USDA Natural Resources Conservation Service

Ecological site PX136X00X210
Mesic Temperature Regime, Basic Upland Woodland, Expansive Clay, Seasonally Wet and Dry

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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 USNVC ASSOCIATIONS
CEGL003714 *Quercus stellata* - *Quercus marilandica* - Carya (carolinae-septentrionalis, glabra) / *Schizachyrium scoparium*; CEGL004037 *Quercus phellos* - Quercus (alba, stellata) - *Carya carolinae-septentrionalis*

APPLICABLE EPA ECOREGIONS
Level III: 45. Piedmont
Level IV: 45e. Northern Inner Piedmont (EPA 2013).

APPLICABLE USFS ECOLOGICAL UNITS
Domain: Humid Temperate
Division: Subtropical
Ecological province: 231. Southeastern Mixed Forest
Ecological sections: 231I.Central 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 seasonally wet and seasonally dry circumneutral soils on broad interfluves, upland flats, and gentle hillslopes. It is geographically restricted to the mesic soil temperature regime portion of the Southern Piedmont, in the northwestern-most

part of the MLRA. This ecological site is subject to wetting and drying cycles typical of "hydroxeric" conditions, due primarily to shrink-swell clay minerology and low relief.

Soils on this ecological site are weathered from mafic intrusive rock. They are typically moderately deep to very deep, somewhat poorly to moderately well drained Alfisols, which formed in residuum from dark colored rocks high in ferromagnesian minerals. The subsoil has a high clay content and the clay fraction is dominated by 2:1 clay minerals. Base saturation is greater than or equal to 35 percent in the subsoil.

A transient water table is present within 12 to 40 inches of the soil surface during the cooler months. Seasonally wetter examples, in which the water table rises close to the surface, are covered by PX136X00X200, a similar and sometimes associated ecological site.

The reference state supports an open to partially open canopy woodland with a species-rich herbaceous understory. Important canopy species include post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), willow oak (*Quercus phellos*), and several species of hickory (Carya spp.). Dominant land uses include pasture and hayland, cropland, planted pine, wildlife habitat, and other land uses meant to conserve threatened plants and animals. Soils are poorly-suited to most building applications or septic system installations because of seasonal wetness and shrink-swell hazard.

ES CHARACTERISTICS SUMMARY
• Mesic soil temperature regime
• Occurs on Piedmont uplands, on broad interfluves, upland flats, and gentle hillslopes
• Parent materials: mafic intrusive rock
• Base saturation: ≥ 35 percent in the subsoil
• Seasonal high water table: perched, 12 - 40 inches from the soil surface
• Soils: moderately deep to very deep, somewhat poorly to moderately well drained Alfisols
• The subsoil has a high clay content and a high shrink-swell potential

Associated sites

PX136X00X200	**Mesic Temperature Regime, Basic Upland Flats and Depressions, Expansive Clay, Seasonally Wet and Dry** Found in slightly lower and wetter landscape positions, in depressions or at the heads of drainageways. The seasonal high water table is shallower (0-12 inches from the soil surface), supporting a relative decrease in dry-site species, of which blackjack oak (Quercus marilandica) is most notable.

PX136X00X220	**Mesic Temperature Regime, Basic Upland Forest, Moist** Found in similar or slightly higher landscape positions. The clay fraction is not dominated by shrink-swell clay minerals, reducing fluctuations in plant available water and allowing moisture-loving plant species to increase in abundance, of which northern red oak (Quercus rubra) is most notable. In addition, the seasonal high water table is deeper (≥ 40 inches from the soil surface, usually deeper). Species tolerant of anaerobic conditions, such as willow oak (Quercus phellos), are generally scarce or absent.
PX136X00X230	**Mesic Temperature Regime, Basic Upland Forest, Depth Restriction, Dry** Found in higher landscape positions on narrow ridges and steep hillslopes. A seasonal high water table is usually absent within 72 inches of the soil surface. Species tolerant of anaerobic conditions, such as willow oak (Quercus phellos), are generally absent.
PX136X00X310	**Mesic Temperature Regime, Acidic Upland Forest, Seasonally Wet** Often found nearby in similar landscape positions. Soils weathered from acidic rocks. Base saturation is less than 35 percent. Basic indicator species are generally scarce or absent in the understory.

Similar sites

PX136X00X710	**Basic Upland Woodland, Expansive Clay, Seasonally Wet and Dry** The soil temperature regime is thermic, occurring within the native range of loblolly pine (Pinus taeda).
PX136X00X200	**Mesic Temperature Regime, Basic Upland Flats and Depressions, Expansive Clay, Seasonally Wet and Dry** Soil properties are similar, but the seasonal high water table is shallower (0-12 inches from the soil surface). Cover from dry-site species tends to decrease as seasonal wetness increases, of which blackjack oak (Quercus marilandica) is most notable.

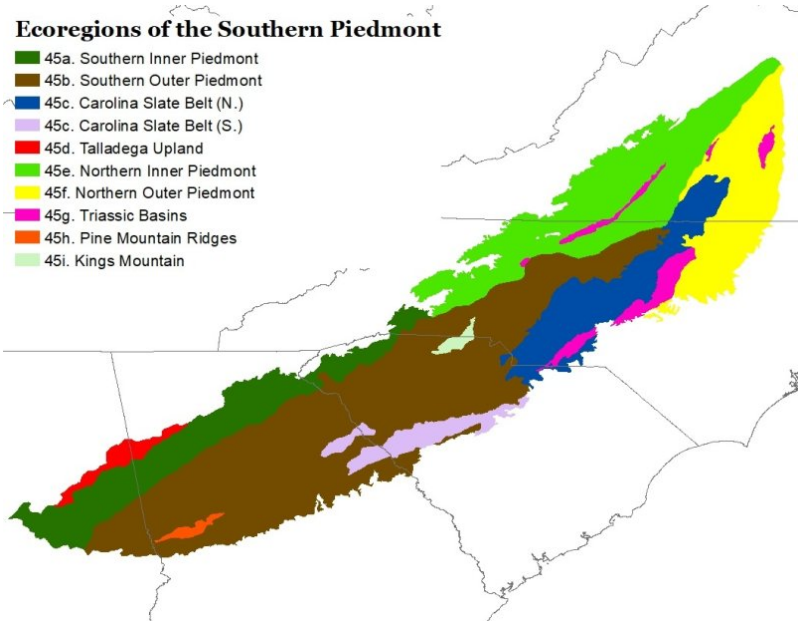


Figure 1. EPA level IV ecoregions of the Southern Piedmont (45).

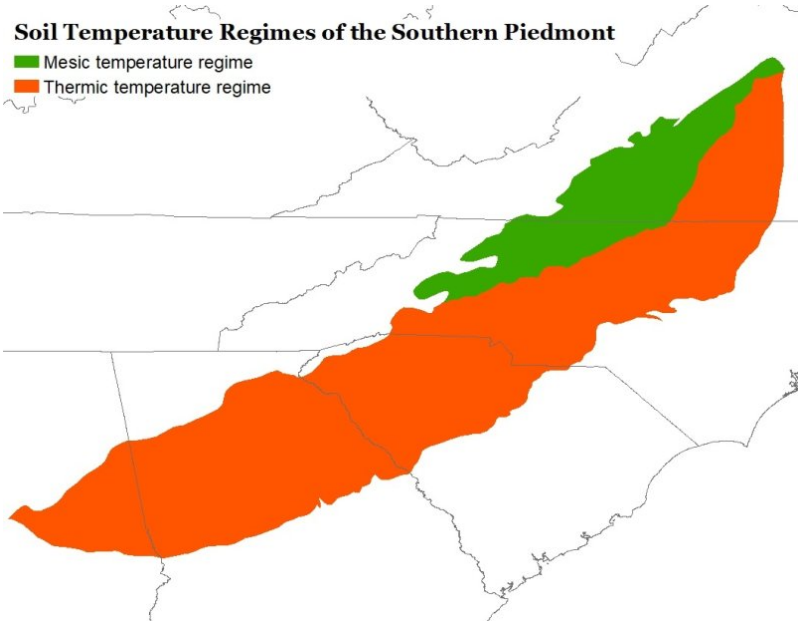


Figure 2. Spatial illustration of soil temperature regimes of the Southern Piedmont.

