

RESTORATION OF A LONGLEAF PINE ECOSYSTEM IN EAST TEXAS
Senior Honors Thesis

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by

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ABSTRACT

Longleaf Pine (*Pinus palustris*) ecosystems, among the most species-rich in the temperate zone, once dominated the southeastern coastal plain of the United States, but now, as a result of fire suppression, land use changes, logging, and exotic invasion, less than 3% of original longleaf communities remain. Restoration programs have been initiated throughout the native range to reestablish these ecosystems. Two problems of particular concern are whether recovery of the ground layer can occur naturally and what level of shrub control is required to permit ground layer recovery. These questions were addressed at a site in Big Thicket National Preserve, Texas where restoration was initiated June 2003 by canopy reduction, burning, and selective herbiciding. I quantitatively measured species composition of the herb, shrub, and canopy layers to determine how many desirable species had persisted on the site, whether invasive species were colonizing, and whether the shrubs or canopy trees were suppressing herb-layer composition or richness. After the first growing season, live tree basal area was 9.03 ± 4.64 m²/ha, live tree density was 127.1 ± 101.2 trees/ha, tall shrubs (>1m) covered 1176 m²/ha (nearly 12%), low shrubs (<1m) covered approximately 13%, ground layer cover was approximately 25%, and the remaining 50% was bare ground. In all, approximately 159 species were found, with *Eupatorium capillifolium* being the most important forb and *Dichanthelium* spp. being the most abundant graminoids. Although diversity appears to be lower than in mature longleaf sites, several desired forbs (e.g. *Pityopsis graminifolia*, *Liatris elegans*) and graminoids (e.g. *Schizachyrium scoparium*, *Bulbostylis ciliatifolia*) were present. Some aggressive early successional species (e.g. *Eupatorium capillifolium*, *Andropogon virginicus*, *Conyza canadensis*) were also present. Woody shrubs did not negatively impact herb species. Nevertheless, their rapid recovery and the presence of undesirable species suggests that a fire regime of frequent, low intensity fires needs to be continued in order to fully restore the native vegetation. Additionally, some manual planting of desired herbs may be necessary to increase herb coverage and prevent the colonization of exotic species.

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INTRODUCTION

This study aims to investigate a longleaf pine (*Pinus palustris*) restoration project begun by the Big Thicket National Preserve and The Nature Conservancy. The site was converted from its native longleaf pine community type to a slash (*Pinus elliottii*) and loblolly (*P. taeda*) pine plantation in the mid 1960s. In this project, I evaluate the success of the first year after site conversion back to native longleaf by comparing the current ground layer vegetation (post logging and burning) to literature data of mature longleaf pine stands and other sandhill communities. The project also addresses the impacts of trees and shrubs on the herbaceous ground cover in the site and the success of colonization and survival of native herbs and longleaf seedlings.

The main objective of this study was to determine whether active species reintroduction would be necessary for restoration by studying the presence, abundance, and richness of native sandhill herbs. Primary questions to be addressed were whether native ground layer vegetation could recover naturally and what level of shrub control might be necessary to ensure native ground layer success. By comparing the composition of the ground layer to that of other longleaf pine communities we can better understand the prospects for full restoration, and make suggestions for additional actions to further increase the abundance, presence and richness of the ground cover. I also sought to generate a better understanding of competition and successional processes by studying the impacts of shrub/hardwood encroachment, alien/weed colonization, and tree basal area on the herbaceous groundcover. By restoring desirable vegetation to the community we will increase acreage of a historically important landscape type and possibly provide suitable habitat for endangered plants and animals that rely on longleaf stands for habitat (Harcombe et al. 1993, Outcalt et al. 1996, NPS 2001).

LITERATURE REVIEW

Prior to European settlement, native longleaf pine (*Pinus palustris*) stretched from Eastern Virginia through the coastal plain and into Eastern Texas. Longleaf pine covered an estimated 92 million acres (37 million hectares) and was found across as much as 59% of this region (Figure 1). Of these stands, approximately 74 million acres were dominated by longleaf pine with the remaining 18 million acres in mixed stands (Frost 1993). Figure 2 shows the historic distribution of longleaf pine in the Big Thicket Region of East Texas (Harcombe et al. 1993).

The abundance of longleaf decreased quickly as European settlers began clearing land for settlement. The introduction of water-powered sawmills, steamboats, and railroads in the 1700-1800s allowed for increased clearing of longleaf pine stands (Frost 1993). By the mid 1800s, longleaf pine was being used for turpentine, tar, pitch, and rosin (collectively called naval stores), particularly in North Carolina and Virginia (Mohr 1896). Into the 1930s, continued logging, the introduction of feral hogs, fire suppression, and the conversion of longleaf pine communities to pine plantations resulted in additional losses. Today, longleaf pine has been displaced from 97% of the lands it once occupied, and covers only 2.5 million acres (Frost 1993).

Much of East Texas escaped the damage caused by European settlers until the 1820s when land west of Florida was purchased for the United States (Frost 1993). Settlement exposed longleaf pines of the Gulf Coastal Plains to lumbering and farming, decreasing stands throughout the region (Quarterman and Keever 1962, Delcourt and Delcourt 1977, Schafale and Harcombe 1983, Walker & Oswald 2000). In addition, active fire suppression, beginning between 1920 to 1950, altered the natural fire regime resulting in changes within the longleaf pine ecosystem (Frost 1993). In 1930 the first pine plantation was established in Texas (Frost 1993). By the 1940s pine plantations were expanding, and between 1965 and 1967 nearly 12.5 million acres were established (Boyce 1979, Frost 1993). These plantations were primarily

loblolly and slash pine, displacing longleaf from its native sites (Frost 1993, Outcalt and Outcalt 1994).

While losses in longleaf pine acreage are obviously detrimental for *P. palustris*, habitat loss is critical for the associated groundcover of these communities. The canopy of longleaf pine dominated stands can be practically monospecific, but the understory is rich in biological diversity (Simberloff 1993). Mesic longleaf woodlands have been observed with up to 140 species per square meter, making them one of the most diverse ecosystems in the world (Walker and Peet 1983, Peet and Allard 1993). Longleaf savannas may contain over 40 species per square meter, which is still highly diverse compared to other temperate and North American community types (Peet and Allard 1993, Peet et al. 1990a). While they may be similar in stand structure and richness to loblolly, slash, and shortleaf pine communities, longleaf pine areas contain significantly more herbaceous species and greater herb cover (Hedman et al 2000).

The diverse ground layer species of longleaf pine ecosystems have evolved to thrive in and depend upon the low intensity, frequent fires that naturally burn these communities (Lemon 1949, Platt et al. 1991, Waldrop et al. 1992, Glitzenstein et al. 2001, Reinhard and Menges 2004). Most herbaceous plants associated with longleaf pine ecosystems respond positively to fire by increased flowering, fruiting, and/or seed germination (Lemon 1949, Wood 1981, Whelan 1985, Platt et al. 1988, Anderson and Menges 1997, Carrington and Keeley 1997, Reinhart and Menges 2000). Periodic fire increases herb layer richness, diversity and evenness (Gilliam and Christensen 1986, Brockway and Lewis 1997).

In addition to having a rich herbaceous ground layer, longleaf pine communities are important as habitats for many rare, endangered, and endemic plants and animals. The understories of longleaf pine communities harbor nearly 200 rare and 96 narrowly endemic (occurring only in one state) species (Hardin and White 1989, Walker 1993, Walker). Red-Cockaded Woodpeckers reside within the native range of longleaf pine communities and depend on these systems for survival (Wahlenburg 1946, Daniels 1997). These birds, which are now endangered due in part to habitat destruction, prefer the longleaf pine for nesting and foraging (Jackson 1971, Daniels 1997). In addition, the longleaf pine habitat is home to various

amphibians, reptiles and endemic arthropods (Guyer and Bailey 1993, Folkerts et al. 1993, Means et al. 1996, Outcalt 2000).

The longleaf pine-bluestem ranges of east Texas provide excellent habitat for bobwhite quail (Grelen and Duvall 1966). In addition to the Red-Cockaded Woodpecker, other east Texas species of concern include the Bachman's Sparrow, the Rafinesque's Big-eared Bat, the Louisiana Pine Snake, the Northern Scarlet Snake, and the Timber Rattlesnake (Table 1) (Harper et al. 1998, NPS 2001, Texas Monitoring Report 2002). Two plants of concern are the Slender Gay Feather and Texas Trailing Phlox, both endemic to Southeast, TX (NPS 2001). These species rely on an open understory, created by frequent burning, for survival (Simberloff 1993, Schwellung et al. [no date], NPS 2001).

The high diversity and important habitat provided by longleaf pine forests make restoration efforts a high priority. Because of its importance as a commercial tree in the 1880s, longleaf pine became one of the first forest plants to be extensively studied (Frost 1993). During early observations, foresters and botanists noticed that logged-over longleaf communities were often limited in their ability to regrow due to the influence of fire suppression and feral hogs (Ashe 1894, Frost 1993). A study by Sherrard in 1903 in South Carolina showed that when both fire and hogs were excluded from plots, longleaf pine was replaced by slash pine (*P. elliotii*). While slash pine is not native to east Texas, this is just one example of the importance of fire in maintaining longleaf pine community composition. In addition, fragmentation limits regeneration by improving access to longleaf seedlings and herbaceous ground layer by hogs, pocket gophers and deer. Fragmentation also interrupts the essential fire regime (Simberloff 1993).

Numerous studies have been conducted on the influence of fire frequency, intensity, and time of burn on the richness, diversity, composition and structure of longleaf pine communities. In the past 50 years, fire suppression has led to canopy closing in savanna areas, the encroachment of hardwoods and shade-tolerant species, and a decrease in herbaceous life (Quartermann & Keefer 1962, Komarek 1974, Myers and Peroni 1983, Glitzenstein et al. 1986, Christensen 1988, Platt et al. 1988, Martin et al. 1993, Ware et al. 1993, Schwartz 1994, Sparks et al. 1998). Studies (Marks and Harcombe 1981, Streng and Harcombe 1982, Schafale and

Harcombe 1983, Liu 1994, Brockway and Lewis 1997, Liu et al. 1997a,b, 2004) suggest that natural fire and prescribed burning help to maintain an open herbaceous ground layer. Dry sites that are not maintained with fire may develop woody understories (Harcombe et al. 1993, Menges & Hawkes 1998, Gilliam & Platt 1999).

In the absence of fire, perhaps the greatest threat to longleaf communities is encroachment by other woody species. Long-term fire exclusion results in the encroachment of dense hardwoods into the large spaces between longleaf stems, changing tree species composition and stand structure (Gilliam and Platt 1999). Hardwood encroachment may cause the forest type to convert to climax communities of Beech and Magnolia or other hardwoods (Marks and Harcombe 1981, Glitzenstein et al. 1986). The intruding hardwoods, such as *Q. hemisphaerica*, *Q. marylandica*, and *Carya spp*, compete for light and shade out the rich ground layer herbs (Menges and Hawkes 1998, Gilliam and Platt 1999). As grass and needle fuel loads are replaced with moisture rich leaf loads, communities may change from flammable to nonflammable and effectively “escape” from fire. (Streng & Harcombe 1992). Fire suppression may also cause a community to switch to loblolly pine or non-native slash pine dominance due to the higher seed production, rapid germination, and rapid growth of these two species (Boyer [no date], Schmidting 1987, Walker 1999, Smith 2000, Outcalt 2000, Gagnon et al. 2003).

In the presence of fire, longleaf pines respond by rapid germination (Lui 2004). Fire reduces fuel loads and decreases the density of large saplings and small trees (Lui 2004). Fire may also reduce the effects and spread of disease and pests (Siggers 1944, Hanula et al. 2002).

Due to the many benefits and historical significance of longleaf pine communities, many scientists have begun restoration projects. Restoration can be defined as a serial process of moving from the current state to a desired condition by incorporating knowledge gained from scientific research and silvicultural techniques applied through management (Brockway et al. 2002). Brockway et al. (2002) list six social, economic, and ecological benefits of restoring native longleaf pine ecosystems: 1) increasing habitat for at-risk species 2) improving habitat quality for many other species 3) diversifying forest land base for timber resources 4) increase availability for pine straw harvesting 5) creating aesthetically pleasing recreational areas 6)

preserve natural and cultural legacies for future generations. Scientists, government, and non-governmental organizations, such as the US Army Corps of Engineers, the US Fish and Wildlife Service, The Nature Conservancy, and The Longleaf Alliance¹, have been working together to restore longleaf pine ecosystems, but more scientific research is needed to understand ecological and management needs (Brockway et al. 2002).

Various methods have been implemented in longleaf pine restoration projects. These projects use a combination of hardwood reduction techniques, fire, manual plantings of woody and herbaceous species, and grazing in attempts to restore native longleaf communities. Hardwood reduction techniques include burning, girdling/felling of hardwoods, and herbicide application (Lui 1997b, Brockway and Lewis 1997, Provencher et al 2001a,b, Heuberger and Putz 2003). While herbicide has been successful in the removal of woody vegetation (particularly juvenile oaks), it has the potential to be detrimental to desired species as well (Brockway et al. 1998, Provencher et al. 2001a,b, Heuberger and Putz 2003). The reintroduction of fire is the most successful long-term solution resulting in changes in species abundance and structure, and perhaps, overtime, changes in composition (Brockway and Lewis 1997, Gilliam and Platt 1999, Reinhart and Menges 2004). Prescribed burning, however, is often negatively viewed by the public, and thus, education is essential in order to gain approval and support for establish necessary fire regimes (Jacobson & Marynowski 1997, Rideout et al. 2003).

In addition to herbicide, burning and manual removal of hardwoods, other techniques are being applied in hopes of restoring and maintaining longleaf pine ecosystems. Because of the high percentage of longleaf pine lands under private ownership, Keyes and Keyes (2000) suggest initiation of silvopastoral agriculture. Heuberger and Putz (2003) advocate that more natural corridors be provided between small stands of longleaf pine for the transport of

¹ The Allatoona Lake Longleaf Pine Restoration Project – US Army Corps of Engineers
<http://allatoona.sam.usace.army.mil/longleaf%20pine%20project%20site.htm>

Partners for Fish and Wildlife Program- Texas, <http://www.fws.gov/partners/pdfs/TX-needs.pdf> US Fish and Wildlife Service <http://www.fws.gov/carolinasandhills/longleaf.html>

The Nature Conservancy- Roy E. Larson Sandylands Sanctuary
<http://nature.org/wherewework/northamerica/states/texas/preserves/art6024.html>

The Longleaf Alliance - <http://www.longleafalliance.org/>

species from one small fragment to another. Others have been experimenting with manually planting longleaf pine and ground layer herbs (Glitzenstein et al. 2001, Barnett and McGilvray 2000).

Management projects in other ecosystem types may also provide valuable information for managers as they try to restore longleaf systems. Restoration projects to reestablish grassland savannas (Brockway et al. 2001), Ponderosa Pine (Abella & Covington 2004), Florida pine savannas (Huffman & Werner 2000), and wet savannas (Harper et al. 1998) may serve as examples in how to successfully incorporate techniques such as fire and manual overstory and shrub removal. In addition, restoration projects undertaken to restore longleaf pine sandhill stands can also increase knowledge about herbicide application, burning, felling and harvesting (Hay-Smith & Tanner 1994, Provencher et al. 2000, Provencher et al. 2001a).

Overall, the majority of research on restoration of disturbed longleaf sites has occurred east of the Mississippi in longleaf-wiregrass communities. The use of herbicide treatment and fire are most common in trying to reestablish the species-rich ground layer (Gilliam & Christensen 1986, Brockway et al. 1998, Barnett 1999, Heuberger & Putz 2003, Kirkman et al. 2004). Brockway et al. 1998 showed that spot application of herbicide treatment worked well to decrease cover of oak species and increase herbaceous cover and richness. Further experiments in that study site revealed that, those areas which were both burned and herbicided had significantly lower oak cover (Brockway and Outcalt 2000).

Kirkman et al. (2004) studied re-colonization potential of various herbs by comparing a 64 year old recovery site to an old growth longleaf savanna. They found species diversity to be similar in plot sizes $>10 \text{ m}^2$ but found that in plots $<10 \text{ m}^2$, the recovery site had significantly fewer herb species. They concluded that while this site was able to reestablish on the community level, on the local level, species competition prevented maximum diversity (Kirkman et al. 2004).

Mulligan et al. (2002a,b) and Kush et al. (2000) explored the impact of season of burn on herb layer recovery in Longleaf-wiregrass systems. As a result of their study, Kush & Meldahl (2000) recommended that biennial winter burns be used to increase herb layer biodiversity. Winter

fires also produced more legume biomass than did spring or summer fires. Mulligan & Kirkman (2002b) studied how survival of young *Aristida beyrichiana* varies with time since last burn. Their results suggest that *Aristida beyrichiana* requires a 1-2 year period post recruitment, free from burning, to get established and drop seed. Mulligan et al. 2002a also considered the establishment of *A. beyrichiana* in terms of canopy coverage. They found that more sparse canopies (basal area of 8m²/ha) had the highest survival of *A. beyrichiana* recruits.

Overall, there have been relatively few studies considering the recovery of little bluestem and associates in the ground layer. More research is needed to better understand the processes of succession and competition in the recovery of native herbaceous ground layer in disturbed historic longleaf sites. This information can then be used by managers to develop more succession restoration techniques.

PROJECT HISTORY

In the 1970's Big Thicket National Preserve near Beaumont, Texas began a slash pine (*Pinus elliotti*) eradication process to eliminate plantations of slash pine totaling 383 acres. The site under consideration in this study has experienced herbicide, girdling/felling, fire, and manual seedling planting as methods for restoring the native longleaf community. The project is part of a slash pine (*Pinus elliotti*) eradication process begun by the Big Thicket National Preserve (BTNP) in the 1970s (NPS 2001).

While slash pine is native to the Southeastern United States, its native range does not include Texas (Figure 3). In the original state, stands of longleaf pine-bluestem covered the area (Figure 4, Grelen and Duvall 1966). In keeping with the National Park Service's mission, "...to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations," BTNP is attempting to restore a 71 acre slash pine plantation to native longleaf pine. To date, 45 acres of this plantation have been logged, burned, herbicided, and seeded with longleaf pine seedlings.

Logging occurred in the slash/loblolly pine plantation of the Turkey Creek Unit, BTNP in June of 2003. At that time, the site contained 35-40 year old trees. NPS biologists marked approximately 80% of slash and loblolly pines (185 trees/ha total) for cutting and a local logging contractor removed the trees. Of the trees cut, 60% were harvested for timber. Five standing snags and ten felled trees were left per acre in hopes of providing habitat for wildlife (Jeansonne et al. 2004).

Two small prescribed fires were completed in July, 2003, to remove logging slash. Subsequent fire was scheduled every 2-3 years. Afterwards, 5 plots set up by Lui 1995 were monitored by Big Thicket Fire Effects Crew for woody species composition and fuel loads (Appendix A).

After burning, the site was planted with containerized grass-stage longleaf seedlings derived from a regional seed source and purchased from International Forest Company in Moultrie, Georgia. A total of 18,000 seedlings were planted at a density of 778 seedlings/ha by an Americorps crew. The seedlings were regularly spaced throughout the site and the planting was completed in November 2003 (Jeansonne et al. 2004)

Chemical treatment for brush control was done in June 2004. Garlon 4 with metholated seed oil foliar spray was applied with backpack sprayers. Approximately 80% of the application was directed toward yaupon holly (*Ilex vomitoria*) with the other 20% being applied to oaks, wax myrtle, and hickory (*Quercus incana*, *Carya texana*, *Morella cerifera*). After two weeks the site was observed and found to have 80% of yaupon holly dead or in decline. Additionally, 20 longleaf seedlings showed signs of phytotoxicity. A second foliar treatment was applied July 12-16, 2004. After the second application a 90% decline/death in yaupon was observed (Jeansonne et al. 2004).

The project plan calls for regularly scheduled prescribed burnings. The 5 fire permanent fire plots established by Lui 1995 will also be sampled regularly. This sampling will primarily consider woody vegetation and will be conducted by the Big Thicket Fire Effects crew post-burning. Additionally, the site will be evaluated for rare species introduction. If suitable habitat can be found, Texas Trailing Phlox (*Phlox nivalis* ssp. *Texensis*), White firewheel (*Gaillardia aestivalis* var. *winkleri*), and Little Bluestem (*Schizachyrium scoparium*) may be reintroduced into the area by manual planting (Jeansonne et al. 2004)

STUDY SITE

Big Thicket

The Big Thicket is an approximately 60x60 km tract of land 40 km inland from the Gulf of Mexico on the Texas Gulf coastal plain². It is bounded on the West by the Trinity River and on the East by the Neches River. The southern boundary consists primarily of coastal prairie on Pleistocene surfaces while rolling uplands situated on older Tertiary landforms are present in other parts of the region (Marks and Harcombe 1981).

The climate of Big Thicket is described as humid subtropical (Harcombe et al. 1993). The temperature averages 19.5°C (Port Arthur 30-year average) with yearly rainfalls of 125 cm (56 year average at Livingston) (Liu et al. 1997a,b).

