USDA Natural Resources
Conservation Service

Ecological site PX136X00X835
Piedmont Riverine Sandhills

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General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

MLRA notes

Major Land Resource Area (MLRA): 136X–Southern Piedmont

This MLRA is on a large piedmont underlain by metamorphic and igneous bedrock. It stretches from north-central Virginia to east-central Alabama, running parallel to the Appalachian highlands to the northwest and the Atlantic coast to the southeast.

MLRA 136 has only subtle climatic differences with MLRA 148 (Northern Piedmont), with which it shares a common geologic origin. This adjacent MLRA sits to the north. Along the fall line, it shares a boundary with MLRA 133A (Southern Coastal Plain), MLRA 137 (Carolina and Georgia Sand Hills), and 133C (Gulf Coastal Plain). Here, unconsolidated Coastal Plain sediments intersect the much older Piedmont bedrock. Along it's northwestern boundary, it sits adjacent to MLRAs 130B (Southern Blue Ridge), 130A (Northern Blue Ridge), and 128 (Southern Appalachian Ridges and Valleys). These MLRAs are distinguished from the Southern Piedmont by topographic and elevational differences, as well as differences in the age, origin, and degree of metamorphism of the underlying bedrock.

Five states are intersected by the MLRA, including North Carolina (29 percent), Georgia (27 percent), Virginia (20 percent), South Carolina (17 percent), and Alabama (7 percent). The MLRA extent makes up about 63,720 square miles (165,034 square kilometers).

MLRA PHYSIOGRAPHY
The landscape is generally rolling to hilly, with a well-defined drainage pattern. Streams have dissected the original Piedmont plateau, forming narrow ridgetops, somewhat broad interfluves, and short, steep side slopes adjacent to the streams and drainageways. With some exceptions, the valley floors are generally narrow and make up about 10 percent or

less of the land area. The associated stream terraces are generally small and of minor extent.

The landscape is moderately dissected overall, with isolated erosional remnants (monadnocks) and other areas of high topographic relief interspersed. Over most of the MLRA, elevation ranges from approximately 325 to 1,315 feet (100 to 400 meters), with elevations generally increasing toward the Appalachian Highlands, in the upper Piedmont, and decreasing toward the Coastal Plain, in the lower Piedmont.

The major rivers that cross this area en route to the ocean include, from north to south, the James, Roanoke, Cape Fear, Savannah, Altamaha, Chattahoochee, and Alabama Rivers. These rivers typically originate within the Piedmont or in the Blue Ridge. They flow east and south across the Coastal Plain and empty into the Atlantic Ocean or the Gulf of America.

MLRA GEOLOGY

Precambrian and Paleozoic metamorphic and igneous rocks underlie almost all of this MLRA. The dominant metamorphic rock types include gneiss, schist, slate, argillite, and phyllite, among others. Dominant igneous rock types include granite and other related felsic crystalline rocks. Mafic intrusive rocks, including gabbro, diabase, amphibolite, and other dark colored rocks, underlie a minority of the upland landscape. These mafic intrusions crop out in the form of dikes and sills, and often weather to produce soils high in base cations.

The Carolina Slate Belt runs lengthwise through the east-central part of the MLRA, in southern Virginia, North Carolina, South Carolina, and the eastern-most part of the Georgia Piedmont. This region is underlain by fine-grained metasedimentary and metavolcanic rock, which generally weathers to produce soils high in silt.

From Virginia to North Carolina, and in a single county in South Carolina, fault-bounded Triassic Basins are scattered amongst the igneous and metamorphic uplands. These basins are underlain by Triassic and Jurassic siltstone, shale, sandstone, and mudstone, which were laid down in response to continental rifting and subsequent erosion during the Mesozoic era.

MLRA SOILS

The dominant soil orders of the MLRA are Ultisols, Inceptisols, and Alfisols. Ultisols and Alfisols are typically found on more stable landforms, such as interfluves, gentle hillslopes, broad ridgetops, and stream terraces, while Inceptisols are typically found on less stable landforms, including flood plains, steep hillslopes, and narrow ridgetops.

Soils of the region predominantly have a thermic temperature regime, a udic moisture regime, and generally have kaolinitic or mixed mineralogy. In the upper Piedmont of Virginia and North Carolina however, soils have a mesic soil temperature regime, as depicted in figure 2. The mesic soil temperature regime portion of the MLRA is oriented from northeast to southwest and occupies approximately 18 percent of the MLRA extent, or 11,729 square miles (30,377 square kilometers).

Broadly speaking, soils of the Southern Piedmont uplands are shallow to very deep, well drained, and loamy or clayey. Soils of the river valleys are generally very deep, well to poorly drained, and loamy. Soils tend to be finer-textured than in Coastal Plain regions.

MLRA CLIMATE
In general, precipitation is evenly distributed throughout the year in this MLRA, with occasional drought-like conditions extending from late summer into autumn. During the growing season, most of the rainfall comes from high-intensity, convective thunderstorms. Significant moisture also comes from the movement of warm and cold fronts across the MLRA from November to April. High amounts of rain can also occur during hurricanes, usually during the months of August through October.

Over most of the MLRA, snowfall is typically light, though overall, the mesic soil temperature regime portion of the MLRA features colder temperatures, more snowfall, and a shorter growing season than in the thermic portion. The cooler climate in this region supports an increase in species with northern or Blue Ridge affinities. Both the mean annual temperature and the length of the freeze-free period increase from north to south and with decreasing elevation from the upper to the lower Piedmont.

MLRA LAND USE AND RESOURCES
Once largely cultivated, much of this region is now planted to loblolly pine or has reverted to successional pine and hardwood forests. The more productive lands support small to medium-size family farms that produce crops and livestock, while the less productive lands have been in forest for some time. Most of the open areas are used for grazing beef cattle, though in years past, dairy cattle were also important to the local economy. The principal crops of the region include corn, soybeans, and small grains. Burley tobacco remains a crop of local importance. Cotton is grown in the thermic soil temperature regime portion of the MLRA.

Several major land cover transformations have occurred in the Southern Piedmont over the past several centuries; from open woodlands sculpted by fire, to farmland, to closed forests and planted pine, past land uses have played an outsized role in shaping present-day soils and vegetation patterns in the region. Land-use intensity peaked with the arrival of the industrial revolution, which gradually increased demand for textiles. Cotton became the dominant crop over much of the region.

In spite of early successes, two centuries of poor management practices accelerated soil erosion, stripping away the fertility and moisture-supplying capacity of soils. In addition to soil losses in the uplands, legacy sediments derived from the eroded land rapidly accumulated in the river valleys below, often leading to changes in hydrology and flooding frequency.

After being stripped of it's loamy topsoil, many areas of the Piedmont had been so badly eroded as to render the land unsuitable or economically impractical for agriculture. The effects of erosion were widespread, with cumulative soil loss estimates ranging from 5 to 10 inches on average. The steeper slopes, which had often been cleared and farmed at the height of the Cotton era, generally suffered greater losses. By the 1930's, crop production was in rapid decline in the Southern Piedmont. The loss of soil productivity due to erosion, losses to the cotton boll weevil, development of synthetic fibers, and the onset of the Great Depression all contributed to rapid abandonment of cropland. By 1960, cropland acres had decreased by more than 50 percent in nearly every county in the Southern Piedmont.

While crop production is still important today on the more productive lands, those of lower productivity, or those that were subject to severe erosion, were often abandoned some time ago. Typically, they have either reverted to forest, or have been converted to other uses. Although the productivity of soils was greatly reduced through erosion, less intensive land uses such as grazing and forestry were still feasible. These land uses gained popularity as patterns of urban migration, low commodity prices, and other factors gradually made crop production less economical on the marginal lands.

In recent years, large-scale adoption of soil conservation practices have led to better outcomes with respect to erosion in much of MLRA, increasing the economic viability and long-term sustainability of Piedmont farms. Despite some success, water erosion remains one of the most important soil resource concerns in the MLRA.

Other major resource concerns include increasing conversion of prime farmland and farmland of statewide importance to urban uses. Throughout the MLRA, metropolitan areas are expanding into lands that have historically been used for timber or agriculture. This change in land use is occurring rapidly in the corridor called the Piedmont Crescent, which extends from Atlanta, Georgia, to Raleigh, North Carolina.

HISTORIC VEGETATION COVER

Over most of the Southern Piedmont uplands, the historic oak-hickory, or oak-hickory-pine forest, once covered large portions of the landscape. It was dominated by upland oaks, such as white oak (Quercus alba), northern red oak (Quercus rubra), and southern red oak (*Quercus falcata*), with a smaller contribution from hickories (Carya spp.) and pines. The principal pine species are shortleaf pine (Pinus echinata), loblolly pine (*Pinus taeda*), and to the north and west, Virginia pine (Pinus virginiana). In the southernmost and easternmost portions of the MLRA, the historic montane longleaf pine forest, dominated by longleaf pine (Pinus palustris), shortleaf pine (P. echinata), and dry-site oaks, was found on ridgetops and steep south or west-facing slopes.

According to historic accounts, forests and woodlands of the past were generally more open and park-like, having been exposed to a more frequent fire regime. Piedmont prairies, likely maintained by Native Americans, were also reportedly common across the landscape, as were fire-maintained canebrakes along the streams (Trimble 1974; Daniels

1987; Griffith et al. 2002; Van Lear et al. 2004; Dearman and James 2019; Schomberg et al. 2020; USDA-NRCS 2022).

LRU notes

MLRA 136 is one of the largest MLRAs in the United States. It has a broad north-south and east-west extent and covers a wide range of elevations. The MLRA is partitioned by the mesic-thermic line, which divides the MLRA into mesic and thermic soil temperature regimes (figure 2.). The mesic soil temperature regime was delineated based on estimates of the native range of loblolly pine, which was historically absent in this part of the MLRA. In addition, this region is said to represent the northern and western limits of cotton production, an important crop to the south and east.

ESDs developed for this MLRA were split geographically into mesic and thermic ecological site concepts. Climate variation across the MLRA extent warrants the development of Land Resource Unit (LRU) classifications, to further subdivide the MLRA and support more precise Ecological Site Descriptions.

Classification relationships

APPLICABLE EPA ECOREGIONS
Level III: 45. Piedmont
Level IV: 45b. Southern Outer Piedmont; 45f. Northern Outer Piedmont (EPA 2013).

APPLICABLE USFS ECOLOGICAL UNITS
Domain: Humid Temperate
Division: Subtropical
Ecological province: 231. Southeastern Mixed Forest
Ecological sections: 231I.Central Appalachian Piedmont; 231A. Southern Appalachian Piedmont (Cleland et al. 2007).