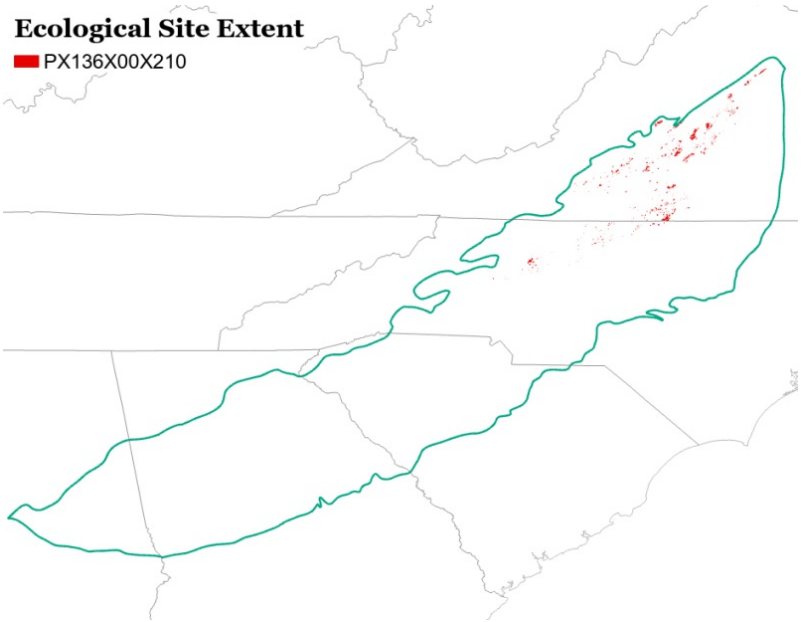


Figure 3. Spatial extent of this ecological site representing the major areas where this site is important on the landscape.

Table 1. Dominant plant species

Tree	(1) *Quercus stellata* (2) *Quercus marilandica*
Shrub	(1) *Viburnum* (2) *Symphoricarpos orbiculatus*
Herbaceous	(1) *Schizachyrium scoparium* (2) *Danthonia spicata*

Legacy ID

F136XY210VA

Physiographic features

This ecological site is found on broad interfluves, upland flats, gentle hillslopes, and on some low ridges. Typically, it is found in low to moderately dissected parts of the upper Piedmont of Virginia and North Carolina, in EPA ecoregion 45e (Northern Inner Piedmont). This ecoregion roughly coincides with the mesic soil temperature regime portion of the Southern Piedmont, the northwestern-most part of the MLRA. Representative locations are nearly level to gently sloping, with a representative slope of 2 to 6 percent and a maximum slope of 15 percent.

The geologic substrate on this ecological site is mafic intrusive rock, such as diabase, gabbro, and other related dark colored rocks high in ferromagnesian minerals. The material was transported upward through fissures in the earth's crust in the form of mafic dikes and sills. These structures cut through the surrounding country rock. As a result, this ecological site often occurs in small patches, and is often adjacent to or intermingled with acidic uplands, or basic uplands with dissimilar soil moisture conditions.

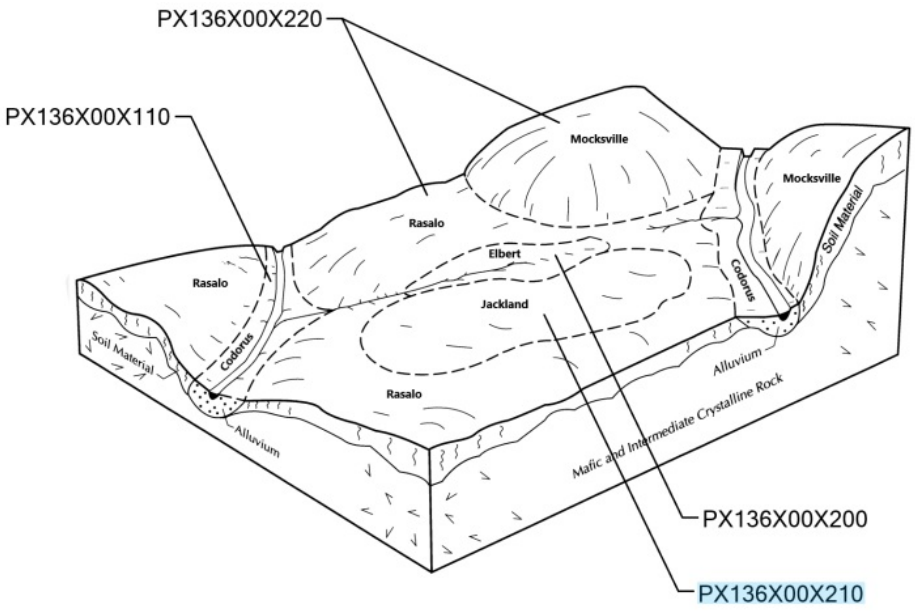


Figure 4. Typical soil-landscape relationships in the Mafic Soil System of the Southern Piedmont. Jackland soils are associated with this ecological site, depicted here on interfluves.

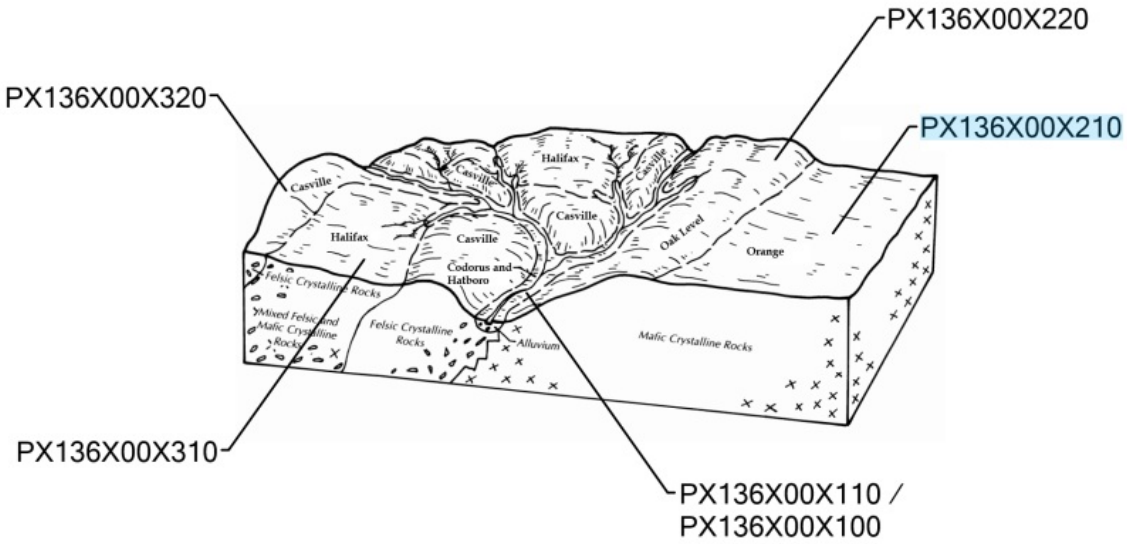


Figure 5. Typical soil-landscape relationships of the Southern Piedmont Mixed Felsic and Mafic Soil System. Orange soils are associated with this ecological site, depicted here on interfluves.

Table 2. Representative physiographic features

Hillslope profile	(1) Summit (2) Shoulder (3) Backslope
Landforms	(1) Piedmont > Interfluve (2) Piedmont > Flat (3) Piedmont > Hillslope (4) Piedmont > Ridge
Runoff class	High to very high
Flooding frequency	None
Ponding frequency	None
Elevation	168–250 m
Slope	2–6%
Water table depth	30–61 cm
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Runoff class	Low to very high
Flooding frequency	None
Ponding frequency	None
Elevation	73–402 m
Slope	0–15%

Water table depth	30–102 cm

Climatic features

On this ecological site, the average mean annual precipitation is 44 inches. On average, the rainiest months occur from May through September, as well as in March. The driest months occur from October through February.