Turkey Creek Site

The slash pine plantation under consideration lies along the northern boundary of the Turkey Creek Unit of Big Thicket National Preserve near Warren, TX in Tyler County (Appendix B). The Turkey Creek unit covers 3,151 ha; it is considered the most diverse unit in the preserve (Jeanson et al. 2004). Soil of the site is classified as Bienville loamy fine sand averaging 60-80 inches in depth. The Turkey Creek trail runs through the plantation, but removal was done only on the West side of the trail (NPS 2001). The site contained 35-40 year old slash and loblolly pine planted in the mid 1960s (Jeanson et al. 2004).

Background on Sandhill Pine Type

The slash pine plantation site is classified as Sandhill Pine Forest vegetation type as defined by Marks and Harcombe (1981)³. This forest type is dominated by pines and/or oaks growing on

² Big Thicket NP map: http://www.lib.utexas.edu/maps/national_parks/bigthicket_park97.pdf

³ Harcombe & Marks (1979) originally mapped this as area as Upper Slope Pine Oak Forest, but subsequently determined that it is, in fact, Sandhill Pine (Harcombe personal communication).

excessively drained soils. Sandhill forests are described as relatively closed stands with pine abundance greater than 95% (Nixon 1985, Schafale and Harcombe 1983). Some authors refer to these communities as longleaf pine savannas (Watson 1975, Ajilvsji 1979, Diamond et al. 1987, Bridges 1988, Bridges and Orzell 1989).

FIELD METHODS

Plot Location and Selection

The first goal was to obtain quantitative data to assess the composition and competition in the site. This was done by randomly sampling plots.

Plot locations were determined randomly by a computer-generated number table. First, an ArcMAP polygon was created of the treated plantation. Measurements were taken of the polygon, including its length, width, and area. Then, a grid with an interval spacing of 10m (the GPS unit general accuracy) was laid on top of the polygon. In the center of each grid square, a point was created. These points were labeled in an attribute file from 0-1086. Next, a computer random numbers generator (www.random.com) was used to generate 97 random numbers between 0-1086. These were the points selected as the center of each plot (APPENDIX C).

The location of these selected points was recorded in UTM's and loaded into a Garmin V GPS unit. This unit was then taken into the field and used to navigate to the point (the first 5 plots were navigated to by pacing because of troubles with the GPS, all others were located using this procedure).

Once the point was located (to the nearest meter by the GPS) a stakewire flag was used to mark the point. The center flag was labeled with the plot name and "Rice U". See Appendix A for GPS plot locations.

Some plots were rejected for the following reasons:

- Located within 20m of the boundary of the site
- Visible signs of human disturbance (large logging tracks, uncharacteristic slash piles, etc)
- Located in an obvious ditch or mound (such as a streambed where there is an obvious vegetation difference between it and the surroundings).
- Located within 10 meters of any edge of another plot

After rejecting a plot, 3 attempts were made to relocate the plot. To relocate a plot, a compass dial was turned (with eyes closed) to get a random bearing. We would then pace 20 meters at that bearing and test again to see if the plot met the necessary criteria. If the plot failed 3 times, it was discarded and we then moved to the nearest plot that appeared to be acceptable. Extra random GPS centers were made to allow the discarding of plots. Additionally, during sampling only every 3rd plot was sampled. This assured full site coverage, but still allowed extra plots to exist if needed. Of the initial 97 plots, 33 were sampled.

Sampling Plots

Once the center point of the plot was established, the plot was sampled as follows:

Herbaceous- 10m² plot (3.16m per side, diagonal= 4.47m)

Cloth tapes 1.58m long were laid down in the cardinal directions and the ends were marked with yellow stakewire flags. Red stakewire flags were then placed at the plot corners (2.23m from the center along ordinal directions). This created 10m² herbaceous plots (3.16m along each side). After establishing the plot, species were identified (presence/absence sampling). Each species was then assigned to a cover abundance class (% coverage area) following Peet et al. 1990b (Table 2). In total, herb plot areas covered 0.18% of the total site area.

Seedlings/ Low Shrubs (<1m tall) - 10m² plot (3.16m per side)

Seedling/Low Shrub sampling followed the same protocol as the herbaceous sampling (10m² square plot). Species were identified and cover-abundance classes were assigned. Additionally, the number and health of longleaf pine seedlings in the plot were noted.

Tall Shrubs >1m tall (5.64 circular plot = 100m²)

A 5.64m tape was extended from the center of the plot to make a circular plot with a radius of 5.64 and an area of 100m². The tape was moved around in a circle and all shrubs clumps >1m tall were identified and measured for length, width, and height (to calculate volume). If a clump fell along the circular boundary, only the portion contained within the plot was measured. If one stem extended well beyond the rest of the plant, both an absolute height (height of highest stem) and a relative height (average height of plant) were measured. Length and width measurements were used to determine coverage area. Stems were not counted and

DBH was not measured since most of the plants grew in obvious clumps with DBHs <1cm. In total, shrub plots (100m²) covered 1.83% of the total site area.

Trees- Variable

Trees were counted and measured in variable-radius plots using the prism method (Grosenbaugh 1958, Husch et al. 1972, Ordwald 1981) with a 2m basal area factor prism. Trees that were counted by this method were then identified to species and measured for DBH (Diagram of Plot Layout: Figure 5). Appendix E explains how tree basal area and density by species were calculated using the variable-radius prism data.

Additional Information - taken at each site

Photographs: Photographs facing East and West, were taken 6 steps from the center of each plot. A Sony Cybershot 3.2 camera was used. The photos were loaded on to a computer for future use (Appendix A).

Location: At each plot, a waypoint was taken on the Garmin V GPS at the center of the plot. In each case, over 75 points were averaged to increase the accuracy. Accuracy, number of points, and UTM coordinates were recorded (Appendix A).

Permanence of Plots

The plots were not designed to be permanent plots, but they remained installed for the duration of the study. A red stake wire flag was left in the center of each plot, which can be replaced with a piece of rebar to make the plots permanent.

Materials and Methods

QUANTITATIVE ANALYSIS

Data were summarized using Microsoft Excel. For ground layer species, the average cover abundance value of Peet et al. (1990b), average cover area (in % of site), frequency, and sum of cover abundance values were calculated. Species were sorted and ranked by frequency and cover abundance. To determine the overall importance of a species, the average cover abundance value of the species was multiplied by its frequency.

Both the volumes and area was calculated for tall shrubs. When analyzed, however, the two were highly correlated ($R^2=0.98$, Table 3, Figure 6). Therefore, only area was considered when analyzing the effects of the tall shrubs on the herb layer.

Unknown species were identified using Shinnery & Mahler's Flora of North Central Texas (Diggs et al. 1999), and then verified by plant taxonomist Dr. Larry Brown of Houston Community College, Houston, TX. Nomenclature followed Kartesz's Synthesis of North American Flora ver. 1.0, 1999.

COMPARATIVE STUDY PROCEDURE

Species Comparisons

The comparisons between listed species observed at the site and a list of desirable species were used to provide insight into i) whether desired species are successfully colonizing the site, ii) the presence and relative abundance of native versus exotic species (as well as positive vs. negative indicator species), iii) whether desired natives are being out-competed by weedy invaders, iv) the success of the applications completed thus far, v) which important species are missing from the site.

Eight sources were used for comparisons. (1) Common Plants of Longleaf Pine-Bluestem Range (Grelen & Duvall 1966) is a US Forest Service publication that describes grasses, forbs, and shrubs that inhabit the longleaf pine-bluestem range covering TX, LA, MS, AL, and FL. This book was used to compare presence/absence of species found in Turkey Creek and longleaf-bluestem ranges. (2) Wildflowers of the Big Thicket (Ajilvsgi 1979) describes species of the Big Thicket organized by plant associations. Comparison studies were primarily concerned with the identification of species in Ajilvsgi's Longleaf-Bluestem Upland association. (3) A short list of species indicative of xeric longleaf sandhills, produced by The Nature Conservancy (Ledbetter, Positive Species Indicator List), was used to establish whether species from this site are desired in xeric longleaf sandhills. (4) The Big Thicket Floristics Inventory list is a list created by the Big Thicket Floristic Project containing information on specimens collected from BTNP. Information for species is on file in the Rice University Plant Ecology Lab in BIOTA (Biodiversity Database Manager, Colwell 1996). Specifically, specimens found in mature longleaf pine sites in the Turkey Creek Unit or collected from sandhills, sandylands, or upland pine forests in Turkey Creek were considered.

(5) Marks and Harcombe (1981) considered woody species composition in 11 vegetation types throughout the Big Thicket. Comparisons were made with the basal areas they collected for upland pine and sandhill pine forests. Harcombe et al. (1993) studied various plant communities in the Big Thicket separated along soil properties lines such as moisture. (6)

Harcombe et al. (1993) contains a herbaceous species list characteristic of upland longleaf pine savannas which was used to identify which characteristic herbs were missing from the Turkey Creek study site. Species were those indicative of xeric stream terrace sand ridge and xeric savanna sandhill subtypes. (7) Peet and Allard (1993) studied longleaf pine vegetation of the Southern Atlantic and Eastern Gulf Coast extending from Texas to Virginia. Vegetation types were first divided along major moisture gradients (xeric, subxeric, mesic, and seasonally wet) and then subdivided into 23 community types. I compared my species list to those of the subtypes Xeric Longleaf Woodlands, Southern Subxeric Longleaf Woodlands, Southern Mesic Longleaf Woodlands, and Southern Longleaf Savanna. (8) Heuberger & Putz 2003 studied the impacts of prescribed fire in small longleaf pine remnants of Gainesville, FL suburbs. They list 91 forb and shrub species identified in their flowering plant surveys. This list was compared to the Turkey Creek list specifically noting those that Heuberger & Putz classified as showy-flowered sandhill species.

After comparing the site species list to the lists compiled from the literature data, each species was given an indicator status. A positive indicator is a desired species that is representative of mature longleaf-pine communities. Species that are mostly restricted to longleaf sites with intact ground cover were given a positive indicator status. Those species that are typically found in longleaf sites with intact native groundcover, but are also found in other upland areas, were given slightly positive indicator status. A negative indicator species is a weedy species that may have a negative impact on ground layer diversity and composition by competing with native, desired herbs. A negative indicator status was given to aggressive, invader species with potential to deflect succession. Those species which are considered weedy, often occupying degraded or disturbed areas and widely distributed throughout the landscape, but are not aggressive, were given a slightly negative indicator status. The indicator status for some species was unknown.

In addition to herb layer comparisons, comparisons were also made for the canopy layer, noting the differences in basal area and tree density between this site and other longleaf pine restoration sites or old growth forests. Tree density comparisons were made to old-growth and second growth longleaf stands in LA, MS, GA and FL studied by Noel et al. (1998) Tree basal area comparisons were made with data from Gilliam and Platt (1999). They studied the effects

of long-term fire exclusion on tree species composition and stand structure in old growth longleaf stands. Tree density and basal area comparisons were made to Brockway and Lewis (1997), which considered long-term effects of prescribed burning on wiregrass systems. And tree basal areas from various vegetation communities of the Big Thicket (Marks and Harcombe 1981) were also compared.

Community Classification Comparisons

To determine the vegetation community type of this site, comparisons were made with Marks and Harcombe (1981), Peet and Allard (1993) and NatureServe's Terrestrial Ecological Classification (2004). Marks and Harcombe (1981) developed a key for identification of vegetation communities in the Big Thicket which was used to identify this community type. Peet and Allard, who studied longleaf pine throughout its native range north to Virginia, divide communities first by a moisture gradient and then by landscape type. Species from the Turkey Creek site were compared to the following Peet and Allard (1993) classes: Southern Xeric Longleaf Woodland, Southern Subxeric Longleaf Woodland, Southern Mesic Woodland, and Southern Longleaf Savanna. NatureServe (2004) classified of all alliances and community associations attributed to the Kistchie National Forest, Louisiana. In all, this document describes 48 plant alliances (by the US National Vegetation Classification Hierarchy) and 85 plant associations that occur in the Southeastern United States. Comparisons were made by first identifying several associations containing dominant species similar to those found in the study site. The specific community type was determined by careful analysis of less abundant but present species and geologic characteristics.

Results

In all, 159 species were collected and of these, 148 were identified to the species level. The remaining species either lacked specimens or specimens lack critical flowers or fruit needed for identification. The list included 96 forbs (including vines), 32 graminoids and 31 woody species. Approximately 50% of the site was bare ground. Herbaceous species in the ground layer covered 25% of the site with woody species in the ground layer covering 13% and shrub layer species covering 12% (Table 4).

QUALITATIVE ANALYSIS OF VEGETATION LAYERS

Herbaceous Ground Layer

Total forbs and graminoids at the site (ground layer) numbered 128 (32 graminoids, 96 forbs). Of these species, 81 (63%) were found in the sampling plots (22 graminoids and 59 herbs and vines). Thus, approximately 69% of graminoid species and 61% of forb species of the total observed species were represented in the sampling plots.

Fourteen species were observed in more than 20% of plots (Table 5). Additionally, thirteen species covered more than 0.5% (50m²/ha) of the site area (Table 6). Four species covered over 2% (200m²/ha) of the site area. These included three *Dichanthelium* species (Species: *D. aciculare*, *D. acuminatum* var. *acuminatum*, *D. sphaerocarpon* var. *sphaerocarpon*) and one herb (*Chamaesyce cordifolia*).

The fifteen most important ground layer species have a weighted frequency abundance value greater than 0.10 (Table 7). Four (27%) are positive indicators, representative of the rich ground layer observed in mature longleaf stands. An additional four are good species (slightly positive) typical of, but not restricted to, mature longleaf sites. However, five species (33%) are negative indicators, i.e. weedy successional and invasive herbs. The competition/successional status of 2 species is unknown. 6 of 15 (40%) of the most important species are considered weedy (Kartesz 1999).

Woody Ground Layer

Twenty-seven species of woody plants were observed in the low shrub layer plots (less than 1.0 meters tall), 87% of the total number of woody species observed. Eleven shrub species were found in more than 20% of plots. Ten species covered more than 200m²/ha (2% of the site, Table 8). Only four species were both abundant (more than 20% of plots) and frequent (more than 200m²/ha): *Quercus stellata*, *Quercus falcata*, *Callicarpa americana*, and *Carya texana*. These species are typical of dry sites and are not considered weedy.

Of woody species occurring in the ground layer, 5 are potential problem species. These include *P. taeda*, *I. vomitoria*, *Q. hemisphaerica*, *Triadica sebifera*, and *L. styraciflua*. *T. sebifera* is an exotic species with highly invasive characteristics that was observed in 5 plots (15%). The other four species are native but are weedy successionalists that may compete with desired herbs for light and nutrients. Small pine seedlings (all of which were identified as *P. taeda*, but may have, instead, been a mix of *P. taeda* and *P. elliotii*) were exceptionally abundant, occurring in 31 plots (94%). The second most abundant woody ground layer species was *I. vomitoria*, occurring in 24 plots (73%). Similarly, high abundance of *Q. hemisphaerica* and *L. styraciflua* are of concern.

Woody Shrub Layer

Of the 31 woody species observed in the site, 15 (48%) appeared in the tall shrub layer (taller than 1 meter). The most common species in the shrub layer were, *Quercus hemisphaerica* (1st), *Q. incana* (2nd), *Callicarpa americana* (3rd), *Carya texana* (4th), *Q. stellata* (5th) and *Q. falcata* (6th). Eight species occurred in more than 20% of the plots, but only one species (*Q. hemisphaerica*) covered greater than 2% (200 m²/ha) of the total land area (Table 9). Overall, unlike the herbs and low shrubs, there was little difference between the list of frequently occurring and most abundant species. Overall around 1176 m²/ha, or 12%, of the site is covered by shrubs.

The site contains 4 shrub layer species of concern. *Quercus hemisphaerica*, *Ilex vomitoria*, *Liquidambar styraciflua*, and *Quercus nigra* are all weedy species that have potential to negatively influence herb layer. The most abundant of these species is *Q. hemisphaerica* which covers 207.8 m²/ha. *I. vomitoria* and *L. styraciflua* are the 7th and 8th most common shrub layer species,

respectively, with *Q. nigra* being the 11th most common. Together, these species in cover 348.3 m²/ha which accounts for 32% of the shrub layer cover area and 3.5% of the total site area.

There is a notable difference in the abundance and frequency of live versus dead *Ilex vomitoria* (Table 10). Considering only live plants, *Quercus hemisphaerica*, *Callicarpa americana*, *Quercus incana*, *Carya texana*, and *Quercus falcata* are the most frequent and cover the largest area. Considering dead plants as well, *Ilex vomitoria* becomes the 4th most abundant species. The cover area of the four undesirable species increases from 348.3 m²/ha to 438.5 m²/ha and from 32% to 37% of total shrub layer cover area. 4.4% of the site is covered by undesirable woody species when standing dead plants are included in the calculations.

Combined Woody Ground and Shrub Layers

Tall shrub area values were converted to cover abundance values and then added to low shrub totals for each species to get a synthetic shrub index (Table 11). In the combined data, rank abundance changes little from the tall shrub list, but *Ilex vomitoria* does increase in importance. In both live and live + dead analysis the top five species in the shrub layer are *Quercus hemisphaerica*, *Callicarpa americana*, *Ilex vomitoria*, *Quercus incana*, and *Carya texana*, the weighted value of *I. vomitoria* changes from 2nd most important to third most important when dead shrubs are no longer considered. Also interesting is that both *Pinus taeda* and *Rhus copallinum* occur in over half of the plots, making them two of the top 5 most frequent woody species.

Canopy Layer

After initial treatment, the canopy of this site was relatively open. Eleven species were observed in the canopy layer (Table 12) Removal treatment reduced the overall percentage of slash pine in the site while increasing the relative abundance of loblolly pine (Table 13). *Pinus elliotii* and *Pinus taeda* were the most abundant species followed by *Quercus stellata*. Other hardwoods (in order of abundance) included *Liquidambar styraciflua*, *Quercus incana*, *Quercus falcata*, *Carya texana*, *Quercus alba*, and *Acer rubrum* (Table 12).

Live tree (all size classes) density was 127.1 ± 101.2 trees/ha and basal area was 9.03 ± 4.64 m²/ha. Live trees greater than or equal to 25.0 DBH had a density of 88.9 ± 48.9 trees/ha and basal area of 8.18 ± 4.22 m²/ha. Considering all trees (live and standing dead) average density

increased to 199.3 ± 40.8 trees/ha (over all size classes) and basal area increased to 12.06 ± 4.62 m²/ha (Table 14).

Of pine trees, 47.0% were slash pine (*Pinus elliotii*), and 44.4% were loblolly pine (*P. taeda*); mature longleaf pine (*P. palustris*) made up only 5 % of the trees. Logging resulted in a decrease in the relative abundance of slash pine and longleaf pine and an increase in relative abundance of shortleaf pine (*P. echinata*) and loblolly pine (Table 13). Basal area decreased for each species (as expected) except for in shortleaf pine where small sample size resulted in a large standard deviation. Overall, pines comprised of 74% of trees while hardwoods (*Quercus stellata* and *Liquidambar styraciflua* being the most abundant) made up the other 26%. Basal area was 8.18 ± 4.25 m²/ha for pines and 0.85 ± 1.42 m²/ha hardwoods (Table 12)

R e s u l t s

IMPACTS OF WOODY SPECIES ON HERBS

Low shrubs are not significantly affecting herb cover or diversity ($R^2 < 0.05$). None of the regressions were significant, but weak trends were observed between woody ground layer diversity and cover and the diversity and cover of herbs (Figure 7). Herb-layer cover and diversity were also not significantly correlated with shrub layer cover or diversity ($R^2 < 0.05$, Figure 8) Tall shrubs were converted to cover class values and added to low shrubs to see if woody plants, in general, were affecting herb cover or diversity. The combination of low and tall shrubs, again, was not significant (Figure 9).

In every case where herb abundance and richness was compared to tree basal area, they decreased with increasing basal area. However, none of the results were significant ($R^2 \leq 0.1092$). Similarly, herb cover and diversity were not significantly correlated with tree density ($R^2 < 0.1$, Figure 10).

R e s u l t s

COMPARISON OF THE SPECIES LIST TO LITERATURE DATA

HERBACEOUS GROUND LAYER

A Positive Indicator Species List provided by Wendy Ledbetter of the Nature Conservancy lists 24 forbs as positive indicators of xeric Longleaf Pine Sandhill forests. Of these 24 species, 13 occurred in this site. Representatives from 4 additional genera on the indicator list were also observed in the plots. The list also contained seven negative indicator species. Of these, only one, *Berlandiera pumila*, was found in the site.

Of the 91 species identified by Heuberger and Putz (2003), I found 26 (29%) in this site (Table 15). Of 77 genera, 33 (43%) occurred at the Turkey Creek study site. Of the 36 showy sandhill herbs, 8 (22%) occurred in this site. Of the 33 genera of showy herbs identified, 16 (48%) were common to our site.

The species list of Grelen & Duvall (1966) contains 151 species common to longleaf-bluestem communities. Of these, 41 species occurred at the Turkey Creek study site (27%), and 36 of the 65 genera were represented (55%) (Table 15).

Of the 76 species classified as being found in Longleaf Bluestem Uplands by Ajilvsgi (1979), 45 (60%) were found in this study. An additional 36 species found in the Turkey Creek site were cited in Ajilvsgi from communities other than Longleaf Bluestem Uplands. Of the 148 species from this site identified to the species level, 81 (55%) are listed in this book (Table 15). An additional 21 are represented at the genus level.