Based on the USGS physiographic classification system (Fenneman and Johnson 1946), most of MLRA 136 is in the Piedmont Upland section of the Piedmont province, in the Appalachian Highlands division.

Ecological site concept

This ecological site includes high stream terraces underlain by sandy alluvial sediments that have been reworked by wind. It is geographically restricted to the thermic soil temperature regime portion of the MLRA. This ecological site is most extensive along the Flint River in Georgia, where Pleistocene eolian sands were deposited over Piedmont bedrock. Landforms of this type have also been documented in the lower Piedmont of Virginia, North Carolina, and South Carolina, though generally these areas are not very extensive and they have not been delineated in soil mapping. These high terraces typically have an irregular, undulating surface and they are usually found on the east sides of north-south flowing reaches of the major rivers that flow through the region. The natural vegetation includes a unique mixture of species with Coastal Plain affinities, as well as species more typical of the Piedmont.

Soils on this ecological site are typically very deep, somewhat excessively drained Ultisols. Parent materials are old, sandy alluvium, later reworked by wind and weathered extensively through time. These soils are sandy throughout but demonstrate visible evidence of pedogenesis. Generally, flooding does not occur.

In the reference state, the canopy is dominated by upland oaks and pines. Important canopy species include post oak (*Quercus stellata*), Darlington oak (*Quercus hemisphaerica*), loblolly pine (*Pinus taeda*), black oak (*Quercus velutina*), and southern red oak (*Quercus falcata*). Dominant land uses include cropland, pasture and hayland, planted pine, and wildlife habitat.

ES CHARACTERISTICS SUMMARY
• Thermic soil temperature regime
• Occurs on high, old stream terraces underlain by sandy sediments
• Base saturation: < 35 percent in the subsoil
• Seasonal high water table: usually absent within 72 inches of the soil surface
• Depth to bedrock: ≥ 40 inches, though usually absent
• Subsoil texture is loamy fine sand or coarser
• Soils: very deep, somewhat excessively drained Ultisols

Associated sites

PX136X00X660	**High Terraces, Very Rare Inundation** Generally found in slightly lower landscape positions where flooding does occur, though infrequently. The seasonal high water table is usually shallower (≥ 18 inches from the soil surface) and soils are finer-textured throughout, supporting lower cover from drought-tolerant upland species such as post oak (Quercus stellata) and higher cover from bottomland hardwoods such as water oak (Quercus nigra) and willow oak (Quercus phellos).
PX136X00X820	**Acidic Upland Forest, Moist** Typically in higher landscape positions, elevated higher above the river channel. Soils are finer-textured throughout and less droughty, supporting higher cover from moisture-loving upland species such as northern red oak (Quercus rubra) and lower cover from drought-tolerant upland species such as post oak (Quercus stellata).
PX136X00X620	**Flood Plain Forest, Moist** Typically in lower landscape positions on active flood plains, supporting higher cover from riparian species which invest in rapid growth and early reproduction (e.g., American sycamore (Platanus occidentalis), sugarberry (Celtis laevigata), etc.). The depth to the seasonal high water table is shallower (≥ 24 inches from the soil surface).

Similar sites

PX136X00X630	**Flood Plain Levee Forest, Sandy** On sandy natural levees of large river systems, which are subject to regular overbank flooding of high energy, supporting increased cover from riparian species which invest in rapid growth and early reproduction (e.g., American sycamore (Platanus occidentalis), sugarberry (Celtis laevigata), etc.). Soils are sandy throughout, but are poorly-developed due to frequent flooding.
PX136X00X660	**High Terraces, Very Rare Inundation** Flooding frequency is usually slightly higher. The seasonal high water table is usually shallower (≥ 18 inches from the soil surface) and soils are finer-textured throughout, supporting lower cover from drought-tolerant upland species such as post oak (Quercus stellata) and higher cover from bottomland hardwoods such as water oak (Quercus nigra) and willow oak (Quercus phellos).

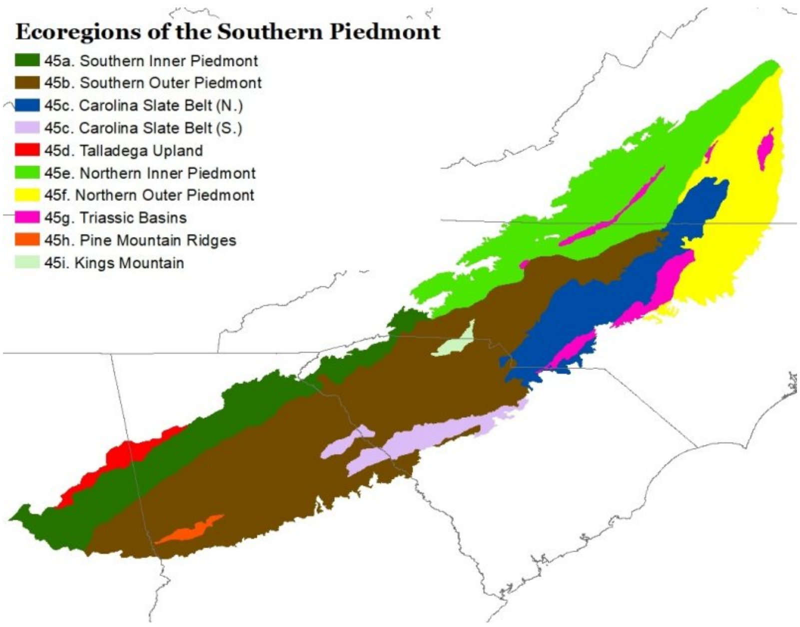


Figure 1. EPA level IV ecoregions of the Southern Piedmont (45).

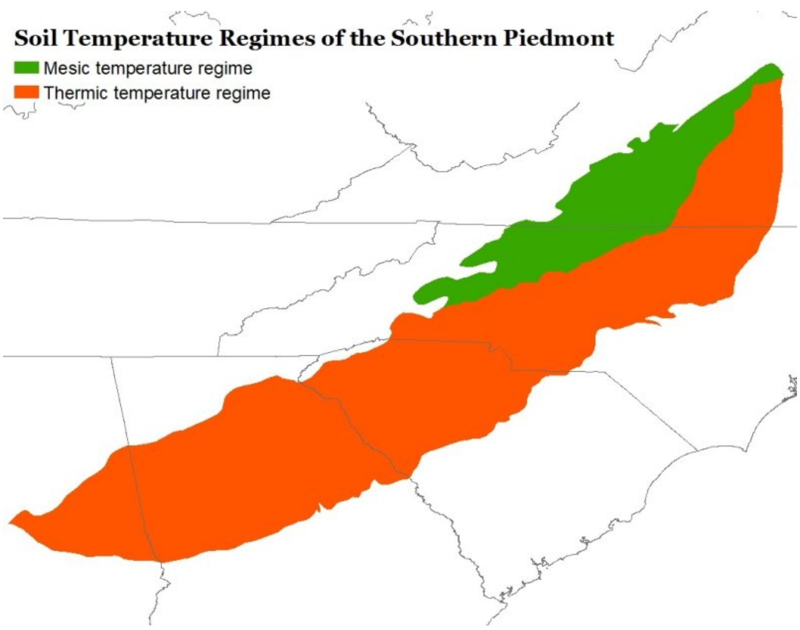


Figure 2. Spatial illustration of soil temperature regimes of the Southern

Piedmont.

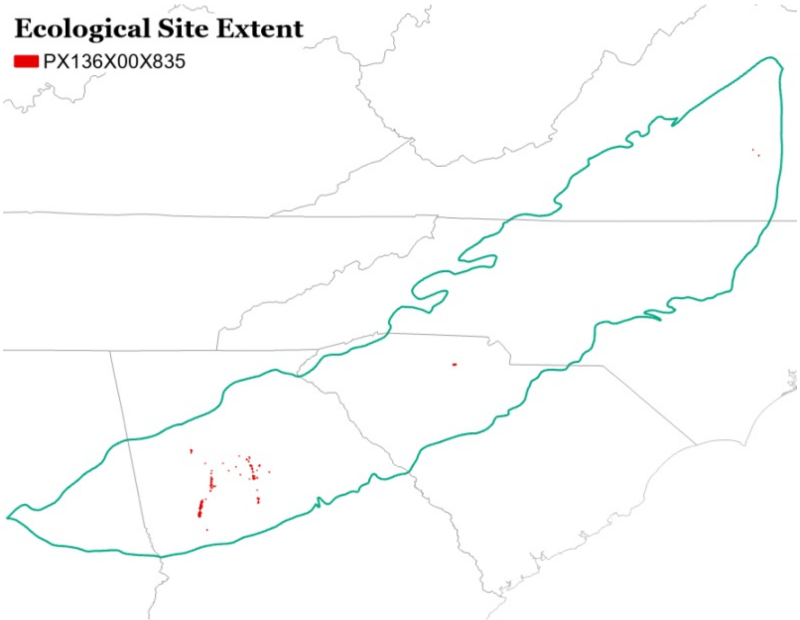


Figure 3. Spatial extent of this ecological site representing the major areas where this site is important on the landscape.

Table 1. Dominant plant species

Tree	(1) *Quercus stellata* (2) *Quercus hemisphaerica*
Shrub	(1) *Vaccinium arboreum*
Herbaceous	(1) *Dichanthelium* (2) *Clitoria mariana*

Legacy ID

F136XY835GA

Physiographic features

This ecological site is found on high stream terraces along the east sides of the major rivers that drain the Piedmont. They were formed by westerly Pleistocene winds, which redistributed sandy overbank deposits along major rivers of the Piedmont and Coastal Plain. The eolian deposits have weathered in place since they were deposited some 20,000 years ago, during the last glacial maximum. These terraces typically have an irregular, undulating surface and are reminiscent of relict sand dunes found in river valleys of the Coastal Plain. These landforms are artifacts of a cooler, drier, and windier climate. They are known colloquially as riverine sandhills.

Riverine sandhills are most extensive in the Coastal Plain province, on the east sides of north-south flowing reaches of major rivers, in MLRAs 133A, 153A, and 137. In the Piedmont, these environments are minor in extent and occupy only small patches of forest along the major rivers, particularly in Georgia. Landforms of this type have also been documented in Virginia, North Carolina, and South Carolina, though these areas have often not been delineated in soil mapping due to their patchy distribution and small extent. Representative locations are gently sloping to nearly level, with a representative slope of 2 to 10 percent (Wharton 1978; Daniels et al. 1999; Edwards et al. 2013; Swezey 2020).

