925-2020	NCD	46.5	20	NP	SE	97	
LIN420A	17	1933-2021	NCD	1934-2020	NCD	18.5	8.5		SE	88	
LIN421A	17	1931-2021	NCD	1932-2020	NCD	24	10	NP	SE	90	
LIN422A	17	1928-2021	NCD	1929-2000	NCD	17.5	8	NP	W	93	
LIN423A	17	1933-2021	NCD	1934-2020	NCD	38.5	19	NP	SE	88	
LIN424A	17	1938-2021	NCD	1939-1990	NCD	18.5	8		SW	83	
LIN425A	18	1782-2021	NCD	1850-2020	NCD	52	22.5	NP	NW	239	Y
LIN426A	18	1776-2021	NCD	1849-2020	NCD	48.5	24.5	NP	SW	245	Y
LIN427A	18	1926-2021	NCD	1927-2020	NCD	37.5	15	P	SW	95	

LIN428A	18	1940-2021	NCD	1941-2020	NCD	31.5	12		NW	81	
LIN429A	18	1937-2021	NCD	1938-2020	NCD	40	16.5		W	84	
LIN430A	18	1927-2021	NCD	1934-2020	NCD	29	12	P	NW	94	Y
LIN431A	18	1932-2021	NCD	1933-2020	NCD	14.5	7	P	NW	89	
LIN432A	18	1926-2021	NCD	1929-2020	NCD	27	11	P	N	95	Y
LIN433A	18	1933-2021	NCD	1934-2020	NCD	23.5	11	P	NW	88	
LIN434A	18	1936-2021	NCD	1937-2020	NCD	13	5	NP	E	85	
LIN435A	18	1930-2021	NCD	1931-2020	NCD	16	7.5	NP	NW	91	
LIN436A	18	1930-2021	NCD	1931-1970	NCD	15	6.5	NP	NW	91	
LIN437A	18	1928-2021	NCD	1929-2020	NCD	41	18	NP	NW	93	
LIN438A	18	1926-2021	NCD	1927-1990	NCD	16	7	P	NW	95	
LIN439A	18	1924-2021	NCD	1925-1975	NCD	16	7	NP	NW	97	
LIN440A	18	1927-2021	NCD	1928-2020	NCD	25	10	P	SW	94	
LIN441A	18	1929-2021	NCD	1930-1976	NCD	20	8.5	NP	W	92	
LIN442A	18	1928-2021	NCD	1929-2020	NCD	36	14	NP	NW	93	
LIN443A	18	1928-2021	NCD	1929-2020	NCD	30.5	12	NP	NW	93	
LIN444A	18	1923-2021	NCD	1924-2020	NCD	26.5	10.5	NP	NW	98	
LIN445A	18	1931-2021	NCD	1932-2020	NCD	32.5	12.5		W	90	
LIN446A	18	1931-2021	NCD	1932-2020	NCD	35	15		SW	90	
LIN447A	18	1934-2021	NCD	1935-2020	NCD	25.5	8.5		W	87	
LIN448A	18	1932-2021	NCD	1933-2020	NCD	28.5	14	NP	SW	89	
LIN449A	18	1931-2021	NCD	1933-2020	NCD	24.5	10	NP	NW	90	
LIN450A	18	1932-2021	NCD	1933-2020	NCD	27.5	10.5		SE	89	
LIN451A	18	1921-2021	NCD	1922-1970	NCD	22.5	9		NW	100	
LIN452A	18	1931-2021	NCD	1932-2020	NCD	24	10	NP	NW	90	
LIN453A	18	1925-2021	NCD	1926-2020	NCD	36.5	17	NP	NW	96	
LIN454A	18	1932-2021	NCD	1933-2020	NCD	30.5	15		NW	89	
LIN455A	18	1892-2021	NCD	1893-2020	NCD	47	20		W	129	
LIN456A	18	1923-2021	NCD	1924-2020	NCD	39.5	17.5		W	98	
LIN457A	19	1921-2021	NCD	1938-2020	NCD	27	12	NP	NW	100	Y
LIN458A	19	1903-2021	NCD	n/a	NCD	49.5	7.5		NW	118	Y
LIN459A	19	1930-2021	NCD	1931-2020	NCD	19.5	8.5	NP	NE	91	
LIN460A	19	1938-2021	NCD	1939-1990	NCD	11	4.5	NP	NW	83	
LIN461A	19	1946-2021	NCD	1947-2019	NCD	26	11		E	75	
LIN462A	19	1937-2021	NCD	1938-2020	NCD	17	14.5		W	82	
LIN463A	19	1938-2021	NCD	1939-1983	NCD	17.5	8	NP	E	83	
LIN464A	19	1940-2021	NCD	1941-2020	NCD	20.5	10.5		W	81	
LIN465A	19	1925-2021	NCD	1926-2020	NCD	28.5	11		W	96	
LIN466A	19	1910-2021	NCD	1911-2020	NCD	36	14.5	NP	E	111	
LIN467A	19	1922-2021	NCD	1923-2020	NCD	23	9.5		NE	99	