Of the 148 species identified to the species level, 145 are native (Kartesz 1999) (Appendix I). The three exotic species are: *Taraxacum officinale*, *Sorghum halepense*, and *Verbascum thapsus*. Over half of the species from this site (77, 52%) are weedy according to Kartesz 1999.

The BIOTA database lists 121 species that have been found in appropriate habitat in the Turkey Creek unit. Of these, 36% of species (43/121) are represented in this site (Table 15). Similarly, 9 of 24 species (37.5%) that were found specifically in longleaf pine dominated uplands or savannahs were also found in this study.

Fifty species from Peet and Allard (1993) were representative of the Southern Mesic Longleaf Woodland community type. 40 species were common to this site and the Southern Subxeric Longleaf Woodland (SSL) community (Table 15). 34 species occurred in Southern Xeric Longleaf Woodlands and 16 were common to Peet and Allard's Southern Longleaf Savanna community (Appendix I).

Of the 159 species identified for this site, 56 were given a positive indicator status based on the literature. These species are all typical of mature longleaf sites and are not known to crowd out other native species when the natural fire regime is maintained. An additional 37 species were considered slightly positive indicators. These species are often found in mature longleaf sites but there is some uncertainty over whether they are considered good species or not. 28 species were classified as slightly negative. These were native weedy and early successional species that are not generally found in mature longleaf sites. Those that are found in mature sites do not cause major problems but may have some minor effects on local vegetation. Five species were classified as negative species. These consisted of the 3 exotic species, the non-native *P. elliotii* and the early successional weed, *Andropogon virginicus*. The remaining 33 species were either neutral or their status could not be determined.

Harcombe et al. 1993 identified 19 woody species that are characteristic of upland longleaf pine savanna (subtype- xeric stream terrace sand ridge). Of these, 8 were observed in this site (Table 15). 15 of the 19 species are represented at the genus level.

Among the seven sources that were used for comparison 215 species were mentioned that were not found in the study site. While this number is high, it overestimates the number of species that should be found since not all of the sources were specific to East Texas and species composition may vary because of edaphic characteristics of the site. Of these 215, only 22 species were mentioned on multiple lists (Table 16). Six species were listed on 3 or more

lists: *Solidago odora*, *Rhynchosia reniformis*, *Helianthus angustifolius*, *Ionactis linariifolia*, *Tephrosia virginiana*, and *Eriogonum longifolium*.

CANOPY LAYER

Tree density is somewhat low compared to density in old-growth longleaf pine ecosystems (180-200 trees/ha) (Noel et al. 1998, Gilliam and Platt 1999). Brockway and Lewis (1997) showed tree density to be substantially higher (879 trees/ha, BA= 14.4 m²/ha) in a longleaf site under 40 years of prescribed burning.

Basal area from this site (9.03 ± 4.64 m²/ha) was comparable to the Wade-Tract Old-growth forest described by Gilliam and Platt 1999 (8.8 m²/ha). Basal area was slightly lower than observed by Marks and Harcombe 1981 (Sandhill Pine Forests 13 m²/ha, Upland Pine Forests 12 m²/ha). Table 17 lists a comparison of basal area by tree species to Marks and Harcombe (1981) Sandhill and Upland Pine Forest vegetation communities.

R e s u l t s

COMMUNITY CLASSIFICATION

Harcombe et al. 1993 classified the historic composition of this site as longleaf pine dominated (based on 1934 Forest Survey data from Cruikshank and Elderedge 1939). Comparing the results of this study with basal area data, the site seems most like the Upland Pine Forest described by Marks and Harcombe 1981. That community type has substantially higher basal area for *Pinus palustris* ($9.3 \text{ m}^2/\text{ha}$ as opposed to $0.48 \pm 1.00 \text{ m}^2/\text{ha}$), but this is expected since the study stand was a plantation and was under fire suppression for numerous years. Basal area and composition observed at this site show similarity to those of Marks and Harcombe's (1981) Sandhill Pine Forest as well, but this site contains more pines compared to the sandhill sites that are dominated by *Quercus incana* and *Q. stellata*. Using Marks and Harcombe's (1981) key the current community type looks most like the Sandhill Pine Forest type, with *Q. stellata* and *Q. incana* dominant species. The Upland Pine Forest contains a denser layer of grasses and legumes which may establish as restoration continues.

Of the species which occurred both in the Peet and Allard (1993) study and in this one, herbs that they found in mesic habitats were the most common (55 of the 59 species common to both studies were in mesic habitats by Peet and Allard [1993], Table 18). This was followed by those species they found in subxeric habitats (53 subxeric species out of 59) and then seasonally wet habitats (46 of 59). Since the least number of species observed in this site were common in xeric habitats (43) this suggests that the site does not suffer from the extremely dry conditions experienced by some other longleaf communities.

The Turkey Creek site seems most similar to the NatureServe (2004) community *Longleaf Pine-(Shortleaf Pine, Loblolly Pine)-(Bluejack Oak, Sand Post Oak)/Little Bluestem Woodland*. However, species of this community type are described as being indicative of "extreme droughtiness." From review of the Peet and Allard 1993 study, this community might better be classified as a *Longleaf Pine/Bluejack Oak/Little Bluestem-Sandhill Croton Woodland*. Descriptions of the species associated with this community type strongly match those observed in this site, but details such as soil type and geological formation differ (Appendix H). NatureServe (2004) describes this community type as typical of plantation and/or fire suppressed stands of historic longleaf pine. Species common to both the site and this community type are listed in Table 15. Other

similar community types defined by NatureServe include the *Longleaf Pine- (Shortleaf Pine, Loblolly Pine)/(Sweetgum)/Little Bluestem Woodland* and the *Longleaf Pine/Little Bluestem-Cattail Gayfeather Woodland*.

Discussion

GROUND LAYER

Currently, the site contains a mix of desired native herbs and successional weedy species. The herbaceous ground layer (11 spp/10 m²) is much less diverse than that observed by Peet and Allard 1993 (40 species/m²), but is only slightly lower than those observed by Hedman et al. 2000 (15 spp/ m²). Many desired herbs, including showy sandhill herbs, legumes, and native grasses are present (Grelen & Duvall 1966, Peet and Allard 1993, Heuberger and Putz 2003, Ledbetter- Positive Indicator List, Ajilvsgi1979).

In total, 56 positive (36% of total) and 37 slightly positive species (24% of total) were observed at the site. Some of the species at the site that were most cited in the literature as typical of healthy, mature longleaf sites include: *Schizachyrium scoparium*, *Bulbostylis ciliatifolia*, *Pityopsis graminifolia*, *Liatris spp.*, *Vernonia texana*, *Croton argyranthemus* and various legume species. It is a positive sign for restoration that a substantial number of species typical of mature sites were found in this site. This suggests that species augmentation is not absolutely necessary to restore native ground layer vegetation. These species are either remnants of the original native longleaf ecosystem or have recently colonized. If remnant, these species have been able to persist for forty years at the site, despite the site being in plantation and under fire suppression.

Unfortunately, none of these positive indicator species was abundant enough to be in the top five most abundant herbs. Of desired herbs, *Liatris elegans* is the 7th most abundant species covering 1.3% of the site followed by *Centrosema virginianum* (10th most abundant, 0.66%). *Schizachyrium scoparium* should be the dominant grass; while it was present at the site, it was too sparse to be observed in any of the sampled plots. The low abundance of *S. scoparium* suggests manual planting may be desirable for timely restoration of the ground layer. *S. scoparium* is easily grown from seed or container-grown starters planted in late spring or early summer. Plants should be watered once a week but should flower and produce seeds in the first season (Lynn 1994).

Given the appearance of the site, it was a surprise that there were so many wetland species represented. While conditions that are too moist may not be favorable to some plants (such as

the threatened Texas Trailing Phlox – *Phlox nivalis* ssp. *texensis* and the Gulf Gayfeather – *Liatris tenuis* which are of particular interest for reintroduction), extremely dry conditions may be too harsh for many species resulting in overall lower diversity (NatureServe 2004). Localized species composition may change to more wetland species due to slight elevation, soil, and moisture changes, particularly near the southern edge where the terrain begins to dip towards a baygall area. This observation might warrant further investigation.

Twenty-two species that were cited by multiple sources as typical of longleaf pine-bluestem communities were not found at the study site (Table 16). This includes seven legumes, six grasses, and five composites. *Solidago odora* was the most frequently cited missing forb followed by *Rhynchosia reniformis*. *S. odora* is a showy sandhill herb while *R. reniformis* is a legume, both desired components of this ecosystem. Both *S. odora* and *R. reniformis* have been collected from within the Turkey Creek Unit. Three other missing species, *Helianthus angustifolius*, *Tephrosia virginiana*, and *Eriogonum longifolium*, have also already been collected from the Turkey Creek Unit. Kirkland et al. (2004) suggest that those species that are wind dispersed (*S. odora*, *H. angustifolius*) are likely to colonize nearby suitable sites, but species that are gravity dispersed (*R. reniformis*, *T. virginiana*) are unlikely to return to the site naturally. *Ionactis linariifolia*, another missing species, is less common. It has not yet been collected from the Big Thicket, but it has been collected in nearby Jasper and Newton Counties (Turner et al. 2003). Some diversity increase can be expected to occur naturally as recruitment time is extended, but poor dispersers may need to be reintroduced by propagules (Kirkland et al. 2004).

Although many favorable herbs are present, the site contains some early successional weedy species as well. The majority of these species were classified as slightly negative impacters because, while they do not belong in mature ground-layer community, they likely will decline normally in the course of succession because they are not aggressive competitors. A possible exception is *Andropogon virginicus*. This species has been seen to overtake areas, particularly overgrazed fields and lands with impoverished soils (Rice, 1972, Redmon et al. 1995). In Hawaii, *A. virginicus* is becoming a major invasive pest. Dry dieback of *A. virginicus* encourages fire, and the grass grows rapidly in response (D'Antonio & Vitousek 1992). *A. virginicus* may also directly impact neighboring plants by inhibitory secretions. Rice (1972) showed that extract from decaying *A. virginicus* inhibited the growth of *Schizachyrium scoparium* and prevented

nodulation in certain legume species. Currently, *A. virginicus* is the 9th most abundant herb occurring on 0.66% of the site. Late season burning appears to reduce vigor of *A. virginicus* but may also negatively impact *S. scoparium* and so should be considered with caution (Butler et al. 2002). Possibly the best way to reduce the likelihood that *A. virginicus* will be a problem is to fill potentially colonizable space with *S. scoparium*, which once established, should reduce the rate of spread of *A. virginicus*.

Another potentially problematic ground layer species is *Eupatorium capillifolium*. It has been found in other longleaf sites and in the Turkey Creek Unit. No studies were found stating that this weedy is particularly invasive. However, it currently covers 1.4% of the site (5th most abundant herb), and thus, should be monitored. Dichantheliums are also very abundant; however, because they are frequent associates of this community type and are not considered weedy, they are of little concern (Grelen & Duvall 1966, Kartesz 1999, NatureServe 2004).

Three other serious impediments to restoration of the native ground cover are two ground layer exotic species, *Sorghum halepense* and *Verbascum thapsus*. Like *A. virginicus*, *S. halepense* thrives on disturbed soils (Newman 1993). It can become a major problem, but is out competed by *Schizachyrium scoparium* when fire is maintained (Newman 1993). *Verbascum thapsus* quickly colonizes open woods and meadows, dispersing 100,000+ seeds that can remain viable in the soil for over 100 years (Ghermandi 2005). However, it has not yet been observed dominating early successional vegetation in East, TX, and so it may not become a problem, especially because it is not very fire resistant (Harcombe, personal communication).

It was surprising that only 3 species at the site are exotics. Other similar ecosystems have suffered greatly from exotic invasion, resulting in decreased species diversity, inhibition of ecosystem function, and threats to endangered species (Harris 2002, Bond 2003). Mesic Pine Flatwoods of Florida have been found with 25 exotic species (5.2% of total observed species, Spikowski, no date). This is 22 more species and nearly three times that observed in this site (1.8% of species observed at this site are exotic). Exotic species can be detrimental to many endangered species by threatening habitat (Harris 2002). More than half of all federally listed species are adversely affected by interactions with non-native species, and nine of the 21 most endangered ecosystems in the United States are significantly affected by exotic invasion (Flather, Joyce and Bloomgarden 1994; Noss and Peters 1995). The invasion of exotic grasses

has had particularly negative impact on the Bobwhite Quail which often inhabits longleaf pine sites (Bond 2003)

Many exotics are present in the Big Thicket area and have been found on open ground and degraded pasture. One species of particular concern is Cogon Grass (*Imperata cylindrica*). This grass has been known to invade longleaf stands and can be difficult to get remove once established (FWS [no date], Simons 1990). Thus far, it has not been observed in pine sandhills in Big Thicket, but it is found in the area (Harcombe, personal communication). Other invasive herbs with the potential to invade this site include *Pennisetum ciliare* var. *ciliare* and *Schinus terebinthifolius*.

Discussion

WOODY PLANT ENCROACHMENT AND IMPACT ON HERBS

The data collected suggests that shrub encroachment and canopy coverage are not yet negatively affecting the herb diversity and abundance. This is a positive sign that hardwood reduction techniques have been successful so far.

It should be noted that four species were both frequent and abundant: *Quercus stellata*, *Q. falcata*, *Callicarpa americana*, and *Carya texana*. These four species are all typical of dry sites and are probably all remnant of the pre-plantation vegetation (Marks and Harcombe 1981). While high abundance of shrubs is not desired, some shrubs naturally persist; all of these species are currently present in the site. *Q. incana*, which occurs in high abundance in this site, is another species which is a natural element of this type of longleaf pine community (Marks and Harcombe 1981, NatureServe 2004).

The low abundance of *Pinus palustris* in the canopy is of concern. The hand planted longleaf seedlings appear healthy, but the high frequency of other pine seedlings (*P. taeda*/*P. elliotii*) in the ground layer may be problematic if burning is too infrequent. The high light availability along with a maintained fire regime should benefit juvenile longleaf pines (Brewer 2001).

While herbicide treatments have reduced the abundance of *I. vomitoria* (dropping it from 4th most abundant to 7th), it was the second most frequently occurring species in the woody ground layer and it ranked first in weighted importance (frequency X abundance). This suggests that while fire should help in maintaining yaupon density, further herbicide application may be necessary.

The high density of *Q. hemisphaerica* is also noteworthy. *Q. hemisphaerica* was observed in the Peet & Allard (1993) Southern Xeric/Subxeric/Mesic Longleaf Woodlands communities and also in Longleaf Pine/Bluejack Oak/Little Bluestem-Sandhill Croton Woodlands (NatureServe 2004). This species was not listed in the Marks and Harcombe (1981) study of Big Thicket vegetation. However, it has increased dramatically at a nearby fire-suppressed site (Harcombe,

personal communication). Fire alone may be enough to maintain this species, but herbicide treatments may also be necessary.

The exotic species *Triadica sebifera* (Chinese Tallow Tree) is also of some concern. *T. sebifera* is exceptionally fast growing; it can grow 1.5m and produce flowers in one growing season. When stands of Chinese Tallow Tree are dense enough, it also has the capacity to suppress fire (Grace et al. 2001). The dry soil conditions of this site, however, may prevent or slow the spread of *T. sebifera*, which is more suited for wetter sites (Barrilleaux 2000).

Discussion

COMMUNITY CLASSIFICATION

Knowing about the present community type is valuable for the insight it provides into the successional processes and what further applications should be applied. For the Longleaf Pine/Bluejack Oak/Little Bluestem – Sandhill Croton Woodlands (NatureServe 2004) the historic fire return interval to maintain the community type is once every 2-10 years (NatureServe 2004). According to NatureServe (2004), this community type is usually the result of forest conversion and/or severe fire suppression of historic longleaf pine stands. This suggests that as fire is reinstated, species composition may change. While the current vegetation is similar to that of the Sandhill Pine Forest (Marks and Harcombe 1981) frequent fire may convert it to an Upland Pine Forest, richer in herbaceous ground cover and containing fewer shrubs. Alternatively, the site may be converted to a more xeric community type when fire is reinstated. The numerous species that are common to these two vegetation types and the study site suggest that this site is suitable habitat for the species associated with mature longleaf pine communities.

Summary

The herbaceous ground layer is not yet as diverse as other mature longleaf stands (11 species/m² compared to 40 species/m²) (Peet and Allard 1993, Peet et al. 1990a), but it does contain many of the desired herbs, including showy sandhill herbs, legumes, and native grasses (Grelen & Duvall 1966, Peet and Allard 1993, Heuberger and Putz 2003, Ledbetter- Positive Indicator List, Ajilvsgi1979). The dominant grass of this system, *Schizachyrium scoparium*, is present but very low in abundance. Manual planting of seed or container-grown starters of forbs and *Schizachyrium scoparium* is probably desirable to accelerate restoration (Lynn 1994).

Some weedy herbs (about half of the present species) do exist at the site. A few are exotic and some are early successional species. *Andropogon virginicus* is the grass of greatest concern because of its rapid growth and fire resistance.

Currently, woody species in the canopy, shrub layer and ground layer are not suppressing herbaceous diversity and cover, but five potentially problematic woody species (*Ilex vomitoria*, *Pinus taeda*, *Quercus hemisphaerica*, *Liquidambar styraciflua*, *Triadica sebifera*) are present. Herbicide applications have been successful in reducing *I. vomitoria*, but it is still abundant so, further application may be necessary.

The high abundance of *A. virginicus* (an early successional species) and relatively low abundance of *Schizachyrium scoparium* (a late successional species) suggests that this community is still early in its succession to a mature longleaf stand.

Due to the high number of positive indicator species, low number of exotics, and historic shrubs, return of this site to an approximation of presettlement condition appears possible. Many of the major species associated with this community type are present, an encouraging fact considering that the site has been in plantation under fire suppression for nearly 40 years. Many of the species that are missing from the site have been found nearby. However, some missing species (particularly those that are gravity dispersed), are unlikely to ever colonize the site without human intervention (Kirkland et al. 2004), and so some reintroduction of ground layer species appears desirable.

Overall, this site appears to be a good candidate for successful restoration to a longleaf pine sandhill/upland forest. Recovery of the herbaceous ground layer should continue naturally with a fire regime of 2-5 years to control shrubs and early successional herbs (Brockway & Lewis 1997, Nature Serve 2004, Fire Ecology), and some species reintroductions and augmentations may be necessary.

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Tables

Table 1: Threatened and Endangered Species Associated with East Texas Longleaf Pine communities (NPS 2001)

Status: E=Endangered, T=Threatened, C=Candidate, SOC= Species of Concern, N/L= Not Listed				
Common Name	Latin Name	Type	Federal Status	State Status
Bachman's Sparrow	<i>Aimophila aestivalis</i>	Bird	N/L	T
Red-Cockaded Woodpecker	<i>Picoides borealis</i>	Bird	E	E
Rafinesque's Big-eared Bat	<i>Corynorhinus rafinesquii</i>	Mammal	SOC	T
Slender Gay Feather	<i>Liatris tenuis</i>	Plant	SOC	N/L
Texas Trailing Phlox	<i>Phlox nivalis</i> var. <i>texensis</i>	Plant	E	E
Louisiana Pine Snake	<i>Pituophis melanoleucus rethveni</i>	Reptile	C	E
Northern Scarlet Snake	<i>Cemophora coccinea copei</i>	Reptile	N/L	T
Timber Rattlesnake	<i>Crotalus horridus</i>	Reptile	N/L	T

Table 2: Cover Abundance Values (from Peet et al. 1990b)

Cover Classes	
1	Trace
2	0-1%
3	1-2%
4	2-5%
5	5-10%
6	10-25%
7	25-50%
8	50-75%
9	75-95%
10	95-100%

Table 3: Tall Shrubs by Area and Volume (excluding standing dead)

Sum of Area m ² /ha		
Species	Area m ² /ha	Volume m ³ /ha
<i>Quercus hemisphaerica</i>	207.8	320.2
<i>Q. incana</i>	174.8	249.0
<i>Callicarpa americana</i>	165.3	212.2
<i>Carya texana</i>	133.6	203.9
<i>Q. stellata</i>	109.0	136.5
<i>Q. falcata</i>	92.5	112.1
<i>Ilex vomitoria</i>	67.0	93.4
<i>Liquidambar styraciflua</i>	60.9	90.2
<i>Q. margarettiae</i>	42.1	54.5
<i>Catalpa speciosa</i>	13.1	26.3
<i>Q. nigra</i>	12.6	24.4
<i>Rhus copallinum</i>	2.7	3.7
<i>Magnolia grandiflora</i>	2.5	2.7
<i>Sassafras albidum</i>	1.2	1.3
<i>Persea borbonia</i>	1.1	1.4
Total	1086.2	1531.9

Table 4: Percent cover by vegetation layer.