Table 4. Representative climatic features

Frost-free period (characteristic range)	152-165 days
Freeze-free period (characteristic range)	180-202 days
Precipitation total (characteristic range)	1,092-1,168 mm
Frost-free period (actual range)	139-174 days
Freeze-free period (actual range)	164-209 days
Precipitation total (actual range)	1,067-1,194 mm
Frost-free period (average)	158 days
Freeze-free period (average)	190 days
Precipitation total (average)	1,118 mm

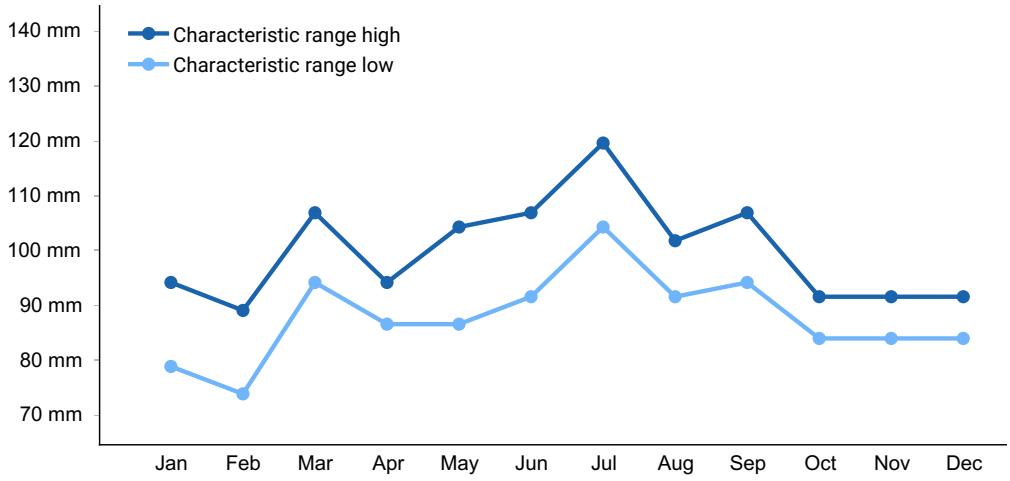


Figure 6. Monthly precipitation range

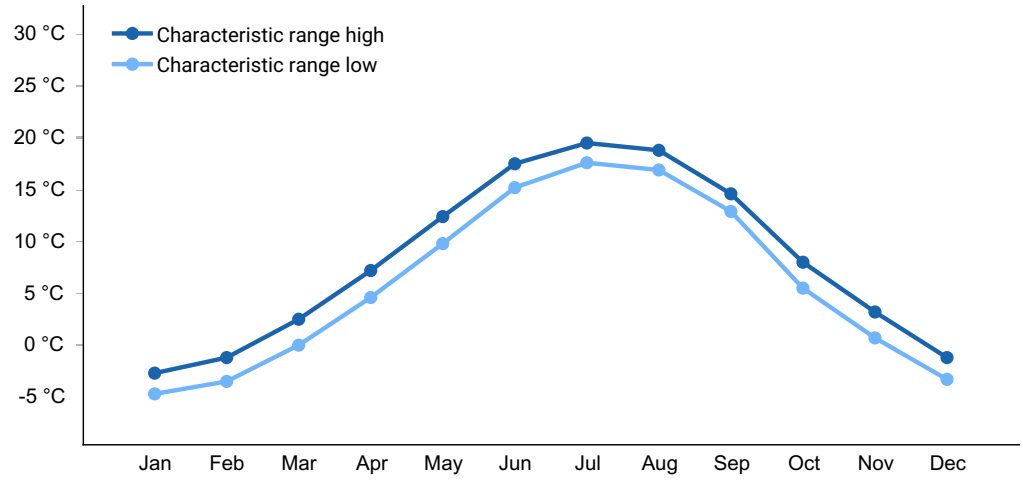


Figure 7. Monthly minimum temperature range

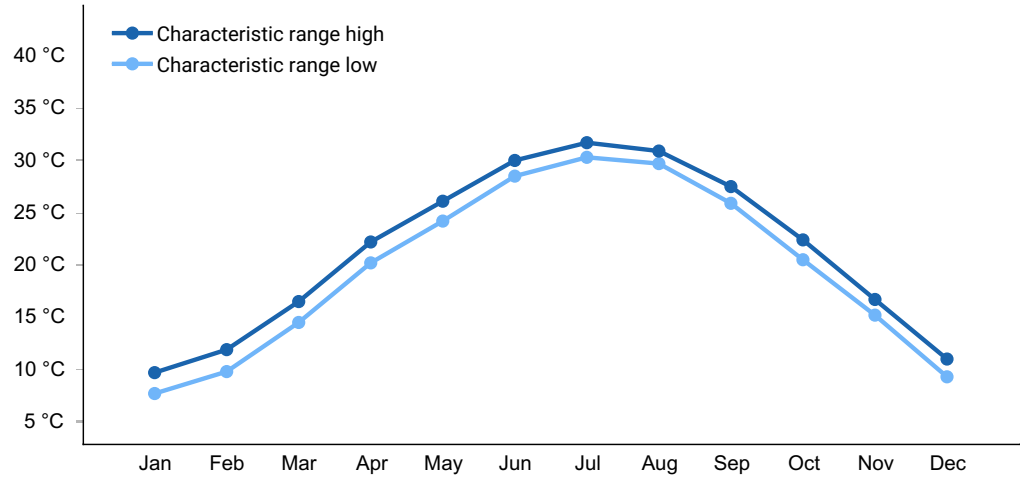


Figure 8. Monthly maximum temperature range

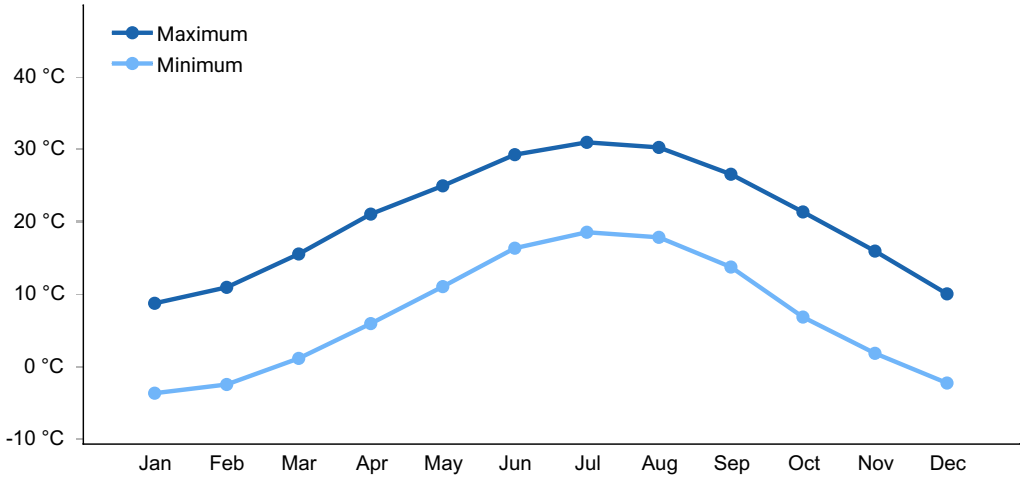


Figure 9. Monthly average minimum and maximum temperature

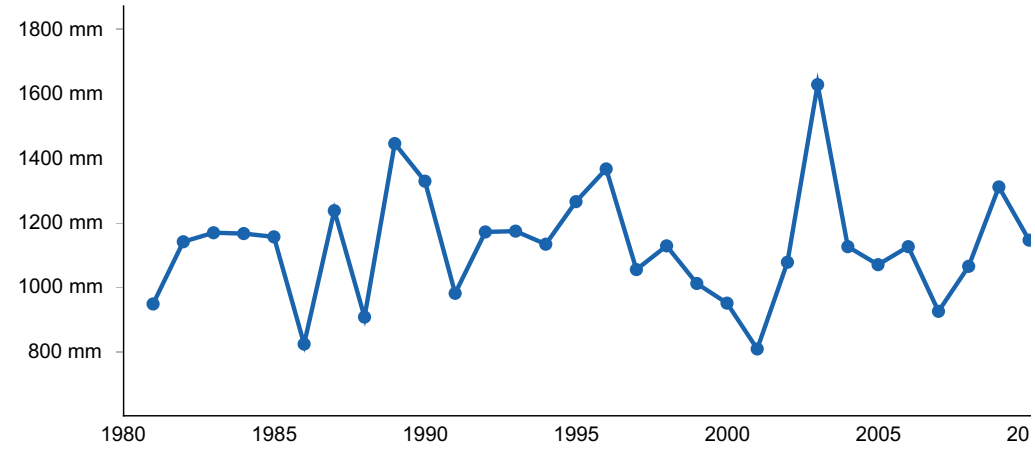


Figure 10. Annual precipitation pattern

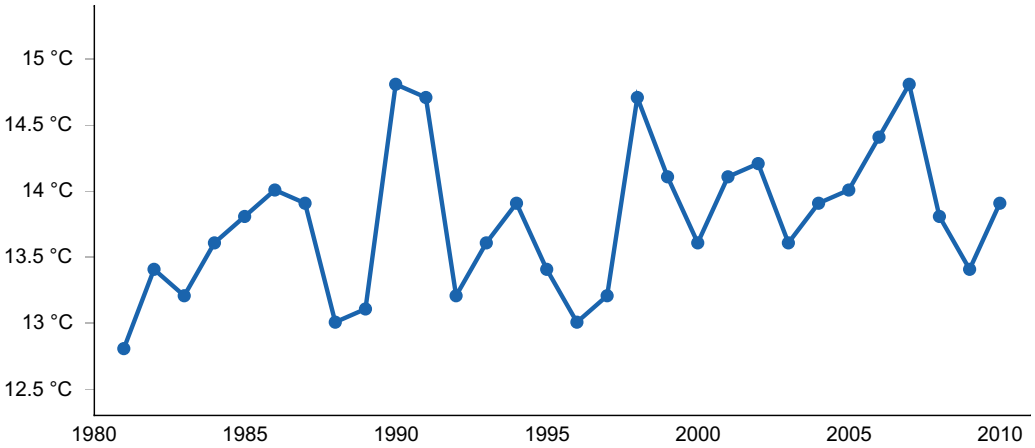


Figure 11. Annual average temperature pattern

Climate stations used

- (1) HIGH POINT [USC00314063], High Point, NC
- (2) REIDSVILLE 2 NW [USC00317202], Reidsville, NC
- (3) STATESVILLE 2 NNE [USC00318292], Statesville, NC
- (4) SALISBURY 9 WNW [USC00317618], Salisbury, NC
- (5) SALISBURY [USC00317615], Salisbury, NC
- (6) MOCKSVILLE 5SE [USC00315743], Mocksville, NC
- (7) LEXINGTON [USC00314970], Lexington, NC
- (8) YADKINVILLE 6 E [USC00319675], East Bend, NC
- (9) RURAL HALL [USC00317548], Rural Hall, NC
- (10) DANBURY [USC00312238], Danbury, NC
- (11) BROOKNEAL [USC00441082], Brookneal, VA
- (12) CHATHAM [USC00441614], Chatham, VA
- (13) BEDFORD [USC00440551], Bedford, VA
- (14) LYNCHBURG #2 [USC00445117], Lynchburg, VA
- (15) LYNCHBURG RGNL AP [USW00013733], Lynchburg, VA
- (16) TYE RIVER 1 SE [USC00448600], Amherst, VA

- (17) APPOMATTOX [USC00440243], Appomattox, VA
- (18) BREMO BLUFF [USC00440993], New Canton, VA
- (19) PALMYRA 3S [USC00446491], Palmyra, VA
- (20) LOUISA [USC00445050], Louisa, VA

Influencing water features

This ecological site is not influenced by surface water features. A perched water table is present at depths between 12 and 40 inches of the surface for some time during the months of December to April.

Soil features

Soils on this ecological site are typically moderately deep to very deep, moderately well drained to somewhat poorly drained Alfisols. Parent materials are residuum derived from mafic intrusive rock, such as diabase, gabbro, amphibolite, and other dark colored rocks high in ferromagnesian minerals.

Soils associated with this ecological site generally have a subsoil with a high clay content and are typically in a fine or very fine particle size family. In representative pedons, subsoil layers have a very plastic, very sticky, and very firm consistence. The clay fraction is dominated by 2:1 clay minerals, namely montmorillonite or others in the smectite group. Slickensides are a common feature. Partially weathered mafic rock is often close to the surface, commonly within 60 inches or less of the soil surface.

Reaction in the subsoil is typically moderately acid to neutral (pH 5.6 to 7.3). In the surface layers, reaction varies with land use and management. Under low input or forested conditions, it generally falls somewhere between pH 5.1 and 7.3. Base saturation is greater than or equal to 35 percent in the subsoil.

