DRY LONGLEAF PINE COMMUNITIES

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DRY LONGLEAF PINE COMMUNITIES THEME

Concept: Dry Longleaf Pine Communities occur in mesic to xeric sites in the Coastal Plain and lower Piedmont, where natural frequent fire promoted open woodland or savanna vegetation structure dominated or codominated by *Pinus palustris*. Drier communities (sandhills) have a distinctive layer of scrub oaks, which moister communities (savannas) lack. In natural condition, all have limited midstory and shrub layers, with the oaks confined to scattered groves and shrub-size sprouts, and all but the most xeric communities have dense grass-dominated herb layers.

Distinguishing Features: Dry Longleaf Pine Communities are distinguished by present or past dominance by *Pinus palustris*. It was usually exclusively or strongly dominant under natural fire regimes, but likely was mixed with *Pinus echinata* and a few other species in the Piedmont and in northern areas. In current conditions of inadequate fire, *Pinus palustris* may remain dominant but without reproduction. If it was removed by logging, evidence of past dominance may remain in the form of boundary trees, stumps boxed for sap collection, or associated species. *Aristida stricta* naturally dominated most communities; it is an extremely conservative species that is always associated with these communities, and its presence even as sparse remnant clumps indicates past presence of a longleaf pine community.

Within the theme, communities are distinguished by environmental gradients of moisture and soil texture, as well as by biogeography. Loamy or silty soils support a larger number of different communities than coarse sandy soils. Communities are broadly divided into sand barrens, sandhills, and mesic pine savannas. Sand barrens are the most extreme excessively drained coarse sands and are distinguished by a naturally sparse herb layer, a sparse pine canopy, and a midstory of *Quercus laevis*. Sandhills are dry to dry-mesic, on a variety of soil textures, with a dense grassy herb layer, and are characterized by a layer of scrub oaks and other small hardwoods, which may form a midstory or may exist mainly as shrub-size sprouts and scattered groves, depending on fire history. Mesic pine savannas occur only on finer-textured soils and largely lack a scrub oak layer. They resemble the wetter pine savannas in structure but contain upland species. They often have extremely high species richness.

Within the three drier community types, a Coastal Fringe Subtype is distinguished. All are marked by the presence of a suite of plants that, in North Carolina, are generally confined to within a few miles of the coast.

Dry Piedmont Longleaf Pine Forest occurs in the Piedmont, on very different soils. It lacks *Aristida stricta* and has a mixed grassy herb layer.

Synonyms: Sandhills, mesic flatwood, mesic savanna.

Sites: Dry Longleaf Pine communities occurred naturally on most upland sites in the Coastal Plain with the exception of bluffs, swamp islands, maritime areas, and other places naturally sheltered from frequent fire. They now are most extensive in the relict dunes and dissected uplands of the Sandhills Region. Examples elsewhere in the Coastal Plain remain on well-drained upland terraces and flats, as well as on relict dune fields, Carolina bay rims, relict floodplain terraces now above flood levels, and low rises in wetter flats. In the Piedmont, they occurred near the Fall Zone

primarily in distinctive areas of sandy soil, silt/clay hardpan on meta-sedimetary rocky, and dry slopes in the Uwharrie Mountains.

Soils: Examples may occur on virtually any kind of non-hydric upland soil, including Entisols and a wide variety of Ultisols.

Hydrology: This theme encompasses the full range of nonwetland hydrology, from the most xeric excessively drained conditions to the transition to wetlands. Seasonal high water tables may be present in the marginal examples.

Vegetation: Dry Longleaf Pine Communities characteristically have an open canopy with a woodland or savanna structure. *Pinus palustris* is virtually the only species present in most examples, but *Pinus echinata* or *Pinus taeda* may be mixed with it in a few of the communities. With long exclusion of fire, the other pines, along with hardwood species, invade most communities. The herb layer characteristically is dense in all but the most xeric communities. *Aristida stricta* dominates in most communities, while *Schizachyrium scoparium* dominates in Piedmont and far northern communities, and a mix of xerophytic species characterizes the most xeric sands. Herbaceous species richness ranges from fairly low to extremely high. Mesic Pine Savannas can have some of the highest values recorded anywhere at small to moderate scales.

The xeric to dry communities have a midstory of small hardwoods, predominantly scrub oaks (*Quercus laevis, Quercus marilandica, Quercus incana,* and *Quercus margaretiae*), which may become dense with exclusion of fire. The mesic communities tend to lack a midstory when frequently burned, but they may be invaded by a variety of other hardwoods, such as *Liquidambar styraciflua* and forest oaks, in the long absence of fire. A low shrub layer generally consists of sprouts of midstory hardwoods and patchy to sparse shrubs of a variety of species. With fire exclusion, shrubs may become dense and the midstory becomes dense and taller.

Dynamics: The distinctive dynamics and characteristics of longleaf pine communities, wet and dry, along with the existence of specialized research stations such as Tall Timbers and Ichuway Plantation and widespread conservation and forestry interest throughout the Southeast has led to a tremendous amount of research. While much remains to be learned, the broad picture of community dynamics and some of the finer details are well known. Dynamics appear to be generally similar across the spectrum from wet to dry longleaf pine communities and across the region, so that studies in Georgia and Florida are likely to apply in North Carolina.

Fire at frequent return intervals and low to moderate intensity is the crucial ecological driver of longleaf pine communities, which occur over a tremendous range of site and soil conditions but rarely occur in settings not conducive to fire spread. Longleaf pine communities embody the paradox that they are some of the most frequently disturbed communities in the world, yet they are naturally some of the most stable and are dominated by extremely conservative, stress-tolerating plants rather than ruderal species. Though fire was generally regarded as harmful to forests in the early 1900s and most fire was suppressed, there was some early recognition (e.g., Wells 1942, Garren 1943) of its importance for longleaf pine communities. Though fire is generally regarded as a disturbance in these communities, historically it was predictable enough that it might better be considered merely a part of the environment comparable to the loss of deciduous biomass caused by winter freezes. As noted by Fill et al. (2015), the view of fire

dynamics through a conceptual model of succession after disturbance may be better replaced by one of vegetation-fire feedbacks and dynamic equilibrium. In that vein, it has been suggested that the pines, by producing particularly pyrogenic fuels, are acting as ecosystem engineers, creating the fire environment that benefits them (Platt et al. 2016). This Louisiana study emphasized pine needles, not grass, as the driver of fire dynamics, but *Aristida stricta* is more flammable than the grasses at their site and appears to be a similarly important driver in most of our communities. Fire return intervals have generally been suggested to be around two to three years. Intervals as short as one year have been suggested by some authors to be beneficial to some aspects of communities (Glitzenstein et al. 2011, Frost 2000, Palmquist et al. 2014), but this frequency appears to be less favorable to other aspects.

All of the characteristic plant species of longleaf pine communities are well adapted to surviving fire, so that a typical fire causes almost no turnover of individuals of characteristic species. Fire recycles nutrients, though Christensen's (1977) experiments found that substantial amounts of major nutrients were lost to the air. Nevertheless, burned soils stimulated growth for reasons that were unclear. Frequent fire is the crucial factor that excludes uncharacteristic species from the community and removes litter. Fires kill the above-ground parts of most understory trees as well as shrub and herbs. *Pinus palustris* is highly specialized to be able to reproduce and mature in conditions of frequent fire, but shrubs and other trees only rarely and locally escaped fire long enough to grow tall. Most individuals existed as short sprouts, though groves apparently occurred in canopy gaps and in natural fire shelters. Although scrub oaks were less abundant under more natural conditions, they are well enough adapted to fire to have been a consistent component of sandhill communities and were important to some other species and ecological functions (Hiers et al. 2014).

There has been increasing evidence that the season when fires occur is important (Parrot 1967, Schneider 1988, Hiers et al. 2000), though it is clear the burning at any season is better than exclusion of fire. Natural fires presumably followed the seasonal pattern of lightning, though fires, once ignited, could burn for long times and spread long distances across the continuous flammable landscapes dominated by longleaf pine. Fires ignited by people far back into prehistory could have been at any season, but the flora and fauna appear to be best adapted for spring and summer fire. However, Hiers et al. (2000) indicate variation in seasonal effects on different herb species, supporting a general idea that variation in fire season may also be important for maintaining plant diversity.

Removal of fire from longleaf pine communities drastically alters these communities, increasingly so over time. Understory trees or shrubs proliferate, and their shade, along with accumulation of litter, suppresses and gradually eliminates the herbaceous species. Hiers et al. (2007) indicate that litter rather than shade itself is primarily responsible for suppressing herbaceous vegetation, at least in xeric sandhills in Florida, though they indicated that shade might be more important in mesic communities where the midstory could become denser. Longleaf pine itself is unable to regenerate in the shade of a dense understory, even if canopy gaps are available. This may be due to litter depth, but its "grass stage" delay in initiation of height growth makes it vulnerable to suppression even by shrubs. The accumulation of oak litter and the loss of grass reduces the effectiveness and likelihood of future fires, while scrub oaks that have grown large are fairly tolerant of fire. It therefore is difficult to restore examples that have gone too long without fire.

Even if dense midstory or canopy cover is mechanically reduced and litter burned, most of the diversity of herbaceous species is very slow to recover, while sprouting of shrubs and trees from well-established root systems quickly returns, or even increases, dense woody cover. However, Fill et al. (2017) reported that fairly rapid vegetative spread of *Aristida beryrichiana* and *Aristida stricta* likely has similar ability to fill space where it remains in a community at reduced density.

Most plant species associated with longleaf pine communities have conservative life histories. Though most have not been studied in detail, the characteristic herb species appear to have long life spans, rarely reproduce by seed, don't readily invade open areas, and don't have long term seed banks. Fill et al. (2014) indicated that species endemic to longleaf pine communities in general were more likely to be perennial than those that weren't. The more important question of how long the perennial species live is much more difficult to address, but most, especially the dominants, appear to turn over only slowly. Fill et al. (2014) found no difference in apparent seed dispersal ability for longleaf pine community endemic species, but they noted that this does not indicate that seedlings can readily establish. Though Fill et al. (2017) found that planted *Aristida beyrichiana* had seeded into nearby disturbed ground, and though seedlings of *Aristida stricta* have been found in a few places in North Carolina, the more common situation is to observe no return of the species to mechanically disturbed areas where it is absent. Even small disturbed areas such as old logging decks remain devoid of wiregrass and most other characteristic species after decades, even when surrounded by healthy stands that are burned regularly. Growing season burns appear to be necessary, but even they rarely lead to new seedlings. Coffey and Kirkman (2006), in Georgia, found no viable seed for *Aristida* in the soil and found only a small minority of experimentally buried seeds remain viable after 4 years. Schneider (1988) also found almost no seed bank for the characteristic dominant species in a savanna, with primarily weedy species in the seed bank. Fire is necessary for many of the species, including *Aristida stricta*, to flower, but additional conditions appear to be necessary for most species to successfully establish even in openings. Species diversity and density of most characteristic species recovers only very slowly from reduction by mechanical disturbance, herbicide use, heavy pine straw raking, and past fire suppression.

Longleaf pine also is a conservative species. It is among the most long-lived trees in the region, capable of exceeding 400 years (Platt et al. 1988). The species has numerous adaptations to help it survive the frequent low-intensity fires characteristic of its habitat, and it also survives strong winds better than most trees. Longleaf pine begins to produce seed at an older age or larger size than most trees, and abundant seed crops occur only every few years. Seeds need bare mineral soil to germinate, so successful seeding requires a seed crop to be preceded by a fire (Boyer and White 1990). The species is generally regarded as being extremely intolerant of shade and having limited seed dispersal, compared to other pines. However, Grace et al. (2004) found that seeds dispersed farther than was believed and that few seeds fell close to the parent tree, at least in her old-growth Georgia study site. The population did not have significant genetic structure, suggesting widespread dispersal within the population. Bhuta et al. (2008) indicated that mature trees can survive many years in dense shaded conditions and can still respond with rapid growth if released. Nevertheless, seedlings and saplings can be observed to be largely confined to canopy gaps, generally ¼ acre or more in size (Boyer and White 1990), though reduced pine litter cover and reduced fire intensity as well as light could be contributing reasons.

Though the conditions for successful reproduction of longleaf pine appear highly specialized today, these conditions were prevalent enough that the species dominated most of the Coastal Plain landscape.

Longleaf pine canopies naturally occur as old-growth, multi-aged woodlands. The natural population structure and dynamics of longleaf pine in North Carolina are believed to be similar to that found by Platt, Evans, and Rathbun (1988) in old growth longleaf pine forest in Georgia. The age structure there was patchy and heterogeneous, reflecting irregularities in both reproduction and mortality of the pines in response to environmental conditions and natural disturbances. Tree regeneration is somewhat episodic. Essentially all ages were represented, up to well beyond 200 years, indicating continuous establishment of long-lived trees. Younger trees tended to establish in small even-aged clumps, in areas with lower density of adult trees. Over time the clumps thinned and became less distinct, so that the old trees were more randomly distributed. This natural patch structure has been lost in most present examples, where past clearcutting has resulted in more uniform even-aged stands. Typical thinning also homogenizes any developing patch structure, but older canopies can be seen to be starting to develop a patchy structure as gaps form.

In addition to an old-growth canopy being characteristic under natural conditions, the herbaceous layer fits the concept of old-growth grasslands as outlined by Veldman et al. (2015), with high species richness; many species that do not occur in more disturbed "second growth" examples; and species with good resprouting ability but poor colonization ability, fire tolerance or dependence, etc. Unlike other grasslands they discussed, grazing does not appear to have been an important factor in maintaining them. Grazing was widespread in early European times and may have caused damage that has not been recognized. Foraging by hogs had a significant effect; by preferentially feeding on the roots of longleaf pine seedlings, they prevented regeneration of the canopy in logged examples and led to loss of longleaf pine cover over large areas.

Some characteristic animals such as *Picoides borealis* (red-cockaded woodpecker) have similar conservative life histories. Others, such as many insects, apparently do not readily escape fire; they depend on metapopulation structures and on rapid reproduction of individuals in unburned patches to repopulate burned areas.

The mechanisms by which soil texture determines differences in communities is not fully understood, though some aspects may be easily surmised. Excessive drainage in coarse, pure sands makes them extremely dry. Though the water table may be close enough that it is reached by the deep roots of established plants, drought stress in the seedling stage likely acts as a filter for species. However, coarse sands also have very low cation exchange capacity and nutrient-holding capacity. Loamy soils are better at retaining and supplying both water and nutrients. The effect of dense clay layers may be more complex. Weaver (1969) demonstrated that *Quercus marilandica* growing on soils with clay layers endured more drought stress than *Quercus laevis* on deep coarse sands uphill from it, apparently due to restricted rooting depth. He concluded that nutrient supply, perhaps manganese, rather than moisture, was what kept *Quercus marilandica* from occupying deep sands. Gilliam et al. (1993) surmised that nutrient availability was the crucial aspect of soil texture in their study site. Either nutrient supply or moisture availability may be the reason for the higher diversity of herbs on loamy soils, and for the much lower diversity and abundance of Fabaceae on sands.

More difficult to understand is the disappearance of scrub oaks in the Mesic Pine Savannas. As one goes downhill into these communities from Pine/Scrub Oak Sandhill, the density and apparent vigor of all scrub oaks decreases until few or none are present. No other midstory species typically replace them, though oak species more typical of forests, such as *Quercus stellata, Quercus falcata*, *Quercus velutina*, and *Quercus nigra,* eventually invade them after long absence of fire. The high species richness and increased density of the herb layer in Mesic Pine Savannas suggest that these sites are more rather than less favorable to plant growth. Competition with the herb layer, increased fire intensity in the more productive sites, or transient high water tables are possible mechanisms that may need investigation. Fill et al. (2017) observed that dense *Aristida beyrichiana*, even recently planted, inhibited the invasion by trees on a loamy soil in South Carolina.

Comments: While many natural communities remain underappreciated, both longleaf pine as a species and longleaf pine communities have received much attention and celebration in the last several decades. As stated by Landers et al. (1990) in a symposium on management of the species: "Probably no other single tree species in any region has so influenced cultural and natural ecology or advancement of the conservation science." The more broadly defined longleaf pine ecosystem is widely regarded as among the most endangered, with an extreme decline from its original abundance. The conservative life histories of most of its flora, including the dominant species, makes restoration difficult. However, areas that retain *Aristida* and other characteristic herbs can be restored by planting *Pinus palustris*. Emphasis by conservation organizations and the forestry community and by specialized organizations such as America's Longleaf Restoration Initiative have sought to reverse the drastic declines in acreage of the tree species and the ecosystems it dominates.

Longleaf pine communities, dry and wet, are the prevailing natural vegetation of the entire Coastal Plain of the Southeastern United States, from southernmost Virginia to eastern Texas. As in North Carolina, they occur over a very broad range of landforms and soil conditions. However, analysis of plot data from Virginia to Florida found that the strongest variation in vegetation was with biogeography (Palmquist et al. in prep). Plots in North Carolina were more similar to each other than they were to plots with comparable moisture levels in Florida. Species richness increases southward, but there also is significant species turnover through the range, with several centers of endemism. The dominant grasses also vary. *Aristida stricta* reaches its northern range limit north of the Neuse River, as well as being absent in the Piedmont. It ranges southward only through the northern third of South Carolina. *Aristida beyrichiana* dominates from southern South Carolina through Florida and the eastern Gulf Coast, but other grasses dominate in central South Carolina, in some inland areas of the Gulf Coastal Plain, and farther west.

Most of the subtypes in this theme were treated as variants in the 3rd Approximation, after being recognized in natural heritage surveys of longleaf pine communities. Most were confirmed by early analysis of CVS data. Recent thorough analysis of CVS plot data (Palmquist et al. in prep), supplemented by data ranging from Virginia to Florida, confirmed the identity of these units. Most of the descriptions here are based on that analysis but are supplemented by other observations.

The terms “savanna” and “flatwoods” have had been widely used in ecological literature in two different ways, applying to both pine and hardwood-dominated communities. At times, they refer simply to vegetation structure, with savannas being grassy and flatwoods being shrubby. In other usages, particularly in the Southeastern U.S., they refer to moisture regimes, with savannas being wetter and flatwoods somewhat drier. Savannas have also often been assumed to have high species richness, flatwoods low. In the 3rd approximation, the terms were used to indicate moisture regimes, with Mesic Pine Flatwoods and Wet Pine Flatwoods drier than Pine Savanna, which was always wet. Because this usage caused confusion, leading some users to expect that the flatwoods communities should naturally be shrubby, the usage in names has been shifted in the 4th Approximation. The species-rich mesic longleaf pine communities that are not naturally more shrubby have been renamed to use the term “savanna.” “Flatwoods” is now reserved for marginally wet sandy communities previously known as Wet Pine Flatwoods, which are low in species richness.

References:

Bhuta, A.A.R., L.M. Kennedy, C.A. Copenheaver, P.M. Sheridan, and J.B. Campbell. 2008. Boundary-line growth patterns to determine disturbance history of remnant longleaf pine (*Pinus palustris* P. Mill.) in mixed forests of southeastern Virginia. Journal of Torrey Botanical Society 135:516-529.

Boyer, W.D., and J.B. White. 1990. Natural regeneration of longleaf pine. In: R.M. Farrar (ed.). Proceedings of the symposium on the management of longleaf pine. Southern Forest Experiment Station General Technical Report SO-75.

Christensen, N.L. 1977. Fire and soil plant nutrient relations in a pine-wiregrass savanna on the Coastal Plain of North Carolina. Oekologia 31:27-44.