Layer	Percent Cover
Herbaceous Ground Layer	25%
Woody Ground Layer	13%
Shrub Layer (Woody > 1m)	12%
Bare Ground	50%

Table 5: Herbaceous Species from sampling plots (sorted by frequency)

Species	Genus	Species	% freq	m ² /ha
DIHF	<i>Dichanthelium</i>	<i>acuminatum</i> var. <i>fasciculatum</i>	0.7	254.5
EUCA	<i>Eupatorium</i>	<i>capillifolium</i>	0.7	140.7
DIBU	<i>Dichanthelium</i>	<i>aciculare</i>	0.52	295.5
DIFS	<i>Dichanthelium</i>	<i>sphaerocarpon</i> var. <i>sphaerocarpon</i>	0.48	57.6
TRCP	<i>Acalypha</i>	<i>gracilens</i>	0.48	39.7
TRBL	<i>Tragia</i>	<i>smallii</i>	0.45	41.2
COCA	<i>Conyza</i>	<i>canadensis</i>	0.42	51.4
CYOB	<i>Cyperus</i>	<i>hystricinus</i>	0.39	80.7
ANVI	<i>Andropogon</i>	<i>virginicus</i>	0.39	66.1
STUM	<i>Strophostyles</i>	<i>umbellata</i>	0.36	31.7
COVI	<i>Commelina</i>	<i>virginica</i>	0.33	28.2
FPSH	<i>Trichostema</i>	<i>setaceum</i>	0.3	27.6
HOSU	<i>Polypremum</i>	<i>procumbens</i>	0.27	41.8
HYHY	<i>Hypericum</i>	<i>hypericoides</i>	0.21	12.5
LIEL	<i>Liatris</i>	<i>elegans elegans</i>	0.18	127.8
LASP	<i>Lactuca</i>	<i>canadensis</i>	0.18	28.2
SCTL	<i>Scleria</i>	<i>triglomerata</i>	0.18	22.2
BUCI	<i>Bulbostylis</i>	<i>ciliatifolia</i>	0.18	12.5
VISP	<i>Vitis</i>	<i>spp.</i>	0.15	44.4
FFBG	<i>Digitaria</i>	<i>villosa</i>	0.15	41.9
GAVO	<i>Galactia</i>	<i>volubilis</i>	0.15	32.3
CIHO	<i>Cirsium</i>	<i>horridulum</i>	0.15	28.8
CARE	<i>Carex</i>	<i>sp.</i>	0.15	9.5
RALI	<i>Hypoxis</i>	<i>curtissi</i>	0.15	6.0
TRAG	<i>Croton</i>	<i>glandulosus</i>	0.15	5.0
TRNL	<i>Tragia</i>	<i>urens</i>	0.15	1.0
CEVI	<i>Centrosema</i>	<i>virginianum</i>	0.12	65.6
TRRE	<i>Tradescantia</i>	<i>reverchonii</i>	0.12	7.0
PHSP	<i>Chamaesyce</i>	<i>cordifolia</i>	0.09	263.1
SLCG	<i>Panicum</i>	<i>brachyanthum</i>	0.09	138.4
GLCA	<i>Glandularia</i>	<i>canadensis</i>	0.09	58.6
ANSP	<i>Pseudognaphalium</i>	<i>obtusifolium</i>	0.09	17.2
VETE	<i>Vernonia</i>	<i>texana</i>	0.09	14.6
SCOL	<i>Scleria</i>	<i>ciliata</i>	0.09	8.5
TORA	<i>Toxicodendron</i>	<i>radicans</i>	0.09	3.0
ASML	<i>Lechea</i>	<i>mucronata</i>	0.09	3.0
DITL	<i>Dichanthelium</i>	<i>sp.</i>	0.06	226.2
PHAM	<i>Phytolacca</i>	<i>americana</i>	0.06	33.3
DICA	<i>Dichondra</i>	<i>carolinesis</i>	0.06	21.2
STBI	<i>Stylosanthes</i>	<i>biflora</i>	0.06	12.6
ELSP	<i>Elephantopus</i>	<i>tomentosus</i>	0.06	11.6
BEPU	<i>Berlandiera</i>	<i>pumila</i> var. <i>scabrella</i>	0.06	9.1
MIST	<i>Mimosa</i>	<i>latidens</i>	0.06	6.5
RHLA	<i>Rhynchosia</i>	<i>difformis</i>	0.06	5.5

ANTE	<i>Andropogon</i>	<i>ternarius</i>	0.06	4.0
ARRE	<i>Aristolochia</i>	<i>reticulata</i>	0.06	3.0
EUNL	<i>Euphorbia</i>	<i>sp.</i>	0.06	3.0
GESE	<i>Gelsemium</i>	<i>sempervirens</i>	0.06	3.0
AMAR	<i>Ambrosia</i>	<i>artemisiifolia</i>	0.06	2.0
BICA	<i>Bignonia</i>	<i>capreolata</i>	0.06	2.0
RUTR	<i>Rubus</i>	<i>trivialis</i>	0.06	2.0
ARCH	<i>Ceanothus</i>	<i>americanus</i>	0.06	2.0
CYTB	<i>Cyperus</i>	<i>retorsus var. retrorsus</i>	0.03	22.7
SOLA	<i>Solanum</i>	<i>ptychanthum</i>	0.03	10.6
TRUR	<i>Tragia</i>	<i>urticifolia</i>	0.03	8.0
CYUB	<i>Juncus</i>	<i>scirpoides</i>	0.03	4.5
CYOC	<i>Cyperus</i>	<i>haspen</i>	0.03	4.5
PASP	<i>Paspalum</i>	<i>setaceum.</i>	0.03	4.5
XYSP	<i>Xyris</i>		0.03	4.5
ANDS	<i>Andropogon</i>	<i>sp.</i>	0.03	2.0
LLCP	<i>Asclepias</i>	<i>verticillata</i>	0.03	2.0
CRCA	<i>Croton</i>	<i>capitatus</i>	0.03	2.0
DISP	<i>Dichantherium</i>	<i>sp.</i>	0.03	2.0
DIVI	<i>Diodia</i>	<i>virginiana</i>	0.03	2.0
EUCO	<i>Euphorbia</i>	<i>corollata</i>	0.03	2.0
HEAN	<i>Echinacea</i>	<i>sanguinea</i>	0.03	2.0
RUHI	<i>Rudbeckia</i>	<i>hirta</i>	0.03	2.0
LAGG	<i>Sorghastrum</i>	<i>elliottii</i>	0.03	2.0
TRSF	<i>Tragia?</i>		0.03	2.0
UVTC	<i>Jacquemontia</i>	<i>tamnifolia</i>	0.03	2.0
CRAR	<i>Croton</i>	<i>argyranthemus</i>	0.03	1.0
DESM	<i>Desmodium</i>	<i>sp.</i>	0.03	1.0
DISR	<i>Dichantherium</i>	<i>spp.</i>	0.03	1.0
IPPA	<i>Ipomea</i>	<i>pandurata</i>	0.03	1.0
TLPV	<i>Passiflora</i>	<i>lutea</i>	0.03	1.0
PIGR	<i>Pityopsis</i>	<i>graminifolia</i>	0.03	1.0
SCSP	<i>Scleria</i>	<i>sp.</i>	0.03	1.0
VETH	<i>Verbascum</i>	<i>thapsus</i>	0.03	1.0
CONC	<i>Hieracium</i>	<i>gronovii</i>	0.03	1.0
FPTG			0.03	1.0
THMN	<i>Mecardonia</i>	<i>acuminata</i>	0.03	1.0
lobed basal leaves			0.03	1.0
unk rosette <i>Dichantherium</i>		<i>spp.</i>	0.03	1.0

Table 6: Most Abundant Herbs

Species	Genus	Species	% freq	% of site	m ² /ha
DIBU	<i>Dichanthelium</i>	<i>aciculare</i>	0.52	2.95	295.5
PHSP	<i>Chamaesyce</i>	<i>cordifolia</i>	0.09	2.63	263.1
DIHF	<i>Dichanthelium</i>	<i>acuminatum</i> var. <i>fasciculatum</i>	0.7	2.54	254.5
DITL	<i>Dichanthelium</i>	<i>sp.</i>	0.06	2.26	226.2
EUCA	<i>Eupatorium</i>	<i>capillifolium</i>	0.7	1.41	140.7
SLCG	<i>Panicum</i>	<i>brachyanthum</i>	0.09	1.38	138.4
LIEL	<i>Liatris</i>	<i>elegans elegans</i>	0.18	1.28	127.8
CYOB	<i>Cyperus</i>	<i>hystericinus</i>	0.39	0.81	80.7
ANVI	<i>Andropogon</i>	<i>virginicus</i>	0.39	0.66	66.1
CEVI	<i>Centrosema</i>	<i>virginianum</i>	0.12	0.66	65.6
GLCA	<i>Glandularia</i>	<i>canadensis</i>	0.09	0.59	58.6
DIFS	<i>Dichanthelium</i>	<i>sphaerocarpon</i> var. <i>sphaerocarpon</i>	0.48	0.58	57.6
COCA	<i>Conyza</i>	<i>canadensis</i>	0.42	0.51	51.4

Table 7: Most Important Herbs (sorted by weighted value)

Code	Genus	Species	% freq	m2/ha	weighted	Indicator	Weed
DIHF	<i>Dichanthelium</i>	<i>acuminatum</i> var. <i>fasciculatum</i>	0.7	254.5	1.78	G	N
DIBU	<i>Dichanthelium</i>	<i>aciculare</i>	0.52	295.5	1.53	P	N
EUCA	<i>Eupatorium</i>	<i>capillifolium</i>	0.7	140.7	0.99	B	Y
CYOB	<i>Cyperus</i>	<i>hystericinus</i>	0.39	80.7	0.32	U	N
DIFS	<i>Dichanthelium</i>	<i>sphaerocarpon</i> var. <i>sphaerocarpon</i>	0.48	57.6	0.28	G	N
ANVI	<i>Andropogon</i>	<i>virginicus</i>	0.39	66.1	0.26	N	Y
PHSP	<i>Chamaesyce</i>	<i>cordifolia</i>	0.09	263.1	0.24	B	N
LIEL	<i>Liatris</i>	<i>elegans elegans</i>	0.18	127.8	0.23	P	N
COCA	<i>Conyza</i>	<i>canadensis</i>	0.42	51.4	0.21	B	Y
TRCP	<i>Acalypha</i>	<i>gracilens</i>	0.48	39.7	0.19	B	Y
TRBL	<i>Tragia</i>	<i>smallii</i>	0.45	41.2	0.18	P	N
DITL	<i>Dichanthelium</i>	<i>sp.</i>	0.06	226.2	0.14	U	N
SLCG	<i>Panicum</i>	<i>brachyanthum</i>	0.09	138.4	0.12	G	N
STUM	<i>Strophostyles</i>	<i>umbellata</i>	0.36	31.7	0.12	P	Y
HOSU	<i>Polypremum</i>	<i>procumbens</i>	0.27	41.8	0.11	G	Y

P= Positive Indicator; G=Good, Slightly Positive; U=Unknown or Neutral;
B=Bad, Slightly Negative; N= Negative

Table 8: Most Important Low Shrubs (sorted by weighted value)

Species	Genus	Species	sum of cover abundance	% freq	Ave CA	Weighted value
ILVO	<i>Ilex</i>	<i>vomitaria</i>	64	0.73	2.67	1.94
CAAM	<i>Callicarpa</i>	<i>americana</i>	59	0.55	3.28	1.79
PITA	<i>Pinus</i>	<i>taeda</i>	55	0.94	1.78	1.67
QUST	<i>Quercus</i>	<i>stellata</i>	40	0.27	4.44	1.21
RHCO	<i>Rhus</i>	<i>copallinum</i>	37	0.55	2.06	1.12
QUHE	<i>Quercus</i>	<i>hemispherica</i>	31	0.33	2.82	0.94
CATE	<i>Carya</i>	<i>texana</i>	30	0.30	3.00	0.91
QUFA	<i>Quercus</i>	<i>falcata</i>	25	0.21	3.57	0.76
LIST	<i>Liquidambar</i>	<i>styraciflua</i>	21	0.24	2.63	0.64
PIPA	<i>Pinus</i>	<i>palustris</i>	20	0.55	1.11	0.61
QUMA	<i>Quercus</i>	<i>margaretiae</i>	15	0.12	3.75	0.45
SMSP	<i>Smilax</i>	<i>spp.</i>	12	0.21	1.71	0.36
SAAL	<i>Sassafras</i>	<i>albidum</i>	12	0.15	2.40	0.36
SASE	<i>Triadica</i>	<i>sebiferum</i>	8	0.15	1.60	0.24
VAAR	<i>Vaccinium</i>	<i>arboreum</i>	8	0.09	2.67	0.24
RHGL	<i>Rhus</i>	<i>glabra</i>	7	0.15	1.40	0.21
MYCE	<i>Morella</i>	<i>cerifera</i>	7	0.03	7.00	0.21
PEBO	<i>Persea</i>	<i>borbonia</i>	6	0.09	2.25	0.20
SMRO	<i>Smilax</i>	<i>rotundifolia</i>	5	0.12	1.25	0.15
PAQU	<i>Parthenocissus</i>	<i>quinquefolia</i>	5	0.06	2.50	0.15
QUAL	<i>Quercus</i>	<i>alba</i>	4	0.03	4.00	0.12
ACRU	<i>Acer</i>	<i>rubrum</i>	3	0.09	1.00	0.09
QUIN	<i>Quercus</i>	<i>incana</i>	3	0.03	3.00	0.09
RUTR	<i>Rubus</i>	<i>trivialis</i>	3	0.03	3.00	0.09
WUNK	<i>Diospyros</i>	<i>virginiana</i>	3	0.03	3.00	0.09
BAHA	<i>Baccharis</i>	<i>halimifolia</i>	1	0.03	1.00	0.03

Table 9: Tall Shrubs (Live only) sorted by weighted value

Code	Scientific Name	Ave Area m ² /ha	% Freq	weighted value
QUHE	<i>Quercus hemisphearica</i>	207.8	0.85	176.3
CAAM	<i>Callicarpa americana</i>	165.3	0.52	85.2
QUIN	<i>Q. incana</i>	174.8	0.45	79.5
CATE	<i>Carya texana</i>	133.6	0.52	68.8
QUFA	<i>Q. falcata</i>	92.5	0.42	39.2
QUST	<i>Q. stellata</i>	109.0	0.30	33.0
LIST	<i>Liquidambar styraciflua</i>	60.9	0.33	20.3
ILVO	<i>Ilex vomitoria</i>	67.0	0.27	18.3
QUMA	<i>Q. margarettiae</i>	42.1	0.18	7.7
CASP	<i>Catalpa speciosa</i>	13.1	0.03	0.40
QUNI	<i>Q. nigra</i>	12.6	0.03	0.38
RHCO	<i>Rhus copallinum</i>	2.7	0.12	0.32
MAGR	<i>Magnolia grandiflora</i>	2.5	0.06	0.15
SASE	<i>Sassafras albidum</i>	1.2	0.06	0.07
PEBO	<i>Persia borbonia</i>	1.1	0.03	0.03

Table 10: Tall Shrubs (all, includes dead) sorted by weighted value

Code	Scientific Name	Ave area m ² /ha	% Freq	weighted value
QUHE	<i>Quercus hemisphearica</i>	216.6	0.85	183.8
ILVO	<i>Ilex vomitoria</i>	148.4	0.64	94.5
CAAM	<i>Callicarpa americana</i>	165.3	0.52	85.2
QUIN	<i>Q. incana</i>	174.8	0.45	79.5
CATE	<i>Carya texana</i>	133.6	0.52	68.8
QUFA	<i>Q. falcata</i>	92.5	0.42	39.2
QUST	<i>Q. stellata</i>	109.0	0.30	33.0
LIST	<i>Liquidambar styraciflua</i>	60.9	0.33	20.3
QUMA	<i>Q. margarettiae</i>	42.1	0.18	7.7
CASP	<i>Catalpa speciosa</i>	13.1	0.03	0.40
QUNI	<i>Q. nigra</i>	12.6	0.03	0.38
RHCO	<i>Rhus copallinum</i>	2.7	0.12	0.32
MAGR	<i>Magnolia grandiflora</i>	2.5	0.06	0.15
SASE	<i>Sassafras albidum</i>	1.2	0.06	0.07
PEBO	<i>Persia borbonia</i>	1.1	0.03	0.03

Table 11: Total Shrubs (combined Tall and Low Shrub data) sorted by weighted value (live plants only)

Code	Scientific Name	Sum of Cover Abundances	% Freq	Ave CA	Weighted value
QUHE	<i>Quercus hemisphearica</i>	216	0.94	6.55	6.15
CAAM	<i>Callicarpa americana</i>	175	0.70	5.30	3.70
ILVO	<i>Ilex vomitoria</i>	94	0.70	2.85	1.99
CATE	<i>Carya texana</i>	120	0.55	3.64	1.98
QUIN	<i>Q. incana</i>	115	0.45	3.48	1.58
PITA	<i>Pinus taeda</i>	55	0.94	1.67	1.57
QUST	<i>Q. stellata</i>	103	0.42	3.12	1.32
QUFA	<i>Q. falcata</i>	95	0.45	2.88	1.31
LIST	<i>Liquidambar styraciflua</i>	73	0.42	2.21	0.94
RHCO	<i>Rhus copallinum</i>	43	0.58	1.30	0.75
QUMA	<i>Q. margarettiae</i>	40	0.21	1.21	0.26
PIPA	<i>Pinus palustris</i>	17	0.45	0.52	0.23
SMSP	<i>Smilax spp.</i>	12	0.21	0.36	0.08
SASE	<i>Triadica sebiferum</i>	10	0.21	0.30	0.06
SAAL	<i>Sassafras albidum</i>	12	0.15	0.36	0.06
RHGL	<i>Rhus glabra</i>	7	0.15	0.21	0.03
VAAR	<i>Vaccinium arboreum</i>	8	0.09	0.24	0.02
SMRO	<i>Smilax rotundifolia</i>	5	0.12	0.15	0.02
PEBO	<i>Persia borbonia</i>	6	0.09	0.18	0.02
PAQU	<i>Parthenocissus quinquefolia</i>	5	0.06	0.15	0.01
ACRU	<i>Acer rubrum</i>	3	0.09	0.09	0.01
MYCE	<i>Morella cerifera</i>	7	0.03	0.21	0.01
QUNI	<i>Q. nigra</i>	7	0.03	0.21	0.01
MAGR	<i>Magnolia grandiflora</i>	3	0.06	0.09	0.01
CASP	<i>Catalpa speciosa</i>	4	0.03	0.12	0.00
QUAL	<i>Q. alba</i>	4	0.03	0.12	0.00
RUTR	<i>Rubus trivialis</i>	3	0.03	0.09	0.00
WUNK	<i>Diospyros virginiana</i>	3	0.03	0.09	0.00
BAHA	<i>Baccharis hamilifolia</i>	1	0.03	0.03	0.00

Table 12: Tree Density and Basal Area separated by species

Species – Live Trees Only	Density in trees/ha	BA in m ² /ha
<i>Acer rubrum</i>	0.47 +/- 2.72	0.06 +/- 0.35
<i>Carya texana</i>	2.07 +/- 11.90	0.06 +/- 0.35
<i>Liquidambar styraciflua</i>	4.58 +/- 20.14	0.24 +/- 0.66
<i>Pinus echinata</i>	3.48 +/- 13.93	0.24 +/- 0.97
<i>P. elliotii</i>	43.99 +/- 43.46	3.64 +/- 3.41
<i>P. palustris</i>	41.65 +/- 46.97	3.81 +/- 3.92
<i>P. taeda</i>	4.60 +/- 9.83	0.48 +/- 1.00
<i>Q. falcata</i>	3.27 +/- 18.94	0.06 +/- 0.35
<i>Q. incana</i>	3.57 +/- 20.54	0.06 +/- 0.35
<i>Q. stellata</i>	18.82 +/- 64.88	0.30 +/- 0.73
<i>Quercus alba</i>	0.52 +/- 2.99	0.06 +/- 0.35
All Pines	93.72 +/- 54.32	8.18 +/- 4.25
Hardwoods	33.34 +/- 83.07	0.85 +/- 1.42
Total	127.1 +/- 101.2	9.03 +/- 4.64

Table 13: Comparison of Pine Composition and Abundance in Plantation Prior to Slash Pine Removal and Now

Species	Abundance (% of pines)		Mean DBH (in)		Mean DBH (cm)		Mean BA (ft ² /acre)		Mean BA (m ² /ha)	
PIEC	0.4	3.7	15.4	11.9	39.1	30.2	.03	1.0	0.007	0.24 +/- 0.97
PIEL	67.5	47.0	10.6	13.3	26.9	33.8	60.7	15.9	13.93	3.64 +/- 3.41
PIPA	8.9	5.0	8.7	14.8	22.1	37.6	8	2.1	1.83	0.48 +/- 1.00
PITA	23.3	44.4	11.4	14.4	29.0	36.6	20.9	16.63	4.79	3.81 +/- 3.92

Table 14: Tree Density and Basal Area by Tree Size Class

Size Class	Density trees/ha		Basal Area m ² /ha	
	Live Trees	All Trees	Live Trees	All Trees
All	127.1 +/- 101.2	199.3 +/- 40.8	9.03 +/- 4.64	12.06 +/- 4.62
≥ 25	88.9 +/- 48.9	112.0 +/- 51.0	8.18 +/- 4.22	10.24 +/- 4.35
≥ 30	62.3 +/- 40.7	75.7 +/- 39.9	6.54 +/- 4.01	8.00 +/- 4.15
≥ 35	32.3 +/- 22.2	40.4 +/- 26.8	4.12 +/- 2.78	5.15 +/- 3.39
≥ 40	13.1 +/- 14.2	15.7 +/- 15.9	2.06 +/- 2.21	2.48 +/- 2.45
≥ 45	5.1 +/- 8.3	6.5 +/- 9.3	0.97 +/- 1.51	1.21 +/- 1.65