As a result of their clay minerology, soils on this ecological site are subject to distinct wetting and drying cycles, fluctuations in plant available water, and seasonal periods of soil saturation and anaerobic conditions. Soils dominated by 2:1 clay minerals can store large volumes of water at field capacity. Soil water content can remain high for extended periods, typically during the winter and early spring. However, these clay minerals also hold on to water more tightly when they do dry out, leaving little water available to plants during dry periods.

The result is a water availability dynamic that alternates between being saturated and anaerobic during the cooler months, to being thoroughly parched during warm-season dry spells. These soil properties interact with landscape position and local hydrology to produce a continuum of soil moisture conditions, from predominantly dry to predominantly wet. This ecological site generally covers the drier of these site conditions, though locally conditions can vary over short distances with microtopography (Buol et al. 2011).

Soils on this ecological site have a seasonal high water table between 12 and 40 inches of the mineral soil surface. The perched water table persists for periods long enough to leave behind redoximorphic features indicative of anaerobic conditions (i.e., iron and manganese depletions). Still, these wet conditions are temporary and in most instances the influence of dry edaphic conditions, which develop over the course of the growing season, are reflected in the character of the vegetation.

Soils on this ecological site have a mesic soil temperature regime, which is characterized by a mean annual soil temperature is 8°C to 15°C and a winter to summer temperature differential of 6°C or more in the subsoil.

Modal soil taxa include: Oxyaquic Vertic Hapludalfs, Aquic Hapludalfs
Modal soil series include: Jackland
Other soils attributed to this ecological site include Orange, Davie, and Sketerville.

Table 5. Representative soil features

Parent material	(1) Residuum–diabase (2) Residuum–gabbro (3) Residuum–diorite (4) Residuum–amphibolite
Surface texture	(1) Loam (2) Silt loam (3) Sandy loam
Family particle size	(1) Fine
Drainage class	Somewhat poorly drained to moderately well drained
Permeability class	Very slow to slow
Depth to restrictive layer	124–191 cm
Soil depth	124–191 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-203.2cm)	17.78–30.48 cm
Soil reaction (1:1 water) (0-101.6cm)	5.6–7.3
Subsurface fragment volume <=3" (0-203.2cm)	0–11%
Subsurface fragment volume >3" (0-203.2cm)	0–1%

Table 6. Representative soil features (actual values)

Drainage class	Somewhat poorly drained to moderately well drained
Permeability class	Very slow to moderately slow
Depth to restrictive layer	91–2,537 cm
Soil depth	91–203 cm
Surface fragment cover <=3"	0–2%
Surface fragment cover >3"	0%
Available water capacity (0-203.2cm)	12.7–35.56 cm
Soil reaction (1:1 water) (0-101.6cm)	5.1–7.8
Subsurface fragment volume <=3" (0-203.2cm)	0–16%
Subsurface fragment volume >3" (0-203.2cm)	0–2%

Ecological dynamics

U.S. National Vegetation Classification (USNVC) associations that are consistent with reference conditions on this ecological site include CEGL003714 *Quercus stellata* - *Quercus marilandica* - Carya (carolinae-septentrionalis, glabra) / *Schizachyrium scoparium*. Under slightly wetter site conditions, CEGL004037 *Quercus phellos* - Quercus (alba, stellata) - *Carya carolinae-septentrionalis* may be more representative (USNVC 2022).