Coffey, K.L., and L.K. Kirkman. 2006. Seed germination strategies of species with restoration potential in a fire-maintained pine savanna. Natural Areas Journal 26:289-299.

Fill, J.M., W.J. Platt, S.M. Welch, J.L. Waldron, and T.A. Mousseau. 2015. Updating models for restoration and management of fiery ecosystems. Forest Ecology and Management 356:54-63.

Fill, J.M., J.S. Glitzenstein, D. Streng, J.P. Stowe, and T.A. Mousseau. 2017. Wiregrass (*Aristida beyrichiana*) may limit woody plant encroachment in longleaf pine (*Pinus palustris*) ecosystems. American Midland Naturalist 177:153-161.

Fill, J.M., S.M. Welch, H. Brown, J.L. Waldron, A.S. Weakley, and T.A. Mousseau. 2014. Life-history correlates of plant endemism in longleaf pine ecosystems. Southeastern Naturalist 13:484-492.

Frost, C.C. 2000. Studies in landscape fire ecology and presettlement vegetation of the southeastern United States. PhD. Dissertation, University of North Carolina, Chapel Hill.

Garren, K.H. 1943. Effects of fire on vegetation of the southeastern United States. Botanical Review 9:617-654.

Gilliam, F.S., B.M. Yurish, and L.M. Goodwin. 1993. Community composition of an old growth longleaf pine forest: relationship to soil texture. Bulletin of the Torrey Botanical Club 120: 287-294.

Glitzenstein, J.S., D.R. Streng, R.E. Masters, K.M. Robertson, and S.M. Hermann. 2011. Fire-frequency effects on vegetation in north Florida pinelands: Another look at the long-term Stoddard fire research plots at Tall Timbers Research Station. Forest Ecology and Management 264:197-209.

Grace, S.L., J.L. Hamrick, and W.J. Platt. 2004. Estimation of seed dispersal in the old-growth population of longleaf pine (*Pinus palustris*) using maternity exclusion analysis. Castanea 69:207-215.

Hiers, J.K., J.J. O'Brien, R.E. Will, R.J. Mitchell. 2007. Forest floor depth mediates understory vigor in xeric *Pinus palustris* ecosystems. Ecological Applications 17:806-814.

Hiers, J.K., J.R. Walters, R.J. Mitchell, J.M. Varner, L.M. Conner, L.A. Blanc, and J. Stowe. 2014. Ecological value of retaining pyrophytic oaks in longleaf pine ecosystems. Journal of Wildife Management 78:383-393.

Hiers, J.K., R. Wyatt, and R.J. Mitchell. 2000. The effects of fire regime on legume reproduction in longleaf pine savannas: is a season selective? Oecologia 125:521-530.

Landers, J.L., N. Byrd, and R. Komarek. 1990. A holistic approach to managing longleaf pine communities. In: R.M. Farrar (ed.). Proceedings of the symposium on the management of longleaf pine. Southern Forest Experiment Station General Technical Report SO-75.

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

Palmquist, K.A., R.K. Peet, and A.S. Weakley. 2014. Changes in plant species richness following reduced fire frequency and drought in one of the most species-rich savannas in North America. Journal of Vegetation Science 25:1426-1437.

Parrot, R.T. 1967. A study of wiregrass (*Aristida stricta*) with particular reference to fire. M.A. thesis, Duke University, Durham, NC.

Platt, W.J., G.W. Evans, and S. L. Rathbun. 1988. The population dynamics of a long-lived conifer (*Pinus palustris*). American Naturalist 13:491-525.

Platt, W.J., D.P. Ellair, J.M. Huffman, S.E. Potts, and B. Beckage. 2016. Pyrogenic fuels produced by savanna trees can engineer humid savannas. Ecological Monographs 86:352-372.

Schneider, R.E. 1988. The effect of variation in season of burning on a pine-wiregrass savanna in the Green Swamp, North Carolina. PhD. Dissertation, Duke University, Durham, NC.

Veldman, J.W., E. Buisson, G. Durigan, G.W. Fernandes, S.L. Stradic, G. Mahy, D. Negreiros, G.E. Overbeck, R.G. Veldman, N.P. Zaloumis, F.E. Putz, and W.J. Bond. 2015. Toward an old-growth concept for grasslands, savannas, and woodlands. Frontiers in Ecology and the Environment 13:154-162. www.frontiersinecology.org.

Weaver, T.W. 1969. Gradients in the Carolina Fall-line Sandhills: environment, vegetation, and comparative ecology of the oaks. Ph.D. Dissertation, Duke University, Durham, NC.

Wells, B.W. 1942. Ecological problems of the southeastern United States Coastal Plain. Botanical Review 8:533-561.

KEY TO DRY LONGLEAF PINE COMMUNITIES

1. Community in the Piedmont region; *Aristida stricta* almost always absent. ..... **Dry Piedmont Longleaf Pine Forest**

1. Community in the Coastal Plain; *Aristida stricta* almost always present in relatively natural examples.

2. Community in the northern Coastal Plain, north of the native range of *Aristida stricta* (roughly the Tar River). ..... **Pine/Scrub Oak Sandhill (Northern Subtype)**

2. Community in the southern Coastal Plain, including the Sandhills region; *Aristida stricta* naturally present and almost always dominant in the herb layer in relatively unaltered examples.

3. Community containing scrub oaks (*Quercus laevis, marilandica, incana, margaretiae, geminata*, etc.) in more than minor numbers, either as a distinct midstory or as sprouts after recent fires (or deliberately removed by herbicide treatment).

4. Community containing a relatively low density of scrub oaks given its management history, exclusively or primarily *Quercus marilandica*; community also containing species more typical of wetter sites, such as *Vaccinium crassifolium, Pyxidanthera barbulata, Bigelowia nudata, Osmundastrum cinnamomeum, Ctenium aromaticum, Cyrilla racemiflora*, and *Vaccinium elliottii* (also keyed elsewhere)

5. Community occurring on a substrate of clay or cemented rock on or near a hilltop in the Sandhills region; *Vaccinium crassifolium* or *Pyxidanthera* usually abundant. ..... **Pine/Scrub Oak Sandhill (Clay/Rock Hilltop Subtype)**

5. Community not occurring on a substate or clay or cemented rock; *Vaccinium crassifolium* and *Pyxidanthera* abundant or not.

6. Community occurring on elevated floodplain terraces along the Little River; community often containing *Vaccinium elliottii*, sometimes containing *Amorpha georgiana*. ..... **Mesic Pine Savanna (Little River Subtype)**

6. Community occurring on upland flats in the inner Coastal Plain of Robeson County or adjacent areas. ..... **Mesic Pine Savanna (Lumbee Subtype)**

4. Community containing a higher density of scrub oaks, as either a midstory or as fire sprouts, often dense if there has been a period of fire suppression in the past, but at least widespread in the community if not treated with herbicide; scrub oaks include abundant *Quercus laevis, Quercus incana,* or other species besides *Quercus marilandica*; wetland species absent or, if present, confined to wetter microsites or abundance and diversity low.

7. Scrub oaks consisting exclusively or almost entirely of *Quercus laevis*; community on dry, excessively drained sands not influenced by finer texture material.

8. Community on uncommon deep, excessively drained coarse sands; herb layer sparse to moderate in density even in natural condition, with abundant *Cladonia* or *Cladina* lichens, *Stipulicida setacea*, *Cnidoscolus stimulosus*, *Bryodesma acanthonota* (*Selaginella arenicola*), and other species adapted to extremely sandy environments; *Aristida stricta* with limited density even in unaltered sites; *Pinus palustris* stature and density reduced compared to other longleaf pine communities with similar management.

9. Community containing species generally indicative of the coastal fringe zone, such as *Quercus geminata, Quercus hemispherica, Cartrema americana, Rhynchospora megalocarpa*, and *Cladina evansii*, at least at low density; community generally within a few miles of the coast, but occasionally in isolated sandy sites inland. ..... **Sand Barren (Coastal Fringe Subtype)**

9. Community not containing species generally indicative of the coastal fringe zone. ..... **Sand Barren (Typic Subtype)**

8. Community on common deep sands that are less excessively drained; *Aristida stricta* at moderate to high density if not altered, dominating the herb layer; *Cladonia, Cladina, Stipulicida, Cnidoscolus, Bryodesma*, and other species specialized for sand often present but not the predominant herbs; *Pinus palustris* of typical density and stature for its management history (note that sites with soil disturbance may resemble the more sparsely vegetated Sand Barren communities).

10. Community containing species generally indicative of the coastal fringe zone, such as *Quercus geminata, Quercus hemispherica, Cartrema americana, Rhynchospora megalocarpa*, and *Cladina evansii*, at least at low density; community generally within a few miles of the coast, but occasionally in isolated sandy sites inland. .... **Xeric Sandhill Scrub (Coastal Fringe Subtype)**

10. Community not containing species generally indicative of the coastal fringe zone. .... **Xeric Sandhill Scrub (Typic Subtype)**

7. Scrub oaks mixed, with *Quercus incana, marilandica*, or *margaretiae* dominant or codominant with *Quercus laevis; c*ommunity on fine sands, sands with a clay layer near the surface, or loamy soil.

11. Community containing species generally indicative of the coastal fringe zone, such as *Quercus geminata, Quercus virginiana, Quercus hemispherica, Cartrema americana, Rhynchospora megalocarpa*, and *Cladina evansii*, at least at low density; community generally within a few miles of the coast, but occasionally in isolated sandy sites inland..... ..... **Pine/Scrub Oak Sandhill (Coastal Fringe Subtype)**

11. Community not containing species generally indicative of the coastal fringe zone.

12. Community, if not heavily altered, with a diverse herb layer containing species indicative of mesic conditions or loamy soil, such as *Lespedeza capitata, Lespedeza hirta*, *Sorghastrum nutans, Gymnopogon brevifolius, Muhlenbergia capillaris, Andropogon gerardii, Panicum virgatum*, *Parthenium integrifolium*, *Ceanothus americana*, and a number of additional legumes.

13. Community in the Sandhills region; containing species such as *Coreopsis major, Viola pedata, Baptisia cinerea, Rhynchosia reniformis, Phlox nivalis, Asclepias amplexifolius,* and *Galium pilosum* that are primarily in that region..... .....**Pine/Scrub Oak Sandhill (Sandhills Mesic Transition Subtype)**

13. Community elsewhere in the Coastal Plain; species more typical of the Sandhills region scarce or absent; species typical of the outer Coastal Plain, such as *Trilisa odoratissima, Tephrosia hispidula, Pterocaulon pycnostachyum, Helianthus heterophyllus*, and *Rhynchospora plumosa* present..... ..... **Pinus/Scrub Oak Sandhill (Coastal Plain Mesic Transition Subtype)**

12. Community with moderate to lower herb diversity, containing few or none of the species indicative of mesic conditions or loamy soil.

14. Community occurring on a substrate of clay or cemented rock at the surface, on or near a hilltop in the Sandhills region; scrub oaks primarily *Quercus marilandica*, with little *Quercus laevis*; scrub oaks reduced in density compared to other sandhill communities with the same management history; *Vaccinium crassifolium* or *Pyxidanthera* usually abundant. ..... **Pine/Scrub Oak Sandhill (Clay/Rock Hilltop Subtype)**

14. Community not occurring on a substate or clay or cemented rock at the surface; scrub oaks mixed, with *Quercus laevis* or *Quercus incana* abundant; scrub oaks at normal density given management history; *Vaccinium crassifolium* generally absent; *Pyxidanthera* abundant or not.

15. Community occurring on sand with a clay or plinthite layer within roughly 2 meters of the surface; scrub oaks a mix of *Quercus marilandica* and *Quercus laevis*; herb layer moderately diverse; common in the Sandhills region but rare elsewhere .... **Pine/Scrub Oak Sandhill (Blackjack Subtype)**

15. Community occurring on fine sand without a clay or plinthite layer; scrub oaks generally lacking *Quercus marilandica*, consisting primarily of *Quercus laevis* and *Quercus incana* or *Quercus margaretiae*; herb diversity somewhat lower; scattered in the Coastal Plain and Sandhills. .....**Pine/Scrub Oak Sandhill (Mixed Oak Subtype)**

3. Community not containing scrub oaks in more than minor numbers, though forest oaks (*Quercus falcata, Quercus stellata, Quercus velutina, Quercus nigra*) may be present in unburned examples; species of mesic or loamy sites abundant.

16. Community in the Sandhills region; containing species typical of that region.

17. Very rare community on high terraces of the Little River; containing a mix of species with a wider range of moisture tolerance than typical; *Quercus marilandica* present in small amounts. .. ..**Mesic Pine Savanna (Little River Subtype)**

17. Uncommon community in swales or on loamy soils in typical Sandhills terrain; species typical of dry to mesic sites with limited wetland flora present. ....**Mesic Pine Savanna (Sandhills Subtype)**

16. Community in the Coastal Plain outside of the Sandhills.

18. Rare community in the inner Coastal Plain of Robeson County and adjacent areas; containing a mix of species with a wider range of moisture tolerance than typical; *Quercus marilandica* and wetland species such as *Osmundastrum cinnamomeum* and *Sarracenia flava* generally co-occurring; *Quercus elliottii* often present. .... **Mesic Pine Savanna (Lumbee Subtype)**

18. Uncommon community elsewhere in the Coastal Plain; containing a mix of species typical of mesic to wet areas with limited species of drier areas. .... **Mesic Pine Savanna (Coastal Plain Subtype)**

DRY PIEDMONT LONGLEAF PINE FOREST

Concept: Dry Piedmont Longleaf Pine Forest covers woodlands or forests of the eastern Piedmont (primarily the Uwharries and nearby fall zone areas) in which *Pinus palustris* naturally dominates or codominates. *Pinus palustris* may be scarce in examples where past logging and fire suppression have removed it and allowed other pines or hardwoods to dominate.

Distinguishing Features: Dry Piedmont Longleaf Pine Forest is distinguished from all other Piedmont dry communities by having *Pinus palustris* dominant or codominant, or by having evidence that it once dominated. In degraded examples, the canopy may resemble Dry Oak–Hickory Forest or Piedmont Monadnock Forest or may be dominated by *Pinus taeda* and *Pinus echinata*, with evidence of *Pinus palustris* limited to scattered individuals or to stumps. It is distinguished from Wet Piedmont Longleaf Pine Forest by its overall dry to dry-mesic vegetation, lacking any appreciable amount of wetland species. It is distinguished from most longleaf pine communities of the adjacent Coastal Plain by lacking *Aristida stricta, Quercus laevis, Quercus incana*, and *Quercus margaretiae*, as well as by its Piedmont location and soils. The Northern Subtype of Pine/Scrub Oak Sandhill also lacks *Aristida stricta* but contains the Coastal Plain scrub oaks.

Synonyms: *Pinus palustris - Pinus echinata - (Pinus virginiana) / Quercus marilandica - (Quercus prinus) / Vaccinium pallidum* Woodland (CEGL008437).
Ecological Systems: Southeastern Interior Longleaf Pine Woodland (CES202.319).

Sites: Dry Piedmont Longleaf Pine Forests may occur on a variety of upland sites in the southeastern Piedmont. Many are in rolling terrain on metasedimentary rocks with deep soils that are particularly high in silt. Less frequently they are found in more rugged terrain on steeper rocky slopes that face south or west.

Soils: Soils are Ultisols, some very silty, some more typical loams. Most examples are mapped as Herndon or Georgeville (Typic Kanhapludults), Biscoe or Secrest (Aeric Epiaquults).

Hydrology: Conditions are dry to dry-mesic, possibly locally mesic. Some soils may be poorly drained and have wetter microsites.

Vegetation: In natural condition this community is believed to have an open savanna to woodland canopy with limited understory and shrub layer and a well-developed herb layer, comparable to most longleaf pine communities. The canopy is dominated or codominated by *Pinus palustris*. *Pinus taeda* and *Pinus echinata* may be codominant, and *Quercus stellata, Quercus falcata*, and *Quercus montana* are believed to be present in the canopy under natural conditions. These species, and other forest hardwoods, often have become dominant in the absence of fire. The understory/midstory includes these hardwoods and additionally may include *Quercus marilandica, Oxydendrum arboreum, Nyssa sylvatica*, *Sassafras albidum*, *Diospyros virginiana*, and *Cornus florida*, which may be characteristic under natural conditions. Other tree species frequent in CVS plots data, *Acer rubrum, Prunus serotina, Quercus coccinea, Quercus alba, Quercus velutina, Liriodendron tulipifera*, and *Liquidambar styraciflua,* presumably became abundant only as a result of fire exclusion and logging. The most abundant shrub species include *Vaccinium tenellum,*

Gaylussacia frondosa, Vaccinium pallidum, Gaylussacia dumosa, Lyonia mariana, Rhus copallinum, and *Vaccinium stamineum*, and many of the hardwood tree species may exist more naturally as shrub-size sprouts. Other characteristic shrub species include *Toxicodendron pubescens, Vaccinium arboreum, Hypericum stragulum, Ceanothus americanus, Castanea pumila*, and *Kalmia latifolia*. *Muscadinia rotundifolia* often is abundant on the ground. *Schizachyrium scoparium* probably dominated the herb layer under more natural fire regimes, but only occasionally does so in plot data of existing examples. The herb layer potentially is very diverse. Frequent herbs in plot data that likely are naturally characteristic include *Tephrosia virginiana, Solidago odora, Pteridium latiusculum*, *Coreopsis major, Iris verna* var. *verna*, *Sorghastrum nutans, Chrysopsis mariana, Pityopsis graminifolia* var. *latifolia,* and *Danthonia sericea*. Other characteristic herbaceous species include *Andropogon gyrans*, *Symphyotrichum patens, Andropogon gerardii, Coreopsis verticillata, Coreopsis major, Helianthus atrorubens, Helianthus divaricatus, Lespedeza hirta, Desmodium nuttallii, Desmodium lineatum,* other *Desmodium* and *Lespedeza* spp., *Mimosa microphylla, Parthenium integrifolium, Hypoxis hirsuta, Eupatorium pilosum, Eupatorium rotundifolium, Galactia erecta, Euphorbia pubentissima, Dichanthelium* spp., *Helianthus laevigatus, Helianthus schweinitzii, Sericocarpus asteroides, Stylosanthes biflora,* and *Ionactis linariifolia*. A number of weedy species may additionally be present in examples that are being restored, and more shade-tolerant species may be present in examples that remain heavily shaded.

Range and Abundance: Ranked G2. In North Carolina, the most intact remaining examples of this community are primarily in the Uwharrie area, but examples are recognizable near the fall zone as far north as Wake County. The equivalent association ranges to Alabama, where it is more extensive, though still limited. Known there as mountain longleaf pine, it occurs in the Ridge and Valley and Interior Plateaus regions as well as the Piedmont. At least a few examples remain in Georgia. This community likely once was abundant in a fairly narrow band at the edge of the Piedmont.

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Associations and Patterns: Dry Piedmont Longleaf Pine Forests sometimes occur in mosaics with Wet Piedmont Longleaf Pine Forest and are often associated with Piedmont Boggy Streamhead and Hillside Seepage Bog communities in embedded wetlands. Piedmont Headwater Stream Forest or Piedmont Alluvial Forest occurs in larger drainages. Dry Piedmont Longleaf Pine Forest is inherently a large patch to matrix forming community in the most suitable fall zone landscapes, but examples now are reduced to small, rarely large patches. However, naturally small patches occur in rugged hilly terrain dominated by oak forests in parts of Uwharrie National Forest. Elsewhere, the natural transition from longleaf pine to the prevailing Piedmont oak forest landscape is not known. They probably were locally interspersed as determined by topography and its conduciveness to fire spread.