Table 15: Species Comparison to Literature Data

Study	Total # in this site	Total # in lit. study	%
TNC Positive Indicator List	13	24	54
Heuberger & Putz 2003	26	91	29
H & P 2003- showy herbs	8	22	36
Grelen & Duvall 1966	41	151	27
Ajilvsgi 1979 - LBU	45	76	59
TC BIOTA specimens	43	121	35
Peet and Allard 1993 - Mesic	50	-	-
P & A 1993- Subxeric	40	-	-
Harcombe et al. 1993	8	19	42

Table 16: Species Missing from Multiple Literature Species Lists

Family	Scientific Name	Lists Present On
Asteraceae	<i>Solidago odora</i>	GD66, NS, TNCNIS, PA, BI
Fabaceae	<i>Rhynchosia reniformis</i>	GD66, PA, PH93, TNCNIS
Asteraceae	<i>Helianthus angustifolius</i>	Aj, GD66, PA
Asteraceae	<i>Ionactis linariifolia</i>	Aj, TNCNIS, PA
Fabaceae	<i>Tephrosia virginiana</i>	GD66, NS, PA
Polygonaceae	<i>Eriogonum longifolium</i>	TNCNIS, NS, Aj
Amaranthaceae	<i>Froelichia floridana</i>	TNCNIS, PH93
Apiaceae	<i>Eryngium yuccifolium</i>	Aj, GD66
Asteraceae	<i>Hymenopappus artemisiifolius</i>	Aj, TNCNIS
Asteraceae	<i>Rudbeckia grandiflora</i> var. <i>alismaefolia</i>	Aj, GD66
Clusiaceae	<i>Hypericum crux-andreae</i>	GD66, PA
Convolvulaceae	<i>Stylisma pickeringii</i>	NS, TNCNIS
Euphorbiaceae	<i>Stillingia sylvatica</i>	NS, PA
Fabaceae	<i>Chamaecrista fasciculata</i> var. <i>fasciculata</i>	Aj, GD66
Fabaceae	<i>Desmodium ciliare</i>	GD66, PA
Fabaceae	<i>Galactia regularis</i>	NS, PA
Fabaceae	<i>Lespedeza hirta</i>	GD66, NS
Fabaceae	<i>Mimosa microphylla</i>	GD66, HP
Poaceae	<i>Anthaenantia rufa</i>	GD66, BI
Poaceae	<i>Eragrostis refracta</i>	GD66, BI
Poaceae	<i>Gymnopogon ambiguus</i>	GD66, PA
Poaceae	<i>Gymnopogon brevifolius</i>	GD66, PA
Poaceae	<i>Panicum virgatum</i>	GD66, NS
Poaceae	<i>Sporobolus junceus</i>	GD66, NS
Scrophulariaceae	<i>Agalinis oligophylla</i>	Aj, BI

CODES:

Aj = Ajilvsgi, Geyata. 1979 Wild Flowers of the Big Thicket (Longleaf-Bluestem Uplands)

GD66= Grelen & Duvall 1976. Common Plants of Longleaf-Bluestem Range

PH81= Harcombe et al. 1993. Vegetation of the Longleaf Pine Region of the West Gulf Coastal Plain

PA = Peet and Allard 1993. Longleaf Pine Vegetation of the Southern Atlantic and Eastern Gulf Coast Regions: A Preliminary Classification (Southern Subxeric Longleaf Woodland and Southern Mesic Longleaf Woodland communities)

BI = Specimens have been found in a longleaf pine-dominated Turkey Creek site

NS= Classified by NatureServe 2004 as belonging to the Longleaf Pine/Bluejack Oak/Little Bluestem-Sandhill Croton Woodland association

TNCNIS = Listed on The Nature Conservancy's Positive Species Indicator List for Xeric Longleaf Pine Sandhill Pinelands

Table 17: Basal Area Comparisons to Marks and Harcombe 1981 by Species

Species	BA m ² /ha Turkey Creek	BA m ² /ha Marks & Harcombe	
		Sandhill Pine	Upland Pine
<i>Pinus echinata</i>	0.24 +/- 0.97	1.3	0.4
<i>P. elliotii</i>	3.64 +/- 3.41	-	-
<i>P. taeda</i>	0.48 +/- 1.00	2.4	0.7
<i>P. palustris</i>	3.81 +/- 3.92	0.6	9.3
<i>Acer rubrum</i>	0.06 +/- 0.35	-	-
<i>Carya texana</i>	0.06 +/- 0.35	-	-
<i>Liquidambar styraciflua</i>	0.24 +/- 0.66	0.1	0.1
<i>Quercus alba</i>	0.06 +/- 0.35	-	-
<i>Q. falcata</i>	0.06 +/- 0.35	-	0.2
<i>Q. incana</i>	0.06 +/- 0.35	4.7	0.5
<i>Q. stellata</i>	0.30 +/- 0.73	3.7	0.1
All Pines	8.18 +/- 4.25	4.3	10.4
Hardwoods	0.85 +/- 1.42	8.7	1.1
Total	9.03 +/- 4.64	13	11.5

Table 18: Species List of This Site in Comparison with Soil Gradients of Peet & Allard (1993)

Moisture Subtype	# of species found in this study
Xeric	43
Subxeric	53
Mesic	55
Seasonally Wet	46
Species Not Listed in P&A 93	89

Figures

Figure 1: Native Longleaf Pine Distribution Presettlement and Current (Trani (Griep) 2002)

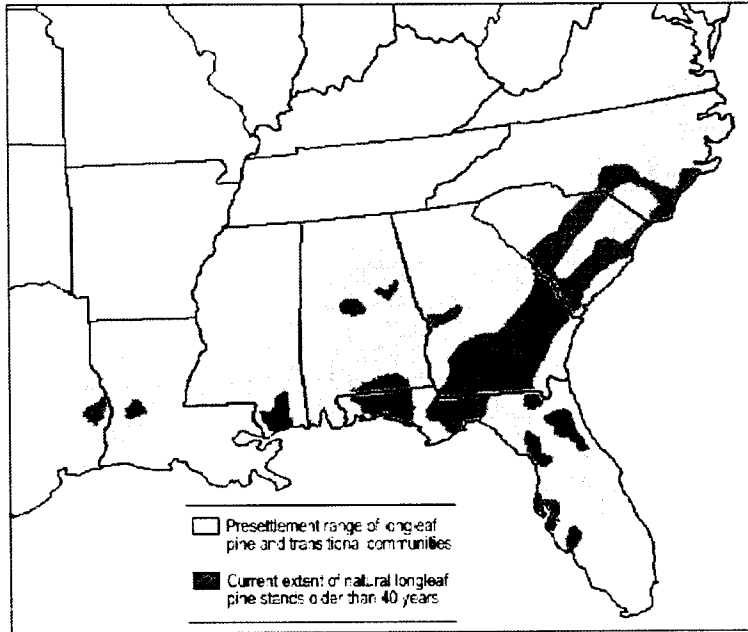


Figure 2: Distribution of Historic Longleaf Pine in Big Thicket Region, East Texas (Harcombe et al. 1993)

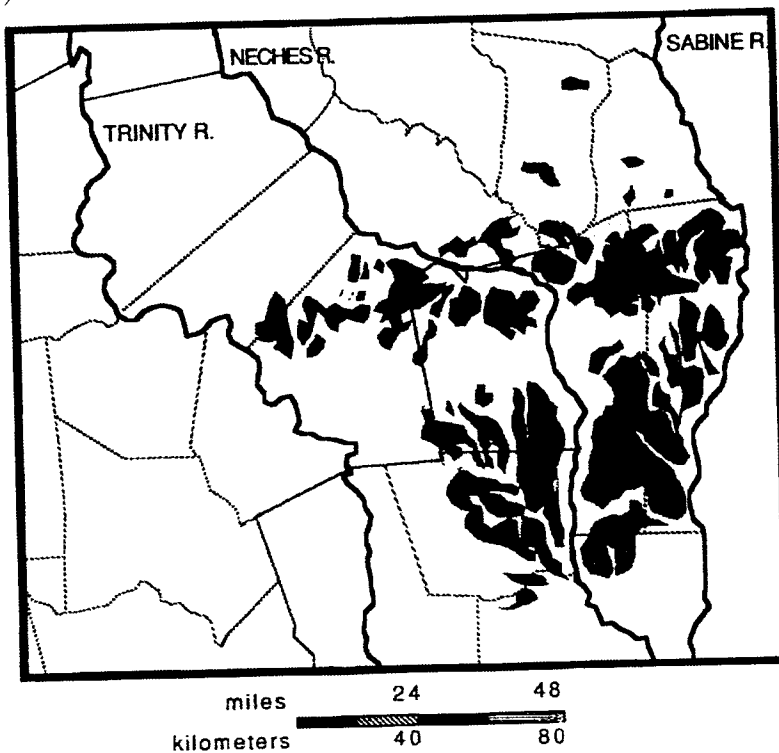


Figure 3: Native Distribution of Slash Pine (*Pinus elliottii*) (Lohrey & Kossuth, no date)

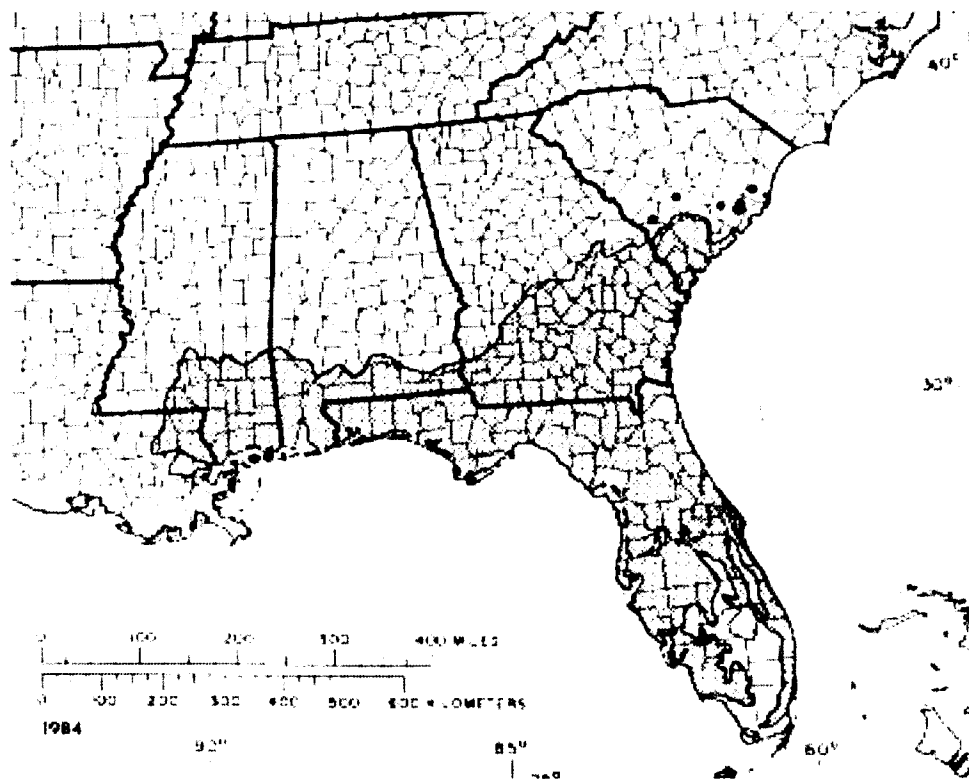
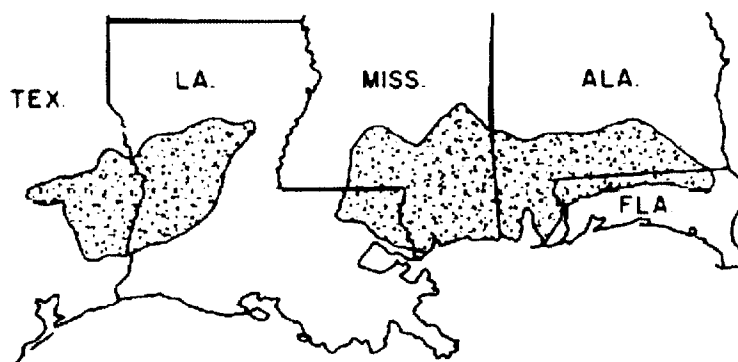


Figure 4: Native Distribution of Longleaf/Bluestem communities (Grelen and Duvall 1966)



The **longleaf** pine-bluestem type.

Figure 5: Diagram of Plot Layout

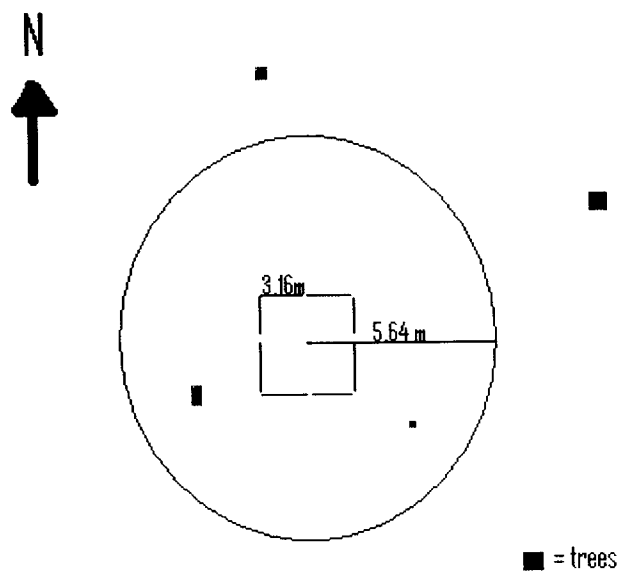


Figure 6: Correlation of Area and Volume for Tall Shrubs

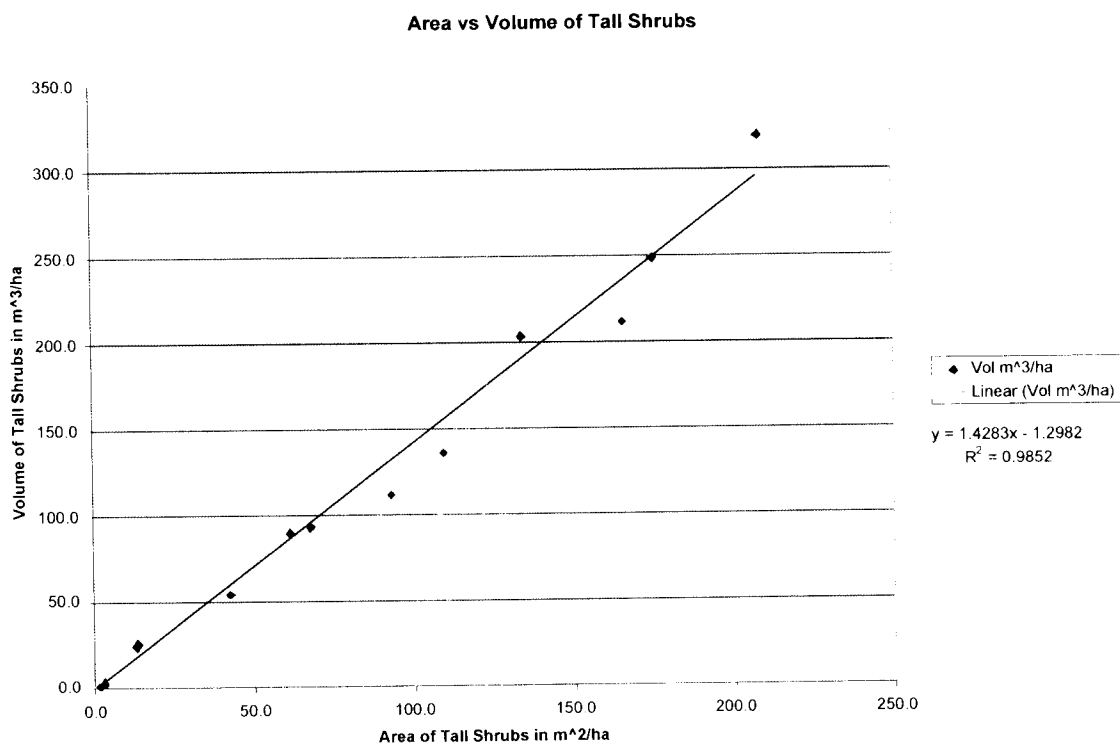


Figure 7: Comparison of Herb Cover and Woody Ground Layer Cover

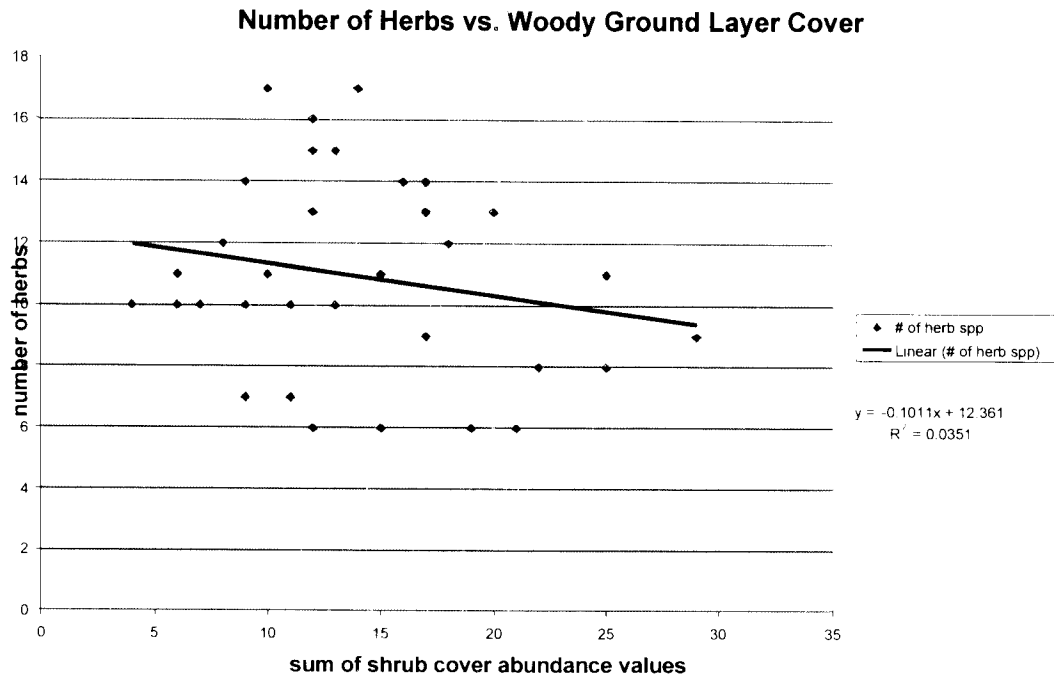


Figure 8: Comparison of Herb Cover and Shrub Layer Cover

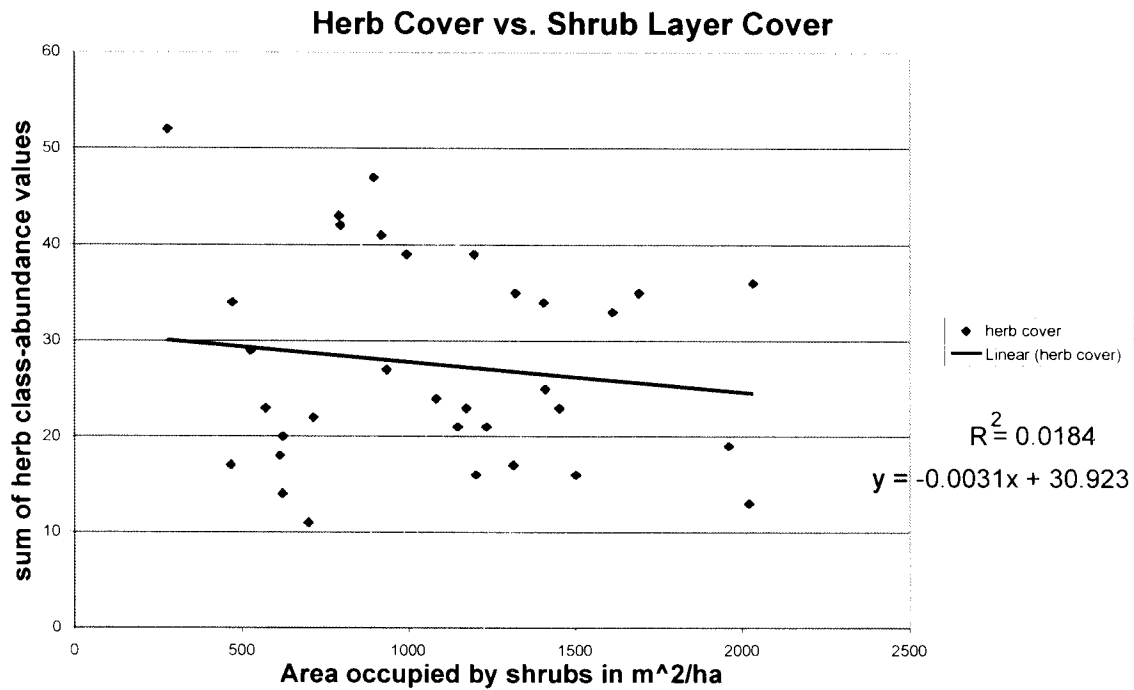


Figure 9: Comparison of Herb Layer to Total Woody Species (Ground Layer + Shrub Layer), live plants only