This ecological site is subject to wetting and drying cycles typical of "hydroxeric" conditions. These conditions include seasonal extremes in plant available water, caused primarily by shrink-swell clay minerology and low relief. The shrinking and swelling properties are responsible for fluctuating soil water potentials and cause shearing of the fine roots of woody plants. Layers of dense, plastic clays, which sit below the surface, can behave somewhat like rock, inhibiting root development, perching or ponding water during wet cycles, while simultaneously limiting the infiltration of water, contributing to dry cycles.

These edaphic factors produce a characteristically stunted canopy and create favorable conditions for recurring fires which would have historically helped maintaine an open woodland structure. Forest patches associated with this ecological site are usually small and insular, being restricted to areas of mafic geology and unusual edaphic conditions. Nonetheless, these areas are not rare. They are considered a characteristic element of the Piedmont landscape from Virginia to Georgia.

Woodlands of this type are known locally by many names, including Piedmont flatwoods, Iredell flatwoods, montmorillonite forests, basic hardpan woodlands, gabbro upland depression forests, diabase barrens, prairie barrens, and vertic diabase woodlands.

Regionally and locally, much variability exists between vegetation communities of this type, but all share a relatively open woodland structure, a fluctuating plant available water dynamic, and a predominance of base-loving plants in the understory.

MATURE FORESTS
The reference state has an open to partially open canopy structure. The canopy is dominated by dry-site oaks, or an unusual mixture of dry-site oaks and bottomland oaks. The understory is characterized by a suite of basic indicator species, including a species-rich herb layer containing species that are seldom seen elsewhere in the Southern Piedmont.

The canopy features stunted dry-site oaks such as post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*), a smaller contribution from hickories (*Carya tomentosa*, *C. glabra*, *C. ovata*), and scattered shortleaf pines (*Pinus echinata*). White oak (*Quercus alba*) is consistent in the canopy, but is usually a minor species.

On the wetter end of the range of variability, site conditions often support a higher cover of willow oak (*Quercus phellos*), which may be codominant. Swamp white oak (*Quercus bicolor*), a species of northern and midwestern affinities may also be present. In the Southern Piedmont, this species is generally restricted to wet mafic sites in the northern-most part of the MLRA. These wetter variants generally have a lower cover of blackjack oak (*Q. marilandica*).

Under reference conditions, the subcanopy layer includes basic indicator species such as eastern redcedar (*Juniperus virginiana*), eastern redbud (*Cercis canadensis*), winged elm (*Ulmus alata*). Subcanopy generalists include sweetgum (*Liquidambar styraciflua*), common persimmon (*Diospyros virginiana*), and white fringetree (*Chionanthus virginicus*), among others.

In the shrub layer, characteristic basic indicator species include rusty blackhaw (*Viburnum rufidulum*) and coralberry (*Symphoricarpos orbiculatus*). Fragrant sumac (*Rhus aromatica*) may also be present, though it is not usually abundant. Generalists include Carolina rose (*Rosa carolina*), St. Andrew's cross (*Hypericum hypericoides* ssp. multicaule), and New Jersey tea (*Ceanothus americanus*), among others. Under slightly wetter conditions, species commonly associated with flood plains may be present, including possumhaw (*Ilex decidua*) and common winterberry (*Ilex verticillata*). These species are rarely found on uplands, except over circumneutral soils weathered from mafic rock.

The herb layer is diverse and distinctive, especially in areas in which fire has been reintroduced. This ecological site is one of the primary habitats for numerous herbaceous species of conservation concern. Many of these species produce seed which can lie in wait in the soil seed bank, and sprout only after fire. Dominant species in the herb layer include poverty oatgrass (*Danthonia spicata*), blackseed speargrass (*Piptochaetium avenaceum*), little bluestem (*Schizachyrium scoparium*), and littlehead nutrush (*Scleria*

oligantha). Under slightly wetter conditions, various sedges (Carex spp.) become more important.

Beginning in the early 20th century, a widespread fire suppression campaign resulted in a dramatic decrease in the frequency of fires across the Southeast. These changes gradually altered the vegetation structure and species composition of ecosystems that were dependent on fire for seedling recruitment, reproduction, and maintenance.

On this ecological site, the partially open canopy structure seen in some remnant examples is maintained, at least in part, by extremes in plant water availability. Few tree species are tolerant of alternating periods of soil saturation and the extremely dry soil conditions which develop during the growing season. Further, herbaceous plants are more tolerant of shrinking and swelling cycles that lead to shearing of the fine roots. Still, the natural fire regime would have produced a much more open canopy and understory than is seen in most examples presently, and promoted a dense herbaceous layer that could efficiently carry fire in future burns.

Because these communities are predominantly small-patch and spatially insular, fires would have spread primarily from the surrounding landscape. In all likelihood, the fire return interval would have largely matched that of the surrounding forests. However, because of extreme fluctuations in soil moisture, the effects of fire would have been greater, presumably maintaining a more open woodland structure than is seen presently. With a dense grassy herb layer, burning would have been more complete and fire more intense than in the current hardwood litter. Under a more regular fire regime, pyrophytic oaks, pines, and other fire-dependent plant species are more competitive. Under these conditions, tree replacement would presumably be less dependent on canopy gaps and more on fire than under fire-suppressed conditions, or compared to the more prevalent oak-hickory forests of the surrounding landscape.

A combination of prescribed burns and selective removals can open up the understory and constrain the growth of fire-intolerant opportunistic species, thereby restoring the health and vigor of forests that evolved under a more regular fire regime (Dayton 1966; Peet and Christensen 1980; Schafale and Weakley 1990; Oakley et al. 1995; Cowell 1998; Spira 2011; Guyette et al. 2012; Schafale 2012a, 2012b; Vander Yacht et al. 2020; Fleming et al. 2021; Spooner et al. 2021)

SPECIES LIST
Canopy layer: *Quercus stellata*, *Quercus marilandica*, *Quercus phellos*, *Carya tomentosa*, *Carya glabra*, *Carya ovata*, *Carya ovalis*, *Pinus echinata*, *Quercus alba*, *Quercus falcata*, *Quercus velutina*, *Ulmus alata*, *Ulmus americana*, *Gleditsia triacanthos*, *Quercus bicolor*, *Carya carolinae-septentrionalis*

Subcanopy layer: *Fraxinus americana*, *Juniperus virginiana*, *Cercis canadensis*, *Ulmus alata*, *Cornus florida*, *Diospyros virginiana*, *Chionanthus virginicus*, *Acer rubrum*, Carya spp., *Ostrya virginiana*, *Ulmus rubra*, *Ilex opaca*, *Celtis pumila*, *Celtis occidentalis*, *Acer*

floridanum

Shrub layer: *Viburnum rufidulum*, *Symphoricarpos orbiculatus*, *Rosa carolina*, *Viburnum prunifolium*, *Ilex decidua*, *Ilex verticillata*, *Hypericum hypericoides* ssp. multicaule, *Rhus aromatica*, *Ceanothus americanus*, *Ligustrum sinense* (I)

Vines/lianas: *Smilax rotundifolia*, *Smilax bona-nox*, *Smilax glauca*, *Vitis rotundifolia*, *Toxicodendron radicans*, *Campsis radicans*, *Parthenocissus quinquefolia*, *Matelea carolinensis*, *Bignonia capreolata*, *Passiflora lutea*, *Lonicera sempervirens*, Loncera japonica (I),