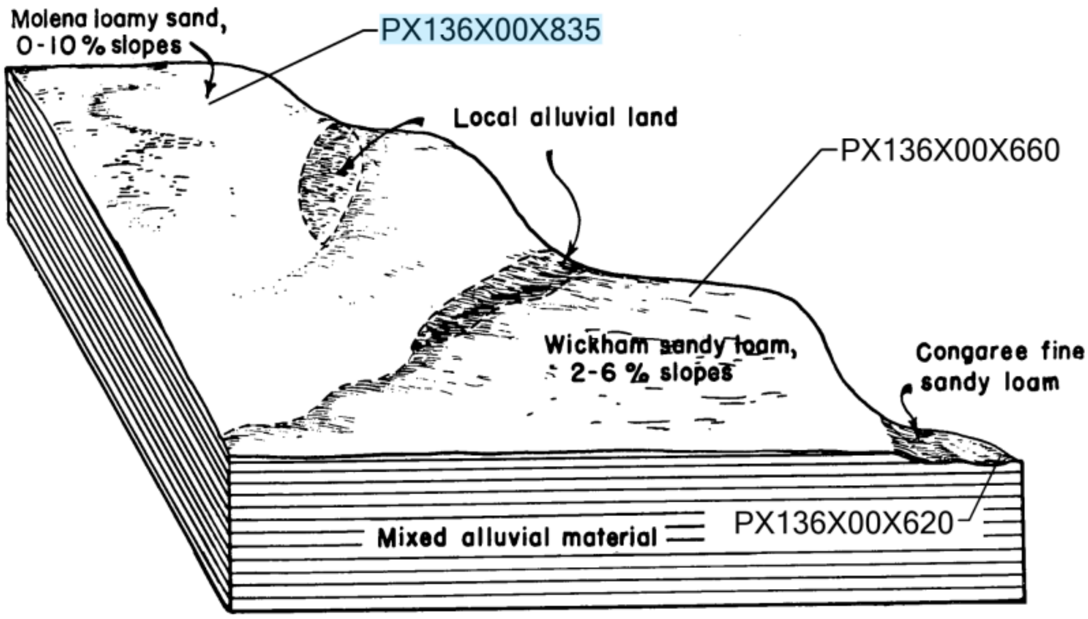


Figure 4. Typical soil-landscape relationships of a river valley with relict sand dunes. Molena soils are associated with this ecological site, depicted here on a high wind-blown terrace.

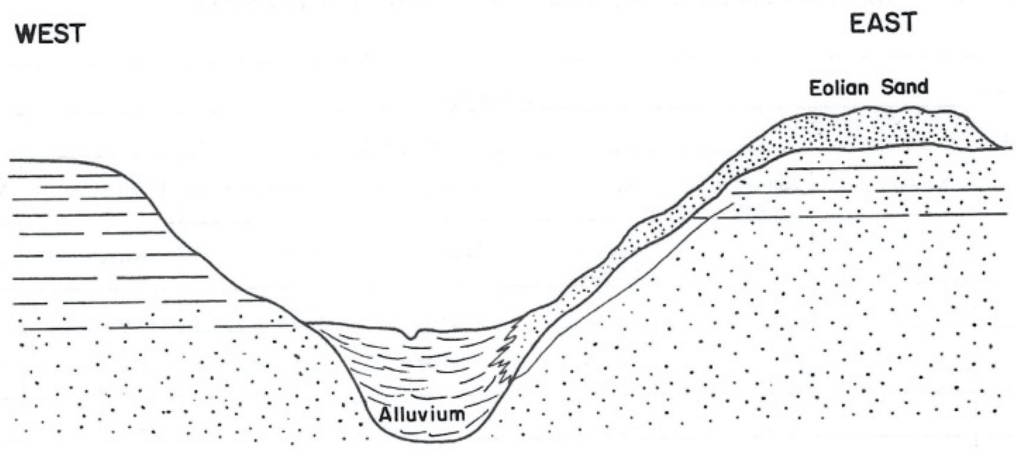


Figure 5. Eolian sands along north-south river reaches. Adapted from Daniels et al. (1999).

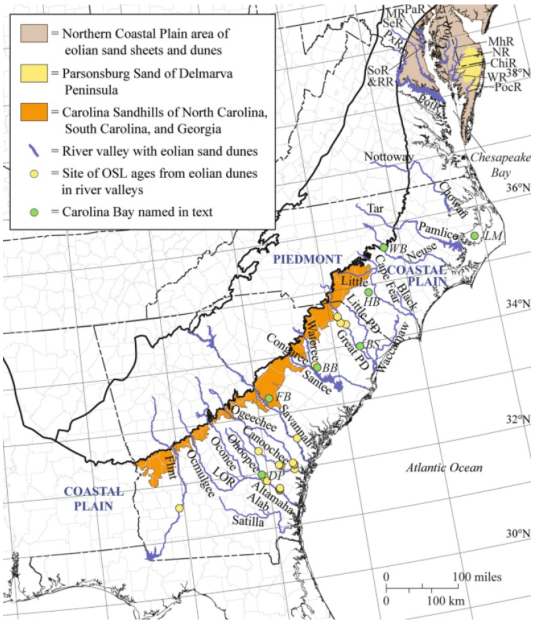


Figure 6. Map showing the distribution of river valleys with areas of relict sand dunes. Generally, riverine sandhills begin to develop in river valleys of the lower Piedmont but are best developed in the broader river valleys of the Coastal Plain (Swezey 2020).

Table 2. Representative physiographic features

Landforms	(1) Piedmont > Stream terrace
Runoff class	Negligible
Flooding frequency	None
Ponding frequency	None
Elevation	189–229 m
Slope	2–10%
Water table depth	183–2,537 cm
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Runoff class	Negligible to very low
Flooding frequency	None
Ponding frequency	None
Elevation	55–247 m
Slope	1–10%
Water table depth	183–2,537 cm

Climatic features

On this ecological site, the average mean annual precipitation is 47 inches. On average, the rainiest months occur in February and March, as well as in July. The driest months occur in April, May, and October.

Table 4. Representative climatic features

Frost-free period (characteristic range)	179-195 days
Freeze-free period (characteristic range)	220-237 days
Precipitation total (characteristic range)	1,168-1,245 mm
Frost-free period (actual range)	177-200 days
Freeze-free period (actual range)	204-246 days
Precipitation total (actual range)	1,118-1,270 mm
Frost-free period (average)	189 days
Freeze-free period (average)	226 days
Precipitation total (average)	1,194 mm