Variation: Dry Piedmont Longleaf Pine Forest covers a broader range of moisture and topographic positions than Piedmont hardwood forests or most longleaf pine forests. The extreme alteration by past logging and fire suppression have made it difficult to tell natural patterns from patterns of alteration. Recent restoration activities, while improving conditions of the communities in many ways, introduce further variation not related to natural patterns. Additional subtypes may become distinguishable as burning continues and as more information is gathered. For the present, two variants are recognized.

1. Typic Variant represents most of the known remaining examples in the fall zone and the eastern Uwharrie region. They have moderate to gentle topography and once occurred as large patch to matrix communities. This variant may warrant further division into mesic, dry-mesic, and dry variants based on topography, or the examples on extremely silty soils may be distinctive.
2. Mountain Variant occurs on steeper slopes in rugged terrain in the Uwharrie region, as small patch communities on dry slope aspects. Known examples are more shrubby than the Typic Variant, but this may be a result of less fire in recent years. However, fire likely was somewhat less frequent in the dissected landscape where this variant occurs.

The mountain longleaf pine forests of Alabama would be a different variant, or perhaps several.

Dynamics: As with other longleaf pine communities, Dry Piedmont Longleaf Pine Forest depends on frequent fire to maintain its ecological character. Without fire, trees and shrubs quickly proliferate, and hardwood trees gradually establish a dense canopy that eliminates the characteristic herbs. However, natural fire likely was somewhat less frequent than in the Coastal Plain, because of fewer thunderstorms and because of the dissected terrain of the Piedmont. The absence of *Aristida stricta* also would make them less conducive to fire spread; no other herbs are as flammable as it, nor able to carry fire in as many conditions. This lower fire frequency may allow other pines and some oaks to coexist with the longleaf pine. However, the abundance of *Pinus palustris* suggests fire at greater frequency than was typical elsewhere in the Piedmont. The Mountain Variant occurs in more dissected terrain, where fire frequency could be expected to be even lower, and dry microsites are probably crucial to its composition. This difference in fire frequency, along with the substrate, presumably is responsible for the different flora and different character of this community.

Comments: Patterson and Knapp (2016) intensively studied the best remaining example of the Mountain Variant, mapping every longleaf pine tree. Dendrochronological study of this site and of small collections of longleaf pines in the rugged parts of the Uwharrie Mountains has revealed the presence of old trees.

Another NVC association, *Pinus palustris - Quercus marilandica - Quercus prinus / Symplocos tinctoria* Woodland (CEGL004554), was formerly recognized in the NVC but later merged. It appears equivalent to the Mountain Variant. If further investigation of the Mountain Variant determines it to be distinct, this association might be revived to cover it. In its present condition, it does not appear distinctive enough for recognition.

The relationship between this community and Xeric Piedmont Slope Woodland needs to be clarified, as both occur in similar settings in the same area.

Rare species:
Vascular plants: *Helianthus laevigatus, Cirsium carolinianum*, and *Pseudognaphalium helleri*.

References:
Patterson, T.W., and P.A. Knapp. 2016. Observations on a rare old-growth montane longleaf pine forest in central North Carolina, USA. Natural Areas Journal 36: 153-161.

SAND BARREN (TYPIC SUBTYPE)

Concept: Sand Barrens are the driest, most barren naturally occurring nonmaritime sandy communities of the Coastal Plain, as well as the driest longleaf pine communities. They have naturally low vegetation cover in all strata and a prominent suite of sand-tolerant (psammophyte) plants. They typically are on Carolina bay rims or on the younger inland sand dunes. The Typic Subtype covers the typical examples in most parts of the Coastal Plain, which lack the plants characteristic of the Coastal Fringe Subtype.

Distinguishing Features: Sand Barrens are distinguished from Xeric Sandhill Scrub and all other longleaf pine communities by low cover of grasses even in natural condition and by high relative abundance of specialized psammophytes, macrolichens, and bare sand. Characteristic plants include *Polygonella polygama, Stipulicida setacea, Mononeuria (Minuartia) caroliniana, Bryodesma (Selaginella) acanthonota*, and *Cnidoscolus stimulosus*, as well as *Aristida stricta* at low density. All vegetation strata typically have low cover. Distinguishing natural Sand Barrens from disturbed sandhill communities of more mesic types can sometimes be difficult. Old-looking or gnarled-looking (though small) longleaf pines and turkey oaks; presence of wiregrass at least in more mesic microsites; a diversity of psammophytes; and absence of weedy plants such as *Andropogon virginicus, Eupatorium capillifolium*, and *Eupatorium compositifolium* are indicators of natural conditions. The Typic Subtype is distinguished from the Coastal Fringe Subtype by the absence of plants that are (in North Carolina at least) confined to the coastal zone — *Cladina evansii, Rhynchospora megalocarpa, Ilex vomitoria*, *Quercus geminata*, and to a lesser degree, *Quercus hemispherica*.

Synonyms: Xeric Sandhill Scrub (Sand Barren Variant); *Pinus palustris / Quercus laevis / Aristida stricta / Cladonia* spp. Woodland (CEGL003584).
Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254). Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: Sand Barrens occur on the coarsest, purest sands, elevated well above the water table. They occur on the highest parts of Carolina bay rims, of younger dunes associated with Carolina bays, and of relict dune systems on the east sides of rivers.

Soils: Soils are Typic Quartzipsamments, generally mapped as the Kureb or Lakeland series. Most areas mapped as these series support Xeric Sandhill Scrub, and only the most extreme minority supports Sand Barrens. The coarse sand, with almost no fine particles and little organic matter, has extremely low capacity for nutrient storage as well as for water retention.

Hydrology: Sites are excessively drained, with rain water quickly passing through the coarse soil, leaving surface soils extremely dry most of the time. These settings have been described as "deserts in the rain" (Wells 1932). However, the water table may be within reach of the roots of larger plants; trees are sometimes described as acting as phreatophytes.

Vegetation: Vegetation is sparse in all strata. The canopy is almost exclusively *Pinus palustris*, but consists of widely scattered individuals or small clumps, the trees small in stature. The midstory is sparse and patchy but may be naturally more extensive than in less extreme sandhill

communities. *Quercus laevis* strongly dominates, but sparse individuals of *Quercus margarettiae, Diospyros virginiana*, or *Sassafras albidum* often are present. Individuals of unexpected species, such as *Quercus nigra*, *Pinus taeda*, *Pinus serotina*, or *Ilex opaca* may also be found in sites with long fire exclusion. The shrub layer consists of low-stature species in a patchy distribution. *Gaylussacia dumosa*, *Vaccinium tenellum*, and *Lyonia mariana* are characteristic, the distinctive dwarf form of *Vaccinium stamineum* may occasionally be seen, and in a few notable sites *Chrysoma pauciflosculosa* is abundant. A variety of species of more moist communities may occasionally be present, including *Gaylussacia frondosa, Clethra alnifolia*, and *Arundinaria tecta*. Most of these species have clonal growth and can spread from rare establishment sites, or even from adjacent communities. Vines, though sparse, may be prominent in patches, especially *Muscadinia rotundifolia* or *Gelsemium sempervirens*. The herb layer is sparse, with much area of bare sand and often high cover of *Cladonia* spp. lichens. *Aristida stricta* is present as scattered individuals or dominating favorable patches in a minority of the area. *Polygonella polygama* may be equally abundant. Other frequent species in CVS plots (Palmquist et al. in prep.) include *Stipulicida setacea*, *Bryodesma acanthonota*, *Cnidoscolus stimulosus, Cuthbertia graminea,* and *Sabulina caroliniana*. As with shrubs, species of wetter areas are occasionally present, especially clonal species such as *Pteridium latiusculum*. Species richness is very low, with an average in CVS plots of only 12. The open sand appears to have a cryptogamic crust in many places where undisturbed. Patches have the sand cemented by black material while in other areas a green layer may be found by scraping away 1-2 millimeters of sand.

Range and Abundance: Ranked G2. The Typic Subtype is widely scattered in the middle and inner Coastal Plain and occasional in the Sandhills region. The largest concentration is in the Bladen Lakes area of Bladen and Cumberland counties. The widespread sand sheets of the Sandhills region appear to be too shallow or have too much fine material to support this community. This subtype ranges into northern South Carolina.

Associations and Patterns: Sand Barrens are small patch or large patch communities. They typically grade to Xeric Sandhill Scrub and Wet Pine Flatwoods on lower parts of the dune systems. Pond Pine Woodland or other peatland communities are often nearby in adjacent Carolina bays and swales.

Variation: Two variants are recognized:

1. Typic Variant: Examples in the Bladen Lakes region and Sandhills, fitting the description above and lacking *Chrysoma pauciflosculosa*.
2. Woody Goldenrod Variant: Examples on river sand dunes along the Lumber River and likely in similar sites in South Carolina, characterized by *Chrysoma pauciflosculosa*, which may be among the most abundant plants.

Dynamics: Sand Barrens differ from all other Dry Longleaf Pine Communities and Wet Longleaf Pine Communities in not necessarily being dependent on frequent fire. The sparse, patchy vegetation makes fire spread irregular; many parts may escape ignition in any given fire. Examples may persist in the absence of fire, long after surrounding communities have been degraded, but slow accumulation of litter may eventually lead to changes and loss of the distinctive character in the absence of fire.

Because of the extremely dry soil conditions, establishment of *Pinus palustris* and perhaps all component plants is likely even more episodic than in other longleaf pine communities, However, it will depend more on the occurrence of wet years than of fire.

Comments: Tiger beetles (*Cicindella* spp.) can often be seen in these communities and may be a more important animal component than elsewhere.

Rare species:
Vascular plants: *Stylisma pickeringii.*

References:
Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

Wells, B.W. 1932. The natural gardens of North Carolina. UNC Press, Chapel Hill NC.

SAND BARREN (COASTAL FRINGE SUBTYPE)

Concept: Sand Barrens are the driest, most barren naturally occurring nonmaritime sandy communities of the Coastal Plain, with low vegetation cover in all strata and a prominent suite of sand-tolerant (psammophyte) plants. The Coastal Fringe Subtype combines this extreme character with a suite of characteristic species that occur in North Carolina only very near the coast.

Distinguishing Features: Sand Barrens are distinguished from Xeric Sandhill Scrub and all other longleaf pine communities in natural condition by low cover of grasses and high cover of specialized psammophytes, macrolichens, and bare sand. Characteristic plants include *Polygonella polygama, Stipulicida setacea, Mononeuria (Minuartia) caroliniana, Bryodesma (Selaginella) acanthonota*, and *Cnidoscolus stimulosus*, as well as *Aristida stricta* at low density. The Coastal Fringe Subtype is distinguished by the presence of characteristic coastal fringe flora, such as *Cladina evansii, Rhynchospora megalocarpa, Ilex vomitoria*, *Quercus geminata*, and to a lesser degree, *Quercus hemispherica*. These species are indicators and may be present only in small numbers or concentrated in moist microsites.

Synonyms: Xeric Sandhill Scrub (Coastal Fringe Variant); *Pinus palustris / Quercus laevis / Aristida purpurascens - Stipulicida setacea - (Rhynchospora megalocarpa, Selaginella acanthonota)* Woodland (CEGL003590).
Ecological Systems: Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: Sand Barrens occur on the coarsest, purest sands, elevated well above the water table. The Coastal Fringe Subtype occurs on relict coastal dunes and beach ridges. Occurrences are in a zone inland of the barrier islands but within a few miles of the coast.

Soils: Soils are Typic Quartzipsamments, generally mapped as the Kureb series. Most areas mapped as these series support Xeric Sandhill Scrub, and only the most extreme minority supports Sand Barrens. The coarse sand, with almost no fine particles and little organic matter, has extremely low capacity for nutrient storage as well as for water retention.

Hydrology: Sites are excessively drained, with rain water quickly passing through the coarse soil, leaving surface soils extremely dry most of the time. However, the water table may be within reach of the roots of larger plants; trees are sometimes described as acting as phreatophytes.

Vegetation: Vegetation is sparse in all strata. The canopy is almost exclusively *Pinus palustris*, but consists of widely scattered individuals or small clumps, the trees small in stature. The midstory is sparse and patchy but may be naturally more extensive than in less extreme sandhill communities. *Quercus laevis* dominates, and *Quercus geminata* and *Quercus hemispherica* range from sparse to codominant. Individuals of other species, such as *Pinus taeda*, *Diospyros virginiana*, *Quercus nigra*, or *Ilex opaca* may also be found occasionally. The shrub layer is patchy in distribution. *Gaylussacia dumosa*, *Vaccinium tenellum*, *Lyonia mariana*, and *Opuntia mesacantha* are characteristic; *Ilex vomitoria* or the distinctive dwarf form of *Vaccinium stamineum* may occasionally be seen. Vines, though sparse, may be prominent in patches, especially *Muscadinia rotundifolia*, *Gelsemium sempervirens*, and possibly *Smilax auriculata*. The herb layer is sparse, with much area of bare sand and often high cover of *Cladina evansii* as well

as *Cladonia* spp. lichens. *Aristida stricta* is present as scattered individuals or dominating favorable patches in a minority of the area. *Polygonella polygama* var. *polygama* may be equally abundant. Other frequent species in CVS plot data (Palmquist et al. in prep.) include *Rhynchospora megalocarpa*, *Stipulicida setacea*, *Bryodesma acanthonota*, *Cnidoscolus stimulosus, Euphorbia ipecacuanhae,* and *Sabulina caroliniana*. As with shrubs, species of wetter areas are occasionally present, especially clonal species such as *Pteridium latiusculum*.

Range and Abundance: Ranked G2, but possibly G1. This subtype is extremely rare in North Carolina, with only a handful of examples known in the southern third of the coastal fringe zone. It is also known in northern South Carolina.

Associations and Patterns: Examples typically grade to the Coastal Fringe subtypes of Xeric Sandhill Scrub and Pine/Scrub Oak Sandhill on lower parts of the dune systems. They may also be associated with Coastal Fringe Evergreen Forest, and with a variety of wetland communities.

Variation: No variants are recognized. Examples can be very heterogeneous and vary with the transition to adjacent communities.

Dynamics: Both subtypes of Sand Barrens differ from all other Dry Longleaf Pine Communities and Wet Longleaf Pine Communities in not necessarily being dependent on frequent fire. The sparse, patchy vegetation makes fire spread irregular; many parts may escape ignition in any given fire. Examples may persist in the absence of fire, long after surrounding communities have been degraded, but slow accumulation of litter may eventually lead to changes and loss of the distinctive character in the absence of fire.

The Coastal Fringe Subtype presumably is subject to more severe occasional disturbance by tropical storms; salt spray may be a more important disturbance than wind damage.

Comments: This subtype is not as strongly differentiated as most subtypes. The characteristic coastal fringe flora are only marginal in their tolerance of Sand Barren habitats, and they are a less prominent part of the community than they are in the Coastal Fringe subtypes of Xeric Sandhill Scrub and Pine/Scrub Oak Sandhill. However, the climatic factors that support coastal fringe flora in all these community types are likely to have effects on other organisms in the community (animals, microbes) and on ecosystem processes, even in the extreme environment of Sand Barrens.

Rare species:
Vertebrate animals: *Picoides borealis* and *Pituophis melanoleucus melanoleucus*.

References:
Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (Pinus palustris) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

XERIC SANDHILL SCRUB (TYPIC SUBTYPE)

Concept: Xeric Sandhill Scrub is the widespread longleaf pine community of dry, coarse, infertile sands, which have a low diversity scrub oak layer strongly dominated by *Quercus laevis*, but which have fairly high cover of *Aristida stricta* and other herbs rather than the sparse vegetation of the Sand Barrens. The Typic Subtype covers most examples of the Sandhills and Coastal Plain, where plants characteristic of the coastal fringe are absent.

Distinguishing Features: Xeric Sandhill Scrub is distinguished from most other communities by the presence of a scrub oak layer strongly dominated by *Quercus laevis*. *Quercus marilandica* is absent, but *Quercus margaretiae* and *Quercus incana* may be present in small amounts. The Typic Subtype is distinguished from the Coastal Fringe Subtype by the absence of characteristic coastal fringe flora, such as *Cladina evansii, Rhynchospora megalocarpa, Cartrema americana, Ilex vomitoria*, and *Quercus geminata*.

Xeric Sandhill Scrub is distinguished from Sand Barren by higher plant cover in the herb layer, especially of *Aristida stricta*. Bare sand patches of any size are absent unless the soil or vegetation has been disturbed. Lichens and specialized psammophytes such as *Stipulicida setacea* and *Minuartia caroliniana (= Arenaria caroliniana)* may be present but are minor in abundance in comparison with *Aristida stricta*.

Synonyms: Xeric Sandhill Scrub (Turkey Oak Variant); Xeric Sandhill Scrub (Coastal Plain Variant); *Pinus palustris / Quercus laevis / Gaylussacia dumosa / Aristida stricta* Woodland (CEGL003586). Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254). Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: Xeric Sandhill Scrub occurs on deep sands throughout the Coastal Plain, including the extensive sand sheets on uplands of the Sandhills region, dunes associated with rivers, rims of Carolina bays, Coastal Plain scarps, and relict beach ridges and dunes.

Soils: Soils characteristically are Typic Quartzipsamments, usually mapped as the Lakeland, Kureb, or Candor series, less often as Alpin or Cainhoy. A minority are mapped as Mandarin (Typic Haplohumod) or Centenary (Entic Haplohumod). Examples occur on a number of other soil map units but probably represent inclusions. The coarse sand, with almost no fine particles and little organic matter, has extremely low capacity for nutrient storage as well as for water retention.

Hydrology: Site are excessively drained, but less extremely so than the Sand Barrens. Water passes quickly through the coarse soil, leaving dry conditions soon after rain events. Perhaps more than in the Sand Barrens, roots of larger plants may reach the water table and find a more abundant water supply.

Vegetation: Vegetation structure is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. In the long absence of fire, the midstory becomes dense and shrubs expand, but otherwise they are sparse and very

patchy. *Pinus palustris* typically is the only canopy tree. The midstory is dominated by *Quercus laevis*. Small numbers of other small tree species may be present, most frequently *Quercus incana* and *Diospyros virginiana*, and less frequently *Quercus margaretiae, Sassafras albidum*, *Nyssa sylvatica*, and occasionally *Crataegus* sp. The most frequent and extensive shrubs are *Gaylussacia dumosa* and *Toxicodendron radicans*, and CVS data (Palmquist et al. in prep) show a surprising high frequency of *Hypericum hypericoides* (perhaps *H. stragulum*). Other shrubs often noted in site-based species lists include *Vaccinium tenellum, Rhus copallinum*, and *Robinia nana*. The herb layer is dense to moderate, with *Aristida stricta* strongly dominant. Other frequent species in Palmquist et al. (in prep), though with low cover, include *Schizachyrium scoparium, Andropogon elliottii, Andropogon gyrans, Carphephorus bellidifolius, Cnidoscolus stimulosus, Euphorbia ipecacuanhae, Pityopsis adenolepis, Galactia volubilis, Solidago odora, Cirsium repandum, Stylisma patens*, and *Stipulicida setacea*. Other species frequently noted include *Tephrosia virginiana, Baptisia cinerea, Sericocarpus linifolius*, and *Euphorbia curtissii*. *Cladonia* spp. lichens are sometimes present but are not usually extensive.

Range and Abundance: Ranked G3? The Typic Subtype is one of the most extensive longleaf pine communities remaining in North Carolina. It is abundant in natural areas in the Sandhills Region, where it makes up a large portion of the landscape mosaic. Xeric Sandhill Scrub is less extensive but is common in sandy areas of the middle and outer Coastal Plain, except in the narrow coastal fringe. This community ranges into northern South Carolina, where it is similarly abundant in natural landscapes.