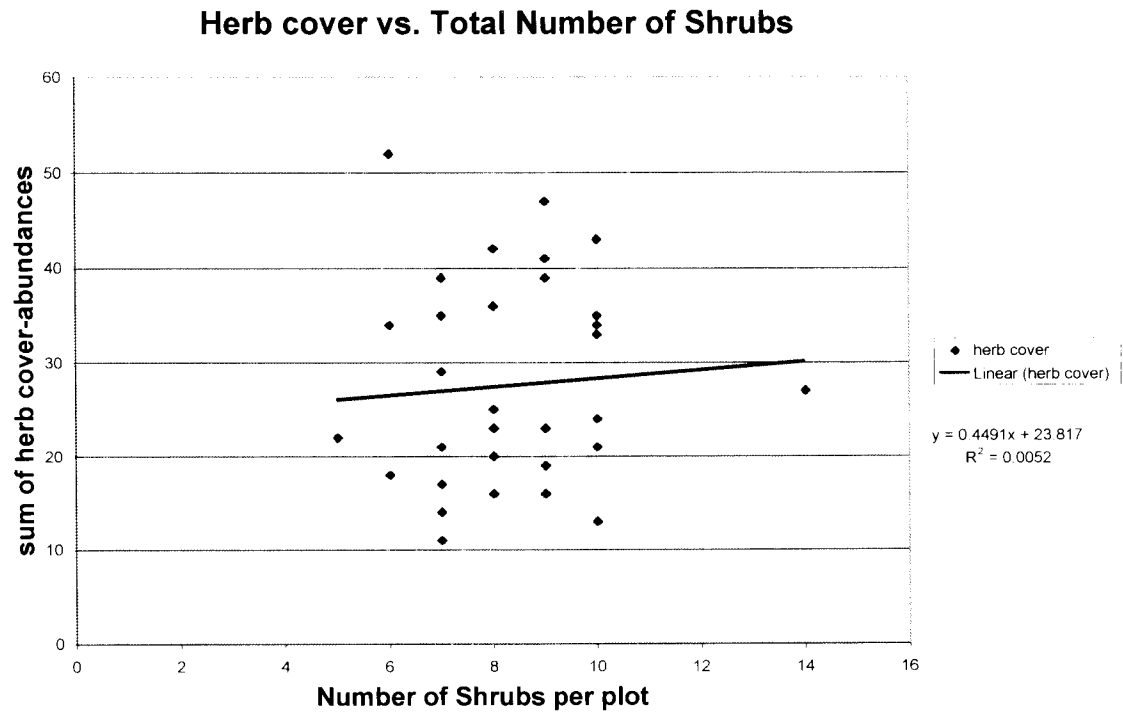
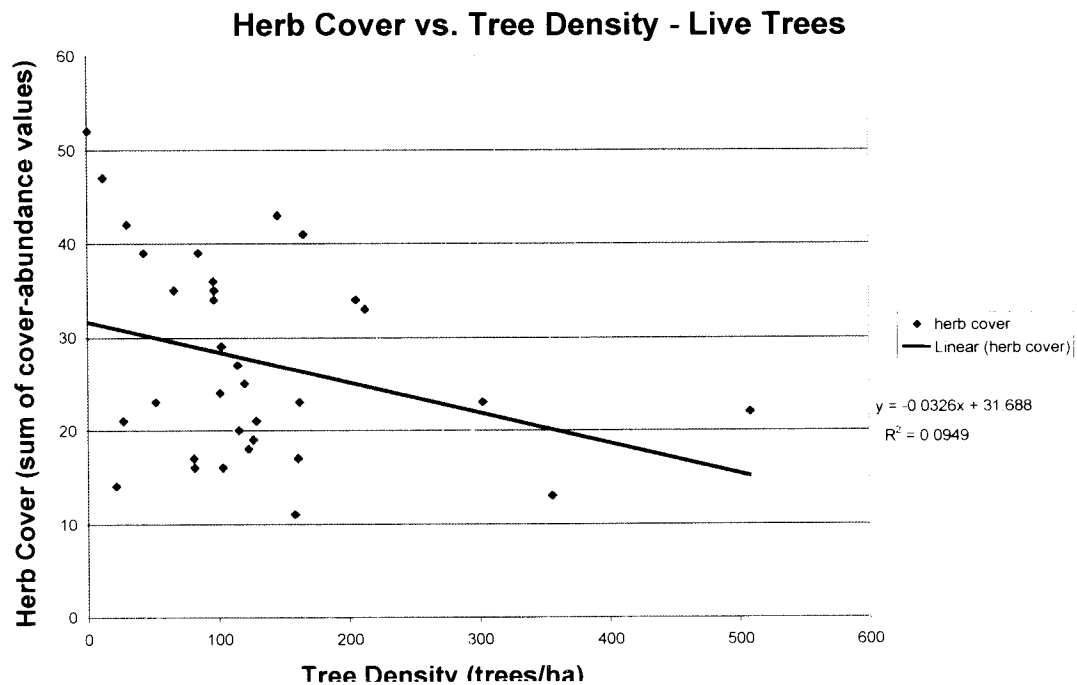


Figure 10: Comparison of Herb Layer to Tree Density (live plants only)



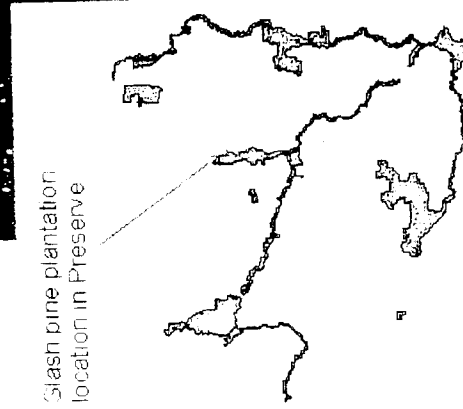
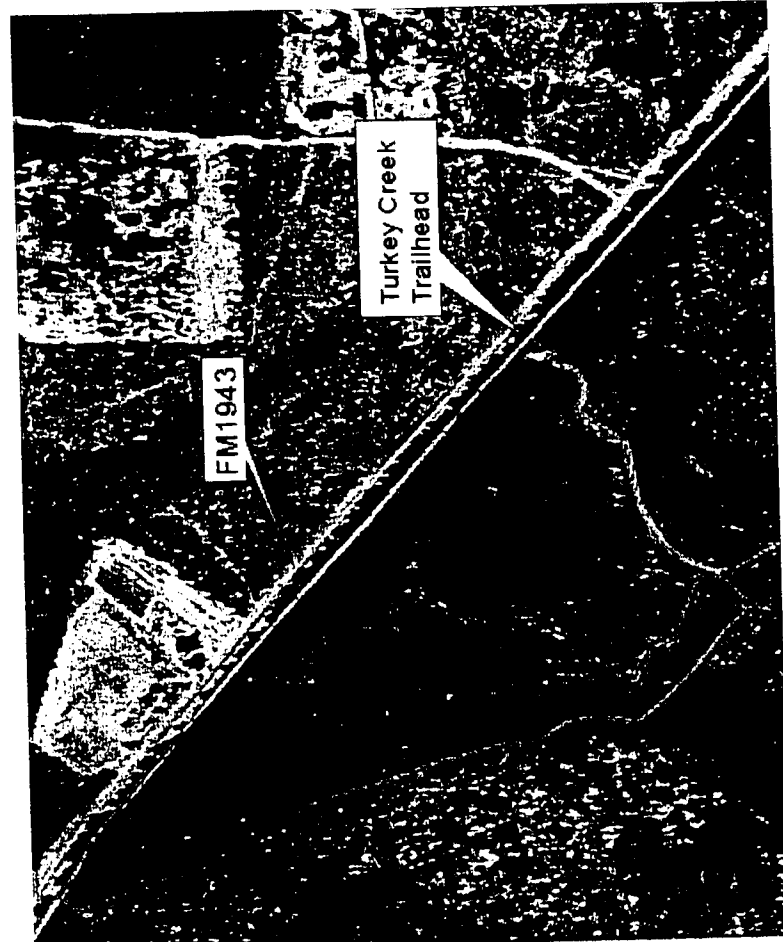
APPENDIX A

See Attached CD

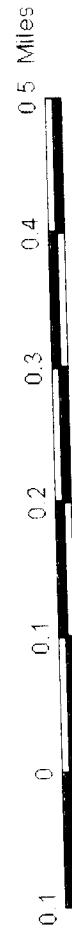
Contains:

- Analyzed Data from this Study
- Comparisons to Literature Data
- GIS Data
- Plot Sampling Information
- Raw Data
- Site Pictures
- Species Lists
- Summarized Fire Data

Appendix B Map of Slash Pine Plantation



*Background image is aerial photograph from 1995 false color infrared photography
 Red indicates evergreen vegetation, blue green indicates hardwood



Turkey Creek Trail
 Slash Pine Plantation
 Boundary of Turkey Creek Unit
 Old logging road



10-08-2004

x = plots sampled

Field Check

Plot Number: _____	Date: _____
Researchers: _____	

[illegible]

TREES SURVEY

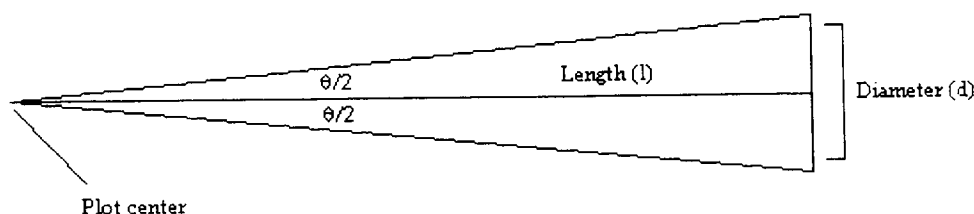
[illegible]

ACRU	Red Maple
RHCO	Winged Sumac
RHGL	Smooth Sumac
ILOP	American Holly
ILVO	Yaupon
COFL	Dogwood
CAAM	Beauty Berry
VAAR	Vaccinium
QUFA	Southern Red
QUHE	Upland Laurel
QUIN	Bluejack
QUMA	Sand Post
QUST	Post Oak
LIST	Sweetgum
CATE	Hickory
PEBO	Red Bay
SAAL	Sassafras
MAGR	Magnolia grand
MAVI	Sweet bay
RHMA	Meadow beauty
PIEC	Shortleaf
PIEL	Slash
PIPA	Longleaf
PITA	Loblolly
ILCO	Gallberry
MYCE	Wax Myrtle
NYSY	Blackgum

Field Check

Appendix E. Calculating the area factor for estimating per-hectare quantities for trees using the Bitterlich 'angle cruising' technique (variable-radius plot method)

The Bitterlich 'angle cruising' technique uses a device that allows one to view an area within a fixed angle and determine whether a particular tree fills that viewing angle or not. For any tree that exactly fills the viewing angle, there is a fixed geometric relationship between dbh (D) and distance from the point (R). If one knows the angle and the tree dbh, one can calculate an effective plot size for that tree ($=\pi R^2$); effective plot size is the area of a plot centered on the observation point that would include the tree.



For any tree that more than fills the viewing angle, the effective area sampled for a tree that size is still πR^2 , where R is a function of D, hence the name variable-radius plot method.

The angles on the cruising devices (we used prisms) are chosen so that the geometry simplifies such that the basal area per unit area can be determined by tallying all trees surrounding a point that more than fill the viewing angle at a point, and multiplying the number of trees by a basal area factor. In the present instance, the basal area factor must be used to calculate effective plot size as a function of D, since the viewing angle is unknown. Basal area per hectare for any given tree is equal to (basal area of the tree/plot area), and the prisms we used are BAF 2(metric). This means that we set BA per hectare equal to 2, substitute formulas for basal area per tree and plot area, as follows:

$$2 = (\pi D^2/4) / (\pi R^2), \text{ expressed in m}^2/\text{ha}.$$

Adjusting for the unit difference (D measured in cm, R measured in m), we get

$$2 * 10^4 = (\pi D^2/4) / (\pi R^2),$$

Simplifying and rearranging, we get

$$\text{effective plot size} = (\pi R^2) = (D^2/8 * 10^4 R).$$

To compute total biomass per hectare for a stand, we first divide individual tree ^{BA}biomass by effective plot area to get the per-hectare contribution of that tree to stand biomass. We then sum by species and point, and average over points. Usually what we have done in stand summaries is to sum by species and divide each species value by 20; total ^{BA}biomass is then the sum across all species. Alternatively, to get total biomass, one could sum by point across species, and divide by 20. This latter method was used to estimate the standard error of total biomass estimates for the 11 stands sampled by this method.

the number of plots

Family	Scientific Name	Author	Common Name	Habit
Acanthaceae				
	<i>Ruellia humilis</i>	Nutt.	Fringe-Leaf Wild Petunia	H
Aceraceae				
	<i>Acer rubrum</i>	L.	Red Maple	W
Anacardiaceae				
	<i>Rhus copallinum</i>	L.	Winged Sumac	W
	<i>Rhus glabra</i>	L.	Smooth Sumac	W
	<i>Toxicodendron radicans</i>	Kuntze	Poison Ivy	H
Apocynaceae				
	<i>Apocynum sp.</i>	L.	Dogbane	H
Aquifoliceae				
	<i>Ilex coriacea</i>	Chapman	Large Gallberry	W
	<i>Ilex opaca</i>	Ait.	American Holly	W
	<i>Ilex vomitoria</i>	Ait.	Yaupon	W
Aristolochiaceae				
	<i>Aristolochia reticulata</i>	Jacq.	Texas Dutchman's Pipe	H
Asclepiadaceae				
	<i>Asclepias verticillata</i>	L.	Whorled Milkweed	H
Asteraceae				
	<i>Ambrosia artemisiifolia</i>	L.	Annual Ragweed	H
	<i>Baccharis halimifolia</i>	L.	Groundseltree	W
		Nesom & B.L.		
	<i>Berlandiera pumila</i> var. <i>scabrella</i>	Turner	Greeneyes	H
	<i>Chrysopsis pilosa</i>	Nutt.	Soft Golden Aster	H
	<i>Cirsium horridulum</i>	Michx.	Yellow Thistle	H
	<i>Conyza canadensis</i>	(L.) Cronq.	Canadian Horseweed	H
	<i>Croptilon divaricatum</i>	(Nutt.) Raf.	Slender Scrachdaisy	H
	<i>Echinacea sanguinea</i>	Nutt.	Sanguin Purple Coneflower	H
			Devil's Grandmother, Tobacco	
	<i>Elephantopus tomentosus</i>	L.	Weed	H
	<i>Erechtites hieraciifolia</i>	(L.) Raf.	American Burnweed	H
	<i>Erigeron strigosus</i>	Muhl. ex Willd.	Prairie Fleabane	H
	<i>Eupatorium capillifolium</i>	(Lam.) Small	Dog-Fennel, Yankee Weed	H
	<i>Eupatorium rotundifolia</i>	L.	Round-Leaf Thoroughwort, Boneset	H
	<i>Hieracium gronovii</i>	L.	Queendevil	H
	<i>Lactuca canadensis</i>	L.	Florida Blue Lettuce	H
	<i>Liatris acidota/pycnostachya</i>		narrow purple gayfeather	H
	<i>Liatris elegans elegans</i>	(Walt.) Michx.	Pink-Scale Gayfeather	H
	<i>Pityopsis graminifolia</i>	(Michx.) Nutt.	Narrow-Leaf Silk-Grass	H
		(L.) Hilliard &		
	<i>Pseudognaphalium obtusifolium</i>	Burt	Blunt-Leaf Rabbit-Tobacco	H
	<i>Rudbeckia hirta</i>	L.	Blackeyed Susan	H

Family	Scientific Name	Author	Common Name	Habit
	<i>Solidago ludoviciana</i>	(Gray) Small	Louisiana Goldenrod	H
	<i>Solidago petiolaris</i>	Ait.	Downy Ragged Goldenrod	H
	<i>Sonchus sp.</i>	L.	Sow-Thistle	H
	<i>Symphotrichum divaricatum</i>	(Nutt.) Nesom	Lawn American-Aster	H
	<i>Vernonia texana</i>	(Gray) Small	Texas Ironweed	H
Bignoniaceae				
	<i>Bignonia capreolata</i>	L.	Crossvine	H
	<i>Catalpa speciosa</i>	Warder ex Engelm.	Northern Catalpa	W
Buddlejaceae				
	<i>Polypremum procumbens</i>	L.	Juniper Leaf	H
Campanulaceae				
	<i>Lobelia puberula</i>	Michx.	Downy Lobelia	H
Cistaceae				
	<i>Lechea mucronata</i>	Raf.	Hairy Pinweed	H
Clusiaceae				
	<i>Hypericum gymnanthum</i>	Gray	Clasping-Leaf St. John's-Wort	H
	<i>Hypericum hypericoides</i>	(L.) Crantz	St. Andrew's-Cross	H
Commelinaceae				
	<i>Commelina erecta</i>	L.	White-Mouth Dayflower	H
	<i>Tradescantia reverchonii</i>	Bush	Reverchon's Spiderwort	H
Convolvulaceae				
	<i>Dichondra carolinesis</i>	Michx.	Carolina Pony's-Foot	H
	<i>Ipomoea pandurata</i>	Mey.	Man-of-the-Earth	H
	<i>Jacquemontia tamnifolia</i>	(L.) Griseb.	Hairy Clustervine	H
Cornaceae				
	<i>Cornus florida</i>	L.	Flowering Dogwood	W
	<i>Nyssa sylvatica</i>	Marsh.	Black Tupelo	W
Cyperaceae				
	<i>Bulbostylis ciliatifolia</i>	(Ell.) Fern.	Capillary Hair Sedge	G
	<i>Carex spp.</i>	L.	Sedge	G
	<i>Cyperus haspen</i>	L.	Sheathed Flat-Sedge	G
	<i>Cyperus hystrixinus</i>	Fern.	Bristly Flat Sedge	G
	<i>Cyperus retrorsus var. retrorsus</i>	Chapman	Pine-Barren Flat Sedge	G
	<i>Fuirena bushii</i>	Kral	Bush's Umbrella Sedge	G
	<i>Rhynchospora inexpansa</i>	(Michx.) Vahl comb. nov.	Nodding Beak Sedge	G
	<i>Rhynchospora recognita</i>	ined.	Coarse Globe Beak Sedge	G
	<i>Scleria ciliata</i>	Michx.	Fringed Nut-Rush	G
	<i>Scleria reticularis</i>	Michx.	Netted Nut-Rush	G
	<i>Scleria triglomerata</i>	Michx.	Whip Nut-Rush	G
Dennstaedtiaceae				
	<i>Pteridium aquilinum</i>	(L.) Kuhn	Northern Bracken Fern	H

Family	Scientific Name	Author	Common Name	Habit
Ebenaceae				
	<i>Diospyros virginiana</i>	L.	Common Persimmon	W
Ericaceae				
	<i>Vaccinium arboreum</i>	Marsh.	Tree Sparkle-Berry	W
Euphorbiaceae				
	<i>Acalypha gracilens</i>	Gray	Slender Three-Seed-Mercury	H
	<i>Chamaesyce cordifolia</i>	(Ell.) Small	Heart-Leaf Sandmat	H
	<i>Cnidoscolus texanus</i>	Small	Texas Bull-Nettle	H
	<i>Croton argyranthemus</i>	Michx.	Healing Croton	H
	<i>Croton capitatus</i>	Michx.	Hogwort	H
	<i>Croton glandulosus</i>	L.	Vente-Conmigo	H
	<i>Euphorbia corollata</i>	L.	Flowering Spurge	H
	<i>Euphorbia</i> sp.	L.		H
	<i>Tragia smallii</i>	Shinners	Small's Noseburn	H
	<i>Tragia urens</i>	L.	Wavy-Leaf Noseburn	H
	<i>Tragia urticifolia</i>	Michx.	Nettle-Leaf Noseburn	H
	<i>Tragia</i> sp.	L.	Noseburn	H
	<i>Triadica sebiferum</i>	(L.) Small	Chinese Tallowtree	W
Fabaceae				
	<i>Centrosema virginianum</i>	(L.) Benth.	Spurred Butterfly-Pea	H
	<i>Desmodium</i> sp.	Desv.	Tick-Trefoil	H
	<i>Erythrina herbacea</i>	L.	Red-Cardinal	H
	<i>Galactia volubilis</i>	(L.) Britt.	Downy Milk-Pea	H
	<i>Mimosa latidens</i>	Turner	Karnes' Mimosa	H
	<i>Rhynchosia difformis</i>	(Ell.) DC. (Muhl. ex	Double-Form Snout-Bean	H
	<i>Strophostyles umbellata</i>	Willd.) Britt.	Pink Fuzzy-Bean	H
	<i>Stylosanthes biflora</i>	(L.) B.S.P	Side-Beak Pencil-Flower	H
	<i>Tephrosia onobrychoides</i>	Nutt.	Multi-Bloom Hoary-Pea	H
Fagaceae				
	<i>Quercus alba</i>	L.	Northern White Oak	W
	<i>Quercus falcata</i>	Michx.	Southern Red Oak	W
	<i>Quercus hemispherica</i>	Bartr. ex Willd.	Upland Laurel Oak, Darlington's Oak	W
	<i>Quercus incana</i>	Bartr.	Bluejack Oak	W
	<i>Quercus margarettiae</i>	Ashe ex Small	Sand Post Oak	W
	<i>Quercus stellata</i>	Wangenh.	Post Oak	W
Hamamelidaceae				
	<i>Liquidambar styraciflua</i>	L.	Sweet-Gum	W
Juglandaceae				
	<i>Carya texana</i>	Buckl.	Black Hickory	W
Juncaceae				
	<i>Juncus scirpoides</i>	Lam.	Needle-Pod Rush	G