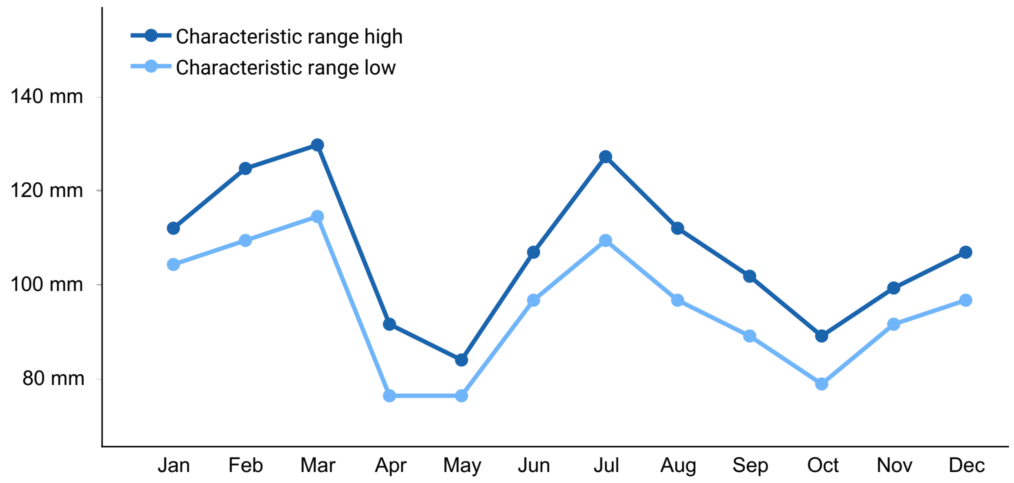


Figure 7. Monthly precipitation range

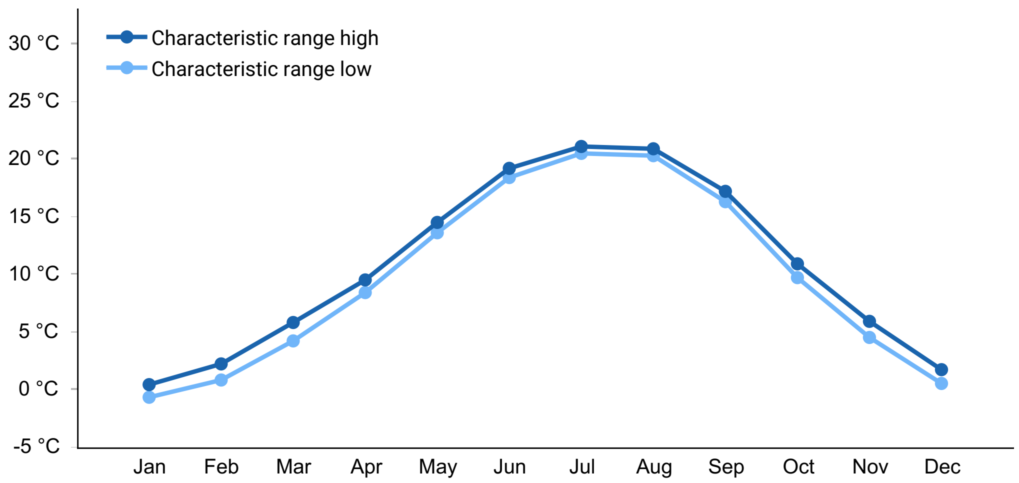


Figure 8. Monthly minimum temperature range

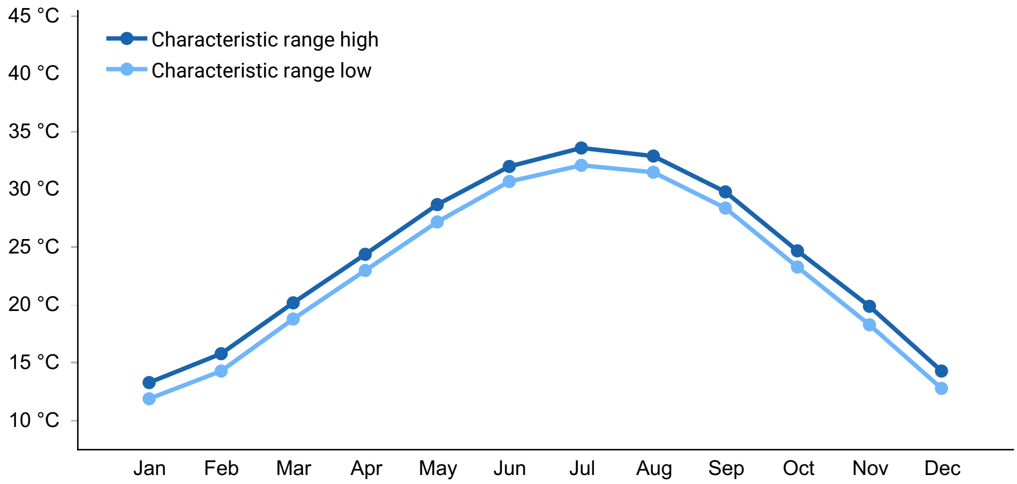


Figure 9. Monthly maximum temperature range

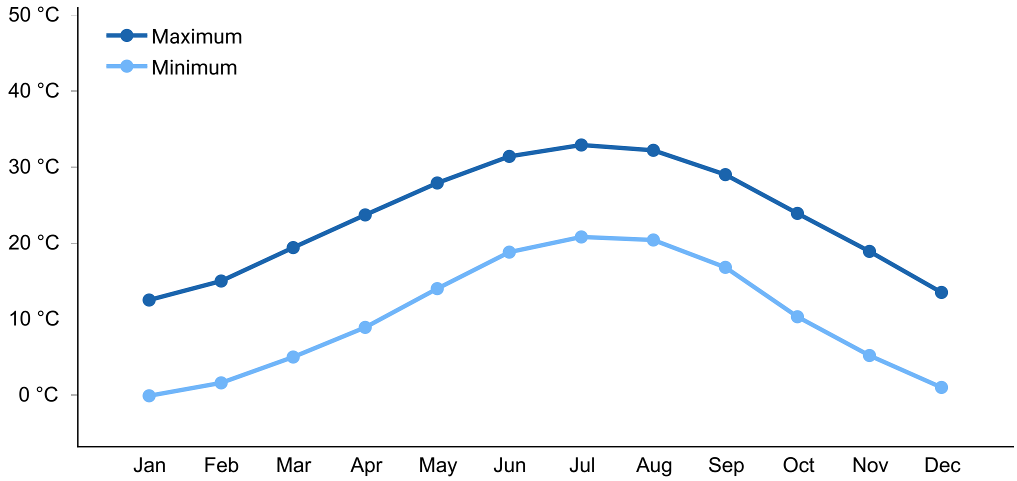


Figure 10. Monthly average minimum and maximum temperature

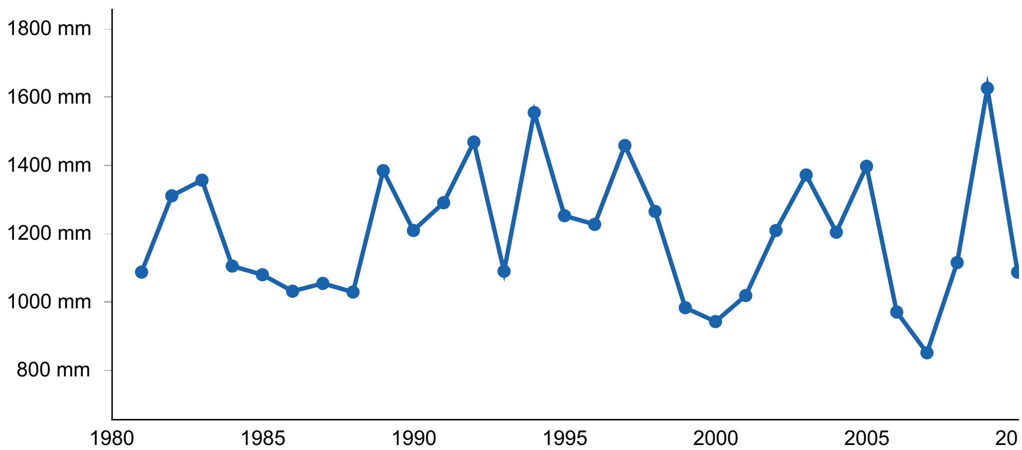


Figure 11. Annual precipitation pattern

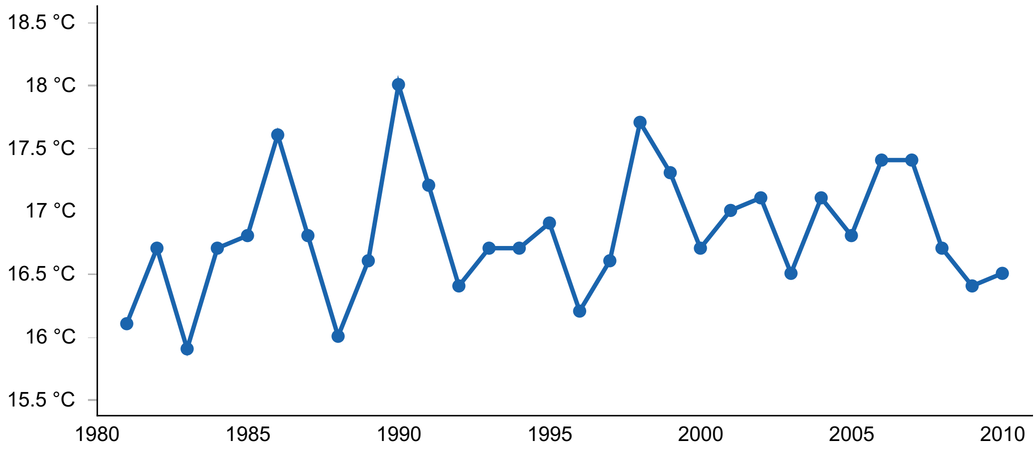


Figure 12. Annual average temperature pattern

Climate stations used

- (1) TALBOTTON [USC00098535], Talbotton, GA
- (2) THOMASTON [USC00098661], Thomaston, GA
- (3) EXPERIMENT [USC00093271], Griffin, GA
- (4) ATLANTA [USW00053819], Peachtree City, GA
- (5) JONESBORO [USC00094700], Jonesboro, GA
- (6) COVINGTON [USC00092318], Covington, GA
- (7) MCDONOUGH [USC00095666], McDonough, GA
- (8) MILLEDGEVILLE [USC00095874], Milledgeville, GA
- (9) WATKINSVILLE 5 SSE [USW00063850], Watkinsville, GA
- (10) ATHENS BEN EPPS AP [USW00013873], Athens, GA
- (11) CLARKS HILL 1 W [USC00381726], Modoc, SC
- (12) CALHOUN FALLS [USC00381277], Calhoun Falls, SC
- (13) PARR [USC00386688], Jenkinsville, SC
- (14) MONTICELLO [USC00095988], Monticello, GA

Influencing water features

Though this ecological site is associated with major rivers, it is not typically influenced by surface or ground water features.

Soil features

Soils on this ecological site are typically very deep, somewhat excessively drained Ultisols, which formed in old, sandy alluvium later reworked by wind. These soils have weathered in place since they were deposited some 20,000 years ago. They are sandy throughout, but demonstrate evidence of clay illuviation in the subsoil. Subsoil texture is loamy fine sand or coarser (≥ 70 percent sand and ≤ 15 percent clay).

Reaction in the subsoil is typically moderately acid to very strongly acid (pH 4.5 to 6.0). In the surface layers, reaction varies with land use and management. Under low input or forested conditions, it generally falls somewhere between pH 4.5 and 6.5. Base saturation is less than 35 percent in the subsoil.

Soils on this ecological site have a thermic soil temperature regime, which is characterized by a mean annual soil temperature of 15°C to 22°C and a winter to summer temperature differential of 6°C or more in the subsoil.

Modal taxa include: Psammentic Hapludults
Modal soil series include: Molena
Few other soils have been attributed to this ecological site.

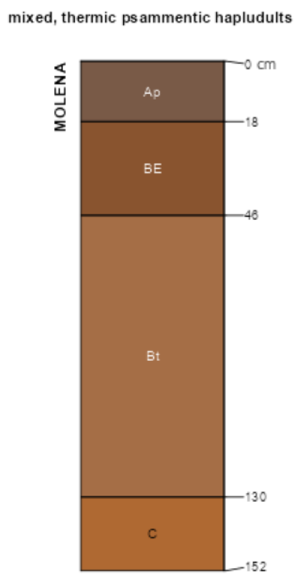


Figure 13. An illustration of a soil profile belonging to the Molena series, a representative soil series associated with this ecological site.

Table 5. Representative soil features

Parent material	(1) Eolian sands–igneous and metamorphic rock (2) Alluvium–igneous and metamorphic rock
Surface texture	(1) Loamy sand (2) Sand (3) Loamy fine sand
Drainage class	Somewhat excessively drained
Permeability class	Rapid
Soil depth	203 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-203.2cm)	10.16–12.7 cm

Soil reaction (1:1 water) (0-101.6cm)	4.5–6
Subsurface fragment volume <=3" (0-203.2cm)	0–3%
Subsurface fragment volume >3" (0-203.2cm)	0%

Table 6. Representative soil features (actual values)

Drainage class	Somewhat excessively drained
Permeability class	Rapid
Soil depth	203 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-203.2cm)	7.62–15.24 cm
Soil reaction (1:1 water) (0-101.6cm)	4.5–6.5
Subsurface fragment volume <=3" (0-203.2cm)	0–5%
Subsurface fragment volume >3" (0-203.2cm)	0–1%

Ecological dynamics

Currently, no U.S. National Vegetation Classification (USNVC) associations apply to the natural vegetation of this ecological site (USNVC 2022). The reference community on this ecological site is roughly equivalent to Edwards et al. (2013) 'Piedmont Sandhills.'

MATURE FORESTS
Under reference conditions, this ecological site supports a unique mixture of species with Coastal Plain affinities, as well as species more typical of the Piedmont. Despite the unusual flora, only limited reconnaissance has been done in these areas. While several loosely characterized vegetation communities have been identified (Edwards et al. 2013; Fleming et al. 2021), most have not been subject to thorough study.

In the reference state, the canopy is dominated by upland oaks and pines. Important canopy species include post oak (*Quercus stellata*), Darlington oak (*Quercus hemisphaerica*), loblolly pine (*Pinus taeda*), black oak (*Quercus velutina*), and southern red oak (*Quercus falcata*). Representative species of the subcanopy layer include sassafras (*Sassafras albidum*) and blackgum (*Nyssa sylvatica*). In the shrub layer, representative species include farkleberry (*Vaccinium arboreum*), huckleberry

(Gaylussacia spp.), small black blueberry (*Vaccinium tenellum*), and common sweetleaf (*Symplocos tinctoria*).