Associations and Patterns: Xeric Sandhill Scrub typically occurs as part of a landscape mosaic with Pine/Scrub Oak Sandhill and Streamhead Pocosin in the Sandhills Region. In other Coastal Plain regions, it occurs in a mosaic with Wet Pine Flatwoods, Pond Pine Woodland, and less frequently Pine/Scrub Oak Sandhill (Mixed Oak Subtype), Sandy Pine Savanna, Sand Barren, or various Coastal Plain Depressional Wetlands.

Variation: There are floristic difference between examples in the Sandhills region and those in the rest of the Coastal Plain. These can be recognized as variants:

1. Sandhills Variant: In the Sandhills Region, usually more diverse, with more legumes, and with *Pityopsis adenolepis* frequent.
2. Coastal Plain Variant: In the inner to outer Coastal Plain, usually less diverse, often with no legumes, without *Pitysopsis adenlepis*, and often with half as many herbaceous species.

Dynamics: Dynamics are typical for longleaf pine/scrub oak communities. In the long absence of fire, scrub oaks become dense enough to inhibit regeneration of longleaf pine and to suppress the herb layer. Once established, *Quercus laevis* persistently resprouts after fire.

Comments:

Rare species:
Vascular plants: *Astragalus michauxii, Carex tenax, Crataegus munda* var. *munda, Euphorbia cordifolia, Pyxidanthera brevifolia, Stylisma pickeringii* var. *pickeringii*, and *Warea cuneifolia*.
Vertebrate animals: *Ophisaurus mimicus, Peucaea aestivalis, Picoides borealis,* and *Pituophis melanoleucus*.

Invertebrate animals: *Hesperia meskei.*

References:

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

XERIC SANDHILL SCRUB (COASTAL FRINGE SUBTYPE)

Concept: Xeric Sandhill Scrub is the longleaf pine community of dry, coarse, infertile sands, which have a low diversity scrub oak layer strongly dominated by *Quercus laevis*, but which have fairly high cover of *Aristida stricta* and other herbs rather than the sparse vegetation of the Sand Barrens. The Coastal Fringe Subtype covers examples near the coast that contain characteristic coastal fringe plant species.

Distinguishing Features: Xeric Sandhill Scrub is distinguished from most other communities by the presence of a scrub oak layer strongly dominated by *Quercus laevis*. *Quercus marilandica* is absent, but *Quercus margaretiae* and *Quercus incana* are often present. The Coastal Fringe Subtype is distinguished from the Typic Subtype by the presence of characteristic coastal fringe flora, such as *Cladina evansii, Rhynchospora megalocarpa, Ilex vomitoria*, *Cartrema americana*, and *Quercus geminata*. The Coastal Fringe Subtype generally occurs within a few miles of the coast.

Xeric Sandhill Scrub is distinguished from Sand Barren by higher plant cover in the herb layer, especially of *Aristida stricta*. Bare sand patches of any size are absent unless the soil or vegetation has been disturbed. Lichens and specialized psammophytes such as *Stipulicida setacea* and *Mononeuria (Minuartia) caroliniana* are generally present but are minor in abundance in comparison with *Aristida stricta*.

Synonyms: *Pinus palustris / Quercus laevis* - *Quercus geminata / Vaccinium tenellum / Aristida stricta* Woodland (CEGL003589).
Ecological Systems: Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: Xeric Sandhill Scrub (Coastal Fringe Subtype) occurs on deep sands of relict coastal dunes, beach ridges, river dunes, and Carolina bay rims, in a zone inland of the barrier islands but within a few miles of the coast.

Soils: Soils characteristically are Typic Quartzipsamments, usually mapped as the Kureb series, less frequently mapped as Centenary (Entic Haplohumod) or Mandarin (Typic Haplohumod). Examples occur on a number of other soil map units but probably represent inclusions. The coarse sand, with almost no fine particles and little organic matter, has extremely low capacity for nutrient storage as well as for water retention, though it is less extreme than in Sand Barren communities.

Hydrology: Sites are excessively drained, but less extremely so than the Sand Barrens. Water passes quickly through the coarse soil, leaving dry conditions soon after rain events. Perhaps more than in the Sand Barrens, roots of larger plants may reach the water table and find a more abundant water supply.

Vegetation: Vegetation structure is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. In the long absence of fire, the midstory becomes dense and shrubs expand, but otherwise they are sparse and very patchy. *Pinus palustris* typically is the only canopy tree. The midstory is dominated by *Quercus laevis* and *Quercus geminata*. Small numbers of other small tree species may be present, most

frequently *Diospyros virginiana*, *Sassafras albidum*, *Quercus incana*, and *Quercus hemispherica*. The prevalent shrubs in Palmquist et al. (in prep) are *Vaccinium tenellum*, *Vaccinium stamineum* (presumably the dwarf form), and *Morella pumila*. *Lyonia mariana* is also frequent; *Ilex vomitoria, Cartrema americanum*, and several species of wetter habitats may occasionally be present. The herb layer is moderate in density, with *Aristida stricta* dominant. Other prevalent species, though with low cover, include *Schizachyrium scoparium*, *Carphephorus bellidifolius, Euphorbia ipecacuanhae, Pityopsis graminifolia, Rhynchospora megalocarpa, Cnidoscolus stimulosus*, and *Galactia* spp. Lichens, *Cladina evansii* as well as *Cladonia* spp., may be abundant.

Range and Abundance: Ranked G2?. This subtype is quite rare, and most likely G2 is appropriate. In North Carolina it is confined to a narrow band near the coast in the southern half of the state. It ranges into northern South Carolina.

Associations and Patterns: Xeric Sandhill Scrub (Coastal Fringe Subtype) occurs in a landscape mosaic with Pine/Scrub Oak Sandhill (Coastal Fringe Subtype), Coastal Fringe Evergreen Forest, and occasionally Sand Barren (Coastal Fringe Subtype). A variety of wetland communities may be associated.

Variation: No variants are recognized. Examples vary with the transition to other communities.

Dynamics: Dynamics generally are typical for longleaf pine/scrub oak communities. However, the evergreen oak litter may affect fire behavior on a fine scale. It has been suggested (Frost 2000) that the evergreen scrub oaks, especially *Quercus geminata*, once established, prevent fire from spreading into their microsites because their curled leaves can hold rain water and stay wet much longer than other leaf litter. Thus, their patches may expand and persist without burning even where fire occurs, and it may be particularly hard to reverse an increase in their abundance with fire suppression.

The reasons for the distinctive flora of the Coastal Fringe subtypes in the area near the coast is not well known, and no published study addresses it. The characteristic coastal fringe species are more widespread inland in states farther south, so the moderation of winter temperatures by the ocean is a likely factor. Input of nutrients by aerosols is also greater near the ocean, and this may affect nutrient dynamics in these communities. Salt spray and wind damage during tropical storms likely causes more disturbance in the coastal fringe than inland. Fire dynamics, too, maybe affected by aspects of the coastal environment, including interspersion with estuaries and influence of sea breezes.

Comments: As with other coastal fringe communities, the interpretation of this subtype's distinctive character as maritime may only apply in North Carolina. Many of the species that mark them occur in inland areas in states farther south. This community does not occur in those areas because of other biogeographic differences.

Rare species:
Vascular plants: *Polygonella articulata, Euphorbia cordifolia,* and *Stylisma pickeringii* var. *pickeringii*.

Vertebrate animals: *Heterodon simus, Mastocophis flagellum, Ophisaurus mimicus, Peucaea aestivalis, Picoides borealis, Pituophis melanoleucus*, and *Sistruris miliaris*.

References:

Frost, C.C. 2000. Studies in landscape fire ecology and presettlement vegetation of the southeastern United States. PhD. Dissertation, University of North Carolina – Chapel Hill.

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

PINE/SCRUB OAK SANDHILL (BLACKJACK SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and infertile than Xeric Sandhill Scrub, and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by species other than *Quercus laevis*. The Blackjack Subtype covers communities where *Quercus marilandica* is a significant component, generally mixed with *Quercus laevis*. They are associated with soils having a layer of dense clay below a sandy surface. These are common in the Sandhills region but occur only occasionally in other parts of the Coastal Plain.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. However, *Quercus laevis* may still codominate. Pine/Scrub Oak Sandhills are distinguished from Mesic Pine Savannas and wetter longleaf pine communities by the presence of scrub oaks (other than the occasional presence of *Quercus marilandica*). In frequently burned sites, most or all scrub oaks may exist as sprouts. In sites where land managers have treated stands with herbicide, scrub oaks may be artificially absent, and this type will have to be distinguished from Mesic Pine Savanna by the lack of the more mesophytic herbaceous and shrub species characteristic of that type. Fire-suppressed Mesic Pine Savannas may contain forest oaks such as *Quercus stellata, Q. falcata, Q. velutina*, and *Q. nigra*, but little or none of the scrub oaks characteristic of this type. Pine/Scrub Oak Sandhill (other than the Northern Subtype) is distinguished from Piedmont Longleaf Pine Forest by the presence of *Aristida stricta;* by the absence of characteristic Piedmont upland forest species such as *Oxydendrum arboreum, Quercus montana*, and *Quercus coccinea*; and, in the most natural examples, by the absence of a substantial component of *Pinus taeda.* Substrate and location readily distinguish these two types in altered examples where *Aristida* may have been lost.

The Blackjack Subtype is distinguished from the Mixed Oak Subtype by the presence of appreciable amounts of *Quercus marilandica*. It is distinguished from the Clay/Rock Hilltop Subtype, which may contain substantial *Quercus marilandica,* by the presence of *Quercus laevis*, the absence of *Vaccinium crassifolium* and other wetland species, and the presence of sand at the soil surface. It is distinguished from the Mesic Transition Subtype, which may contain substantial *Quercus marilandica* but generally has little *Quercus laevis*, by the absence of characteristic more-mesic herbs and shrubs; though the herb layer may be fairly diverse, it is less rich in plant species than the Mesic Transition Subtype. The Blackjack Subtype is distinguished from the Northern Subtype by the presence, at least historically, of *Aristida stricta*.

Synonyms: *Pinus palustris / Quercus marilandica / Gaylussacia dumosa / Aristida stricta* Woodland (CEGL003595).
Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254). Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281) (rarely).

Sites: The Blackjack Subtype occurs in sites with sandy surface material overlying a clay layer near the surface. Most occurrences are on side slopes in the dissected terrain of the Sandhills Region, where stream erosion has exposed interbedded sands and clays beneath the aeolian sand

layer that covers the flatter uplands. A few examples occur in other parts of the Coastal Plain in similar settings.

Soils: Soils are coarse sands with a clay layer beneath. They are classified as Ultisols, but the clay layer apparently generally is part of the parent material rather than solely a result of translocation of clay material. Plinthite is common. The most common soil map units are Candor (Arenic Paleudult), Blaney (Arenic Hapludult), Vaucluse (Typic Hapludult), Gilead (Aquic Hapludult), and Fuquay (Plinthic Paleudult), less often Dothan (Plinthic Paleudult) and Ailey (Arenic Kanhapludult). Many examples are also mapped as Lakeland, a sandy Entisol, but these likely represent inclusions.

Hydrology: Sites are usually dry to xeric but may have a perched water table for brief periods. Weaver (1969) demonstrated that, during drought, the scrub oaks in this community endured more water stress than those in nearby Xeric Sandhill Scrub, presumably because the clay layer restricted root access to the deeper soil and bound remaining water too tightly for it to be used.

Vegetation: Vegetation structure in the Blackjack Subtype is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. *Pinus palustris* is usually the only canopy species, but occasional *Pinus echinata* or *Pinus taeda* may be present. The midstory and low shrub layer are sparse and patchy when the community is frequently burned but become increasingly dense with fire exclusion. The midstory is dominated by *Quercus laevis* and *Quercus marilandica*. Other frequent species in CVS plot data (Palmquist et al. in prep), seldom abundant, include *Quercus incana, Quercus margarettiae, Diospyros virginiana, Sassafras albidum, Nyssa sylvatica*, *Carya pallida*, and *Cornus florida*. *Gaylussacia dumosa* and *Toxicodendron pubescens* usually are the most abundant shrubs, and *Vaccinium tenellum* and *Rhus copallinum* var. *copallinum* may be frequent. The herb layer is moderate to dense and fairly diverse. *Aristida stricta* dominates, and a number of grasses and forbs are frequent but not dominant. Frequent species in CVS plots include *Schizachyrium scoparium* var. *scoparium*, *Andropogon gyrans*, *Andropogon ternarius*, *Sporobolus junceus*, *Tephrosia virginiana*, *Pityopsis adenolepis, Baptisia cinerea*, *Solidago odora*, *Carphephorus bellidifolius*, *Symphyotrichum walteri*, *Ionactis linariifolia*, *Sericocarpus tortifolius*, *Silphium compositum*, *Coreopsis major, Cirsium repandum*, *Liatris pilosa, Euphorbia curtisii*, *Tragia urens*, *Galactia regularis*, *Stylosanthes biflora*, *Danthonia sericea*, *Scleria nitida, Scleria ciliata*, *Iris verna*, *Vernonia angustifolia*, and *Dichanthelium* spp. In the transition to wetter communities, *Pteridium pseudocaudatum*, *Lyonia mariana*, and *Clethra alnifolia* appear and may be abundant.

Range and Abundance: Ranked G2G3. The Blackjack Subtype is one of the most extensive communities in intact areas of the Sandhills Region, with large acreage occurring on Fort Bragg and the Sandhills Game Land. However, good examples are scarce beyond these areas, and the limited range, limited number of good examples, and vulnerability to deterioration in the absence of fire threaten it. It is rare elsewhere in the Coastal Plain. It ranges into northern South Carolina, where it also is abundant in the limited intact landscapes.

Associations and Patterns: In the Sandhills, this is a matrix community. It occurs in a mosaic, occupying most of the side slopes while Xeric Sandhill Scrub (Typic Subtype) covers the deeper sands on the rolling uplands and Streamhead Pocosin fills most of the numerous drainages. This mosaic covers most of the Sandhills landscape, with other communities embedded in it as small

patches. Sandhill Seep, Pine/Scrub Oak Sandhill (Mesic Transition Subtype), Mesic Pine Savanna, Sandhill Streamhead Swamp, Streamhead Atlantic White Cedar Forest, Streamhead Canebrake, and Coastal Plain Semipermanent Impoundment are among the communities that may border the Blackjack Subtype. The transition to other longleaf pine communities is often very gradual but the transition to the wetland communities is usually abrupt. It may be more gradual under a natural fire regime, but the shift in soil from a sand to muck surface creates an ecological discontinuity. This edge is sometimes a diverse ecotonal zone that resembles a wetter pine savanna community.

Variation:

1. Typic Variant: Typical common examples in the Sandhills Region.
2. Coastal Plain Variant: The rare examples in the middle to outer Coastal Plain. Differences are not well known, but there are floristic differences between the Sandhills and the outer Coastal Plain.

Dynamics: The dynamics of this subtype are typical of longleaf pine communities in general, as described in the Dry Longleaf Pine Communities theme.

Comments: The Blackjack Subtype, in a general sense, fit into a moisture and fertility gradient between Xeric Sandhill Scrub and Mesic Pine Flatwoods. However, this is complicated by varying conditions in areas with clay layers near the surface. These areas may be moist or even wet at times, but the clay layer may limit rooting depth. Weaver (1969) found that sites with *Quercus marilandica* were drier than those with just *Q. laevis*, and that *Q. marilandica* endured greater moisture stress during droughts. He suggested that lack of nutrients rather than dryness was responsible for excluding *Q. marilandica* from Xeric Sandhill Scrub

This community is confined to the range of *Aristida stricta* and is replaced by a different "wire grass gap" community in central South Carolina, and by the Northern Subtype in northern North Carolina.

Rare species:

Vascular plants: *Astragalus michauxii, Crocanthemum carolinianum, Galactia mollis, Liatris squarrulosa, Polygala grandiflora, Pseudognaphalium helleri, Pyxidanthera brevifolia, Rhus michauxii, Schwalbea americana,* and *Solidago verna*.
Vertebrate animals: *Peucaea aestivalis, Picoides borealis,* and *Pituophis melanoleucus*.

References:

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

Weaver, T.W. 1969. Gradients in the Carolina Fall-line Sandhills: environment, vegetation, and comparative ecology of the oaks. Ph.D. Dissertation, Duke University, Durham, NC.

PINE/SCRUB OAK SANDHILL (MIXED OAK SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities containing a scrub oak layer, but that are less xeric than Xeric Sandhill Scrub due to at least some fine-textured material in the sandy soil. The scrub oak layer contains a mix of species rather than being strongly dominated by *Quercus laevis*. The Mixed Oak Subtype covers examples on fine sands or on slightly silty soils without clay, where *Quercus incana* or less often *Quercus margaretiae* are abundant but *Quercus marilandica* is not a significant component.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished by having a mix of scrub oaks or having oaks other than *Quercus laevis* dominant or codominant beneath the *Pinus palustris* canopy. The Mixed Oak Subtype is distinguished from Xeric Sandhill Scrub and other drier communities by having codominant or abundant *Quercus incana* or, less often, *Quercus margaretiae*. *Quercus laevis* is, however, usually codominant.

The Mixed Oak Subtype is distinguished from the Blackjack and Clay/Rock Hilltop subtypes by lacking any significant amount of *Quercus marilandica*. It is distinguished from the Mesic Transition Subtype, which may also have dominant *Quercus incana*, by a lower species richness, limited number of leguminous species, and lack of the diverse suite of mesic species characteristic of that subtype, such as *Crotalaria purshii, Desmodium lineatum, Rhynchosia reniformis, Tephrosia florida, Panicum virgatum, Gymnopogon brevifolius, Anthenantia villosa, Andropogon gerardii*, and *Sorghastrum nutans*. It is distinguished from the Northern Subtype by occurring within the range of *Aristida stricta*, and, at least historically, having it present. It is distinguished from the Coastal Fringe Subtype by lacking plants that, in North Carolina at least, are largely confined to near the coast. These include *Quercus geminata, Quercus virginiana, Osmanthus americanus, Ilex vomitoria, Rhynchospora megalocarpa*, and *Cladina evansii*. *Quercus hemisphaerica* is more often abundant in the Coastal Fringe Subtype but may also occur in the Mixed Oak Subtype.

Synonyms: *Pinus palustris / Quercus laevis - Quercus (incana, margarettiae) / Gaylussacia dumosa / Aristida stricta* Woodland (CEGL003591).
Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254). Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: The Mixed Oak Subtype occurs on in deep sand sites where the sand is fine-textured or contains some silt. In the Sandhills Region, it tends to occur in small swales but may occur in larger expanses on the rolling upland surface. In the rest of the Coastal Plain, it is sometimes found in dissected sandy uplands or on Carolina bay rims.

Soils: Soils are believed to be fine sand or sand mixed with some silt but without a clay layer or substantial clay component. No soil series or map unit seems to be specifically associated with this subtype. At least 24 series are mapped for known occurrences. Some of the more common are Centenary (Grossarenic Alorthod), Baymeade (Arenic Hapludult), Kenansville (Arenic Hapludult), Wakulla (Psammentic Hapludult), and Kureb (Spodic Quartzipsamment).

Hydrology: Moisture conditions are dry and well drained but are not xeric and are not as excessively drained as in Xeric Sandhill Scrub. Sites are above the high water table but may be close enough that wet conditions occur in lower microsites or in ecotones.