LIN468A	19	1936-2021	NCD	1937-1977	NCD	13	6		W	85	
LIN469A	19	1944-2021	NCD	1945-2020	NCD	25.5	8		W	77	
LIN470A	19	1942-2021	NCD	1943-2020	NCD	32	11			79	
LIN471A	19	1935-2021	NCD	1936-2020	NCD	36	13		W	86	
LIN472A	19	1926-2021	NCD	1927-2016	NCD	26.5	10.5	NP	W	95	
LIN473A	19	1932-2021	NCD	1933-2020	NCD	33.5	14	NP	W	89	
LIN474A	19	1925-2021	NCD	1926-2020	NCD	23	10	NP	W	96	
LIN475A	19	1934-2021	NCD	n/a	NCD	20.5	9	NP	W	87	Y
LIN476A	19	1931-2021	NCD	1932-2020	NCD	28	10.5		SE	90	
LIN477A	19	1947-2021	NCD	1948-2020	NCD	36	10.5		W	74	
LIN478A	19	1931-2021	NCD	1932-2020	NCD	43	19	NP	W	90	
LIN479A	19	1923-2021	NCD	1924-2020	NCD	43.5	19		W	100	
LIN480A	20	1952-2021	NCD	n/a	NCD	15	9		NW	69	Y
LIN481A	20	1908-2021	NCD	1909-2020	NCD	55	22	NP	NW	113	
LIN482A	20	1938-2021	NCD	1939-2020	NCD	44.5	18				
LIN483A	20	1932-2021	NCD	1933-2020	NCD	49	22		NW	83	
LIN484A	20	1940-2021	NCD	1941-2020	NCD	42.5	17		N	80	
LIN485A	20	1922-2021	NCD	1923-2020	NCD	49	20.5	P	W	99	
LIN486A	20	1933-2021	NCD	1934-2020	NCD	35.5	14	NP	NW	88	
LIN487A	20	1942-2021	NCD	1943-2020	NCD	30.5	13		W	79	
LIN488A	20	1940-2021	NCD	1941-2016	NCD	27	10		W	81	
LIN489A	20		NCD		NCD						
LIN490A	0	1794-2021	NCD	1903-2020	NCD	66.5	31	P	NE	227	Y
LIN491A	21	1942-2021	NCD	1943-2020	NCD	45.5	16		W	79	
LIN492A	21	1936-2021	NCD	1937-2020	NCD	39	21.5	NP	E	85	
LIN493A	21	1936-2021	NCD	1937-2020	NCD	31.5	13		NW	85	
LIN494A	21	1938-2021	NCD	1939-2020	NCD	36	16.5		E	83	
LIN495A	21	1933-2021	NCD	1934-2020	NCD	41	20	NP	SE	88	
LIN496A	21	1937-2021	NCD	1938-2020	NCD	34	14		W	84	
LIN497A	21	1945-2021	NCD	1946-2020	NCD	22.5	10.5		SE	75	
LIN498A	21	1940-2021	NCD	1941-2020	NCD	35.5	14.5	NP	E	81	
LIN499A	21	1951-2021	NCD	1952-2020	NCD	22	7.5		W	70	
LIN500A	21	1934-2021	NCD	n/a	NCD	27	8	NP	NW	87	Y
LIN501A	21	1930-2021	NCD	1931-2020	NCD	48.5	18	P	NW	91	
LIN502A	21	1931-2021	NCD	1933-2020	NCD	41	18.5	NP	SE	90	
LIN503A	21	1928-2021	NCD	1929-2020	NCD	32	15	NP	E	93	
LIN504A	21	1936-2021	NCD	1938-2020	NCD	28.5	10.5	NP	NW	85	
LIN505A	21	1930-2021	NCD	1931-2020	NCD	24.5	8.5	P	NW	91	
LIN506A	21	1931-2021	NCD	1932-2020	NCD	34.5	16.5	P	SE	90	
LIN507A	21	1945-2021	NCD	1946-2020	NCD	42	20.5		SE	76	

LIN508A	21	1944-2021	NCD	1945-1980	NCD	17	6		SW	77	
LIN509A	21	1944-2021	NCD	1945-2020	NCD	44	19.5		NW	77	
LIN510A	21	1939-2021	NCD	1940-2020	NCD	26.5	10.5	NP	NW	82	
LIN511A	21	1943-2021	NCD	1945-2020	NCD	21.5	9.5		NW	78	
LIN512A	21	1953-2021	NCD	1954-2014	NCD	21	6.5		NW	68	
LIN513A	21	1944-2021	NCD	1945-2020	NCD	37	17.5		SE	77	
LIN514A	21	1945-2021	NCD	1946-2010	NCD	22	8		NW	76	
LIN515A	21	1924-2021	NCD	1925-2020	NCD	43	19	P	SE	97	
LIN516A	21	1937-2021	NCD	1938-2020	NCD	27	13.5		NW	84	
LIN517A	21	1954-2021	NCD	n/a	NCD	18.5	7		NW	67	Y
LIN518A	21	1923-2021	NCD	1924-2020	NCD	41.5	20	P	SE	98	
LIN519A	0	1825-2021	NCD	1858-2020	NCD	52	20		NW	196	Y
LIN520A	0	1833-2021	NCD	1834-2020	NCD	71.5	33		SE	188	
LIN521A	0	1852-2021	NCD	1853-2020	NCD	61	22.5	NP	SW	169	
LIN522A	0	1853-2021	NCD	1854-2020	NCD	60.5	24.5	NP	NW	168	
LIN523A	0	1903-2021	NCD	1904-2020	NCD	58	27.5	NP	S	118	