The herb layer is sparse under a closed canopy. Sites that are kept more open, through fire or other means, support species such as devil's-tongue cactus (*Opuntia humifusa*), Atlantic poison oak (*Toxicodendron pubescens*), and various native grasses and leguminous forbs.

Sites that grade down closer to the river can support species such as willow oak (*Quercus phellos*), sweetbay (*Magnolia virginiana*), silky dogwood (*Cornus amomum*), and giant cane (*Arundinaria gigantea*), among others.

DYNAMICS OF NATURAL SUCCESSION AND FIRE ECOLOGY
Because the natural vegetation on this ecological site has received only minimum study, field investigations will be needed to capture the specifics of how it responds to disturbances of various types. Given the relatively dry character of the vegetation, fire likely played some role in the historical ecology. Canopy cover was likely lower in the past and it presumably exhibited a more open structure and a denser, grassier herb layer (Wharton 1978; Edwards et al. 2013; Fleming et al. 2021).

SPECIES LIST
Canopy layer: *Quercus stellata*, *Quercus hemisphaerica*, *Pinus taeda*, *Quercus velutina*, *Quercus falcata*, *Quercus phellos*, *Quercus nigra*,

Subcanopy layer: *Sassafras albidum*, *Nyssa sylvatica*, *Magnolia virginiana*, *Cornus amomum*

Shrub layer: *Vaccinium arboreum*, *Gaylussacia dumosa*, *Gaylussacia frondosa*, *Vaccinium tenellum*, *Vaccinium elliottii*, *Yucca filamentosa*, *Opuntia humifusa*, *Hypericum hypericoides* ssp. multicaule, *Toxicodendron pubescens*, *Symplocos tinctoria*, *Arundinaria gigantea*,

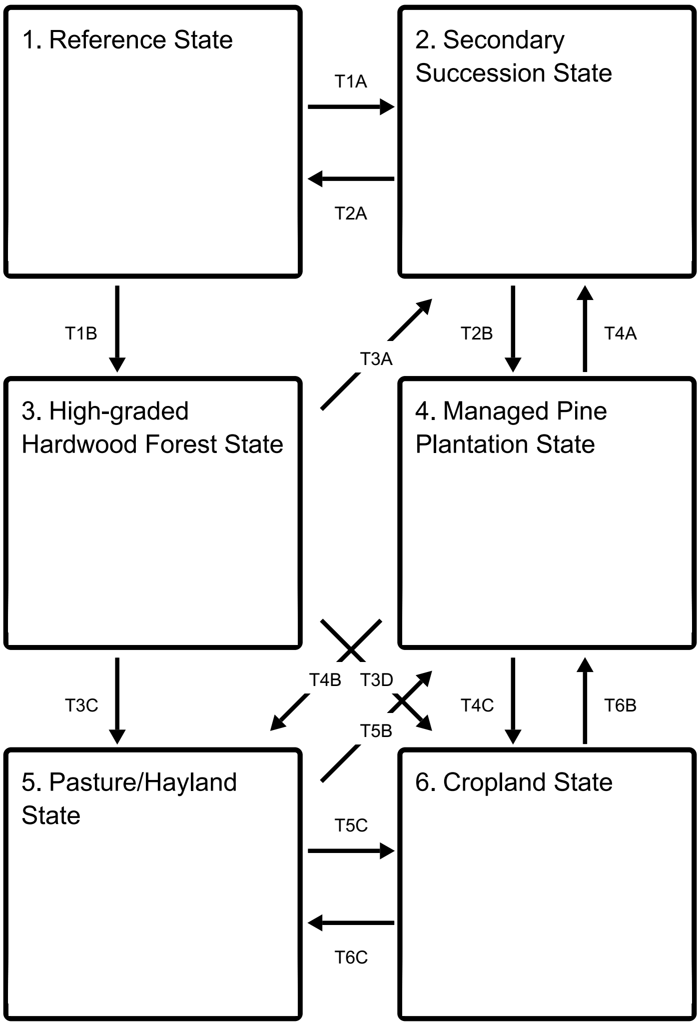
Vines/lianas: *Gelsemium sempervirens*, *Smilax bona-nox*, *Smilax glauca*,

Herb layer - forbs: *Clitoria mariana*, *Rhynchosia tomentosa*, *Tephrosia virginiana*, Desmodium spp., Lespedeza spp., *Solidago odora*, *Coreopsis major*, *Hypericum gentianoides*, *Euthamia caroliniana*, *Polypremum procumbens*, *Cnidoscolus urens* var. stimulosus

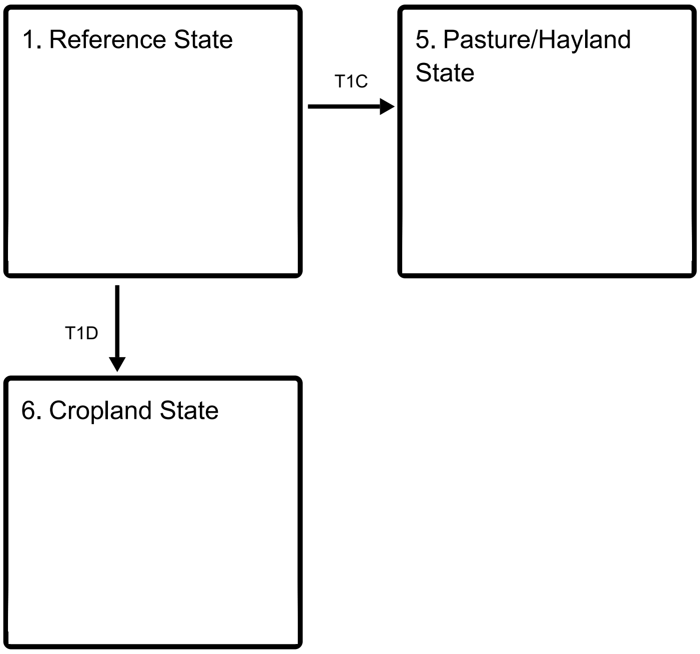
Herb layer - graminoids: Dichanthelium spp., *Danthonia sericea*, *Danthonia spicata*, *Schizachyrium scoparium*, *Andropogon ternarius*, *Sorghastrum nutans*, *Saccharum alopecuroides*, *Saccharum brevibarbe* var. contortum, *Cyperus echinatus*, *Aristida purpurascens*

State and transition model

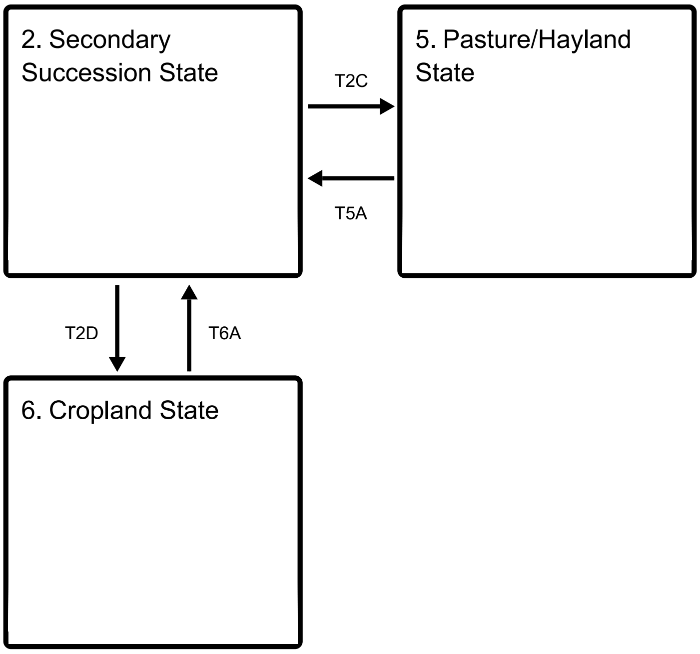
Ecosystem states



States 1, 5 and 6 (additional transitions)



States 2, 5 and 6 (additional transitions)



T1A - Clearcut logging or other large-scale disturbances that cause canopy removal.

T1B - Selective removals of the most valuable timber specimens, leaving inferior trees behind.

T1C - Mechanical tree/brush/stump/debris removal, seedbed preparation, and planting of perennial grasses and forbs.

T1D - Mechanical tree/brush/stump/debris removal, seedbed preparation, applications of fertilizer/lime, and planting of crop or cover crop seed.

T2A - Long-term natural succession.

T2B - Site preparation and tree planting.

T2C - Mechanical tree/brush/stump/debris removal, seedbed preparation, and planting of perennial grasses and forbs.

T2D - Mechanical tree/brush/stump/debris removal, seedbed preparation, applications of fertilizer/lime, weed control, planting of crop or cover crop seed.

T3A - Clearcut logging or other large-scale disturbances that cause canopy removal.

T3C - Mechanical tree/brush/stump/debris removal, seedbed preparation, and planting of perennial grasses and forbs.

T3D - Mechanical tree/brush/stump/debris removal, seedbed preparation, applications of fertilizer/lime, weed control, planting of crop or cover crop seed.

T4A - Abandonment of forestry practices.

T4B - Timber harvest, mechanical stump and debris removal, seedbed preparation, and planting of perennial grasses and forbs.

T4C - Timber harvest, mechanical stump and debris removal, seedbed preparation, fertilizer/lime, weed control, planting of crop or cover crop seed.

T5A - Long-term cessation of grazing.

T5B - Site preparation and tree planting.

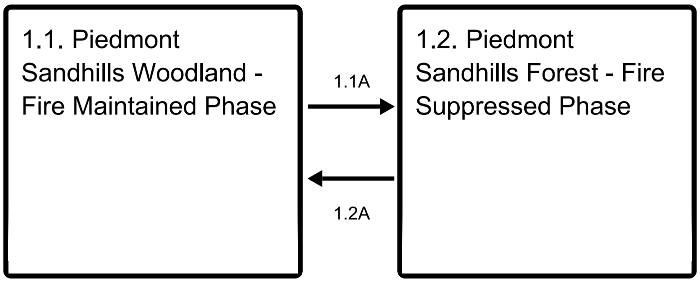
T5C - Seedbed preparation, applications of fertilizer/lime, weed control, and planting of crop or cover crop seed.

T6A - Agricultural abandonment.

T6B - Site preparation and tree planting.

T6C - Seedbed preparation, weed control, and planting of perennial grasses and forbs.