Vegetation: The Mixed Oak Subtype has an open canopy strongly dominated by *Pinus palustris*. The scrub oak layer is usually a mix of *Quercus incana* and *Quercus laevis*, sometimes with abundant *Quercus margaretiae*. Other oaks are scarce, but *Diospyros virginiana* or *Sassafras albidum* may also occur. In the Palmquist et al. (in prep) detailed analysis of CVS plot data, and similarly in site descriptions, *Gaylussacia dumosa* and *Vaccinium tenellum* are highly constant and often dominate patches. *Morella pumila, Gaylussacia frondosa, Vaccinium stamineum,* and *Ilex glabra* are also highly constant among shrubs, and *Toxicodendron pubescens, Vaccinium arboreum,* and *Rhus copallinum* are frequent. The herb layer is dominated by *Aristida stricta*. Other highly constant species include *Schizachyrium scoparium, Cnidoscolus stimulosus, Pityopsis graminifolia, Sericocarpus tortifolius, Ionactis linariifolia, Liatris* spp., *Tragia urens, Solidago odora, Euphorbia ipecacuanhae,* and *Scleria nitida*. Also frequent are *Galactia* spp., *Andropogon ternarius, Cirsium repandum, Symphyotrichum walteri*, *Scleria ciliata*, and, in the outer Coastal Plain, *Trilisa odoratissima*.

Range and Abundance: Ranked G3? The Mixed Oak Subtype occurs in the Sandhills and is scattered throughout the southern half of both the outer and inner Coastal Plain. About 35 occurrences are known, but few are in very good condition. Many occur on small privately owned sites in areas with no other longleaf pine communities nearby, though some are present on larger public lands. The NVC association is questionably attributed to South Carolina, and it is likely this community occurs there.

Associations and Patterns: The Mixed Oak Subtype likely once functioned as a mosaic community, making up a frequent part of the landscape mosaic though not predominating, and this is still true in some larger natural areas. However, most of the occurrences are now isolated remnants that now more resemble small patch communities.

Variation: Variation is not well characterized. Given the wide range of this subtype, it is likely that there are biogeographic differences among the regions where it occurs, but this is obscured by the alteration caused by lack of fire in many examples.

Dynamics: Dynamics are similar to other sandhill communities, as described in the Dry Longleaf Pine Communities theme description.

Comments: This subtype is one of the less well studied of longleaf pine communities and perhaps one of the less distinctive. It does, however, have a clear niche in the gradient of moisture and soil texture, though the niche appears to be narrower than for most communities. No plant species are known to have it as their primary habitat. It is defined mainly by the absence of characteristic species and features of other longleaf pine communities.

Rare species:
Vascular plants: *Astragalus michauxii* and *Yucca gloriosa*.

Vertebrate animals: *Peucaea aestivalis, Picoides borealis,* and *Pituophis melanoleucus melanoleucus,*

References:

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Xeric and subxeric longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties.

PINE/SCRUB OAK SANDHILL (SANDHILLS MESIC TRANSITION SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and less infertile than Xeric Sandhill Scrub and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by oak species other than *Quercus laevis*. The Sandhills Mesic Transition Subtype covers those with loamy soil, greater fertility, or possibly closer proximity to the water table that support a very diverse flora that includes mesic herb and shrub species, and that contain the distinctive flora of the Sandhills region. They share many plants with Mesic Pine Savannas but differ in having a significant scrub oak component.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. The Sandhills Mesic Transition Subtype is transitional to Mesic Pine Savanna (Sandhills Subtype). It can be distinguished by the presence of scrub oaks in significant numbers (these may be reduced in density and present as shrub-size sprouts if the site has been frequently burned). Communities in which oaks have been artificially eradicated may be difficult to distinguish but will lack the small component of wetland species usually found in Mesic Pine Savanna.

The Sandhills Mesic Transition Subtype is distinguished from other subtypes by a combination of a suite of mesic species with a suite of species typical of the Sandhills region, coupled with absence or scarcity of a suite characteristic of the outer Coastal Plain. Mesic species include *Anthenantia villosa, Sorghastrum nutans, Andropogon gerardii, Paspalum bifidum, Tridens carolinianus, Lespedeza capitata, Lespedeza hirta*, *Helianthus divaricatus, Sorghastrum elliottii*, *Sporobolus clandestinus*, *Lithospermum (Onosmodium) virginianum*, *Muhlenbergia capillaris*, *Ceanothus americanus*, and several *Desmodium* and other *Lespedeza* species. The scrub oaks may be less dense in this subtype than in the Blackjack Subtype under the same management regime. Forest oaks such as *Quercus falcata* and *Quercus stellata*, plus *Liquidambar styraciflua,* often proliferate in the absence of fire. Species frequent in the Sandhills Mesic Transition Subtype and not in the Coastal Plain Mesic Transition Subtype include *Toxicodendron pubescens, Ceanothus americanus. Galium pilosum, Coreopsis major, Baptisia cinerea, Viola pedata, Rhynchosia reniformis, Phlox nivalis, Asclepias amplexifolius, Astragalus michauxii, Cuthbertia graminea, Carphephorus bellidifolius, Oenothera fruticosa*, and a number of others. Species typical of the Coastal Plain Mesic Transition Subtype include *Eupatorium rotundifolium, Chasmanthium laxum, Baptisia tinctoria, Trilisa odoratissima, Tephrosia hispidula, Pterocaulon pycnostachyum,* and a number of species shared with wetter communities, such as *Polygala lutea, Gymnopogon ambiguus, Helianthus heterophyllus*, and *Rhynchospora plumosa*.

Synonyms: Pine/Scrub Oak Sandhill (Loamy Soil Variant); “pea swales”; *Pinus palustris / Quercus incana / Aristida stricta - Sorghastrum nutans - Anthaenantia villosa* Woodland (CEGL003578). Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254).

Sites: The Sandhills Mesic Transition Subtype occurs where the substrate, though sandy, contains a significant component of finer material. It occurs on lower slopes or in gently sloping swales.

Soils: The Sandhills Mesic Transition Subtype has soils with sandy loam or loam texture. They are generally not distinguished well in soil mapping. They are generally mapped in larger units of Blaney (Arenic Hapludult), Gilead (Aquic Hapludult), Candor (Arenic Paleudult), or Vaucluse (Typic Hapludult), sometimes as sandy soils such as Lakeland (Typic Quartzipsamment).

Hydrology: Sandhills Mesic Transition Subtype sites are well-drained but are less dry than most sandhills because of the loamy soil texture.

Vegetation: Vegetation structure in the Sandhills Mesic Transition Subtype is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. *Pinus palustris* is often the only canopy species, but *Pinus echinata* or *Pinus taeda* may be present and occasionally abundant. The midstory and low shrub layer are sparse and patchy when the community is frequently burned but become increasingly dense with fire exclusion. The midstory is dominated by a mix of *Quercus incana. Quercus marilandica*, *Quercus margaretiae*, and *Quercus laevis*. *Quercus stellata* or *Quercus falcata* may be present, and *Liquidambar styraciflua* may become abundant in unburned sites. *Diospyros virginiana, Sassafras albidum, Nyssa sylvatica, Carya pallida*, and *Cornus florida* are also frequent. The highly constant shrubs in CVS plot data (Palmquist et al. in prep.) are *Gaylussacia dumosa, Vaccinium tenellum, Toxicodendron pubescens*, and *Rhus copallinum*, but species more distinctive to this community also occur, including *Ceanothus americanus* and *Rhus michauxii*.

The herb layer is dominated by *Aristida stricta* but includes a high diversity of species shared with drier sandhills, a suite of distinctive mesic species that are shared with Mesic Pine Savannas, and limited abundance of species typical of wetter communities. Highly constant herb species in CVS plot data (Palmquist et al. in prep.) include *Schizachyrium scoparium, Andropogon gyrans, Andropogon ternarius, Ionactis linariifolia, Solidago odora, Pityopsis graminifolia, Stylosanthes biflora, Cirsium repandum, Galium pilosum, Sericocarpus tortifolius, Coreopsis major, Symphyotrichum walteri, Silphium compositum, Eupatorium album, Symphyotrichum concolor, Baptisia cinerea, Liatris* sp., *Rhynchosia reniformis, Viola pedata,* and *Euphorbia curtisii*. A large number of other species are frequent in plot data, some more constant in site reports. There are numerous legumes, including *Lespedeza* (*capitata, hirta, repens, virginica*), *Desmodium* (*lineatum, ciliare, obtusum, strictum*), *Tephrosia* (*virginica, florida, spicata*), *Galactia erecta, Galactia regularis, Clitoria mariana, Rhynchosia reniformis, Pediomelum canescens, Chamaecrista* spp., and *Crotalaria purshii*. Other frequent species include *Tragia urens, Iris verna, Euphorbia curtisii, Euphorbia ipecacuanhae, Dichanthelium* (*ovale, aciculare, oligosanthes* and others), *Hieracium marianum, Stylisma angustifolia/patens, Phlox nivalis, Vernonia angustifolia, Carphephorus bellidifolius, Asclepias amplexicaulis, Cuthbertia graminea, Cnidoscolus stimulosus, Chrysopsis gossypina, Oenothera fruticosa, Sericocarpus asteroides, Symphyotrichum dumosum, Eupatorium pilosum, Hieracium gronovii, Hypoxis hirsuta, Hypoxis wrightii, Epigaea repens, Euphorbia exserta, Lithospermum virginianum, Parthenium integrifolium, Sphenopholis filiformis, Sporobolus junceus, Stillingia sylvatica Gentiana villosa*, and *Rhynchospora grayi*. Species less frequent in plots but characteristic of this community include *Paspalum bifidum, Tridens carolinianus, Orbexilum lupinellus, Dalea pinnata, Anthenantia villosa, Andropogon gerardii, Phaseolus sinuatus*, and several species shared with drier sandhills, such as *Pycnanthemum flexuosum, Angelica venenosa, Hypericum stragulum, Nabalus autumnalis,* and *Physalis heterophylla*. Several more legumes are present at somewhat

lower frequency, including *Mimosa microphylla, Lespedeza* (*procumbens, stuevei*), *Desmodium* (*laevigatum, paniculatum, marilandicum*), *Rhynchosia tomentosa,* and *Galactia mollis*.

Range and Abundance: Ranked G2G3. This community appears to be confined to the Sandhills region but may possibly be found in nearby areas with similar site conditions. Most examples known are within Fort Bragg, but they do occur on other lands in the central Sandhills. This community also occurs in northern South Carolina.

Associations and Patterns: The Sandhills Mesic Transition Subtype usually occurs as a small patch community, in localized areas of unusual soil. Rarely it occurs as large patches, where the loamy conditions it needs are more extensive. It generally grades uphill to Pine/Scrub Oak Sandhill (Blackjack Subtype) or Xeric Sandhill Scrub. It may grade downhill to Mesic Pine Savanna (Sandhills Subtype) or may be bordered by Streamhead Pocosin. Sandhill Seeps may less often occur adjacent to it.

Variation: There is substantial variation among examples, but no variants are recognized. The pronounced floristic differences between Mesic Transition communities in the Sandhills and in the outer Coastal Plain, treated as well-defined variants in earlier drafts of the 4th Approximation, has been shown by Palmquist et al. (in prep.) to be strong enough to create two associations and two subtypes.

It has been suggested by Bruce Sorrie that there are repeatable differences within the Sandhills Mesic Transition Subtype between examples on lower slopes or large loamy soil areas and those in local swales. This needs further investigation.

Dynamics: The dynamics of the Sandhills Mesic Transition Subtype are similar to those of the Dry Longleaf Pine Forests theme in general. Because their productivity is higher than that of other sandhills, they develop dense midstories even faster in the absence of fire, and they are likely to be invaded by forest oaks and *Liquidambar* as well as scrub oaks.

The environmental factors that control the shift from mesic transition sandhills to Mesic Pine Savanna are not clear. Scrub oaks generally quickly drop out in the transition, and they appear to be excluded from the Mesic Pine Savanna even in the absence of fire. It may be that, though the savanna is generally mesic, occasional high water tables make survival of scrub oaks difficult. However, increased fire intensity with the increased productivity of the herb layer may also be involved, and competitiveness of the herbs may be significant.

Comments: Numerous species differentiate this subtype from the Coastal Plain Mesic Transition Subtype. Some are species common in other sandhill communities, which are more abundant in the Sandhills region, but a number are found primarily in mesic sites and are shared primarily with Mesic Pine Savannas. The Coastal Plain Mesic Transition Subtype, in contrast, usually contains more species of wet sites. This may reflect the greater abundance of wet savannas in the outer Coastal Plain and the greater abundance of drier sandhill communities in the Sandhills landscapes.

Rare species:
Vascular plants: *Amorpha georgiana, Rhus michauxii, Schwalbea americana,* and *Solidago verna*.

Vertebrate animals: *Picoides borealis*.

References:

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

PINE/SCRUB OAK SANDHILL (COASTAL PLAIN MESIC TRANSITION SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and less infertile than Xeric Sandhill Scrub, and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by oak species other than *Quercus laevis*. The Mesic Transition Subtype covers the examples with loamy soil, greater fertility, or possibly closer proximity to the water table, which support a very diverse flora that includes mesic herb and shrub species. They share many plants with Mesic Pine Savannas but differ in having a significant scrub oak component.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. The Mesic Transition Subtype is transitional to Mesic Pine Savanna. It can be distinguished by the presence of scrub oaks in significant numbers (these may be reduced in density and present as shrub-size sprouts if the site has been frequently burned). Communities in which oaks have been artificially eradicated may be difficult to distinguish but will lack the small component of wetland species usually found in Mesic Pine Savanna.

The Coastal Plain Mesic Transition Subtype is distinguished from other subtypes by a combination of a suite of mesic species with a suite of species typical of the Coastal Plain region, coupled with absence or scarcity of a suite characteristic of Sandhills. Mesic species include *Anthenantia villosa, Sorghastrum nutans, Andropogon gerardii, Lespedeza capitata, Lespedeza hirta*, *Helianthus divaricatus, Sorghastrum elliottii*, *Sporobolus clandestinus*, *Muhlenbergia capillaris*, *Ceanothus americanus*, several *Desmodium* spp., and other *Lespedeza* species. The scrub oaks may be less dense in this subtype than in the Blackjack Subtype under the same management regime. Forest oaks such as *Quercus falcata* and *Quercus stellata*, plus *Liquidambar styraciflua,* often proliferate in the absence of fire. Species frequent in the Coastal Plain Mesic Transition Subtype include *Eupatorium rotundifolium, Chasmanthium laxum, Baptisia tinctoria, Trilisa odoratissima, Tephrosia hispidula, Pterocaulon pycnostachyum,* and a number of species shared with wetter communities, such as *Polygala lutea, Gymnopogon ambiguus, Helianthus heterophyllus*, and *Rhynchospora plumosa*. Species frequent in the Sandhills Mesic Transition Subtype and not in the Coastal Plain Mesic Transition Subtype include *Ceanothus americanus, Galium pilosum, Coreopsis major, Baptisia cinerea, Viola pedata, Phlox nivalis, Asclepias amplexifolius, astragalus michauxii, Cuthbertia graminea, Carphephorus bellidifolius, Oenothera fruticosa*, and a number of others.

Synonyms: Pine/Scrub Oak Sandhill (Loamy Soil Variant); A new NVC association is being named. Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254). Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: The Coastal Plain Mesic Transition Subtype occurs where the substrate, though sandy, contains a significant component of finer material. It usually occurs on rolling dissected uplands.

Soils: The Mesic Transition Subtype has soils with sandy loam or loam texture. They are generally not distinguished well in soil mapping. They are included in a variety of map units, from Kureb (Spodic Quartzipsamment) to Baymeade (Arenic Hapludult) to Foreston (Aquic Paleudult).

Hydrology: Coastal Plain Mesic Transition Subtype sites are well drained but are less dry than most sandhills because of the loamy soil texture.

Vegetation: Vegetation structure in the Sandhills Mesic Transition Subtype is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. *Pinus palustris* is often the only canopy species, but *Pinus taeda* may become abundant. The midstory and low shrub layer are sparse and patchy when the community is frequently burned but become increasingly dense with fire exclusion. The midstory is dominated by a mix of *Quercus incana* and *Quercus marilandica*, frequent presence of *Quercus margaretiae, Quercus laevis, Quercus falcata*, *Quercus stellata*, *Diospyros virginiana*, and *Sassafras albidum*. *Liquidambar styraciflua* may become abundant in unburned sites. *Vaccinium tenellum* or *Gaylussacia dumosa* dominate patches of the shrub layer, and *Gaylussacia frondosa, Morella pumila*, and *Ilex glabra* have high constancy. Other frequent shrubs include *Vaccinium fuscatum, Persea palustris*, and *Toxicodendron pubescens*, while *Vaccinium arboreum* also sometimes occurs.

The herb layer is dominated by *Aristida stricta*, and it shares a high diversity of species with drier sandhills as well as a number with wetter communities. Highly constant species in the limited number of CVS plots (Palmquist et al. in prep.) include *Andropogon* (*ternarius, gyrans*), *Schizachyrium scoparium, Solidago odora, Galactia erecta, Ionactis linariifolia, Pityopsis graminifolia, Sericocarpus tortifolia, Symphyotrichum walteri, Cirsium repandum, Eupatorium rotundifolium, Tragia urens, Trilisa odoratissima, Cnidoscolus stimulosus, Lespedeza capitata, Liatris* sp., *Scleria ciliata, Pteridium pseudocaudatum, Stylosanthes biflora*, and *Euphorbia ipecacuanhae*. Other frequent species in plot data include many legumes: *Lespedeza hirta, Lespedeza angustifolia, Desmodium tenuifolium, Desmodium ciliare, Tephrosia florida, Tephrosia hispidula,* and *Crotalaria purshii*. Additional frequent species include *Scleria nitida, Chrysopsis gossypina, Eupatorium album, Lechea minor, Vaccinium crassifolium, Dichanthelium ovale, Dichanthelium webberianum, Rhynchospora plumosa, Carphephorus tomentosus, Panicum virgatum, Pteridium pseudocaudatum, Symphyotrichum concolor, Xyris caroliniana,* and *Polygala lutea*. Additional species that are less frequent in plots but are characteristic of the community include *Baptisia tinctoria, Carphephorus bellidifolius, Gymnopogon brevifolius, Crocanthemum carolinianum, Hieracium marianum, Danthonia sericea, Lobelia nuttallii, Orbexilum pedunculatum, Sericocarpus linifolius, Silphium compositum*, *Pterocaulon pycnostachyum, Gymnopogon ambiguus, Helianthus heterophyllus*, and several more legumes.

Range and Abundance: The new association is not yet ranked, but it may be G1. Well-developed examples are known only in a handful of sites, primarily within Camp Lejeune. The community could possibly occur in northern South Carolina.

Associations and Patterns: The Coastal Plain Mesic Transition Subtype usually occurs as a small patch community, though it once was likely more extensive in local areas. It tends to grade downhill to Mesic Pine Savanna (Coastal Plain Subtype) or Wet Loamy Pine Savanna. It may grade uphill to Pine/Scrub Oak Sandhill (Mixed Oak Subtype).

Variation: Details of variation in this newly defined subtype are not known.

Dynamics: The dynamics of the Coastal Plain Mesic Transition Subtype are similar to those of the Dry Longleaf Pine Forests theme in general. Because their productivity is higher than that of other sandhills, they develop dense midstories even faster in the absence of fire, and they are likely to be invaded by forest oaks and *Liquidambar* as well as scrub oaks. They may also be invaded by some of the more aggressive species of wetter communities.