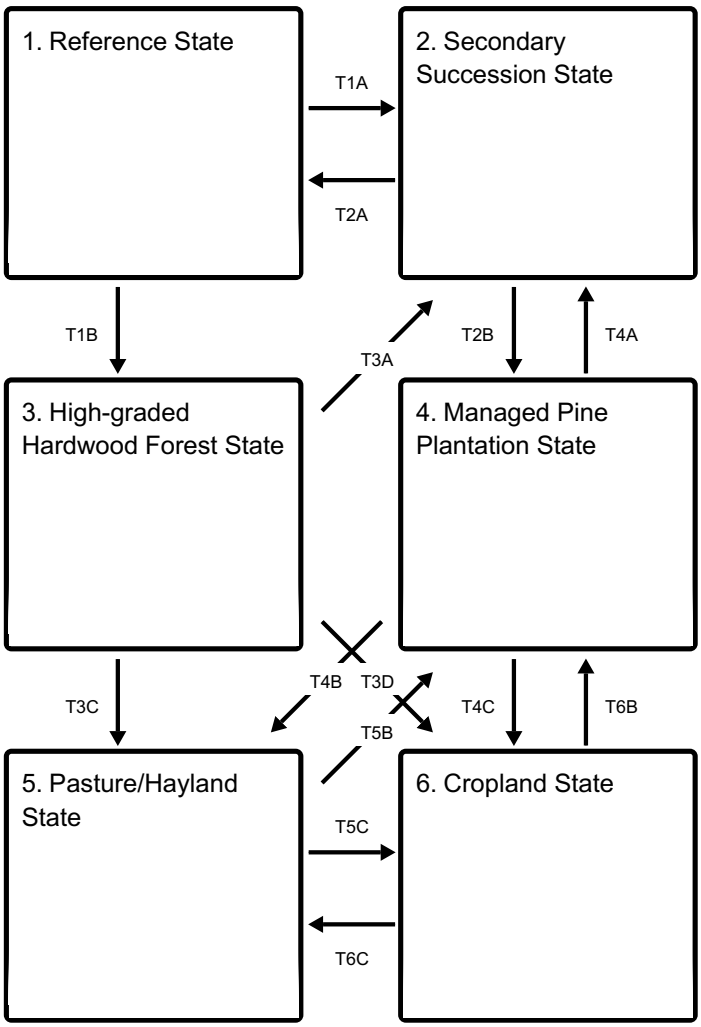
Herb layer - forbs: *Scutellaria elliptica*, *Scutellaria integrifolia*, *Solidago odora*, *Eryngium yuccifolium*, *Clematis ochroleuca*, *Blephilia ciliata*, *Parthenium integrifolium*, *Oenothera fruticosa*, *Desmodium paniculatum*, *Lespedeza virginica*, *Lespedeza procumbens*, *Desmodium laevigatum*, *Coreopsis major*, *Stylosanthes biflora*, *Sericocarpus linifolius*, *Potentilla canadensis*, *Solidago nemoralis*, *Hypoxis hirsuta*, *Elephantopus tomentosus*, *Erigeron strigosus*, *Polygonatum biflorum*, *Asplenium platyneuron*, *Pleopeltis polypodioides*, *Ruellia purshiana*, *Hypericum gentianoides*, *Allium canadense*, *Climacium americanum*, *Oxalis violacea*, *Hieracium venosum*, *Hieracium gronovii*, *Galium circaezans*, *Galium pilosum*, *Antennaria plantaginifolia*, *Ranunculus hispidus*, *Agrimonia pubescens*, *Thalictrum dioicum*, *Ophioglossum vulgatum*, *Angelica venenosa*, *Physalis virginiana*, *Symphyotrichum undulatum*, *Symphyotrichum dumosum*, *Pycnanthemum tenuifolium*, Phlox spp., *Trifolium reflexum*,

Herb layer - graminoids: *Danthonia spicata*, *Piptochaetium avenaceum*, *Schizachyrium scoparium*, *Scleria oligantha*, *Sorghastrum nutans*, *Dichanthelium boscii*, *Carex complanata*, *Carex caroliniana*, *Melica mutica*, *Andropogon ternarius*, *Elymus hystrix*, *Panicum anceps*, *Danthonia sericea*, *Dichanthelium laxiflorum*, *Paspalum floridanum*, *Tridens flavus*, *Cyperus echinatus*, *Juncus coriaceus*, *Carex planispicata*, *Sphenopholis obtusata*, *Andropogon gerardii*,

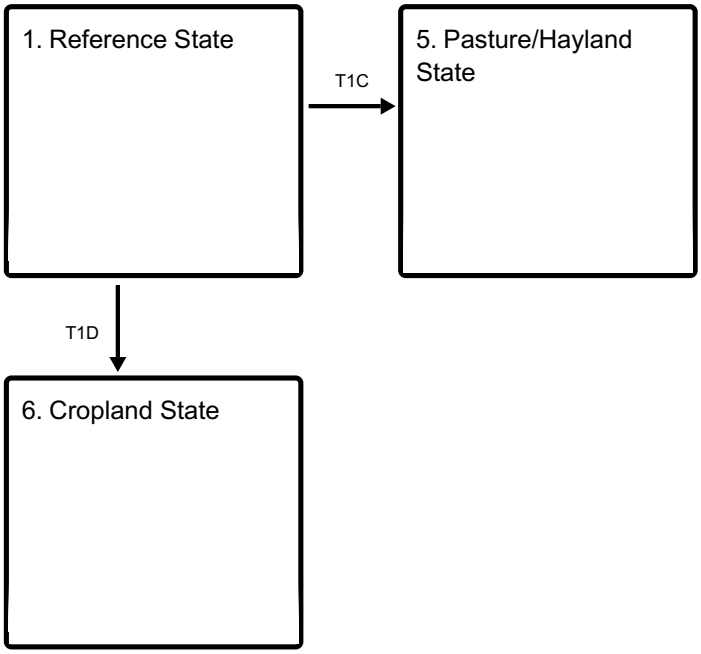
(I) = introduced

State and transition model

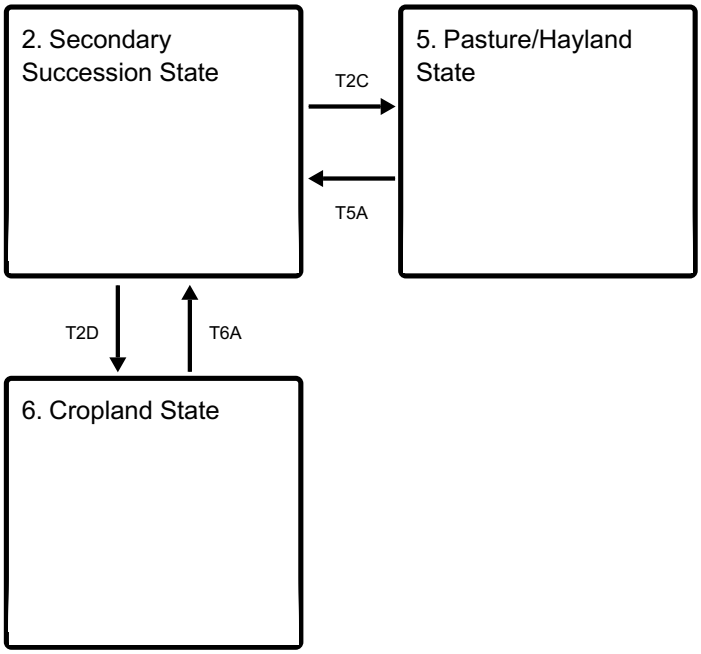
Ecosystem states



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, applications of fertilizer/lime, weed control, 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.

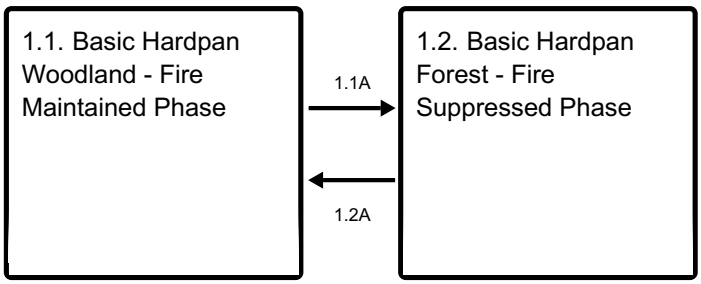
T5C - Seedbed preparation, applications of fertilizer/lime, weed control, and planting of crop or cover crop seed.

T6A - Agricultural abandonment.