Family	Scientific Name	Author	Common Name	Habit
Lamiaceae				
	<i>Monarda punctata</i>	L.	Spotted Beebalm	H
	<i>Scutellaria cardiophylla</i>	Gray	Gulf Scullcap	H
	<i>Trichostema setaceum</i>	Houtt.	Narrow-Leaf Bluecurls	H
Lauraceae				
	<i>Persea borbonia</i>	(L.) Spreng	Red Bay	W
	<i>Sassafras albidum</i>	(Nutt.) Nees	Sassafras	W
Liliaceae				
	<i>Hypoxis curtissii</i>	Rose	Curtiss' Yellow Star-Grass	H
Loganiaceae				
	<i>Gelsemium sempervirens</i>	(L.) Ait. f.	Evening Trumpet Flower	H
Magnoliaceae				
	<i>Magnolia grandiflora</i>	L.	Southern Magnolia	W
	<i>Magnolia virginiana</i>	L.	Sweet-Bay	W
Melastomataceae				
	<i>Rhexia mariana</i>	L.	Maryland Meadow Beauty	W
Myricaceae				
	<i>Morella cerifera</i>	(L.) Small	Wax Myrtle, Southern Bayberry	W
Onagraceae				
	<i>Gaura longiflora</i>	Spach	Long-Flower Beeblossom	H
	<i>Ludwigia hirtella</i>	Raf.	Spendleroot	H
Passifloraceae				
	<i>Passiflora lutea</i>	L.	Yellow Passion-Flower	H
Phytolaccaceae				
	<i>Phytolacca americana</i>	L.	American Pokeweed	H
Pinaceae				
	<i>Pinus echinata</i>	P. Mill.	Shortleaf Pine	W
	<i>Pinus elliotii</i>	Engelm.	Slash Pine	W
	<i>Pinus palustris</i>	P. Mill.	Longleaf Pine	W
	<i>Pinus taeda</i>	L.	Loblolly Pine	W
Poaceae				
	<i>Andropogon gerardii</i>	Vitman	Big Bluestem	G
	<i>Andropogon ternarius?</i>	Michx.	Split-Beard Bluestem	G
	<i>Andropogon virginicus</i>	L.	Broom-Sedge	G
	<i>Aristida purpurascens</i>	Poir.	Arrow-Feather Three-Awn	G
	<i>Dichanthelium</i>	Gould &		
	<i>aciculare/sphaerocarpon</i>	C.A. Clark	Needle-Leaf Rosette Grass	G
	<i>Dichanthelium acuminatum</i> var. <i>acuminatum</i>	(Sw.) Gould & C.A. Clark	Tapered Rosette Grass	G
	<i>Dichanthelium sphaerocarpon</i> var. <i>sphaerocarpon</i>	(Ell.) Gould	Round-Seed Rosette Grass	G
		(A.S. Hitchc. & Chase) Gould	Rosette Grass	G
	<i>Dichanthelium</i> spp.			

Family	Scientific Name	Author	Common Name	Habit
	<i>Digitaria villosa</i>	(Walt.) Pers.	Shaggy Crab Grass	G
	<i>Eragrostis elliottii</i>	S. Wats	Elliott's Love Grass	G
	<i>Eragrostis spectabilis</i>	(Pursh) Steud.	Petticoat Climber	G
		(Lam.) Mez ex		
	<i>Oplismenus hirtellus</i> ssp. <i>setarius</i>	Ekman	Long-Leaf Basket Grass	G
	<i>Panicum brachyanthum</i>	Steud.	Prairie Panic Grass	G
	<i>Panicum verrucosum</i>	Muhl.	Warty Panic Grass	G
	<i>Panicum</i> sp.	L.	Panic Grass	G
	<i>Paspalum setaceum</i>	Michx.	Slender Crown Grass	G
	<i>Schizachyrium scoparium</i> var?	(Michx.) Nash	Little False Bluestem	G
	<i>Sorghastrum elliottii</i>	(C. Mohr) Nash	Long-Bristle Indian Grass	G
	<i>Sorghum halepense</i>	(L.) Pers.	Johnson Grass	G
	<i>Sporobolus</i> sp.	R. Br.	Smutgrass, Dropseed	G
Ranunculaceae				
	<i>Clematis reticulata</i>	Walt.	Net-Leaf Leather-Flower	H
Rhamnaceae				
	<i>Ceanothus americanus</i>	L.	New Jersey-Tea	H
Rosaceae				
	<i>Rubus trivialis</i>	Michx.	Southern Dewberry	H
Rubiaceae				
	<i>Diodia teres</i>	Walt.	Poorjoe	H
	<i>Diodia virginiana</i>	L.	Virginia Buttonweed	H
	<i>Oldenlandia uniflora</i>	L.	Clustered Mile-Graines	H
Scrophulariaceae				
	<i>Mecardonia acuminata</i>	(Walt.) Small	Axil-Flower	H
	<i>Verbascum thapsus</i>	L.	Great Mullien	H
Smilacaceae				
	<i>Smilax pumila</i>	Walt.	Sarsparilla Vine	H
	<i>Smilax</i> sp.	L.	Greenbriar	H
Solanaceae				
	<i>Datura wrightii</i>	Regal	Sacred Thorn-Apple	H
	<i>Solanum ptychanthum</i>	Dunal	Eastern Black Nightshade	H
Verbenaceae				
	<i>Callicarpa americana</i>	L.	American Beauty-Berry	W
	<i>Glandularia canadensis</i>	(L.) Nutt.	Rose Mock Vervain	H
Vitaceae				
	<i>Parthenocissus quinquefolia</i>	(L.) Planch.	Virginia-Creeper	H
	<i>Vitis aestivalis</i> ?	Michx.	Summer Grape	H
	<i>Vitis rotundifolia</i>	Michx.	Muscadine	H
Xyidaceae				
	<i>Xyris jupicai</i>	L.C. Rich	Richard's Yellow-Eyed-Grass	H
	<i>Xyris</i> sp.	L.	Yellow-Eyed-Grass	H

Wild Flowers of Big Thicket Guide

G. Ajilvsgi 1979

Species of Longleaf-Bluestem Uplands

Species	Common Name	Page
<i>Aesculus pavia</i>	Red buckeye	188
<i>Agalinis oligophylla</i>	Scale-leaved gerardia	265
<i>Agalinis purpurea</i>	Purple gerardia	265
<i>Agrimonia microcarpa</i>	Agrimony	155
<i>Antennaria fallax</i>	Everlasting	300
<i>Apios americana</i>	Groundnut	175
<i>Apocynum cannabinum</i>	Indian hemp	230
<i>Aristolochia reticulata</i>	Texas Dutchman's Pipe	132
<i>Asclepias obovata</i>	Savannah milkweed	232
<i>Asclepias variegata</i>	White-flowered milkweed	233
<i>Asclepias viridiflora</i>	Green milkweed	233
<i>Ascyrum hypericoides</i>	St. Andrew's cross	197
<i>Aster pratensis</i>	Meadow aster	296
<i>Aureolaria grandiflora</i>	False foxglove	264
<i>Baptisia leucantha</i>	White false indigo	161
<i>Bheterotheca mariana</i>	Maryland golden aster	291
<i>Bidens aristosa</i>	Tickseed	312
<i>Boltonia diffusa</i>	Small-head boltonia	299
<i>Caeanothus americanus</i> var. <i>pitcheri</i>	New Jersey Tea	190
<i>Callirhoe papaver</i>	Wine-Cup	194
<i>Cassia fasciculata</i>	Partridge Pea	159
<i>Centrosema virginianum</i>	Butterfly Pea	175
<i>Clitoria mariana</i>	Pigeon-wings	175
<i>Commelina erecta</i> var. <i>deamiana</i>	Erect Day flower	108
<i>Cornus florida</i>	Flowering Dogwood	217
<i>Desmodium nudiflorum</i>	Bare-stem tick-trefoil	172
<i>Desmodium paniculatum</i>	Panicled desmodium	172
<i>Echinacea sanguinea</i>	Purple cone-flower	304
<i>Eriogonum longifolium</i>	Long-leaf wild buckwheat	132
<i>Eriogonum multiflorum</i>	Heart-sepal wild buckwheat	133
<i>Eryngium yuccifolium</i>	Button Snake-root	215
<i>Eustylis purpurea</i>	Purple pleat-leaf	121
<i>Gelsmium sempervirans</i>	Carolina jessamine	223
<i>Hedyotis australis</i>	Southern blues	276
<i>Hedyotis nigricans</i> var. <i>filifolia</i>	Fine-leaf bluets	275
<i>Heliantus angustifolia</i>	Swamp sunflower	309
<i>Heliantus hirsutus</i>	Stiff-haired sunflower	308
<i>Heterotheca graminifolia</i>	Silk-grass	291
<i>Hyedyotis crassifolia</i>	Small bluets	276
<i>Hymenopappus artemisiaefolius</i>	Wooly-white	318
<i>Hypochoeris microcephala</i>	Cat's ear	323
<i>Hypoxis hirsuta</i>	Yellow star-grass	117
<i>Indigofera miniata</i> var. <i>leptosepala</i>	Scarlet Pea	164
<i>Ionactis linariifolia</i>	Savory-leaf aster	298
<i>Liatris tenuis</i>	Slender gay-feather	286
<i>Linaria canadensis</i>	Old-field toad flax	263
<i>Linum rigidum</i> var. <i>berlandieri</i>	Stiff-stem flax	180

Species	Common Name	Page
<i>Lithospermum caroliniense</i>	Puccoon	245
<i>Lyonia mariana</i>	Stagger bush	220
<i>Passiflora lutea</i>	Yellow Passion-flower	204
<i>Penstemon laxiflorus</i>	Loose-flowered penstemon	262
<i>Physostegia praemorsa</i>	Blunt false dragon-head	252
<i>Pycnanthemum albescens</i>	Mountain-mint	258
<i>Rudbeckia grandiflora</i>	Rough cone-flower	305
<i>Rudbeckia hirta</i> var. <i>angustifolia</i>	Brown-eyed Susan	305
<i>Ruellia humilis</i> var. <i>longiflora</i>	Low ruellia	273
<i>Salvia azurea</i> var. <i>grandiflora</i>	Blue Sage	256
<i>Salvia coccinea</i>	Tropical sage	256
<i>Scutellaria ovata</i>	Egg-leaf skullcap	251
<i>Senecio tomentosus</i>	Woolly groundsel	319
<i>Sisyrinchium exile</i>	Yellow blue-eyed grass	118
<i>Sisyrinchium sagittiferum</i>	Blue-eyed grass	119
<i>Solidago boottii</i>	Boott goldenrod	293
<i>Solidago petiolaris</i>	Downy goldenrod	295
<i>Strophostyles umbellata</i>	Perennial wild bean	178
<i>Stylisma humistrata</i>	White stylisma	237
<i>Stylosanthes biflora</i>	Pencil-flower	171
<i>Tradescantia hirsutiflora</i>	Hairy-flowered spiderwort	109
<i>Trichostema dichotomum</i>	Forked Blue Curls	249
<i>Verbena candensis</i>	Rose vervain	247
<i>Viola affinis</i> forma. <i>albiflora</i>	Thicket violet	204
<i>Viola lovelliana</i>	Lovell violet	201
<i>Viola pedata</i>	Bird-foot violet	201
<i>Viola rafinesquii</i>	Field-pansy	199
<i>Wahlenbergia marginata</i>	Wahlenbergia	281

<http://www.natureserve.org/library/kisatchieNF.pdf>

LONGLEAF PINE - (SHORTLEAF PINE, LOBLOLLY PINE) - (BLUEJACK OAK, SAND POST OAK) / LITTLE BLUESTEM WOODLAND

ELEMENT IDENTIFIERS

NVC association: *Pinus palustris* - *Pinus (echinata, taeda)* - *Quercus (incana, margarettiae)* / *Schizachyrium scoparium* Woodland

Database Code: CEG007513

Formation: Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)

Alliance: *Pinus palustris* / *Quercus* spp. Woodland Alliance (A.499)

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ELEMENT CONCEPT

Summary: This xeric forest develops on fuel-limited, xeric, deep sands within the range of *Pinus palustris* in the West Gulf Coastal Plain of Louisiana and Texas. A midstory of *Quercus incana* or *Quercus margarettiae* is usually present, indicative of the extreme droughtiness of the sites. The short-shrub stratum is patchy to dense and may include *Vaccinium arboreum*, *Ilex vomitoria*, *Sideroxylon lanuginosum* ssp. *lanuginosum*, *Asimina parviflora*, *Chionanthus virginicus*, *Stillingia sylvatica*, *Frangula caroliniana*, *Hamamelis virginiana*, and seedlings of canopy species. The scattered herbaceous layer contains *Schizachyrium scoparium*, *Aristida desmantha*, and *Cnidioscolus texanus*. Scattered fruticose lichens (*Cladonia* spp.) often occur. The ground cover is sparse, due to extreme site conditions. This community generally occurs on uplands surrounded by *Pinus palustris*-dominated woodlands.

Environment: This forest occurs on ridgetops and flat xeric uplands. This type occurs on excessively well-drained, acidic, sandy, often Grossarenic soils on xeric uplands. The extremely permeable soils on which this community is found include Betis, Briley and Boykin loamy sands; it is known particularly from sandy strata in the Sparta, Catahoula, and Fleming geologic formations and the Wilcox geologic group.

Vegetation: The fairly open to closed, mixed *Pinus* - *Quercus* canopy (10-22 m high) ranges from 60-100% cover. Due to its lower stature *Quercus incana* is generally low in the canopy or forms a subcanopy stratum. In addition to the nominal species, *Quercus hemisphaerica* may occur. The short-shrub stratum (0.5-2 m in height) is patchy to dense and includes *Vaccinium arboreum*, *Ilex vomitoria*, *Sideroxylon lanuginosum* ssp. *lanuginosum*, *Asimina parviflora*, *Chionanthus virginicus*, *Stillingia sylvatica*, *Frangula caroliniana*, *Hamamelis virginiana*, and seedlings of canopy species. The scattered herbaceous layer contains *Schizachyrium scoparium*, *Aristida desmantha*, and *Cnidioscolus texanus*. Other herbs that may occur in examples of this community include *Eriogonum longifolium*, *Eriogonum multiflorum*, *Penstemon murrayanus*, *Polanisia erosa*, *Polygonella americana*, *Polygonella polygama*, and *Zornia bracteata*. Scattered fruticose lichens (*Cladonia* spp.) often occur.

Dynamics: The natural fire regime is thought to be lower than that of other *Pinus palustris* communities because of naturally sparse fuel conditions. This community

results from forest conversion and/or severe fire suppression of historical xeric *Pinus palustris* woodlands.

Similar Associations:

- *Pinus echinata* - *Quercus* (*incana*, *stellata*, *margarettae*) / *Cnidocolus texanus* Forest (CEGL007507) -- has a canopy containing less than 25% *Pinus palustris* and often occurs on fire-suppressed, historical *Pinus echinata*, as opposed to historical *Pinus palustris*, upland sites.
- *Pinus palustris* / *Quercus incana* - *Quercus margarettiae* / *Vaccinium arboreum* / *Cnidocolus texanus* - *Stylisma pickeringii* var. *pattersonii* Woodland (CEGL003602) - is the frequently burned longleaf sandhill of the same region.
- *Pinus palustris* / *Quercus incana* / *Schizachyrium scoparium* - *Liatris elegans* - *Opuntia humifusa* var. *humifusa* Woodland (CEGL003580) -- occurs on related soils in stream terraces.

Related Concepts:

- Bluejack Oak-Pine Series (Diamond 1993) B
- Loblolly Pine - Hardwood (USFS 1988) ?
- Loblolly Pine - Hardwood: 82 (Eyre 1980) B
- Longleaf Pine (21) (USFS 1988) B
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) B

Classification Comments: This is a natural type that occurs on fire-protected or fire-infrequent, extremely deep xeric sands in the West Gulf Coastal Plain.

CONSERVATION RANKING & RARE SPECIES

GRank: G1G2 (1999-12-4): This association only occurs west of the Mississippi River in west-central Louisiana and possibly eastern Texas. It is naturally restricted to extreme xeric conditions found only on deep sands. This association is a component of the endangered Longleaf Pine Ecosystem of the West Gulf Coastal Plain. It is threatened by fire suppression, forestry and agricultural land conversion, and mechanical disturbance caused by off-road vehicles. Most of those natural occurrences which have not been destroyed are severely degraded. This type remains poorly documented and understood, and further study is needed to clarify the degree of uncertainty in the rank.

High-ranked species: *Cyperus grayoides* (G3)

ELEMENT DISTRIBUTION

Range: This type is known from western Louisiana and eastern Texas.

Subnations: LA, TX

TNC Ecoregions: 40:C, 41:C

USFS Ecoregions: 231Ea:CCC, 232Fa:CCC, 232Fb:CCP, 232Fe:CCP

Federal Lands: USFS (Angelina?, Kisatchie, Sabine NF)

ELEMENT SOURCES

References: Allred and Mitchell 1955, Diamond 1993, Eyre 1980, Hatchell 1964, Martin and Smith 1991, Martin and Smith 1993, Orzell 1990, Reed 1982, Soil Conservation Service 1990, Southeastern Ecology Working Group n.d., Turner 1935a, Turner et al. unpubl. data, USFS 1988

**LONGLEAF PINE / BLUEJACK OAK / LITTLE BLUESTEM - SANDHILL
CROTON WOODLAND**

ELEMENT IDENTIFIERS

NVC association: *Pinus palustris* / *Quercus incana* / *Schizachyrium scoparium* - *Croton argyranthemus* Woodland

Database Code: CEGLO08572

Formation: Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)

Alliance: *Pinus palustris* / *Quercus* spp. Woodland Alliance (A.499)

ELEMENT CONCEPT

Summary: This subxeric woodland of the West Gulf Coastal Plain is dominated by an open to fairly closed *Pinus palustris* canopy. *Pinus palustris* is usually the only overstory tree present in high-quality, well-burned examples. *Quercus incana* is the other most diagnostic and important woody species. Unlike more xeric sites, the herbaceous layer is fairly continuous and dominated by *Schizachyrium scoparium* with patches of lichen cover (*Cladonia* spp. and *Cladina* spp.) with patches of exposed sand encountered only infrequently. This community is further characterized by the presence of many species typical of very dry/subxeric sites of the region, such as *Croton argyranthemus*, *Tragia urticifolia*, *Tragia smallii*, and *Pityopsis graminifolia*. Indicator species of the most extreme xeric sites in the region (*Stylisma pickeringii*, *Cnidoscolus texanus*, *Eriogonum longifolium*, etc.) may be present but in relatively low levels.

Environment: This community occurs on ridgetops and upper slopes in highly dissected to rolling topography over extremely well-drained, deep (Grossarenic) sands. In eastern Texas this community is found primarily on the Carrizo Formation and more rarely on the Wilcox Formation, and possibly on the Catahoula, Manning, and Wellborn formations. In western and central Louisiana this type

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is presumably more widespread on the Pleistocene High Terraces, certain members of the Fleming Formation, and is particularly well-expressed on the Catahoula and Sparta formations.

Vegetation: *Pinus palustris* is usually the only overstory tree present in high-quality, well-burned examples. The presence of *Pinus echinata* and *Pinus taeda* in the canopy indicate lower quality, fire-suppressed examples, such as within the Upland Island Wilderness Area of the Angelina National Forest in eastern Texas. In addition to *Quercus incana*, woody species encountered in eastern Texas also include *Sassafras albidum*, *Rhus copallinum*, *Cornus florida*, *Callicarpa americana*, *Ilex vomitoria*, *Liquidambar styraciflua*, and *Pinus taeda*. The latter three species are thought to have become more common in the absence of frequent fire. The understory supports a well-developed herbaceous layer dominated by *Schizachyrium scoparium*, along with *Andropogon gerardii*, *Panicum virgatum*, *Andropogon ternarius*, *Dichanthelium aciculare*, *Sporobolus junceus*, and *Coelorachis cylindrica*. Other species include *Scleria oligantha*, *Galactia regularis*, *Aristolochia reticulata*, *Physalis pumila*, *Vernonia texana*, *Solidago odora*, *Euphorbia corollata*, *Stillingia sylvatica*, *Lespedeza hirta*, *Tephrosia virginiana*, *Stylosanthes biflora*, *Vitis aestivalis*, *Berlandiera pumila*, and others.

Dynamics: This type exists in a matrix of pyrogenic *Pinus palustris* communities and is believed to have been subject to historically frequent fires with average return intervals of approximately 2-10 years. This type is known from the Upland Island Wilderness Area (Angelina National Forest) in eastern Texas which has not been burned since the mid 1980s. Among the vegetation differences between these stands and examples known from other parts of the national forests in Texas which are still fire managed are greater shrub and *Pinus taeda* density and lower species richness in the graminoid layer (notably lacking in *Sporobolus junceus*, *Coelorachis* spp., etc).