As in the Sandhill Mesic Transition Subtype, the environmental factors that control the shift to Mesic Pine Savanna are not clear. Though it needs more investigation, scrub oaks appear not to drop out as quickly at the boundary in the Coastal Plain Mesic Transition Subtype and they do in the Sandhills. However, though the savanna is generally mesic, occasional high water tables may make survival of scrub oaks difficult. Increased fire intensity with the increased productivity of the herb layer may also be involved, and competitiveness of the herbs may be significant.

Comments: This is one of the most recently recognized communities in the 4th Approximation, distinguished as a result of the analysis of plot data by Palmquist et al. (in prep.). Floristic differences between the Sandhills and other parts of the Coastal Plain are visible in many longleaf pine communities. It appears that the mesic to wet ones, with a large pool of species, show enough difference to recognize as different subtypes. The differences shown by the drier communities are somewhat less, perhaps solely because of the smaller number of species present.

Part of the floristic difference between the Sandhills Mesic Transition Subtype and Coastal Plain Mesic Transition Subtype is in a greater number of drier site species in the former and a greater number of wetter site species in the latter. This may reflect the greater abundance of wet savannas in the outer Coastal Plain and the greater abundance of drier sandhill communities in the Sandhills landscapes.

This subtype is less well characterized than the Sandhills Mesic Transition Subtype because it is less abundant and because fewer plots have been sampled. The vegetation description here is largely based on five CVS plots.

Rare species:
Vascular plants:
Vertebrate animals: *Peucaea aestivalis* and *Picoides borealis*.

References:
Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

PINE/SCRUB OAK SANDHILL (COASTAL FRINGE SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and infertile than Xeric Sandhill Scrub and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by species other than *Quercus laevis*. The Coastal Fringe Subtype has evergreen scrub oaks as a major component, as well as other coastal fringe indicator species.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. However, *Quercus laevis* may still codominate. In frequently burned sites, most or all scrub oaks may exist as sprouts.

The Coastal Fringe Subtype is distinguished by the presence of plant species that, at least in North Carolina, are confined to areas near the coast. These include *Quercus geminata, Cartrema americana, Ilex vomitoria, Rhynchospora megalocarpa*, and *Cladina evansii*. *Quercus hemisphaerica* is often abundant in the Coastal Fringe Subtype but may occur in small amounts in other sandhill communities such as the Mixed Oak Subtype.

Among the Coastal Fringe subtypes of the different sandhill types, this community is distinguished by being less dry and having greater overall plant cover and diversity than the Xeric Sandhill Scrub or Sand Barren. *Quercus geminata* often is more abundant than *Quercus laevis*, and *Q. hemisphaerica, Q. incana, Q. margarettiae*, and *Q. virginiana* are generally present. Bare sand is limited in extent and the most specialized psammophytes, though often present, are not abundant.

Synonyms: Coastal Fringe Sandhill; *Pinus palustris - Pinus taeda / Quercus geminata - Quercus hemisphaerica - Osmanthus americanus var. americanus / Aristida stricta* Woodland (CEGL003577). Ecological Systems: Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: The Coastal Fringe Subtype occurs on relict coastal dunes and beach ridges, in a zone inland of the barrier islands but within a few miles of the coast. It occurs on lower dunes and lower parts of dunes, downhill of Xeric Sandhill Scrub.

Soils: Soils are deep sandy Entisols or dry Spodosols. Most are mapped as Kureb (Typic Quartzipsamment) or Mandarin (Typic Haplohumod), a few as Echaw (Entic Haplohumod), Wando (Typic Udipsamment), Pactolus (Aquic Quartzipsamment), or Leon (Aeric Haplohumod). A few examples may occur on sandy Ultisols. The coarse sand has little capacity for retaining water or nutrients, but conditions are less dry than in Xeric Sandhill Scrub or Sand Barren due to some fine-texture material or to a water table that is more readily within reach of plant roots.

Hydrology: Sites are excessively drained and are dry most of the growing season. Though the water table does not reach the surface, it is not extremely deep; many plant roots may reach an abundant water supply once established.

Vegetation: Vegetation structure is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a moderate to dense grassy herbaceous layer. *Pinus palustris* may solely dominate, or it may be mixed with *Pinus taeda*. A midstory of scrub oaks and a low shrub layer are sparse and patchy under a natural fire regime but become dense with long exclusion of fire. CVS data (Palmquist et al. in prep) show *Quercus hemispherica, Quercus laevis*, and *Quercus geminata* as most abundant in the midstory. *Sassafras albidum, Quercus incana, Quercus margaretiae*, and *Sassafras albidum* are frequent. *Quercus virginiana* is present in some occurrences. *Vaccinium arboreum* is the most frequent and abundant shrub in the plot data. *Vaccinium tenellum, Ilex vomitoria, Morella pumila, Morella cerifera*, *Amorpha herbacea*, *Gaylussacia dumosa*, *Cartrema americanum*, *Persea palustris*, and *Vaccinium stamineum* are frequent. The herb layer is dominated by *Aristida stricta*. Other frequent herbs in plots are *Schizachyrium scoparium*, *Cnidoscolus stimulosus, Euphorbia ipecacuanhae, Pityopsis graminifolia, Euphorbia pubentissima, and Solidago odora*. Lichens, both *Cladonia* spp, and *Cladoina evansii* are often abundant.

Range and Abundance: Ranked G2. The Coastal Fringe Subtype primarily occurs within a few miles of the coast in the southern half of the state. However, a few depauperate disjunct examples occur inland as far as Robeson County on sand dunes along rivers. This subtype also occurs in northern South Carolina.

Associations and Patterns: Pine/Scrub Oak Sandhill (Coastal Fringe Subtype) may occur in lower parts of relict dunes in mosaics with Xeric Sandhill Scrub (Coastal Fringe Subtype) and Sand Barren (Coastal Fringe Subtype). It may grade to Wet Pine Flatwoods in lower sandy areas, or to Pond Pine Woodland, Tidal Swamp, or other wetland communities.

Variation: The inland examples differ in having fewer of the coastal fringe species. Some are on isolated upland areas surrounded by swamp, where fire may have been infrequent but where extreme sandy substrates have prevented development of other communities. These may be recognized as a distinct variant. Other examples vary with the transition to adjacent wetter or drier communities, perhaps with distance from the coast, and perhaps with subtype variations in soil texture.

1. Swamp Island Variant: Occurs farther inland, on isolated sand ridges along rivers or lakes. These isolated locations may burn infrequently even with a natural fire regime. These inland locations are also floristically depauperate, having fewer of the coastal fringe species and therefore being conceptually transitional to the inland Pine/Scrub Oak Sandhill (Mixed Oak Subtype).
2. Typic Variant: Occurs within a few miles of the coast. Fits the above description more precisely.

Dynamics: Dynamics are generally typical for longleaf pine/scrub oak communities. However, the evergreen oak litter may affect fire behavior on a fine scale. It has been suggested (Frost 2000) that the evergreen scrub oaks, especially *Quercus geminata*, once established, prevent fire from spreading into their microsites because their curled leaves can hold rainwater and stay wet much longer than other leaf litter. Thus, their patches within the community may expand and persist

without burning even where fire occurs, and it may be particularly hard to reverse an increase in their abundance with fire suppression.

As with Coastal Fringe Evergreen Forest and the coastal fringe subtypes of other sandhill communities, the reasons for the distinctive flora of the Coastal Fringe subtypes in the area near the coast is not well known, and no published study specifically addresses it. The species are more widespread inland farther south, suggesting a moderated climate may be important. Input of nutrients by salt spray aerosols may also be important, as may effects of sea breezes on fire regimes.

Comments: The Coastal Fringe Sandhill type of the 3rd Approximation has been reduced to a series of subtypes under the other sandhill types in the 4th. This represents a conclusion that the ecological and floristic differences caused by differences in moisture regime are more important than those related to the coastal fringe floristic component.

Rare species:
Vascular plants: *Asclepias pedicellata, Chrysoma pauciflosculosa, Crocanthemum nashii,* and *Crocanthemum carolinianum*.
Vertebrate animals: *Heterodon simus, Mastocophis flagellum, Ophisaurus mimicus, Peucaea aestivalis, Picoides borealis, Pituophis melanoleucus*, and *Sistruris miliaris*.

References:
Frost, C.C. 2000. Studies in landscape fire ecology and presettlement vegetation of the southeastern United States. PhD. Dissertation, University of North Carolina, Chapel Hill.

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

PINE/SCRUB OAK SANDHILL (CLAY/ROCK HILLTOP SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and infertile than Xeric Sandhill Scrub, and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by species other than *Quercus laevis*. The Clay/Rock Hilltop Subtype covers communities occurring on exposed clay or rock layers in the Sandhills region, where *Quercus marilandica* predominates, *Quercus laevis* is generally absent or scarce, and unusual wetland species are present.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. The Clay/Rock subtype is distinguished from all other subtypes by occurrence on sandstone or hard clay surfaces rather than sand or loam, by the near absence of *Quercus laevis,* and by the presence of *Vaccinium crassifolium* or *Pyxidanthera barbulata* in a hilltop location that would otherwise be well drained. The Clay/Rock Hilltop sometimes has very limited scrub oak abundance, comparable to that in some subtypes of Mesic Pine Savanna. In this case it may still be distinguished by the distinctive environment and by a distinctive low-diversity flora.

Synonyms: *Pinus palustris / Quercus marilandica / Vaccinium crassifolium / Aristida stricta* Woodland (CEGL003599).
Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254).

Sites: The Clay/Rock Hilltop Subtype occurs in distinctive sites where dense clay or cemented sandstone forms the surface on a ridge top or upper slope.

Soils: Soils in the Clay/Rock Hilltop Subtype are shallow or have properties that restrict root penetration but that may perch rainwater. Plinthite is common, but cemented beds of underlying Cretaceous formations may also support this community. This subtype occurs in small patches that are not distinguished in soil mapping. Occurrences are mapped as the typical Ultisols of the Sandhills, most as Vaucluse (Typic Hapludult), Gilead (Aquic Hapludult), and Blaney (Arenic Hapludult).

Hydrology: Moisture conditions are driven by a combination of rainfall and limited water penetration. Seepage is not a significant source of moisture because there is not a catchment for shallow groundwater uphill. The typical presence of wetland plants and perhaps the scarcity of most oak species suggests they perch water long enough to produce wetland conditions at times. Conversely, the scarcity of wetland species, as well as the setting, suggests they become quite dry at other times.

Vegetation: The Clay/Rock Hilltop Subtype has a typical open, patchy canopy of *Pinus palustris*, generally with no other species. The scrub oak layer is sparser than in most sandhills. *Quercus marilandica* is the only abundant species. *Quercus laevis, Quercus incana*, *Quercus margaretiae*, and forest oaks, along with *Diospyros virginiana, Nyssa sylvatica*, *Sassafras albidum*, and *Prunus serotina* may be present but only in small numbers and with limited cover even in unburned examples. The dominant shrubs are usually *Gaylussacia dumosa* and *Vaccinium tenellum*, but

Kalmia latifolia is fairly frequent and may dominate substantial patches. Other shrubs that are constant or frequent in CVS plot data (Palmquist et al. in prep) and field observations are *Lyonia mariana, Clethra alnifolia, Gaylussacia frondosa, Morella pumila, Hypericum hypericoides*, and *Rhus copallinum*. *Cyrilla racemiflora*, *Ilex glabra*, *Vaccinium arboreum*, and *Symplocos tinctoria* are less frequent but indicative. *Aristida stricta* generally dominates the herb layer, but its overall cover is often less than in most sandhills. *Vaccinium crassifolium* is highly constant and often dominates large patches, and *Pyxidanthera barbulata* may also dominate patches. *Schizachyrium scoparium* and *Andropogon* spp. are frequent. Other species that are frequent in CVS plots include *Carphephorus bellidifolius, Epigaea repens, Sericocarpus asteroides, Tephrosia virginiana, Pteridium latiusculum, Pityopsis graminifolia, Sericocarpus linifolius, Dichanthelium ovale/villosissimum, Dichanthelium commutatum, Seymeria cassioides, Solidago odora, Chamaecrista* spp., *Coreopsis verticillata, Danthonia sericea, Lespedeza virginica, Liatris* sp., *Scleria ciliata, Stylosanthes biflora, Symphyotrichum walteri,* and *Hieracium marianum*. However, many of these species have lower frequency than in most sandhill communities, and the average plot species richness of 30 is lower than in most.

Dynamics: As with other sandhill communities, frequent fire is a natural part of the Clay/Rock Hilltop Subtype. However, the presence of rock outcrops and patches of less flammable plants such as *Pyxidanthera barbulata* may make fires less intense or more patchy. The frequent presence of *Kalmia latifolia*, a species that is not well adapted to frequent fire, suggests some degree of natural fire sheltering. The extreme site appears to be less prone to invasion by woody plants in the absence of fire.

Range and Abundance: Ranked G2?. The Clay/Rock Hilltop Subtype is confined to the fall line Sandhills region. It is very rare in North Carolina. Similar clay/rock hilltops are more abundant in South Carolina, but it is unclear how many represent this community rather than the more southerly "wiregrass gap" analogue of it.

Associations and Patterns: The Clay/Rock Hilltop Subtype is a small patch community, confined to small patches and absent in typical landscapes in the region.

Variation: Little is known of variation. Examples with and without *Kalmia latifolia* may warrant recognition as variants.

Comments:

Rare species:
Vascular plants: *Pyxidanthera brevifolia*.
Vertebrate animals: *Picoides borealis*.

References:
Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

PINE/SCRUB OAK SANDHILL (NORTHERN SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and infertile than Xeric Sandhill Scrub, and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by species other than *Quercus laevis*. The Northern Subtype covers the now-very-rare examples that are north of the natural range of *Aristida stricta*. It conceptually includes a broader range of moisture and soil conditions than the other subtypes, because remaining examples are too few and too degraded to refine the category further.

Distinguishing Features: The Northern Subtype is distinguished from all other Coastal Plain Dry Longleaf Pine Communities by its geographic location north of the natural range of *Aristida stricta*, roughly at Pamlico Sound and the Tar River. The only other dry longleaf pine community that naturally lacks *Aristida stricta* is the Dry Piedmont Longleaf Pine Forest, of which none are known this far north and that differ in their composition and substrate. A number of species occur only in the Northern Subtype, including *Gaylussacia baccata* and *Kalmia angustifolia*, and *Vaccinium pallidum* is abundant.

Synonyms: *Pinus palustris / Quercus laevis - Quercus incana / Gaylussacia dumosa - Gaylussacia (baccata, frondosa)* Woodland (CEGL003592).
Ecological Systems: Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: Pine/Scrub Oak Sandhill (Northern Subtype) occurs on relict sand dunes and potentially in other sandy upland areas.

Soils: Soils are deep sandy Entisols. Most of the few examples are mapped as Alaga (Typic Quartzipsamment) or Pactolus (Aquic Quartzipsamment).

Hydrology: The Northern Subtype, as defined, occupies a broader range of moisture conditions than most other longleaf pine communities, but all are excessively drained and dry for most of the time in the growing season.

Vegetation: All of the few remaining examples have been substantially altered by past fire suppression as well as logging. The natural condition is less well known than for most longleaf pine communities. Natural vegetation structure is presumed to be similar, with an open savanna to woodland canopy, a sparse patchy midstory and shrub layer, and a moderate to dense grassy herb layer. *Pinus palustris* dominates the canopy; *Pinus taeda* is generally mixed with it at present, sometimes codominant or dominant, and may have been in the past as well. *Quercus laevis* characteristically dominated the midstory. *Diospyros virginiana* and *Sassafras albidum* are constant in plots (Palmquist et al. in prep) and likely are abundant under natural conditions. The other midstory species frequent in CVS plots (Palmquist et al. in prep.), *Prunus serotina*, *Quercus nigra, Quercus falcata*, and *Pinus serotina,* likely are present only because of fire exclusion. Frequent shrubs in plots are *Gaylussacia frondosa, Castanea pumila, Vaccinium pallidum, Vaccinium tenellum, Gaylussacia dumosa*, *Morella pumila, Lyonia mariana*, and *Toxicodendron pubescens*. *Gaylussacia baccata* and *Kalmia carolina* are fairly frequent and sometimes dominant in plots. *Schizachyrium scoparium* is frequent in the herb layer and likely dominates under natural frequently burned conditions. Other frequent herbs in plots are *Euphorbia ipecacuanhae*

Carphephorus bellidifolius, Dichanthelium spp., and *Cnidoscolus stimulosus*. Fairly frequent herbs, likely more abundant with more frequent fire, include *Tephrosia virginiana*, *Pityopsis graminifolia*, and *Lupinus perennis*. Several species are somewhat less frequent but are notable for their presence and are distinctive to this subtype. Besides *Gaylussacia baccata*, *Kalmia angustifolia* (narrow sense) has been found. One notable plot contained *Pinus rigida*. These species are not otherwise known in the Coastal Plain of North Carolina, but are frequent in dry sites in the Mountain Region, and are characteristic of sandy habitats in states to the north.

Range and Abundance: Ranked G1. Only a few examples remain, none in very good condition. This community occurs north of Pamlico Sound and the Tar River, extending into southern Virginia. It is unclear how extensive it was. Much of this region is peatland and swamp, and a significant portion of the well-drained uplands farther north in it appear to naturally support oak-hickory forests. All remaining examples are confined to unusual sand dune landforms, which are rare in the region.

Associations and Patterns: Natural patterns are not well known. Some of the remaining examples are large patch communities, some small patch. Associated communities include various floodplain communities, small depression wetlands, and sometimes oak-hickory forests. Examples in the past likely graded to Northern Wet Pine Savanna.

Variation: This community is variable in apparent moisture levels and perhaps in soil texture, but the natural state is not well enough known to recognize variants. It is likely that analogues of Xeric Sandhill Scrub, Pine/Scrub Oak Sandhill, and Mesic Pine Savanna once existed north of the range of *Aristida stricta*.

Dynamics: It is not well known how the dynamics of this subtype might naturally differ from other longleaf pine communities. Canopy structure and tree regeneration probably were similar. Fire may have been somewhat less frequent: there may have been fewer thunderstorms, and the large estuaries and extensive peatlands and hardwood wetlands would have provided more natural firebreaks. None of the herbaceous species is quite as flammable as *Aristida stricta*, and none will carry fire under as wide a range of conditions. However, the predominance of *Pinus palustris* indicates a regime of frequent fire.

Comments: This subtype, at least the remaining examples, appears to primarily be analogous to the Mixed Oak Subtype and to Xeric Sandhill Scrub in its moisture and soil characteristics.

Rare species:
Vascular plants: *Kalmia angustifolia*.
Vertebrate animals: *Picoides borealis*.

References:
Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

MESIC PINE SAVANNA (COASTAL PLAIN SUBTYPE)

Concept: Mesic Pine Savannas are longleaf pine communities of environments intermediate between sandhills and wet savannas. Scrub oaks are absent or sparse, though other oaks and various hardwoods may invade with fire suppression. The herb layer is dense and diverse, generally containing a diversity of legume species and limited wetland species. The Coastal Plain Subtype covers the typical examples of the lower and middle Coastal Plain, which differ floristically and in landscape relations from the other subtypes.

Distinguishing Features: Mesic Pine Savannas are distinguished from Pine/Scrub Oak Sandhill and other dry longleaf pine communities by the absence or near absence of scrub oaks. When scrub oaks are present, they often are combined with a small component of wetland species not found in sandhills, and additionally with forest oaks such as *Quercus nigra, Q. falcata*, or *Q. stellata*. A diverse herbaceous flora containing mesophytic species such as *Panicum virgatum* and *Gymnopogon brevifolius* and a large number of legumes distinguishes Mesic Pine Savannas from most sandhill communities, but Pine/Scrub Oak Sandhill (Mesic Transition Subtype) shares most of these species. In examples altered by fire suppression, invasion by *Liquidambar styraciflua* can be used to tell Mesic Pine Savannas from sandhills other than the Mesic Transition Subtype. In this situation, the minor component of wetland species usually present in Mesic Pine Savannas may be helpful.