T6B - Site preparation and tree planting.

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

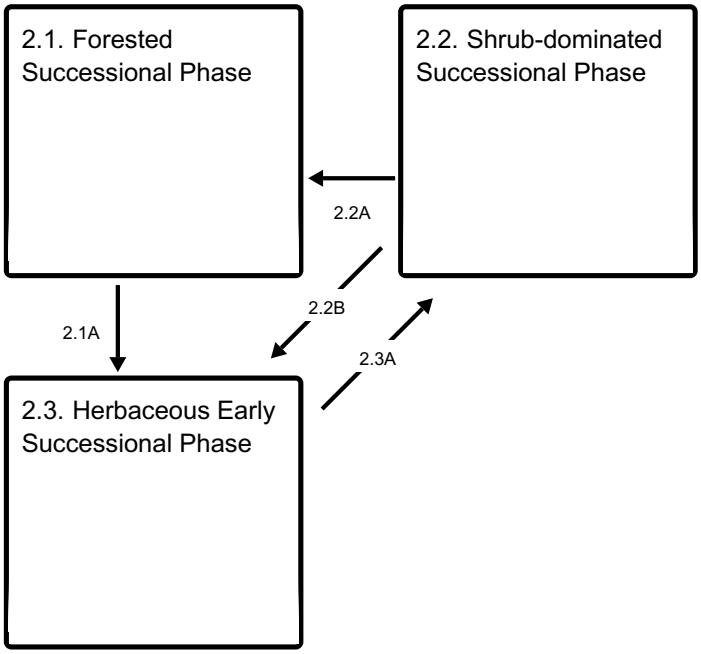
State 1 submodel, plant communities



1.1A - Long-term exclusion of fire.

1.2A - Prescribed burns and selective removals.

State 2 submodel, plant communities



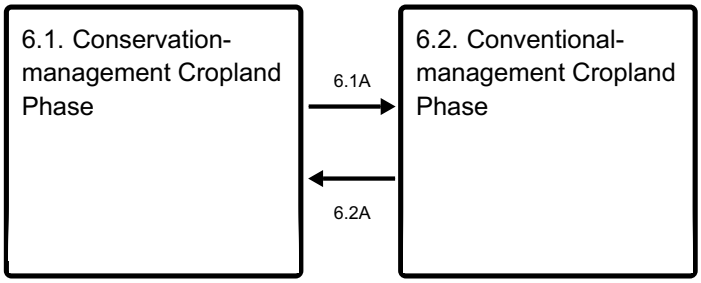
2.1A - Clearcut logging.

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 - Implementation of conservation tillage and other soil conservation practices

State 1
Reference State

This mature forest state is generally dominated by dry-site oaks or an unusual mixture of dry-site oaks and bottomland oaks. Pines are usually interspersed.

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

Resilience management. Deer population management is critical to sustaining the diversity of herbaceous understory species.

Community 1.1
Basic Hardpan Woodland - Fire Maintained Phase

This is an open canopy mature forest community/phase. Regular low-intensity fires have been reintroduced, keeping the understory 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 oaks. Representative species include post oak (Quercus stellata) and blackjack oak (Quercus marilandica). Other important canopy species include hickory (Carya tomentosa, C. glabra, C. ovata), shortleaf pine (Pinus echinata), white oak (Quercus alba), and winged elm (Ulmus alata).

Forest understory. Representative understory tree species include eastern redcedar (Juniperus virginiana), eastern redbud (Cercis canadensis), winged elm (Ulmus alata), white ash (Fraxinus americana), and white fringetree (Chionanthus virginicus).

Representative understory shrub species include rusty blackhaw (Viburnum rufidulum), coralberry (Symphoricarpos orbiculatus), Carolina rose (Rosa carolina), and New Jersey tea (Ceanothus americanus).

The herb layer is diverse and well developed. It can contain many species of conservation concern.

Dominant plant species

- post oak (*Quercus stellata*), tree

- blackjack oak (*Quercus marilandica*), tree
- mockernut hickory (*Carya tomentosa*), tree
- shortleaf pine (*Pinus echinata*), tree
- white oak (*Quercus alba*), tree
- winged elm (*Ulmus alata*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- eastern redbud (*Cercis canadensis*), tree
- willow oak (*Quercus phellos*), tree
- white ash (*Fraxinus americana*), tree
- rusty blackhaw (*Viburnum rufidulum*), shrub
- coralberry (*Symphoricarpos orbiculatus*), shrub
- Carolina rose (*Rosa carolina*), shrub
- New Jersey tea (*Ceanothus americanus*), shrub
- maroon Carolina milkvine (*Matelea carolinensis*), shrub
- blackseed speargrass (*Piptochaetium avenaceum*), grass
- poverty oatgrass (*Danthonia spicata*), grass
- little bluestem (*Schizachyrium scoparium*), grass
- littlehead nutrush (*Scleria oligantha*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- bluestem (*Andropogon*), grass
- rosette grass (*Dichanthelium*), grass
- twoflower melicgrass (*Melica mutica*), grass
- eastern bottlebrush grass (*Elymus hystrix*), grass
- hirsute sedge (*Carex complanata*), grass
- hairy skullcap (*Scutellaria elliptica*), other herbaceous
- helmet flower (*Scutellaria integrifolia*), other herbaceous
- anisescented goldenrod (*Solidago odora*), other herbaceous
- button eryngo (*Eryngium yuccifolium*), other herbaceous
- curlyheads (*Clematis ochroleuca*), other herbaceous
- downy pagoda-plant (*Blephilia ciliata*), other herbaceous
- wild quinine (*Parthenium integrifolium*), other herbaceous
- narrowleaf evening primrose (*Oenothera fruticosa*), other herbaceous
- ticktrefoil (*Desmodium*), other herbaceous
- lespedeza (*Lespedeza*), other herbaceous

Community 1.2
Basic Hardpan Forest - Fire Suppressed Phase

This is a partially open to closed canopy mature forest community/phase. This phase accounts for the majority of contemporary examples. Canopy cover is higher than in stands in which fire has been reintroduced and the understory usually contains a greater proportion of fire-intolerant species. The herb layer is typically sparser.

Forest overstory. The overstory is dominated by oaks. Representative species include post oak (Quercus stellata), blackjack oak (Quercus marilandica), and willow oak (Quercus

phellos). Other important canopy species include hickory (Carya tomentosa, C. glabra, C. ovata), shortleaf pine (Pinus echinata), white oak (Quercus alba), and winged elm (Ulmus alata).

Forest understory. Representative understory tree species include eastern redcedar (Juniperus virginiana), eastern redbud (Cercis canadensis), white ash (Fraxinus americana), red maple (Acer rubrum), American holly (Ilex opaca), and common persimmon (Diospyros virginiana).

Representative understory shrub species include rusty blackhaw (Viburnum rufidulum) and coralberry (Symphoricarpos orbiculatus), along with several vines.

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

Dominant plant species

- post oak (*Quercus stellata*), tree
- blackjack oak (*Quercus marilandica*), tree
- willow oak (*Quercus phellos*), tree
- mockernut hickory (*Carya tomentosa*), tree
- shortleaf pine (*Pinus echinata*), tree
- white ash (*Fraxinus americana*), tree
- eastern redbud (*Cercis canadensis*), tree
- winged elm (*Ulmus alata*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- red maple (*Acer rubrum*), tree
- American holly (*Ilex opaca*), tree
- rusty blackhaw (*Viburnum rufidulum*), shrub
- coralberry (*Symphoricarpos orbiculatus*), shrub
- greenbrier (*Smilax*), shrub
- eastern poison ivy (*Toxicodendron radicans*), shrub
- trumpet creeper (*Campsis radicans*), shrub
- maroon Carolina milkvine (*Matelea carolinensis*), shrub
- Virginia creeper (*Parthenocissus quinquefolia*), shrub
- rosette grass (*Dichanthelium*), grass
- poverty oatgrass (*Danthonia spicata*), grass
- hirsute sedge (*Carex complanata*), grass
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous
- American climacium moss (*Climacium americanum*), other herbaceous

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 hardwood 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
Forested Successional Phase

This successional phase develops in the wake of long-term agricultural abandonment or other large-scale disturbances that have led to canopy removal in the recent past. Stands are even-aged and species diversity is low. The canopy is usually dominated by a mixture of opportunistic hardwoods and pines. Species that exhibit pioneering traits are usually most abundant.