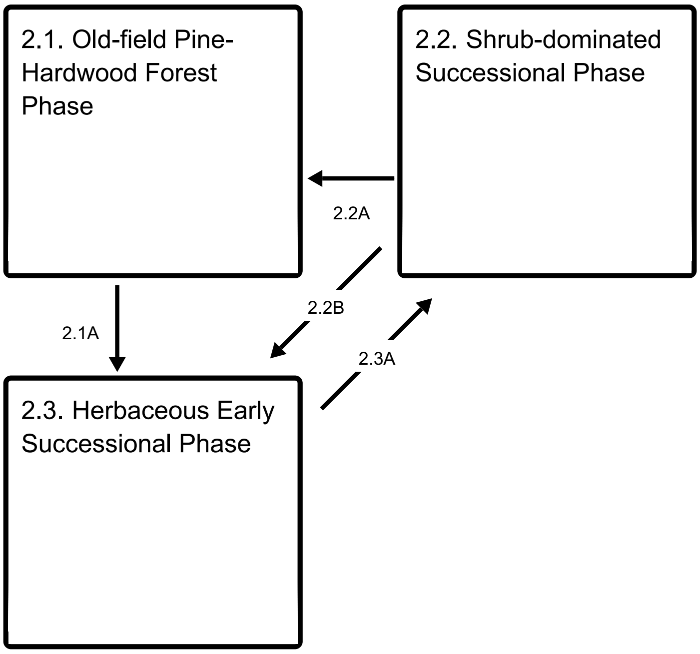
State 1 submodel, plant communities



1.1A - Long-term exclusion of fire.

1.2A - Prescribed burns and selective removals.

State 2 submodel, plant communities



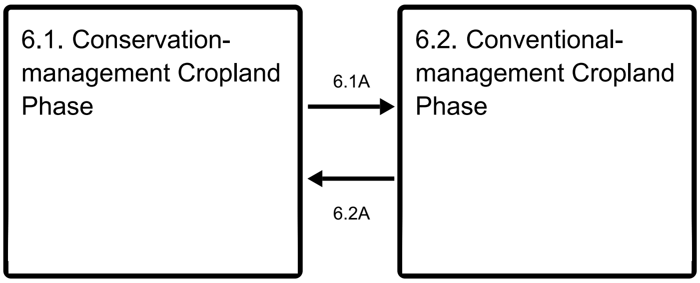
2.1A - Clearcut logging.

2.2A - Natural succession.

2.2B - Brush management.

2.3A - Natural succession.

State 6 submodel, plant communities



6.1A - Conventional tillage is reintroduced.

6.2A - Cessation of conventional tillage, implementation of conservation tillage.

State 1
Reference State

This mature forest state is generally dominated by a mixture of dry-site oaks and pines, with acid-tolerant flora in the understory.

Characteristics and indicators. Stands are uneven-aged with at least some old trees present.

Community 1.1
Piedmont Sandhills Woodland - Fire Maintained Phase

This is an open canopy mature forest community/phase. Regular low-intensity fires have been reintroduced, keeping the understory somewhat open, increasing the cover and diversity of herbaceous species and limiting the importance of fire-intolerant woody species.

Resilience management. This community/phase is maintained through regular prescribed burns. The recruitment of fire-adapted oaks and pines benefits from regular low-intensity ground fires, as these forests evolved under a more regular fire regime. Tree ring data suggests that the mean fire return interval of the past in the Southern Piedmont is approximately 6 years, though the actual return interval varied from 3 to 16 years. To approximate the pre-colonial fire regime, prescribed burns should be carried out every 4 to 8 years.

Forest overstory. The overstory is dominated by dry-site oaks and pines, including post oak (Quercus stellata), Darlington oak (Quercus hemisphaerica), black oak (Quercus velutina), and southern red oak (Quercus falcata). Canopy cover is lower than in the fire suppressed phase.

Forest understory. Representative understory tree species include sassafras (Sassafras albidum) and blackgum (Nyssa sylvatica). Understory shrub species include farkleberry (Vaccinium arboreum), huckleberry (Gaylussacia spp.), and small black blueberry (Vaccinium tenellum).

The herb layer is denser and grassier than in the fire suppressed phase.

Dominant plant species

- post oak (*Quercus stellata*), tree
- Darlington oak (*Quercus hemisphaerica*), tree
- black oak (*Quercus velutina*), tree
- southern red oak (*Quercus falcata*), tree
- sassafras (*Sassafras albidum*), tree
- blackgum (*Nyssa sylvatica*), tree
- farkleberry (*Vaccinium arboreum*), shrub

- dwarf huckleberry (*Gaylussacia dumosa*), shrub
- blue huckleberry (*Gaylussacia frondosa*), shrub
- small black blueberry (*Vaccinium tenellum*), shrub
- blackberry (*Rubus*), shrub
- evening trumpetflower (*Gelsemium sempervirens*), shrub
- saw greenbrier (*Smilax bona-nox*), shrub
- Elliott's blueberry (*Vaccinium elliottii*), shrub
- Adam's needle (*Yucca filamentosa*), shrub
- devil's-tongue (*Opuntia humifusa*), shrub
- rosette grass (*Dichanthelium*), grass
- downy danthonia (*Danthonia sericea*), grass
- little bluestem (*Schizachyrium scoparium*), grass
- splitbeard bluestem (*Andropogon ternarius*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- silver plumegrass (*Saccharum alopecuroides*), grass
- Atlantic pigeonwings (*Clitoria mariana*), other herbaceous
- twining snoutbean (*Rhynchosia tomentosa*), other herbaceous
- Virginia tephrosia (*Tephrosia virginiana*), other herbaceous
- ticktrefoil (*Desmodium*), other herbaceous
- lespedeza (*Lespedeza*), other herbaceous
- anisescented goldenrod (*Solidago odora*), other herbaceous
- greater tickseed (*Coreopsis major*), other herbaceous
- orangegrass (*Hypericum gentianoides*), other herbaceous

Community 1.2
Piedmont Sandhills Forest - Fire Suppressed Phase

This is a closed canopy mature forest community/phase. Canopy cover is higher than in stands in which fire has been reintroduced and the herb layer is typically sparser.

Forest overstory. The overstory is dominated by dry-site oaks and pines, including post oak (Quercus stellata), Darlington oak (Quercus hemisphaerica), loblolly pine (Pinus taeda), black oak (Quercus velutina), and southern red oak (Quercus falcata). Canopy cover is higher than in the fire maintained phase.

Forest understory. Representative understory tree species include sassafras (Sassafras albidum) and blackgum (Nyssa sylvatica). Understory shrub species include farkleberry (Vaccinium arboreum), huckleberry (Gaylussacia spp.), and small black blueberry (Vaccinium tenellum).

The herb layer is sparser, less grassy, and less diverse than in the fire maintained phase.

Dominant plant species

- post oak (*Quercus stellata*), tree
- Darlington oak (*Quercus hemisphaerica*), tree

- loblolly pine (*Pinus taeda*), tree
- black oak (*Quercus velutina*), tree
- southern red oak (*Quercus falcata*), tree
- sassafras (*Sassafras albidum*), tree
- blackgum (*Nyssa sylvatica*), tree
- willow oak (*Quercus phellos*), tree
- water oak (*Quercus nigra*), tree
- farkleberry (*Vaccinium arboreum*), shrub
- dwarf huckleberry (*Gaylussacia dumosa*), shrub
- blue huckleberry (*Gaylussacia frondosa*), shrub
- small black blueberry (*Vaccinium tenellum*), shrub
- roundleaf greenbrier (*Smilax rotundifolia*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- Elliott's blueberry (*Vaccinium elliottii*), shrub
- rosette grass (*Dichanthelium*), grass
- downy danthonia (*Danthonia sericea*), grass

Pathway 1.1A
Community 1.1 to 1.2

Long-term exclusion of fire causes an increase in fire-intolerant understory species and a deterioration of the abundance and diversity of herbaceous species.

Pathway 1.2A
Community 1.2 to 1.1

The fire suppressed phase can be managed towards the fire maintained phase through a combination of prescribed burns and selective removals. To approximate the pre-colonial fire regime, prescribed burns should be carried out every 4 to 8 years.

Context dependence. After decades of fire suppression, most upland forests of the Southeast have undergone mesophication, or succession toward forest systems that are less apt to burn. If prescribed fire is to be used as a management tool in fire suppressed ecosystems of the Piedmont, planning will be needed in some forest systems to overcome the effects of mesophication in the early stages of fire reintroduction.

State 2
Secondary Succession State

This state develops in the immediate aftermath of agricultural abandonment, clearcut logging, or other large-scale disturbances that lead to canopy removal. Which species colonize a particular location in the wake of a disturbance does involve a considerable degree of chance. It also depends a great deal on the type, duration, and magnitude of the disturbance event.

Characteristics and indicators. Plant age distribution is even. Plants exhibit pioneering traits such as rapid growth, early reproduction, and shade-intolerance.

Community 2.1
Old-field Pine-Hardwood Forest Phase

This forested successional phase develops in the wake of recent, large-scale disturbances which have resulted in canopy removal. Stands are even-aged and species diversity is low. The canopy is usually dominated by pines, though opportunistic hardwoods can also be important, particularly in the early stages of tree establishment. Species that exhibit pioneering traits are usually most abundant.

Forest overstory. The overstory is typically dominated by loblolly pine (Pinus taeda).

Forest understory. Common understory tree species include sassafras (Sassafras albidum) and blackgum (Nyssa sylvatica). Farkleberry (Vaccinium arboreum) is most representative of the shrub layer. Seedlings of dry-site oaks are usually present in the understory. These seedlings are released gradually as the forest matures and the pines begin to die off.

Dominant plant species

- loblolly pine (*Pinus taeda*), tree
- sassafras (*Sassafras albidum*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- blackgum (*Nyssa sylvatica*), tree
- oak (*Quercus*), tree
- farkleberry (*Vaccinium arboreum*), shrub
- sassafras (*Sassafras albidum*), shrub
- evening trumpetflower (*Gelsemium sempervirens*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub

Community 2.2
Shrub-dominated Successional Phase

This successional phase is dominated by shrubs, along with seedlings of opportunistic hardwoods and pines. It grades into the forested successional phase as tree seedlings become saplings and begin to occupy more of the canopy cover.

Forest overstory. The composition varies considerably from location to location.