Mesic Pine Savannas are distinguished from Wet Loamy Pine Savanna and other wet pine savannas by having a substantial component of mesophytic and drier site plants and only small amounts of wetland plants. Mesic Pine Savannas contain a substantial and usually diverse collection of legume species, of which only a few occur in wetter pine savannas. They also contain a large number of species shared with sandhills but generally absent in wet savannas. Characteristic plants that occur in wet savannas and not in mesic savannas include *Sporobolus pinetorum, Ctenium aromaticum, Muhlenbergia expansa*, most *Rhynchospora* species, *Andropogon glomeratus, Xyris* spp., *Eriocaulon* spp., *Bigelowia nudata, Zigadenus* spp., and all the carnivorous plants.

The Coastal Plain Subtype is distinguished from the other subtypes of Mesic Pine Savanna by geographic and floristic differences. The Little River and Lumbee Subtype each occur in a limited geographic area, and they generally have a mix of scrub oaks and wetland species in greater abundant than the other subtypes. The distinction with the Sandhills Subtype is based on floristic differences and is more subtle, but the two can readily be distinguished by geographic location, as no examples are known in North Carolina outside of their respective geographic areas. Plants that occur in the Coastal Plain Subtype and seldom or never in the Sandhills Subtype include *Amorpha herbacea var. herbacea, Trilisa odoratissima, Tephrosia hispidula,* and *Pterocaulon pycnostachyum*, along with many wetter savanna species. Plants that occur in the Sandhills Subtype and seldom or never in the Coastal Plain include *Baptisia cinerea, Vernonia acaulis, Coreopsis major, Coreopsis verticillata, Angelica venenosa, Helianthus atrorubens, Paspalum bifidum,* and *Tridens carolinianus*. The Coastal Plain Subtype usually occurs on flat terrain distant from drainages, in large to small patches, or often in a fine-scale mosaic with Wet Loamy Pine

Savanna communities. The Sandhills Subtype usually occurs as small patches in upland swales or on lower slopes.

Synonyms: Mesic Pine Flatwoods (Coastal Plain Variant); *Pinus palustris / Amorpha herbacea var. herbacea / Aristida stricta - Sorghastrum nutans* Woodland (CEGL003569).
Ecological Systems: Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: The Coastal Plain Subtype occurs on upland flats or terraces, in shallow swales, and on low ridges amid wetter areas, all where the substrate contains some silt or clay component and is not pure coarse sand.

Soils: Soils in the Coastal Plain Subtype are a variety of mesic to wet Ultisols. The largest number of occurrences is mapped as Rains (Typic Paleaquult), with multiple sites mapped as Lynchburg (Aeric Paleaquult) and Onslow (Spodic Paleudult), and a few with a wide variety of other Udults and Aquults. All of these series, as typically mapped, cross the boundary between Mesic Pine Savanna and Wet Loamy Pine Savanna.

Hydrology: Mesic Pine Savannas appear to have predominantly moist terrestrial conditions. Seasonal high water tables may occur to some degree, but they are not sufficient to lead to dominance by wetland plants. However, mesic conditions may be marginal, as wetter microsites are common within them, and soils often show some mottling.

Vegetation: Mesic Pine Savannas in natural condition have a typical open, patchy canopy of *Pinus palustris*. More than most other longleaf pine communities, *Pinus taeda* or *Pinus echinata* may be present in minor amounts, sometimes increasing drastically with fire suppression. Scrub oaks are absent or limited to sparse individuals of *Quercus marilandica, Quercus margaretiae,* or *Quercus incana*. However, taller oaks such as *Quercus stellata* and *Quercus falcata* are often present as sprouts, and they can grow into the canopy with long absence of fire. *Diospyros virginiana, Persea palustris, Magnolia virginiana,* and *Acer rubrum* also are frequent as sprouts or taller stems. *Liquidambar styraciflua* invades quickly and heavily in the absence of fire.

Where frequently burned, the herb layer is dense and diverse. CVS plots (Palmquist et al. in prep) show an average of 57 species per 1/10 hectare, the majority herbs, and it is much higher in some plots. *Aristida stricta* dominates, though *Vaccinium crassifolium* or *Pteridium pseudocaudatum* may be abundant and may come to dominate large portions with inadequate fire. Highly constant species in CVS plot data are *Pityopsis graminifolia, Ionactis linariifolia, Liatris* sp., *Solidago odora, Symphyotrichum walteri, Eupatorium rotundifolium, Sericocarpus tortifolius, Lespedeza angustifolia, Desmodium tenuifolium*, and *Dichanthelium ovale*. *Schizachyrium scoparium* and *Andropogon* spp. (*ternarius, gyrans, virginicus*) are collectively highly constant, though not well distinguished. The herb layer includes a great diversity of species in the Fabaceae. Additional frequent species in CVS plot data include *Galactia erecta, Stylosanthes biflora, Tephrosia hispidula,* several *Desmodium* (*tenuifolium, lineatum, ciliare*), and *Lespedeza* (*capitata, hirta*), *Chamaecrista* spp., and *Crotalaria purshii*. Several other species are only slightly less frequent, including more *Lespedeza* (*virginica, stuevei*), and *Desmodium* (*ciliare, paniculatum, rotundifolium*), *Tephrosia florida, Tephrosia virginiana, Amorpha herbacea*, and *Baptisia tinctoria*. Other herb species that are frequent in plots include *Iris verna, Trilisa odoratissima,*

Eupatorium mohrii, Eupatorium leucolepis, Gymnopogon brevifolius, Danthonia sericea, Sericocarpus linifolius, and *Symphyotrichum dumosum*. Several species typical of wet savannas are also frequent in plots but are confined to wetter microsites, including *Polygala lutea, Rhynchospora plumosa, Xyris caroliniana*, and *Anchistea virginica*, while species of drier sandhills, such as *Cnidoscolus stimulosus* and *Euphorbia ipecacuanhae,* are also frequent in minor amounts. Additional species less frequent in plots but characteristic of mesic conditions include *Panicum virgatum, Chasmanthium laxum, Cirsium repandum,* and *Carphephorus bellidifolius*.

The shrub layer is naturally low in cover where frequently burned but becomes dense with inadequate fire. *Gaylussacia frondosa*, *Ilex glabra*, or *Gaylussacia dumosa* are highly constant and usually dominate. Other highly constant shrubs in CVS data are *Vaccinium tenellum, Morella pumila*, and *Lyonia mariana*, and additional frequent species include *Aronia arbutifolia, Hypericum hypericoides, Rhus copallinum,* and *Hypericum hypericoides*. *Smilax glauca, Smilax bona-nox*, *Muscadinia rotundifolia*, and *Gelsemium sempervirens* are frequent vines, though generally not extensive.

Range and Abundance: Ranked G2G3. Around 25 occurrences are known but many are not in good condition. This subtype probably was extensive in the outer, middle, and inner Coastal Plain, but has been widely converted to agriculture. Remnants are scattered throughout the southern half of the Coastal Plain but are more abundant in the outer portion. The NVC association also occurs in adjacent South Carolina.

Associations and Patterns: The Coastal Plain Subtype functions in current circumstances as a large patch community. Occurrences often are tens of acres, though often including multiple patches. In the past, this subtype probably was a matrix community in many places, making up a substantial portion of the landscape mosaic in areas that are now primarily agricultural. Some examples of the Coastal Plain Subtype occur in fine-scale mosaics, closely intermixed with Wet Loamy Pine Savanna. Most would naturally grade downhill to Wet Loamy Pine Savanna or uphill to Pine/Scrub Oak Sandhill (Mesic Transition Subtype).

Variation: Examples vary with the gradation to adjacent communities. No other patterns of variation are known.

Dynamics: Most of the general dynamics discussed in the Dry Longleaf Pine Forests theme description apply to this community. Frequent fire is even more crucial in Mesic Pine Savannas than in sandhills, because of the high productivity and the rapid invasion by hardwood trees without it.

As discussed for the theme, the cause of the disappearance of scrub oaks in the transition from sandhills to Mesic Pine Savannas is unclear, since the mesic sites seem favorable. Their absence in burned sites suggests that competition with mesophytic trees is not the cause, while their absence in unburned sites suggests increased fire intensity due to the dense herb layer is not the cause.

Mesic Pine Savannas are conceptually a slice of the moisture gradient between drier sandhill communities and wetter pine savannas. However, they occur as recognizable communities only on finer-textured soils. While distinct communities often are locally missing from gradients of

communities, no mesic longleaf pine community has been found on pure sand. Wet Pine Flatwoods adjoin Xeric Sandhill Scrub communities without a mesic community between. Finer texture material allows differentiation into a larger number of distinct communities. This may be due to the larger pool of species on loamy soils, and the presence of multiple species with narrower niches due to competition. However, it may be that true mesic moisture conditions do not occur with the limited water-holding capacity of the pure sands, but rather that excessive drainage creates drier conditions in all places that lack a high water table.

Comments: The distinction between the Coastal Plain and Sandhills subtypes needs further examination and clarification, but appears warranted, and is supported by analysis of plot data collected by the Carolina Vegetation Survey. However, these subtypes share virtually all of their dominant species.

The terms "savanna" and "flatwoods" have been used in various ways in the literature of the Coastal Plain (and in even more various ways in other regions). Communities named savannas may be wetter, shrubbier, or more diverse than those named flatwoods, with these usages sometimes contradicting each other. The 3rd Approximation used the name flatwoods for drier communities and savanna for wetter ones. This moisture-based use of the names has been dropped in favor of one based on diversity and possible natural structure. Mesic Pine Savannas are not naturally shrubby under a natural fire regime and can have extremely high species richness.

Rare species:
Vascular plants: *Andropogon mohrii, Asclepias pedicellata,* and *Solidago verna*.
Vertebrate animals: *Ophisaurus mimicus, Peucaea asesivalis,* and *Picoides borealis*.

References:
Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

MESIC PINE SAVANNA (SANDHILLS SUBTYPE)

Concept: Mesic Pine Savannas are longleaf pine communities of environments intermediate between sandhills and wet savannas. Scrub oaks are absent or sparse, though other oaks and various hardwoods may invade with fire suppression. The herb layer is dense and diverse, generally containing a diversity of legume species and limited wetland species. The Sandhills Subtype covers the typical examples of the Sandhills Region, which differ floristically from the other subtypes.

Distinguishing Features: Mesic Pine Savannas are distinguished from Pine/Scrub Oak Sandhill and other dry longleaf pine communities by the absence or near absence of scrub oaks. When scrub oaks are present, they often are combined with a small component of wetland species not found in sandhills, and with forest oaks such as *Quercus nigra, Q. falcata*, or *Q. stellata*. Invasion by *Liquidambar styraciflua* can be used to tell Mesic Pine Savannas from sandier communities such as Pine/Scrub Oak Sandhill (Mixed Oak Subtype) but not from the Mesic Transition Subtype.

Where land managers have treated Pine/Scrub Oak Sandhill with herbicide, so that scrub oaks are absent, Mesic Pine Savannas in good condition can be distinguished from most sandhills by the distinctive mesic herbaceous flora with a high diversity of legumes, including *Lespedeza hirta, Lespedeza capitata, Crotalaria purshii*, and many species of *Desmodium*, and by other mesic species such as *Panicum virgatum* and *Gymnopogon brevifolius*. Pine/Scrub Oak Sandhill (Mesic Transition Subtype) shares many of these species and may remain difficult to distinguish. In this situation, the minor component of wetland species usually present in Mesic Pine Savannas may be helpful.

The Sandhills Subtype is distinguished from the Lumbee Subtype and the Little River Subtype by the lesser presence of scrub oaks and by the lesser presence of wetland plants. The distinction with the Coastal Plain Subtype is based on floristic differences that are more subtle, but the two can readily be distinguished by geographic location, as no examples are known in North Carolina outside of their respective geographic areas. Plants that occur in the Coastal Plain Subtype and seldom or never in the Sandhills Subtype include *Amorpha herbacea* var. *herbacea, Trilisa odoratissima, Tephrosia hispidula,* and *Pterocaulon pycnostachyum*, along with many wetter savanna species. Plants that occur in the Sandhills Subtype and seldom or never in the Coastal Plain include *Baptisia cinerea, Vernonia acaulis, Coreopsis major, Coreopsis verticillata, Angelica venenosa, Helianthus atrorubens, Paspalum bifidum,* and *Tridens carolinianus*. The Coastal Plain Subtype usually occurs on flat terrain distant from drainages, in large to small patches, or often in a fine-scale mosaic with Wet Loamy Pine Savanna communities. The Sandhills Subtype usually occurs as small patches in upland swales or on lower slopes.

Synonyms: Mesic Pine Flatwoods (Sandhills Subtype); *Pinus palustris / Aristida stricta - Sorghastrum nutans - Anthaenantia villosa* Woodland (CEGL003570).
Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254).

Sites: The Sandhills Subtype occurs in swales or local flat areas in the rolling upland terrain of the Sandhills, or on lower slopes with loamy soil.

Soils: Soils in the Sandhills Subtype are loamy, with a mix of sand with finer material. Since patches are small, their soils are inclusions in map units. Most are mapped as widespread soil series, primarily Gilead (Aquic Hapludult), Blaney (Arenic Hapludult), and Fuquay (Plinthic Kandiudult).

Hydrology: Mesic Pine Savannas appear to have predominantly moist terrestrial conditions. Seasonal high water tables may occur to some degree, but they are not sufficient to lead to dominance by wetland plants. However, mesic conditions may be marginal, as wetter microsites are common within them, and soils often show some mottling.

Vegetation: Mesic Pine Savannas in natural condition have a typical open, patchy canopy of *Pinus palustris*. More than most other longleaf pine communities, *Pinus taeda* or *Pinus echinata* may be present in minor amounts, sometimes increasing drastically with fire suppression. Scrub oaks are absent or limited to sparse individuals of *Quercus marilandica, Quercus margaretiae,* or *Quercus incana*. However, forest oaks such as *Quercus stellata* and *Quercus falcata* are often present as sprouts, and they can grow into the canopy with long absence of fire. *Diospyros virginiana, Sassafras albidum, Cornus florida,* and *Acer rubrum* also are frequent as sprouts or taller stems. *Liquidambar styraciflua* invades quickly and heavily in the absence of fire.

Where frequently burned, the herb layer is dense and diverse. CVS plots (Palmquist et al. in prep) show an average of 68 species per 1/10 hectare, the majority herbs, and it is much higher in some plots. *Aristida stricta* dominates, though *Pteridium pseudocaudatum* may be abundant and may come to dominate large portions with inadequate fire. *Panicum virgatum* may be abundant. Other highly constant herb species in CVS plot data (Palmquist et al. in prep) are *Solidago odora, Iris verna, Ionactis linariifolia, Eupatorium rotundifolium, Symphyotrichum walteri, Symphyotrichum dumosum, Dichanthelium tenue, Euphorbia curtisii*, and *Rhexia alifanus*. *Schizachyrium scoparium* and *Andropogon* spp. (*ternarius, gyrans, virginicus*) are collectively highly constant, though not well distinguished. Numerous additional herbaceous species are frequent in CVS plot data. These include many species in the Fabaceae: *Baptisia cinerea, Stylosanthes biflora, Galactia erecta, Tephrosia* (*virginiana, florida, spicata*), *Lespedeza* (*capitata, hirta, angustifolia, virginica, repens*), *Desmodium lineatum, Orbexilum psoralioides*, and *Chamaecrista* spp. Many Poaceae, Asteraceae, and many other species are also frequent, including *Danthonia sericea, Gymnopogon brevifolius, Sorghastrum nutans,* several *Dichanthelium* (*aciculare, strigosum, ovale*)*, Pityopsis graminifolia, Sericocarpus tortifolius, Coreopsis major, Coreopsis verticillata, Eupatorium album, Eupatorium mohrii, Eupatorium leucolepis, Euthamia caroliniana, Vernonia angustifolia, Vernonia acaulis, Sericocarpus linifolius, Helianthus atrorubens, Chrysopsis mariana, Silphium compositum, Hieracium marianum, Aletris farinosa, Scleria ciliata, Scleria nitida, Tragia urens, Lechea minor, Lobelia nuttallii, Oenothera fruticosa, Potentilla canadensis, Pycnanthemum flexuosum, Viola pedata, Rhexia mariana, Sisyrinchium capillare, Angelica venenosa,* and *Gentiana autumnalis*. Though somewhat less frequent, other frequent or characteristic species include *Parthenium integrifolium, Carphephorus bellidifolius, Cirsium repandum, Sericocarpus asteroides, Andropogon gerardii, Paspalum bifidum, Tridens carolinianus,* several more *Desmodium* (*strictum, ciliare, nuttallii, paniculatum*), *Lespedeza procumbens, Mimosa (Schrankia) microphylla, Crotalaria purshii,* and *Schwalbea americana*.

The shrub layer is naturally low in cover where frequently burned but becomes dense with inadequate fire. Highly constant species in CVS plot data are *Vaccinium tenellum*, *Gaylussacia dumosa, Ilex glabra*, and *Rhus copallinum*. Other frequent shrubs include *Toxicodendron pubescens, Gaylussacia frondosa, Lyonia mariana, Aronia arbutifolia, Hypericum hypericoides, Hypericum crux-andreae, Morella pumila*, and *Clethra alnifolia*.

Range and Abundance: Ranked G2G3 but probably appropriately G2 given the dependence of very frequent fire. About 20 occurrences are known in North Carolina but most are parts of clusters confined to Fort Bragg. Only a few good examples are known in the rest of the Sandhills. This community also occurs in the northern Sandhills of South Carolina.

Associations and Patterns: The Sandhills Subtype is a small patch community. Though some occurrences are complexes of tens of acres, most individual patches are no more than a few acres and are not a regularly occurring part of Sandhills landscapes. Mesic Pine Savannas are usually just downhill of Pine/Scrub Oak Sandhill (Mesic Transition Subtype or Blackjack Subtype). Unlike the Coastal Plain Subtype, the Sandhills Subtype is seldom associated with wetter savannas, though it may adjoin Streamhead Pocosin.

Variation: Examples vary with the gradation to adjacent communities. No other patterns of variation are known.

Dynamics: Dynamics of the Sandhills Subtype appear to be similar to the Coastal Plain Subtype. Most of the general dynamics discussed in the Dry Longleaf Pine Forests theme description apply to this community. Frequent fire is even more crucial in Mesic Pine Savannas than in sandhills, because of the high productivity and the rapid invasion by hardwood trees without it. As discussed for the theme, the cause of the disappearance of scrub oaks in the transition from sandhills to Mesic Pine Savannas is unclear.

Mesic Pine Savannas are conceptually a slice of the moisture gradient between drier sandhill communities and wetter communities, but recognizable examples are not generally present in most places on the landscape. In the Sandhills region, they appear to depend on distinctive topography, perhaps a widening of the slope to provide enough space in the precise part of the moisture gradient needed. However, it may alternatively be that these landforms correlate with the loamy soil texture needed. The more common Sandhills region pattern of dense clay underlying sand tends to support abrupt transitions from Pine/Scrub Oak Sandhill (Blackjack Subtype) to Sandhill Seep or Streamhead Pocosin, as seepage causes a rapid shift from dry to saturated conditions.

Comments: Early recognition of this community used the name “pea swales” or “bean dips”, in recognition of their tendency to occur in local low areas and their tendency to have a very high diversity of legumes.