Similar Associations:

- *Pinus palustris* / *Quercus incana* - *Quercus margarettiae* / *Vaccinium arboreum* / *Cnidioscolus texanus* - *Stylisma pickeringii* var. *pattersonii* Woodland (CEGL003602) -
- found on more xeric sites of the region.

Related Concepts:

- Bluejack Oak-Pine Series (Diamond 1993) B
- IB6a. Western Xeric Sandhill (Allard 1990) B
- Longleaf Pine - Bluejack Oak / *Tragia Grossarenic* Dry Uplands (Turner et al. 1999) B

Classification Comments:

CONSERVATION RANKING & RARE SPECIES

GRank: G2G3 (2002-9-3): As with all other longleaf pine types it is believed the areal extent has diminished since European settlement. It is threatened by alteration of fire regimes and conversion to other pine types. This community is known only from very limited areas of eastern Texas, but potentially occurs in western Louisiana.

High-ranked species: No information

ELEMENT DISTRIBUTION

Range: This type is restricted to the West Gulf Coastal Plain of eastern Texas and likely occurs in central and western Louisiana as well.

Subnations: LA?, TX

TNC Ecoregions: 40:C, 41:C

USFS Ecoregions: 232Fa:CCC, 232Fb:CCP, 232Fe:CCP

Federal Lands: USFS (Angelina, Kisatchie?, Sabine NF)

ELEMENT SOURCES

References: Allard 1990, Diamond 1993, Smith 1996a, Southeastern Ecology Working Group n.d., Turner et al. 1999, Turner et al.

LONGLEAF PINE - (SHORTLEAF PINE, LOBLOLLY PINE) / (SWEETGUM) / LITTLE BLUESTEM WOODLAND

ELEMENT IDENTIFIERS

NVC association: *Pinus palustris* - *Pinus (echinata, taeda)* / (*Liquidambar styraciflua*) / *Schizachyrium scoparium* Woodland

Database Code: CEG003609

Formation: Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)

Alliance: *Pinus palustris* Woodland Alliance (A.520)

ELEMENT CONCEPT

Summary: This association includes various regenerated, silviculturally altered, and/or naturally fire-suppressed *Pinus palustris* woodlands in Louisiana and Texas, primarily the West Gulf Coastal Plain. It is broadly defined to represent the wide variation which can be present in semi-natural and/or fire-suppressed longleaf pine stands. This type is recognized by the presence of *Pinus echinata* and/or *Pinus taeda* in the overstory (abundant enough to constitute 25-75% of the canopy density) along with *Pinus palustris*.

It includes silviculturally managed stands of *Pinus palustris* as well as fire-suppressed or otherwise ecologically disturbed longleaf pine forests with oaks or other hardwoods that may enter the canopy. This association tentatively applies to longleaf stands along the range periphery of the species in Texas, where stands are heavily mixed in the overstory.

Environment: As broadly defined, this type extends across a moisture gradient from mesic flats to xeric ridgetops. Soil textures can be extremely variable from fine-textured silty soils to sandy loam soils overlying clay, and coarse-textured sands. Some specific soils series from examples in Louisiana include Smithdale, Ruston, Betis, and Briley. Some examples may be naturally occurring, unmanaged types still suffering from fire suppression, in which the areas are naturally sheltered from frequent fire.

Vegetation: *Pinus taeda* is generally a codominant on more mesic sites and flats, while *Pinus taeda* and/or *Pinus echinata* may codominate on drier sites. *Pinus echinata* tends to be the only codominant pine on xeric sites. The vegetation tends to have a patchy understory due to fire suppression. Depending on the moisture regime, understory species may include *Liquidambar styraciflua*, *Quercus alba*, *Quercus stellata*, *Quercus falcata*, and *Quercus hemisphaerica*. Part of the canopy (but typically not more than 25%) may be composed of these or other hardwood species. Shrubs that may be present, depending on fire history and moisture, include *Cornus florida*, *Callicarpa americana*, *Ostrya virginiana*, *Ilex vomitoria*, and *Vaccinium arboreum*. Herbaceous cover is sparse to fairly dense, and is typically dominated by *Schizachyrium scoparium*. The ground cover is greatly decreased in stands with a high canopy cover.

Dynamics: This type can result from partial thinning or regeneration cutting of formerly pure longleaf stands and/or from infrequent burning of plantations and naturally regenerated stands.

Similar Associations:

- *Pinus palustris* / *Quercus (falcata, stellata)* - *Liquidambar styraciflua* - *Carya texana* / *Schizachyrium scoparium* Woodland (CEGL003576) -- also ranked GM with conceptual overlap in the West Gulf Coastal Plain.

Related Concepts:

- IF3b. Plantation (Hardwood or Conifer) (Allard 1990) B

- Loblolly Pine - Hardwood: 82 (Eyre 1980) B
- Loblolly Pine-Hardwood (13) (USFS 1988) ?
- Longleaf Pine (21) (USFS 1988) ?
- Longleaf Pine - Scrub Oak: 71 (Eyre 1980) B Shortleaf Pine - Oak: 76 (Eyre 1980) B
- Shortleaf Pine-Oak (11) (USFS 1988) ?

Classification Comments: More information is needed on vegetation reported from the East Gulf Coastal Plain of Louisiana (232Ba), which is tentatively included here as well. This type was apparently first described from the Kisatchie Ranger District on dry to dry-mesic acidic sandy loams. Variability is primarily determined by burning and thinning frequencies; more open examples having denser shrub and herbaceous strata. The moisture regime and other site conditions also affect the floristic composition of the vegetation. It is primarily disturbed through silvicultural management techniques such as burning and thinning; prescribed burns generally occur at three-year intervals.

CONSERVATION RANKING & RARE SPECIES

GRank: GNA (modified/managed) (2001-6-25): This association consists of various regenerated, silviculturally altered, and/or naturally fire-suppressed *Pinus palustris* stands in the West Gulf Coastal Plain. It is broadly defined to represent the wide variation which can be present in semi-natural and/or fire-suppressed longleaf pine stands, and is not in and of itself a conservation target, although examples may provide habitat for rare and threatened plant and animal species.

High-ranked species: No information

ELEMENT DISTRIBUTION

Range: This association is found in the West Gulf Coastal Plain of the United States.

Subnations: LA, TX

TNC Ecoregions: 40:P, 41:C, 53:C

USFS Ecoregions: 231Ea:CPP, 232Ba:CCC, 232Fa:CCC, 232Fb:CCP, 232Fe:CCP

Federal Lands: USFS (Angelina, Davy Crockett?, Kisatchie, Sabine NF)

Vegetation of the Kisatchie National Forest April 30 2004 Copyright © 2004

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ELEMENT SOURCES

References: Allard 1990, Allred and Mitchell 1955, Burns and Honkala 1990a, Eyre 1980, Hatchell 1964, Martin and Smith 1991, Martin and Smith 1993, Martin et al. 1993, Reed 1982, Smith pers. comm., Southeastern Ecology Working Group n.d., Turner 1935b,

LONGLEAF PINE / LITTLE BLUESTEM - CATTAIL GAYFEATHER WOODLAND

ELEMENT IDENTIFIERS

NVC association: *Pinus palustris* / *Schizachyrium scoparium* - *Liatris pycnostachya*
Woodland

Database Code: CEGl003571

Formation: Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
(II.A.4.N.a)

Alliance: *Pinus palustris* Woodland Alliance (A.520)

ELEMENT CONCEPT

Summary: This mesic longleaf pine woodland occurs in the West Gulf Coastal Plain. It is dominated by a generally open canopy of mature, tall *Pinus palustris* (20-25 m in height). The herbaceous layer is extremely diverse and is dominated by graminoids, legumes, and composites. This community occurs on gently rolling topography over moderately well-drained silt loams and fine sandy loams, typically downslope from 'tableland' flatwoods which occur on broad flat ridgetops. This community occurs west of the Mississippi River in west-central Louisiana and eastern Texas, particularly on the Pleistocene Intermediate and High Terraces, and also possibly on the Fleming Formation. This is a pyrogenic community with fire-return intervals of 2-5 years (Bridges and Orzell 1989a, Martin and Smith 1991, 1993).

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Environment: This community occurs on gently rolling topography. Soils are well-drained sandy loams or occasionally fine sandy loams, and are more calciferous than soils of East Gulf Coastal Plain *Pinus palustris* woodlands. Soils include the Typic Albaqualfs, Typic Hapludults, and Typic and Vertic Hapludalfs soil subgroups (Bridges and Orzell 1989a, Martin and Smith 1991).

Typical soils for this association are Beauregard (silt loam) and Glenmora (silt loam).

Vegetation: This evergreen woodland is dominated by a tall (typically 20-25m) *Pinus palustris* canopy (approximately 30-60% cover). A sparse *Pinus palustris* subcanopy occurs at 7-15m. Widely scattered hardwoods such as *Liquidambar styraciflua* and *Quercus falcata* may occur in the sparse subcanopy. Scattered shrubs (less than 2 m) occur, generally *Vaccinium elliotii*, *Morella cerifera* (= *Myrica cerifera*), *Rhus copallinum*, *Callicarpa americana*, and *Cornus florida*. The herbaceous layer is extremely rich and is dominated primarily by members of the Poaceae, Asteraceae, and Fabaceae, although many other families are also represented.

Dynamics: This is a pyrogenic community with an average fire-return interval of 2-5 years. The historical fire season in this region is from late March to July, peaking in May and June. These frequent fires are low-intensity ground fires, with needles and ground cover detritus being the main sources of fuel. The draping tendency of the long *Pinus palustris* needles over the branches of underlying shrubs increases the flammability of the deciduous plants. Fire often burns into the low-shrub stratum and at least top-kills the shrubs.

If fire suppression occurs for approximately 8-12 years, this community will likely turn into an overgrown woodland. With continued fire suppression, this community will experience increased hardwood invasion and cover and succeed to a mixed *Pinus palustris* forest.

Similar Associations:

- *Pinus palustris* / *Schizachyrium scoparium* - *Rudbeckia grandiflora* var. *alismifolia* Woodland (CEGL003572)

Related Concepts:

- IB6k. West Gulf Coastal Plain Upland Longleaf Pine Forest (Allard 1990) B
- Longleaf Pine (21) (USFS 1988) ?
- Longleaf Pine / *Schizachyrium* - *Drosera* Loamy Dry-Mesic Uplands (Turner et al. 1999) B
- Longleaf Pine-Little Bluestem Series (Diamond 1993) B

APPENDIX H: NatureServe 2004 Community Type Descriptions

• Longleaf Pine: 70 (Eyre 1980) B

Classification Comments: *Pinus palustris*-dominated woodlands on the West Gulf Coastal Plain are threatened by fire suppression, forestry and agricultural land conversion, and over-grazing. The nominals of this type are too general, and the name may need revision to tie it more specifically. This type is closely related to *Pinus palustris* / *Schizachyrium scoparium* - *Rudbeckia grandiflora* var. *alismifolia* Woodland (CEGL003572).

CONSERVATION RANKING & RARE SPECIES

GRank: G2G3 (1997-11-23): This mesic longleaf pine woodland community occurs on gently rolling topography over moderately well-drained silt loams and fine sandy loams and is restricted to areas west of the Mississippi River in west-central Louisiana and eastern Texas. This is a pyrogenic community with fire-return intervals of 2 to 5 years. *Pinus palustris*-dominated woodlands on the West Gulf Coastal Plain are threatened by fire suppression, forestry and agricultural land conversion, and over-grazing. This was historically one of the most important upland forest types within its range. Few high-quality sites, with a mature canopy and an intact herbaceous layer, remain. In order to maintain the diverse herb layer, control hardwood invasion, and promote *Pinus palustris* regeneration, growing-season, low-intensity fires should be used approximately every 2 to 5 years to simulate the historic fire regime. If fire suppression occurs for approximately 8 to 12 years, this community will likely become overgrown with *Liquidambar styraciflua* and other hardwoods. With continued fire suppression, this community will experience increased hardwood invasion and cover and succeed to a mixed *Pinus palustris* Forest. Remaining examples are highly threatened by development, conversion, and alteration of fire regimes.

High-ranked species: *Botrychium jenmanii* (G3G4), *Echinacea sanguinea* (G3), *Picoides borealis* (G3), *Schwalbea americana* (G2), *Tridens carolinianus* (G3)

ELEMENT DISTRIBUTION

Range: This community occurs west of the Mississippi River in west-central Louisiana and eastern Texas.

Subnations: LA, TX

TNC Ecoregions: 40:?, 41:C

USFS Ecoregions: 231E:CC, 232F:CC

Federal Lands: USFS (Angelina, Kisatchie, Sabine NF)

ELEMENT SOURCES

References: Allard 1990, Bridges and Orzell 1989a, Correll and Johnston 1970, Diamond 1993, Eyre 1980, Hatchell 1964, Martin and Smith 1991, Martin and Smith 1993, Martin et al. 1993, Orzell 1990, Patterson et al. 1994, Smith 1996a, Southeastern Ecology Working Group n.d., Turner et al. 1999, USFS 1988

Species List Sorted by Habit (nomenclature per Kartesz 1999)																		
habit	Family	Genus	Species	Native?	Weed?	Ajivisgi 79	Nature Conserv Indicator List	Harcombe 1993	BT Floristics Project	Marks & Harcombe 81	Peet and Allard 1993				Heuberger & Putz 03	G	G	NatureServe 04
											XS	Listed?	S Xeric Woods	S Suberic Woods	S Mesic Woods	S Savanna		
G	Cyperaceae	Bulbostylis	ciliatifolia	N														
G	Cyperaceae	Carex	spp.	N	W													
G	Cyperaceae	Cyperus	haspen	N														
G	Cyperaceae	Cyperus	hystricinus	N														
G	Cyperaceae	Cyperus	retrorsus var. retrorsus	N														
G	Cyperaceae	Fiurena	bushii	N														
G	Cyperaceae	Rhynchospora	inexpansa	N	W													
G	Cyperaceae	Rhynchospora	recognita	N	W													
G	Cyperaceae	Scleria	ciliata	N														
G	Cyperaceae	Scleria	reticularis	N														
G	Cyperaceae	Scleria	triglomerata	N							SW							
G	Juncaceae	Juncus	scirpoides	N														
G	Poaceae	Andropogon	gerardii	N	W	LBU												
G	Poaceae	Andropogon	ternarius	N	W	LBU			*									
G	Poaceae	Andropogon	virginicus	N	W	LBU			*									
G	Poaceae	Aristida	purpurascens	N		LBU (BMLS)												
G	Poaceae	Dichanthelium	aciculare/sphaerocarpon	N														
G	Poaceae	Dichanthelium	acuminatum var. acuminatu.	N														
G	Poaceae	Dichanthelium	sphaerocarpon var. sphaerc	N														
G	Poaceae	Dichanthelium	spp.	N														
G	Poaceae	Digitaria	villosa	N					*									
G	Poaceae	Eragrostis	elliottii	N	W													
G	Poaceae	Eragrostis	spectabilis	N	W													
G	Poaceae	Opismenus	hirtellus ssp. setarius	N														
G	Poaceae	Panicum	brachyanthum	N														
G	Poaceae	Panicum	verrucosum	N														
G	Poaceae	Panicum	sp.	N														
G	Poaceae	Paspalum	setaceum	N	W				*									
G	Poaceae	Schizachyrium	scoparium	N					*									
G	Poaceae	Sorghastrum	elliottii	N		MGP			*									
G	Poaceae	Sorghum	halepense	E	W													
G	Poaceae	Sporobolus	asper	N		MGP												
H	Acanthaceae	Ruellia	humilis	N		LBU			*									

Species List Sorted by Habit (nomenclature per Kartesz 1999)																	
habit	Family	Genus	Species	Native?	Weed?	Ajivisgi 79	Nature Conserv Indicator List	Harcombe 1993	BT Floristics Project	Marks & Harcombe 81	Peet and Allard 1993				Heuberger & Putz 03	Grelen, Duvall 66	NatureServe 04
H	Apocynaceae	Apocynum	sp.	N	N			Y	*								Y
H	Aristolochiaceae	Aristolochia	reticulata	N	W	MGP (LBS)											G
H	Asclepiadaceae	Asclepias	verticillata	N	W				*								
H	Asteraceae	Ambrosia	artemisiifolia	N	W												
H	Asteraceae	Baccharis	halimifolia	N	W	MGP											
H	Asteraceae	Berlandiera	pumila var. scabrella	N		OFS	B		*								Y
H	Asteraceae	Chrysopsis	pilosa	N													
H	Asteraceae	Cirsium	horridulum	N	W	R (POF, SOF, LBS, LBU, OFS)				SM	X						G
H	Asteraceae	Conyza	canadensis	N	W												
H	Asteraceae	Croptilon	divaricatum	N	W		P										L
H	Asteraceae	Echinacea	sanguinea	N	W	LBU (MGP)	P	Y									
H	Asteraceae	Elephantopus	tomentosus	N		BMLS (LBU)					X	X					G
H	Asteraceae	Erechtites	hieraciifolia	N	W												L
H	Asteraceae	Erigeron	strigosus	N	W	R (LBU)			*			X					Y
H	Asteraceae	Eupatorium	capillifolium	N	W	LBS			*			X	X				Y
H	Asteraceae	Eupatorium	rotundifolia	N					*			X	X				Y
H	Asteraceae	Hieracium	gronovii	N	W						X	X					
H	Asteraceae	Krigia	wrightii	N													
H	Asteraceae	Lactuca	canadensis	N	W												
H	Asteraceae	Liatris	acidota/pycnostachya	N		LBS (MGP)	P										G
H	Asteraceae	Liatris	elegans elegans	N		OFS (LBU)	P		*								Y
H	Asteraceae	Pityopsis	graminifolia	N	W	LBU	P	Y			X	X	X	S			Y
H	Asteraceae	Pseudognaphaliur	obtusifolium	N		OFS (LBU)											
H	Asteraceae	Rudbeckia	hirta	N	W	LBU (OFS)			*			X					Y
H	Asteraceae	Solidago	ludoviciana	N			G										S
H	Asteraceae	Solidago	petiolaris	N		LBU	G										S
H	Asteraceae	Sonchus	sp.	N		R (LBU)											G
H	Asteraceae	Symphotrichum	divaricatum	N	W												
H	Asteraceae	Vernonia	texana	N		SOF	P	Y									Y
H	Bignoniaceae	Bignonia	capreolata	N	W												G
H	Buddleiaceae	Polypremum	procumbens	N	W	OFS (SOF)			*								L
H	Campanulaceae	Lobelia	puberula	N		MGP (LBU)											G
H	Cistaceae	Lechea	mucronata	N			P		*								N

Species List Sorted by Habit (nomenclature per Kartesz 1999)														
habit	Family	Genus	Species	Native?	Weed?	Agilvsgi 79	Nature Conserv Indicator List	Harcombe 1993	BT Floristics Project	Marks & Harcombe 81	Peet and Allard 1993	Heuberger & Putz 03	Grelen, Duvall 66	NatureServe 04
H	Scrophulariac	Mecardonia	acuminata	N	W	R (MGP, SOF, LBU)			sandhills, upland pine					
H	Scrophulariac	Penstemon	laxiflorus	N	W	LBU								
H	Scrophulariac	Verbascum	thapsus	E	W									
H	Solanaceae	Datura	wrightii	N										
H	Solanaceae	Solanum	ptychanthum	N	W	OFS (SOF, LBU)								
H	Xyidaceae	Xyris	jupicai	N		LBS (BGB)								
H	Xyidaceae	Xyris	sp.	N										
V	Anacardiacee	Toxicodendron	radicans	N	W									
V	Convolvulace	Ipomea	pandurata	N	W	R (SOF, LBU, OFS)								
V	Convolvulace	Jacquemontia	tamnifolia	N	W	R (POF, SOF)								
V	Fabaceae	Centrosema	virginianum	N	W	LBU (OFS)								
V	Fabaceae	Galactia	volubilis	N	W	OFS (LBU)								
V	Fabaceae	Mimosa	latidens	N	W	MGP								
V	Fabaceae	Rhynchosia	difformis	N		MGP (LBU, CG								
V	Fabaceae	Strophostyles	umbellata	N	W	SOF (POF, LBU)		*						
V	Fabaceae	Stylosanthes	biflora	N		LBU		*						
V	Passifloraceae	Passiflora	lutea	N		LBU (SOF, BMLS)								
V	Rosaceae	Rubus	trivialis	N	W	R (MGP, SOF, LBU, OFS)								
V	Rubiaceae	Diodia	teres	N	W									
V	Smilacaceae	Smilax	pumila	N	W									
V	Smilacaceae	Smilax	spp.	N	W									
V	Verbenaceae	Glandularia	canadensis	N	W	LBU (MGP, POF)								
V	Vitaceae	Parthenocissus	quinquefolia	N	W									
V	Vitaceae	Vitis	aestivalis?	N										
V	Vitaceae	Vitis	rotundifolia	N	W	SOF		*						
W	Aceraceae	Acer	rubrum	N	W									
W	Anacardiaceae	Rhus	copallinum	N	W	LBU								
W	Anacardiaceae	Rhus	glabra	N	W			*						
W	Aquifoliaceae	Ilex	coriacea	N		BGB								
W	Aquifoliaceae	Ilex	opaca	N		SOF								
W	Aquifoliaceae	Ilex	vomitaria	N	W			*						
W	Bignoniaceae	Catalpa	speciosa	N										
W	Cornaceae	Cornus	florida	N	W									