Dominant plant species

- loblolly pine (*Pinus taeda*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- silktree (*Albizia julibrissin*), tree

- Chinaberrytree (*Melia azedarach*), tree
- Callery pear (*Pyrus calleryana*), tree
- sassafras (*Sassafras albidum*), tree
- winged elm (*Ulmus alata*), tree
- rose (*Rosa*), shrub
- blackberry (*Rubus*), shrub
- winged sumac (*Rhus copallinum*), shrub
- St. Johnswort (*Hypericum*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- Chickasaw plum (*Prunus angustifolia*), shrub
- greenbrier (*Smilax*), shrub
- grape (*Vitis*), shrub
- broomsedge bluestem (*Andropogon virginicus*), grass
- sericea lespedeza (*Lespedeza cuneata*), other herbaceous
- thoroughwort (*Eupatorium*), other herbaceous
- goldenrod (*Solidago*), other herbaceous

Community 2.3
Herbaceous Early Successional Phase

This transient community is composed of the first herbaceous invaders in the aftermath of agricultural abandonment, clearcut logging, or other large-scale natural disturbances that lead to canopy removal.

Resilience management. If the user wishes to maintain this community/phase for wildlife or pollinator habitat, a prescribed burn, mowing, or prescribed grazing will be needed at least once annually to prevent community pathway 2.3A. To that end, as part of long-term maintenance, periodic overseeding of wildlife or pollinator seed mixtures can be helpful in ensuring the viability of certain desired species and maintaining the desired composition of species for user goals.

Dominant plant species

- St. Johnswort (*Hypericum*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- broomsedge bluestem (*Andropogon virginicus*), grass
- splitbeard bluestem (*Andropogon ternarius*), grass
- crabgrass (*Digitaria*), grass
- lovegrass (*Eragrostis*), grass
- arrowfeather threeawn (*Aristida purpurascens*), grass
- thoroughwort (*Eupatorium*), other herbaceous
- Canadian horseweed (*Conyza canadensis*), other herbaceous
- goldenrod (*Solidago*), other herbaceous
- dwarf cinquefoil (*Potentilla canadensis*), other herbaceous
- camphorweed (*Heterotheca subaxillaris*), other herbaceous
- annual ragweed (*Ambrosia artemisiifolia*), other herbaceous

- blackeyed Susan (*Rudbeckia hirta*), other herbaceous
- partridge pea (*Chamaecrista fasciculata*), other herbaceous
- slender scratchdaisy (*Croptilon divaricatum*), other herbaceous
- juniper leaf (*Polypremum procumbens*), other herbaceous

Pathway 2.1A
Community 2.1 to 2.3

The old-field pine-hardwood forest phase can return to the herbaceous early successional phase through clearcut logging or other large-scale disturbances that cause canopy removal.

Context dependence. Note: if the user wishes to use this community pathway to create wildlife or pollinator habitat, please contact a local NRCS office for a species list specific to the area of interest and user needs.

Pathway 2.2A
Community 2.2 to 2.1

The shrub-dominated successional phase naturally moves towards the old-field pine-hardwood forest through natural succession.

Pathway 2.2B
Community 2.2 to 2.3

The shrub-dominated successional phase can return to the herbaceous early successional phase through brush management, including herbicide application, mechanical removal, prescribed grazing, or fire.

Context dependence. Note: if the user wishes to use this community pathway to create wildlife or pollinator habitat, please contact a local NRCS office for a species list specific to the area of interest and user needs. If the user wishes to maintain the shrub-dominated successional phase long term, for wildlife habitat or other uses, periodic use of this community pathway is necessary to prevent community pathway 2.2A, which happens inevitably unless natural succession is set back through disturbance.

Pathway 2.3A
Community 2.3 to 2.2

The herbaceous early successional phase naturally moves towards the shrub-dominated successional phase through natural succession. The process takes approximately 3 years on average, barring any major disturbances capable of inhibiting natural succession.

State 3

High-graded Hardwood Forest State

This state develops as a consequence of high-grading, where the most valuable trees are removed, leaving less desirable timber specimens behind. Trees left behind include undesirable timber species, trees of poor form, diseased trees, or genetically inferior trees.

Characteristics and indicators. Typically, high-graded stands consist of a combination of residual stems from the previous stand, a high proportion of undesirable shade-tolerant species, along with some regrowth from desirable timber species. In some cases, large-diameter trees of desirable timber species may be present, but upon closer inspection, these trees usually have serious defects that resulted in their being left behind in earlier cuts.

Resilience management. Landowners with high-graded stands have two options for improving timber production: 1) rehabilitate, or 2) regenerate. To rehabilitate a stand, the landowner must evaluate existing trees to determine if rehabilitation is justified. If the proportion of high-quality specimens present in the stand is low, then the stand should be regenerated. In many cases, poor quality of the existing stand is the result of decades of mismanagement. Drastic measures are often required to get the stand back into good timber production.

Dominant plant species

- blackgum (*Nyssa sylvatica*), tree
- sassafras (*Sassafras albidum*), tree
- common persimmon (*Diospyros virginiana*), tree
- oak (*Quercus*), tree
- loblolly pine (*Pinus taeda*), tree

State 4
Managed Pine Plantation State

This converted state is dominated by planted timber trees. Loblolly pine (*Pinus taeda*) is the most commonly planted species. Even-aged management is the most common timber management system. Note: if the user wishes to convert stands dominated by hardwoods to planted pine, clearcutting will usually be necessary first, allowing herbaceous pioneers to establish on the site in the weeks or months prior to planting. Users should utilize measures described in transition T2B under these circumstances.

Resilience management. Hardwood Encroachment: Hardwood encroachment can be problematic in managed pine plantations. Good site preparation, proper stocking, and periodic thinning are advisable to reduce hardwood competition. Overstocking: The overstocked condition commonly occurs in naturally regenerated stands. When competition from other pines begins to impact the health and productivity of the stand, precommercial thinning should be considered. At this point, the benefit of thinning usually outweighs the potential for invasion and competition from non-pine species. As the target window for thinning passes, the condition of the stand can slowly deteriorate if no action is taken. Under long-term overstocked conditions, trees are more prone to stresses, including pine bark beetle infestation and damage from wind or ice. High-grading: In subsequent commercial thinnings, care should be taken in tree selection. High quality specimens should be left to reach maturity, while slower growing trees or those with defects should be removed sooner. If high quality specimens are harvested first, trees left behind are often structurally unsound, diseased, genetically inferior, or of poor form. This can have long-term implications for tree genetics and for the condition of the stand (Felix III 1983; Miller et al. 1995, 2003; Megalos 2019).

Dominant plant species

- loblolly pine (*Pinus taeda*), tree
- blackgum (*Nyssa sylvatica*), tree
- sassafras (*Sassafras albidum*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- oak (*Quercus*), tree
- blueberry (*Vaccinium*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- greenbrier (*Smilax*), shrub
- blackberry (*Rubus*), shrub
- St. Johnswort (*Hypericum*), shrub
- rosette grass (*Dichanthelium*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- longleaf woodoats (*Chasmanthium sessiliflorum*), grass
- silver plumegrass (*Saccharum alopecuroides*), grass
- sortbeard plumegrass (*Saccharum brevibarbe var. contortum*), grass

State 5
Pasture/Hayland State

This converted state is dominated by herbaceous forage species.

Resilience management. Overgrazing and High Foot Traffic: In areas that are subject to high foot traffic from livestock and equipment, and/or long-term overgrazing, unpalatable weedy species tend to invade, as most desirable forage species are less competitive under these conditions. High risk areas include locations where livestock congregate for water, shade, or feed, and in travel lanes, gates, and other areas of heavy use. Plant species that are indicative of overgrazing or excessive foot traffic on this ecological site include buttercup (Ranunculus spp.), plantain (Plantago spp.), curly dock (*Rumex crispus*), sneezeweed (*Helenium amarum*), cudweed (Pseudognaphalium spp.), slender yellow woodsorrel (*Oxalis dillenii*), Carolina horsenettle (*Solanum carolinense*), Virginia pepperweed (*Lepidium virginicum*), black medick (*Medicago lupulina*), Japanese clover (*Kummerowia striata*), annual bluegrass (*Poa annua*), poverty rush (*Juncus tenuis*), rattail fescue (*Vulpia myuros*), and Indian goosegrass (*Eleusine indica*), among others. A handful of desirable forage species are also tolerant of heavy grazing and high foot traffic, including white clover (*Trifolium repens*), dallisgrass (*Paspalum dilatatum*), and bermudagrass (*Cynodon dactylon*). An overabundance of these species, along with poor plant vigor and areas of bare soil, may imply that excessive foot traffic and/or overgrazing is a concern, either in the present or in the recent past. Soil Fertility and pH Management: Like overgrazing and excessive foot traffic, inadequate soil fertility and pH management can lead to invasion from several common weeds of pastures and hayfields. Species indicative of poor soil fertility and/or suboptimal pH on this ecological site include broomsedge bluestem (*Andropogon virginicus*), sweet vernalgrass (*Anthoxanthum odoratum*), dogfennel (*Eupatorium capillifolium*), Japanese clover (*Kummerowia striata*), common sheep sorrel (*Rumex acetosella*), and Carolina horsenettle (*Solanum carolinense*), among others. Most of these weedy invaders do not compete well in dense, rapidly growing pastures and hayfields. By maintaining soil fertility and pH, managing grazing to favor desirable forage species, and clipping behind grazing rotations when needed, forage grasses and forbs can usually outcompete weedy invaders. Brush Encroachment: Brush encroachment can be problematic in some pastures, particularly near fence lines where there is often a ready seed source. Pastures subject to low stocking density and long-duration grazing rotations can also be susceptible to encroachment from woody plants. Shorter grazing rotations of higher stocking density can help alleviate pressure from shrubs and vines with low palatability or thorny stems. Clipping behind grazing rotations, annual brush hogging, and multispecies grazing systems (cattle with or followed by goats) can also be helpful. Common woody invaders of pasture on this ecological site include rose (Rosa spp.), blackberry (Rubus spp.), saw greenbrier (*Smilax bona-nox*), Japanese honeysuckle (*Lonicera japonica*), common persimmon (*Diospyros virginiana*), eastern redcedar (*Juniperus virginiana*), black cherry (*Prunus serotina*), and Chinese privet (*Ligustrum sinense*).