The distinction between the Coastal Plain and Sandhills subtypes needs further examination and clarification but appears warranted and is supported by analysis of plot data collected by the Carolina Vegetation Survey. However, these subtypes share virtually all of their dominant species.

Rare species:

Vascular plants: *Amorpha georgiana, Rhus michauxii, Schwalbea americana,* and *Solidago verna*.
Vertebrate animals: *Picoides borealis*.

References:

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

MESIC PINE SAVANNA (LITTLE RIVER SUBTYPE)

Concept: Mesic Pine Savannas are longleaf pine communities of environments intermediate between sandhills and wet savannas. Scrub oaks are absent or sparse, though other oaks and various hardwoods may invade with fire suppression. The herb layer is dense and diverse, generally containing a diversity of legume species and limited wetland species. The Little River Subtype covers the rare examples on high river terraces in the Sandhills Region, which contain plants with atypically large differences in typical moisture tolerance and includes some plants characteristic of floodplains. This subtype is known only along the Little River of Cumberland, Hoke, and Moore counties.

Distinguishing Features: Mesic Pine Savannas are distinguished from Pine/Scrub Oak Sandhill and other dry longleaf pine communities by the absence or near absence of scrub oaks. However, the Little River Subtype has more frequent and more diverse scrub oaks than the Sandhills or Coastal Plain Subtype. As with other Mesic Pine Savannas, it has a diverse suite of legumes that distinguish it from all sandhill communities other than Pine/Scrub Oak Sandhill (Mesic Transition Subtype).

The Little River Subtype is easily distinguished from the Sandhills and Coastal Plain subtypes by its location on the high, nonflooded terraces of the Little River. The differences in flora and vegetation that distinguish it from other subtypes are subtle. They include a greater range in moisture tolerance among the plant species present, with small but frequent presence of *Quercus marilandica* and other drier site species mixing with wetter site species such as *Bigelowia nudata* and *Ctenium aromaticum*. The overall flora shares most of the species of the Sandhills Subtype, including all that distinguish it from the Coastal Plain Subtype, but it also includes some, such as *Bigelowia nudata* and *Cyrilla racemiflora*, that are more characteristic of the Coastal Plain Subtype. It also includes a number of species not typical of either, including *Eurybia compacta, Ageratina aromatica, Ludwigia virgata, Penstemon australis, Penstemon laevigatus, Comandra umbellata, Viola primulifolia, Eryngium yuccifolium, Stylisma humistrata, Vaccinium elliottii, Bignonia capreolata, Campsis radicans, Thyrsanthella difformis, Crataegus uniflora*, and *Chionanthus virginicus*.

Synonyms: Mesic Pine Flatwoods (Little River Variant); *Pinus palustris / Vaccinium elliottii - Clethra alnifolia / Aristida stricta - Panicum virgatum* Woodland (CEGL003573).
Ecological Systems: Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland (CES203.254).

Sites: All known sites for this subtype are located along the Little River in Cumberland, Moore, Hoke, and Harnett counties. The Little River is distinctive in being deeply entrenched and having relict floodplain terraces high above the present river floodplain, due to downcutting and perhaps recent geologic uplift. Sites have fluvial landforms but generally upland conditions, without influence of river flooding.

Soils: Soils of the Little River Subtype are poorly known. Soil mapping is extremely variable. The only soil that is mapped at more than one occurrence, Pactolus (Aquic Quartzipsamment), likely

does not match the soil in the community. Other soils mapped include several Udults, a Udipsamment, and some alluvial soils.

Hydrology: Details of the hydrology in this subtype are uncertain. Though it occurs on river terraces, the terraces are high above the river and are unlikely to flood other than for brief times in the most extreme floods. Like other Mesic Pine Savannas, it appears to primarily be moist, with seasonal wetness that is not sufficient to promote dominance by wetland plants. However, the mixed vegetation suggests a greater role for wet microsites or intermittent wetness than in the Sandhills or Coastal Plain subtypes.

Vegetation: Mesic Pine Savannas in natural condition have a typical open, patchy canopy of *Pinus palustris*. More than most other longleaf pine communities, *Pinus taeda* or *Pinus echinata* may be present in minor amounts, sometimes increasing drastically with fire suppression. Scrub oaks are limited, but *Quercus marilandica* is highly constant and *Quercus margaretiae, Quercus incana*, and even *Quercus laevis* are frequent, though sparse. Forest oaks, especially *Quercus stellata,* may also be present, and *Liquidambar styraciflua* often invades in the absence of fire. A number of understory hardwoods are frequent as sprouts or potentially midstory stems, including *Nyssa sylvatica, Diospyros virginiana, Cornus florida, Sassafras albidum, Chionanthus virginicus, Crataegus uniflora,* and *Magnolia virginiana*.

Where frequently burned, the herb layer is dense and diverse. CVS plots (Palmquist et al. in prep) show an extremely high species richness, averaging 98 species per 1/10 hectare, the majority herbs. Numbers in the vicinity of 130 species per 1/10 hectare were found in some plots. *Aristida stricta* dominates, though *Pteridium pseudocaudatum* may be abundant and may come to dominate large portions with inadequate fire. Highly constant species in CVS data (Palmquist et al. in prep) include *Solidago odora, Tephrosia virginiana, Pityopsis graminifolia, Silphium compositum, Danthonia sericea, Rhexia alifanus, Parthenium integrifolium, Symphyotrichum walteri, Vernonia acaulis, Ionactis linariifolia, Lespedeza angustifolia, Mimosa (Schrankia) microphylla, Eupatorium rotundifolium,* and *Vaccinium crassifolium*. *Schizachyrium scoparium* and *Andropogon* spp. (*ternarius, gyrans, virginicus*) are collectively highly constant, though not well distinguished in plots. Numerous additional herbaceous species are frequent in CVS plot data. These include many species in the Fabaceae: *Baptisia cinerea, Baptisia tinctoria, Stylosanthes biflora, Galactia erecta, Tephrosia florida, Tephrosia spicata*, several *Lespedeza* (*capitata, hirta, angustifolia, virginica, repens*), several *Desmodium lineatum, Desmodium ciliare, Crotalaria purshii, Orbexilum psoralioides*, and *Chamaecrista* spp. Many Poaceae, Asteraceae, and many other species are also frequent, including *Panicum virgatum, Danthonia sericea, Gymnopogon brevifolius, Sorghastrum nutans,* several *Dichanthelium* (*aciculare, consanguineum, ovale, strigosum, dichotomum, sphaerocarpon, tenue*), *Aristida purpurascens*, and small amounts of *Ctenium aromaticum*, *Sericocarpus tortifolius, Sericocarpus linifolius, Coreopsis major, Coreopsis verticillata, Symphyotrichum dumosum, Symphyotrichum concolor*, several *Eupatorium* (*album, mohrii, leucolepis, pilosum*), *Carphephorus bellidifolius, Helianthus atrorubens, Eurybia compacta, Ageratina aromatica, Chrysopsis mariana, Cirsium repandum, Aletris farinosa, Penstemon laevigatus, Penstemon australis, Potentilla canadensis, Stylisma humistrata, Viola primulifolia, Viola pedata, Polygala lutea, Comandra umbellata, Eryngium yuccifolium, Lachnocaulon anceps, Ludwigia virgata, Phlox nivalis, Scleria ciliata, Xyris caroliniana, Euphorbia ipecacuanhae,* and *Hypoxis hirsuta/curtisii*. Additional species that are less frequent in

plots but distinguish this subtype from others or appear characteristic in site descriptions include *Euthamia caroliniana, Helenium flexuosum, Bigelowia nudata, Chasmanthium laxum, Scleria pauciflora*, and more legumes: *Clitoria mariana* and *Desmodium* (*laevigatum, tenuifolium, obtusum, strictum*).

The shrub layer is naturally low in cover where frequently burned but becomes dense with inadequate fire. Highly constant species in CVS plot data are *Vaccinium tenellum*, *Gaylussacia dumosa, Ilex glabra*, *Lyonia mariana, Rhus copallinum*, and *Hypericum crux-andreae*. *Clethra alnifolia* is frequent and sometimes dominates patches. A great number of other shrub species are frequent in plots, including *Aronia arbutifolia, Toxicodendron pubescens, Amelanchier obovalis, Cyrilla racemiflora, Morella caroliniana, Vaccinium arboreum, Vaccinium elliottii, Vaccinium formosum, Ceanothus americana, Symplocos tinctoria*, and *Arundinaria tecta*. Less frequent but notable shrub species include *Rhododendron atlanticum* and *Amorpha georgiana*, which is nearly endemic to this community. Vines are more diverse than in other Dry Longleaf Pine Communities. Constant and frequent species in plots include *Smilax glauca, Gelsemium sempervirens, Smilax rotundifolia, Bignonia capreolata, Muscadinia rotundifolia*, and other notable species include *Thyrsanthella difformis, Campsis radicans*, and *Toxicodendron radicans*.

Range and Abundance: Ranked G1. This is one of the rarest natural communities in North Carolina. It is confined to a handful of occurrences in close proximity along the Little River. It is unclear that any other location was suitable for it in the past.

Associations and Patterns: The Little River Subtype may be regarded as a small patch or large patch community. Most occurrences are a few tens of acres. It is unlikely larger occurrences existed in the past. Occurrences may border floodplain communities closer to the river, or may border sandhill communities on higher areas. One notable area is associated with a Sand Barren on a dune on the river terrace.

Variation: Examples vary with the gradation to adjacent communities. No other patterns of variation are known.

Dynamics: Dynamics of the Little River Subtype are believed to be similar to the other subtypes. Most of the general dynamics discussed in the Dry Longleaf Pine Forests theme description apply to this community. Frequent fire is even more crucial in Mesic Pine Savannas than in sandhills, because of the high productivity and the rapid invasion by woody vegetation without it. However, the distinctive environment of the river terrace may lead to somewhat reduced natural fire frequency, since fires would be unlikely to spread across the river and less likely to spread downhill from the uplands.

While some of the distinctive flora of this subtype is related to occurrence with floodplain communities, the cause of other aspects of its distinctive character are unclear. Variation in hydrology in the unique river terrace environment is likely important.

Comments:

Rare species:

Vascular plants: *Amorpha georgiana, Astragalus michauxii,* and *Solidago verna*.
Vertebrate animals: *Picoides borealis*.

References:

Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]

MESIC PINE SAVANNA (LUMBEE SUBTYPE)

Concept: Mesic Pine Savannas are longleaf pine communities of environments intermediate between sandhills and wet savannas. Scrub oaks are absent or sparse, though other oaks and various hardwoods may invade with fire suppression. The herb layer is dense and diverse, generally containing a diversity of legume species and limited wetland species. The Lumbee Subtype covers the rare examples on loamy inner Coastal Plain soils, which contain plants with large differences in typical moisture tolerance that are mesophytic on "average." These communities are presently known in North Carolina only in Robeson County and its vicinity, in the inner Coastal Plain.

Distinguishing Features: Mesic Pine Savannas are distinguished from Pine/Scrub Oak Sandhill and other dry longleaf pine communities by the absence or near absence of scrub oaks. However, the Lumbee Subtype, like the Little River Subtype, has more frequent and more diverse scrub oaks than the Sandhills or Coastal Plain Subtype. As with other Mesic Pine Savannas, it has a diverse suite of legumes which distinguish it from all sandhill communities other than Pine/Scrub Oak Sandhill (Mesic Transition Subtype).

The Lumbee Subtype is distinguished from the Sandhills and Coastal Plain subtypes, as well as from Wet Loamy Pine Savanna and Pine/Scrub Oak Sandhill, by having unusual combinations of plants that include some scrub oaks along with some wetland species, so that the overall "average" of the flora is mesic. It is distinguished from all other subtypes by the frequent presence of *Quercus elliottii*. Otherwise, it shares many species with the Sandhills Subtype, but combines them with species shared with the Coastal Plain Subtype and absent in the Sandhills. Other species frequent in plots of the Lumbee Subtype and not in other subtypes include *Balduina uniflora, Solidago virgata, Eupatorium semiserratum,* and *Vaccinium virgatum*. Because remnants of all savannas are so sparse in the middle Coastal Plain, it is unclear where the natural boundary between the Lumbee Subtype and the Coastal Plain Subtype would occur.

Synonyms: Pine Savanna (Lumbee Variant); *Pinus palustris - Pinus taeda - Pinus serotina / Quercus marilandica / (Quercus pumila) / Aristida stricta* Woodland (CEGL003664).
Ecological Systems: Atlantic Coastal Plain Upland Longleaf Pine Woodland (CES203.281).

Sites: The Lumbee Subtype occurs on flat upland terraces of the inner or middle Coastal Plain in Robeson County and adjacent areas.

Soils: Soils in the Lumbee Subtype are a variety of mesic to wet Ultisols. Most occurrences are mapped as Rains (Typic Paleaquult), Lynchburg (Aeric Paleaquult), or Goldsboro (Aquic Paleudult), a couple as Plummer (Grossarenic Paleaquult), and several as other Udults and Aquults. All of these series, as typically mapped, cross the boundary between Mesic Pine Savanna and Wet Loamy Pine Savanna.

Hydrology: Details of the hydrology in this subtype are uncertain. The mixed vegetation, with a greater component of wetland plants than other Mesic Pine Savannas but still many upland plants, suggests unusual micro-scale variation in wetness or perhaps temporal variation, which allows the species to coexist.

Vegetation: Mesic Pine Savannas in natural condition have a typical open, patchy canopy of *Pinus palustris*. More than most other longleaf pine communities, *Pinus taeda* may be present in minor amounts, sometimes increasing drastically with fire suppression. Scrub oaks are limited, but *Quercus marilandica* is highly constant. Forest oaks, especially *Quercus stellata* and *Quercus falcata*, may also be present, and *Liquidambar styraciflua* and *Quercus nigra* often invade in the absence of fire. A number of understory hardwoods are frequent as sprouts or potentially midstory stems, including *Nyssa sylvatica, Diospyros virginiana, Sassafras albidum, Magnolia virginiana,* and *Acer rubrum*, are frequent.

The herb layer is presumed to be dense and diverse when frequently burned, but no examples remain in very good condition. Nevertheless, CVS plots (Palmquist et al. in prep) show an average of 85 species per 1/10 hectare, the majority herbs. *Aristida stricta* dominates naturally, with *Panicum virgatum* dominating some patches, but *Pteridium pseudocaudatum* and *Andropogon* spp. dominate parts of most plots at present. Highly constant herbs in CVS plots include *Eupatorium rotundifolium, Iris verna, Lespedeza capitata, Rhexia alifanus, Solidago odora, Symphyotrichum walteri, Xyris caroliniana, Dichanthelium strigosum, Pityopsis graminifolia, Stylosanthes biflora, Desmodium tenuifolium, Eupatorium leucolepis, Eupatorium pilosum*, and *Lobelia nuttallii*. Numerous additional herbaceous species are frequent in CVS plot data. These include many species in the Fabaceae: *Crotalaria purshii, Galactia* spp., several *Tephrosia (virginiana, hispidula, spicata*), several *Lespedeza* (*angustifolia virginica, procumbens, repens*), several *Desmodium* (*lineatum, ciliare, paniculatum*), *Orbexilum psoralioides, Baptisia cinerea,* and *Chamaecrista* spp. Many Poaceae, Asteraceae, and many other species are also frequent, including *Schizachyrium scoparium, Sorghastrum nutans, Gymnopogon brevifolius,* several *Dichanthelium* (*ensifolium, tenue, ovale*), *Ionactis linariifolia, Sericocarpus tortifolius, Trilisa paniculata, Erigeron vernus, Chrysopsis mariana, Vernonia acaulis, Balduina uniflora, Bigelowia nudata, Carphephorus tomentosus, Eupatorium semiserratum, Solidago virgata*, *Euthamia caroliniana*, *Aletris farinosa,* several *Scleria* (*minor, ciliata, pauciflora*), *Sisyrinchium capillare, Rhynchospora plumosa* and other *Rhynchospora* species, *Cleistesiopsis divaricata, Scutellaria integrifolia, Hypoxis* sp., *Rhexia petiolata, Viola edulis/septemloba*, *Drosera capillaris, Juncus dichotomus,* and *Anchistea virginica*. Additional species that are less frequent in plots but distinguish this subtype from others or appear characteristic in site descriptions include *Anthenantia villosa, Ctenium aromaticum, Andropogon glomeratus, Dichanthelium aciculare, Dichanthelium webberianum, Chaptalia tomentosa, Eupatorium mohrii, Helianthus angustifolius, Hieracium gronovii, Ludwigia virgata, Helianthus atrorubens,* several species of *Ludwigia* (*linifolia, obtusifolia, aphylla, fasciculata*), and several more species of *Lespedeza* and *Desmodium*.

The shrub layer is presumably naturally low in cover where frequently burned but becomes dense with inadequate fire. Distinct to this subtype is high constancy and sometimes high cover of *Quercus elliottii*. *Clethra alnifolia, Vaccinium tenellum, Gaylussacia frondosa*, and *Rhododendron atlanticum* dominate patches, at least under current conditions. Other highly constant shrubs in plots include *Ilex glabra, Aronia arbutifolia, Morella pumila, Lyonia mariana, Gaylussacia dumosa*, and *Rhus copallinum*. Additional frequent species in plots include *Hypericum crux-andreae, Symplocos tinctoria, Amelanchier obovalis, Vaccinium formosum,*

Vaccinium fuscatum, Vaccinium virgatum, Vaccinium stamineum, Eubotrys racemosa, and *Morella caroliniana*. *Smilax rotundifolia* and *Muscadinia rotundifolia* are also frequent.

Range and Abundance: Ranked G1. Fewer than 10 occurrences are known, few in good condition. A single example is apparently known in adjacent South Carolina. This subtype was likely once extensive in the southern inner Coastal Plain and perhaps in adjacent South Carolina, but this region has been heavily converted to agriculture.

Associations and Patterns: The Lumbee Subtype may be regarded as a small patch community, as only small remnants are left. It may have once been a matrix community within its primary range. Virtually all examples are surrounded by heavily altered landscapes, obscuring natural associations.

Variation: Examples are heavily altered by fire suppression and cutting, so that natural variation is not possible to determine.

Dynamics: Dynamics of the Lumbee Subtype are believed to be similar to the other subtypes. Most of the general dynamics discussed in the Dry Longleaf Pine Forests theme description apply to this community. Frequent fire is even more crucial in Mesic Pine Savannas than in sandhills, because of the high productivity and the rapid invasion by woody vegetation without it.

It is unclear what distinctive aspect of the environment allows plants to coexist that are normally more segregated by moisture. While great variation in microsites is not immediately obvious, it may be involved. It is possible that temporal variation in wetness allows different species to coexist. Cypress Savannas, which are concentrated in the same region as the Lumbee Subtype, show substantial variation in water level in multi-year cycles, leading to drastic variation in vegetation driven by a long-term seed bank. Because the Mesic Pine Savanna flora is long-lived and conservative, individuals may remain visible even in parts of the cycle that are not optimal for them.

Comments:

Rare species:
Vascular plants: *Eurybia spectabilis, Liatris squarrulosa,* and *Quercus elliottii*.
Vertebrate animals: *Picoides borealis*.

References:
Palmquist, K.A., R.K. Peet, S.C. Carr. M.T. Lee, M.P. Schafale, A.S. Weakley, and T.R. Wentworth. In prep. Longleaf pine (*Pinus palustris*) vegetation of the Atlantic and East Gulf Coast Coastal Plain, USA: Vegetation classification, biogeography, and soil properties. [Title being determined.]