Forest overstory. The overstory is dominated by opportunistic hardwoods and pines, such as red maple (Acer rubrum), winged elm (Ulmus alata), Virginia pine (Pinus virginiana), and shortleaf pine (P. echinata). Though this ecological site is outside of the native range of loblolly pine (P. taeda), escapes from nearby timber stands are becoming more common in the region.

Forest understory. Common understory tree species include red maple (Acer rubrum), eastern redcedar (Juniperus virginiana), and white ash (Fraxinus americana). Sweetgum (Liquidambar styraciflua) can also be important in young secondary stands, though its importance gradually declines to the north and west. Seedlings of oaks and hickories are usually present in the understory. These seedlings are released gradually as the forest

matures.

Dominant plant species

- red maple (*Acer rubrum*), tree
- winged elm (*Ulmus alata*), tree
- Virginia pine (*Pinus virginiana*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- white ash (*Fraxinus americana*), tree
- shortleaf pine (*Pinus echinata*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- eastern redbud (*Cercis canadensis*), tree
- sassafras (*Sassafras albidum*), tree
- oak (*Quercus*), tree
- hybrid hickory (*Carya*), tree
- greenbrier (*Smilax*), shrub
- trumpet creeper (*Campsis radicans*), shrub
- eastern poison ivy (*Toxicodendron radicans*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- Virginia creeper (*Parthenocissus quinquefolia*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- littlehead nutrush (*Scleria oligantha*), grass
- rosette grass (*Dichanthelium*), grass
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous
- wild garlic (*Allium vineale*), other herbaceous
- sparselobe grapefern (*Botrychium biternatum*), other herbaceous

Community 2.2
Shrub-dominated Successional Phase

This successional phase is dominated by shrubs and vines, along with seedlings of opportunistic hardwoods and pines. It typically develops beginning in the third year after agricultural abandonment or clearcut logging. 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

- winged elm (*Ulmus alata*), tree
- white ash (*Fraxinus americana*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- Callery pear (*Pyrus calleryana*), tree
- common persimmon (*Diospyros virginiana*), tree
- black cherry (*Prunus serotina*), tree

- tree of heaven (*Ailanthus altissima*), tree
- honeylocust (*Gleditsia triacanthos*), tree
- blackberry (*Rubus*), shrub
- rose (*Rosa*), shrub
- greenbrier (*Smilax*), shrub
- trumpet creeper (*Campsis radicans*), shrub
- winged sumac (*Rhus copallinum*), shrub
- eastern poison ivy (*Toxicodendron radicans*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- grape (*Vitis*), shrub
- Chinese privet (*Ligustrum sinense*), shrub
- coralberry (*Symphoricarpos orbiculatus*), shrub
- velvet panicum (*Dichanthelium scoparium*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- Canada goldenrod (*Solidago altissima*), other herbaceous
- aster (*Symphyotrichum*), other herbaceous
- sericea lespedeza (*Lespedeza cuneata*), other herbaceous
- Indianhemp (*Apocynum cannabinum*), 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. Species composition is highly variable at this stage of succession. In addition to the named species, other herbaceous pioneers common to this ecological site include Virginia threeseed mercury (*Acalypha virginica*), Indianhemp (*Apocynum cannabinum*), evening primrose (Oenothera spp.), great ragweed (*Ambrosia trifida*), Canada toadflax (*Nuttallanthus canadensis*), curly dock (*Rumex crispus*), dwarf cinquefoil (*Potentilla canadensis*), hairy cat's ear (*Hypochaeris radicata*), and many others.

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

- Japanese honeysuckle (*Lonicera japonica*), shrub
- greenbrier (*Smilax*), shrub
- trumpet creeper (*Campsis radicans*), shrub
- eastern poison ivy (*Toxicodendron radicans*), shrub
- broomsedge bluestem (*Andropogon virginicus*), grass

- hairy crabgrass (*Digitaria sanguinalis*), grass
- southern crabgrass (*Digitaria ciliaris*), grass
- velvet panicum (*Dichanthelium scoparium*), grass
- annual bluegrass (*Poa annua*), grass
- annual ragweed (*Ambrosia artemisiifolia*), other herbaceous
- American burnweed (*Erechtites hieraciifolius*), other herbaceous
- American pokeweed (*Phytolacca americana*), other herbaceous
- thoroughwort (*Eupatorium*), other herbaceous
- Canadian horseweed (*Conyza canadensis*), other herbaceous
- Canada goldenrod (*Solidago altissima*), other herbaceous
- aster (*Symphyotrichum*), other herbaceous
- Carolina horsenettle (*Solanum carolinense*), other herbaceous
- fleabane (*Erigeron*), other herbaceous
- cudweed (*Pseudognaphalium*), other herbaceous

Pathway 2.1A
Community 2.1 to 2.3

The forested successional 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 forested successional phase 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

- elm (*Ulmus*), tree
- red maple (*Acer rubrum*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- common persimmon (*Diospyros virginiana*), tree
- eastern redbud (*Cercis canadensis*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- oak (*Quercus*), tree
- hybrid hickory (*Carya*), 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, though Virginia pine (*Pinus virginiana*) can also be successfully managed for timber in this part of the MLRA. 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
- red maple (*Acer rubrum*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- Virginia pine (*Pinus virginiana*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- flowering dogwood (*Cornus florida*), tree
- eastern redbud (*Cercis canadensis*), tree
- sassafras (*Sassafras albidum*), tree
- oak (*Quercus*), tree
- hybrid hickory (*Carya*), tree
- grape (*Vitis*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- greenbrier (*Smilax*), shrub
- blackberry (*Rubus*), shrub
- St. Johnswort (*Hypericum*), shrub
- blueberry (*Vaccinium*), shrub
- rosette grass (*Dichanthelium*), grass
- littlehead nutrush (*Scleria oligantha*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- sedge (*Carex*), grass
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous

- sericea lespedeza (*Lespedeza cuneata*), other herbaceous
- aster (*Symphyotrichum*), other herbaceous
- thoroughwort (*Eupatorium*), other herbaceous
- dwarf cinquefoil (*Potentilla canadensis*), other herbaceous

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. 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*), and black cherry (*Prunus serotina*).

Dominant plant species

- tall fescue (*Schedonorus arundinaceus*), grass
- dallisgrass (*Paspalum dilatatum*), grass
- beaked panicgrass (*Panicum anceps*), grass
- purpletop tridens (*Tridens flavus*), grass
- Bermudagrass (*Cynodon dactylon*), grass
- Indiangrass (*Sorghastrum nutans*), grass

- hairy crabgrass (*Digitaria sanguinalis*), grass
- Johnsongrass (*Sorghum halepense*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- white clover (*Trifolium repens*), other herbaceous
- red clover (*Trifolium pratense*), other herbaceous
- vetch (*Vicia*), other herbaceous
- narrowleaf plantain (*Plantago lanceolata*), other herbaceous
- black medick (*Medicago lupulina*), other herbaceous
- field clover (*Trifolium campestre*), other herbaceous
- common dandelion (*Taraxacum officinale*), other herbaceous
- wild garlic (*Allium vineale*), other herbaceous
- chicory (*Cichorium intybus*), other herbaceous
- dogfennel (*Eupatorium capillifolium*), 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.

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

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

Pathway 6.1A
Community 6.1 to 6.2

The conservation-management cropland phase can shift to the conventional-management 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-management cropland phase can be brought into the conservation-management cropland phase through the implementation of one of several conservation tillage options, including no-tillage or strip-tillage, along with implementation of other soil conservation practices.

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.

Context dependence. 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 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 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) weed control, 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 regard 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) weed control, 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.

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

Charles Stemmans, 5/02/2025

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:**

   _____

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:

---

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

---

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:**

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17. **Perennial plant reproductive capability:**