Dominant plant species

- Bermudagrass (*Cynodon dactylon*), grass
- dallisgrass (*Paspalum dilatatum*), grass
- bahiagrass (*Paspalum notatum*), grass
- Johnsongrass (*Sorghum halepense*), grass
- hairy crabgrass (*Digitaria sanguinalis*), grass
- common carpetgrass (*Axonopus fissifolius*), grass
- tall fescue (*Schedonorus arundinaceus*), grass
- purpletop tridens (*Tridens flavus*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- white clover (*Trifolium repens*), other herbaceous
- narrowleaf plantain (*Plantago lanceolata*), other herbaceous
- dogfennel (*Eupatorium capillifolium*), other herbaceous
- field clover (*Trifolium campestre*), other herbaceous
- black medick (*Medicago lupulina*), other herbaceous
- Japanese clover (*Kummerowia striata*), other herbaceous
- sericea lespedeza (*Lespedeza cuneata*), other herbaceous

State 6
Cropland State

This converted state produces food or fiber for human uses. It is dominated by domesticated crop species, along with typical weedy invaders of cropland. Soils associated with this ecological site are not well-suited to crop production. Erosion, plant water limitations, and soil fertility limitations can all be problematic on this ecological site when soils are put into crop production.

Community 6.1
Conservation-management Cropland Phase

This cropland phase is characterized by the practice of no-tillage or strip-tillage, and other soil conservation practices. Though no-till systems offer many benefits, several weedy species tend to be more problematic under this type of management system. In contrast with conventional tillage systems, problematic species in no-till systems include biennial or perennial weeds, owing to the fact that tillage is no longer used in weed management.

Dominant plant species

- corn (*Zea mays*), grass
- common wheat (*Triticum aestivum*), grass
- grain sorghum (*Sorghum bicolor ssp. bicolor*), grass
- soybean (*Glycine max*), other herbaceous
- upland cotton (*Gossypium hirsutum*), other herbaceous
- cultivated tobacco (*Nicotiana tabacum*), other herbaceous

Community 6.2
Conventional-management Cropland Phase

This cropland phase is characterized by the recurrent use of tillage as a management tool. Due to the frequent disturbance regime, weedy invaders tend to be annual herbaceous species that reproduce quickly and are prolific seed producers.

Resilience management. The potential for soil loss is high under this management system. Measures should be put in place to limit erosion.

Dominant plant species

- corn (*Zea mays*), grass
- common wheat (*Triticum aestivum*), grass
- grain sorghum (*Sorghum bicolor ssp. bicolor*), grass
- soybean (*Glycine max*), other herbaceous
- upland cotton (*Gossypium hirsutum*), other herbaceous
- cultivated tobacco (*Nicotiana tabacum*), other herbaceous

Pathway 6.1A
Community 6.1 to 6.2

The conservation-tillage cropland phase can shift to the conventional-tillage cropland phase through cessation of conservation tillage practices and the reintroduction of conventional tillage practices.

Context dependence. Soil and vegetation changes associated with this community pathway typically occur several years after reintroduction of conventional tillage practices. These changes continue to manifest as conventional tillage is continued, before reaching a steady state.

Pathway 6.2A
Community 6.2 to 6.1

The conventional-tillage cropland phase can be brought into the conservation-tillage cropland phase through cessation of conventional tillage and implementation of one of several conservation tillage options, including no-tillage or strip-tillage.

Context dependence. Soil and vegetation changes associated with this community pathway typically occur several years after implementation of conservation tillage. These changes continue to manifest as conservation tillage is continued, before reaching a steady state.

Transition T1A
State 1 to 2

The reference state can transition to the secondary succession state through clearcut logging or other large-scale disturbances that cause canopy removal.

Transition T1B
State 1 to 3

The reference state can transition to the high-graded hardwood forest state through selective removal of the most valuable trees, leaving undesirable timber specimens behind. This may occur through multiple cutting cycles over the course of decades or longer, each cut progressively worsening the condition of the stand.

Transition T1C
State 1 to 5

The reference state can transition to the pasture/hayland state through 1) mechanical tree/brush/stump/debris removal, 2) seedbed preparation, and 3) planting of perennial grasses and forbs.

Context dependence. Herbicide applications, fire, and/or root-raking can be helpful in transitioning treed land to pasture. This is done in part to limit coppicing, as many woody plants are capable of sprouting from residual plant structures left behind after clearing. Judicious use of root-raking is recommended, as this practice can have long-term repercussions with regard to soil structure. Applications of fertilizer and lime can also be helpful in establishing perennial forage species. Grazing should be deferred until grasses and forbs are well established.

Transition T1D
State 1 to 6

The reference state can transition to the cropland state through 1) mechanical tree/brush/stump/debris removal, 2) seedbed preparation, 3) applications of fertilizer/lime, and 4) planting of crop or cover crop seed.

Context dependence. A broad spectrum herbicide, fire, and/or root-raking can be helpful in transitioning treed land to cropland. This is done in part to limit coppicing, as many woody plants are capable of sprouting from residual plant structures left behind after clearing. Judicious use of root-raking is recommended, as this practice can have long-term repercussions with regard to soil structure. Weedy grasses and forbs can also be problematic on these lands.

Transition T2A
State 2 to 1

The secondary succession state can transition to the reference state through long-term natural succession. This process can be accelerated to some degree by a combination of prescribed burns and selective harvesting of pines and opportunistic hardwoods.

Transition T2B
State 2 to 4

The secondary succession state can transition to the managed pine plantation state through site preparation and planting of timber trees. Thinning alone may be sufficient for portions of the forest if pines have already established, though it is rarely sufficient for an entire forest patch.

Transition T2C
State 2 to 5

The secondary succession state can transition to the pasture/hayland state through through 1) mechanical tree/brush/stump/debris removal, 2) seedbed preparation, and 3) planting of perennial grasses and forbs.

Context dependence. A broad spectrum herbicide, fire, and/or root-raking can be helpful in transitioning wooded or semi-wooded land to pasture. This is done in part to limit coppicing, as many woody pioneers are capable of sprouting from residual plant structures left behind after clearing. Judicious use of root-raking is recommended, as this practice can have long-term repercussions with regard to soil structure. Applications of fertilizer and lime can also be helpful in establishing perennial forage species. Grazing should be deferred until grasses and forbs are well established.

Transition T2D
State 2 to 6

The secondary succession state can transition to the cropland state through 1) mechanical tree/brush/stump/debris removal, 2) seedbed preparation, 3) applications of fertilizer/lime, 4) weed control, 5) planting of crop or cover crop seed.

Constraints to recovery. A broad spectrum herbicide, fire, and/or root-raking may be needed to successfully transition land that has been fallow for some time back to cropland. This is done in part to limit coppicing, as many woody pioneers are capable of sprouting from residual plant structures left behind after clearing. Judicious use of root-raking is recommended, as this practice can have long-term repercussions with regard to soil structure. Weedy grasses and forbs can also be problematic on these lands.

Transition T3A
State 3 to 2

The high-graded hardwood forest state can transition to the secondary succession state through clearcut logging or other large-scale disturbances that cause canopy removal.

Transition T3C
State 3 to 5

The high-graded hardwood forest state can transition to the pasture/hayland state through 1) mechanical tree/brush/stump/debris removal, 2) seedbed preparation, and 3) planting of perennial grasses and forbs.

Context dependence. Herbicide applications, fire, and/or root-raking can be helpful in transitioning treed land to pasture. This is done in part to limit coppicing, as many woody plants are capable of sprouting from residual plant structures left behind after clearing. Judicious use of root-raking is recommended, as this practice can have long-term repercussions with regards to soil structure. Applications of fertilizer and lime can also be helpful in establishing perennial forage species. Grazing should be deferred until grasses and forbs are well established.

Transition T3D

State 3 to 6

The high-graded hardwood forest state can transition to the cropland state through 1) mechanical tree/brush/stump/debris removal, 2) seedbed preparation, 3) applications of fertilizer/lime, 4) herbicide application, 5) planting of crop or cover crop seed.

Context dependence. A broad spectrum herbicide, fire, and/or root-raking can be helpful in transitioning treed land to cropland. This is done in part to limit coppicing, as many woody pioneers are capable of sprouting from residual plant structures left behind after clearing. Judicious use of root-raking is recommended, as this practice can have long-term repercussions with regards to soil structure. Weedy grasses and forbs can also be problematic on these lands.

Transition T4A
State 4 to 2

The managed pine plantation state can transition to the secondary succession state through abandonment of forestry practices (with or without timber tree harvest).

Transition T4B
State 4 to 5

The managed pine plantation state can transition to the pasture/hayland state through 1) timber harvest, 2) mechanical stump and debris removal, 3) seedbed preparation, 4) planting of perennial grasses and forbs.

Context dependence. Applications of fertilizer and lime can be helpful in establishing perennial forage species. Grazing should be deferred until grasses and forbs are well established.

Transition T4C
State 4 to 6

The managed pine plantation state can transition to the cropland state through 1) timber harvest, 2) mechanical stump and debris removal, 3) seedbed preparation, 4) applications of fertilizer/lime, 5) herbicide application, 6) planting of crop or cover crop seed.

Transition T5A
State 5 to 2

The pasture/hayland state can transition to the secondary succession state through long-term cessation of grazing.

Transition T5B
State 5 to 4

The pasture/hayland state can transition to the managed pine plantation state through site preparation and tree planting.

Transition T5C
State 5 to 6

The pasture/hayland state can transition to the cropland state through 1) seedbed preparation, 2) applications of fertilizer/lime, 3) weed control, and 4) planting of crop or cover crop seed.

Transition T6A
State 6 to 2

The cropland state can transition to the secondary succession state through agricultural abandonment.

Transition T6B
State 6 to 4

The cropland state can transition to the managed pine plantation state through site preparation and tree planting.

Context dependence. Applications of herbicide may be needed to remove common agricultural weeds.

Transition T6C
State 6 to 5

The cropland state can transition to the pasture/hayland state through 1) seedbed preparation, 2) weed control, and 3) planting of perennial forage grasses and forbs.

Context dependence. To convert cropland to pasture or hayland, weed control and good seed-soil contact are important. It is also critical to review the labels of herbicides used for weed control and on the previous crop. Many herbicides have plant-back restrictions, which if not followed could carryover and kill forage seedlings as they germinate. Grazing should be deferred until grasses and forbs are well established.

Additional community tables

Inventory data references

Data collection and analysis of field data will be performed during the Verification Stage of ESD development.

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Approval

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	05/21/2025
Approved by	Charles Stemmans
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

   ____

2. **Presence of water flow patterns:**

   ____

3. **Number and height of erosional pedestals or terracettes:**

   ____

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

   ____

5. **Number of gullies and erosion associated with gullies:**

   ____

6. **Extent of wind scoured, blowouts and/or depositional areas:**

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7. **Amount of litter movement (describe size and distance expected to travel):**

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

---

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

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14. **Average percent litter cover (%) and depth (in):**

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

17. **Perennial plant reproductive capability:**