Ecological site PX136X00X370
Mesic Temperature Regime, Acidic Upland Woodland, Depth Restriction, 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
CEGL008521 *Quercus alba* - Quercus (coccinea, velutina, montana) / *Gaylussacia baccata*

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 dry, acidic, nutrient-poor uplands, found at low elevations, in the gentler parts of the upper Piedmont plateau. It is typically found on narrow ridges and short, steep side slopes, as well as on some interfluves underlain by weathering-resistant rock. It is geographically restricted to the mesic soil temperature regime portion of the

Southern Piedmont, in the northwestern-most part of the MLRA.

Soils on this ecological site are typically shallow to moderately deep, well drained to somewhat excessively drained Inceptisols, although shallow Ultisols are included in the range of variability. Soils are generally thin and poorly developed, with unweathered or partially weathered bedrock found within 40 inches of the soil surface. Parent materials are typically residuum derived from acidic igneous or metamorphic rock. Base saturation is less than 35 percent in the subsoil.

The reference state typically supports an open to partially open woodland dominated by upland oaks, with acid-tolerant flora in the understory, and with Important canopy species include white oak (*Quercus alba*), post oak (*Q. stellata*), black oak (*Quercus velutina*), blackjack oak (*Q. marilandica*), and southern red oak (*Q. falcata*), among others. Dominant land uses include wildlife habitat, pasture and hayland, and planted pine. Though soils have historically been used for crop production, they are poorly-suited to most crops due to their low natural fertility and susceptibility to drought.

ES CHARACTERISTICS SUMMARY
• Mesic soil temperature regime
• Occurs on Piedmont uplands, on narrow ridges, short, steep side slopes, or on interfluves underlain by weathering-resistant rock, found at low elevations, in the gentler parts of the upper Piedmont plateau
• Base saturation: < 35 percent in the subsoil
• Seasonal high water table: usually absent within 72 inches of the soil surface
• Depth to bedrock is < 40 inches, AND the available water storage capacity of the profile (from the soil surface to 80 inches, or to paralithic or lithic bedrock, whichever is shallower) is less than 4 inches
• Soils: shallow to moderately deep, well drained to somewhat excessively drained Inceptisols, Entisols, or shallow Ultisols

Associated sites

PX136X00X330	**Mesic Temperature Regime, Acidic Upland Forest, Depth Restriction, Dry-moist** Found in slightly more stable parts of the landscape (e.g., gentler hillslopes, broader ridges, etc.), where the potential for soil weathering exceeds the potential for geologic erosion. The depth to bedrock is similar or slightly deeper, though soils are better developed and less droughty. The available water storage capacity of the profile is slightly higher (4-6 inches), supporting a relative decrease in dry-site species such as post oak (Quercus stellata), as well as a slight increase in cover from hickories (Carya spp.).

PX136X00X320	**Mesic Temperature Regime, Acidic Upland Forest, Moist** Found in more stable parts of the landscape (e.g., broader interfluves and ridges, gentler hillslopes, etc.) where the potential for soil weathering greatly exceeds the potential for geologic erosion. Soils are deeper, better developed, and considerably more moist throughout the growing season. The available water storage capacity of the profile is higher (≥ 6 inches), supporting higher cover from moisture-loving species, such as northern red oak (Quercus rubra), as well as a slight increase in cover from hickories (Carya spp.).

Similar sites

PX136X00X870	**Lower Piedmont Acidic Upland Woodland, Depth Restriction, Dry** The soil temperature regime is thermic, occurring within the native range of loblolly pine (Pinus taeda).
PX136X00X380	**Mesic Temperature Regime, Acidic High Hills and Isolated Ridges, Depth Restriction, Dry** Found on high hills and prominent ridges in highly dissected and higher elevation parts of the MLRA, supporting a higher contribution from species that are more abundant in cooler regions, of which chestnut oak (Quercus montana) is most notable. In the past, this ecological site would have supported mixed stands of upland oaks (Quercus spp.) and the American chestnut (Castanea dentata). Aspect has greater influence over species composition, with north-facing slopes being cooler and moister compared to south or west-facing slopes. The depth to bedrock and relative moisture status are similar.

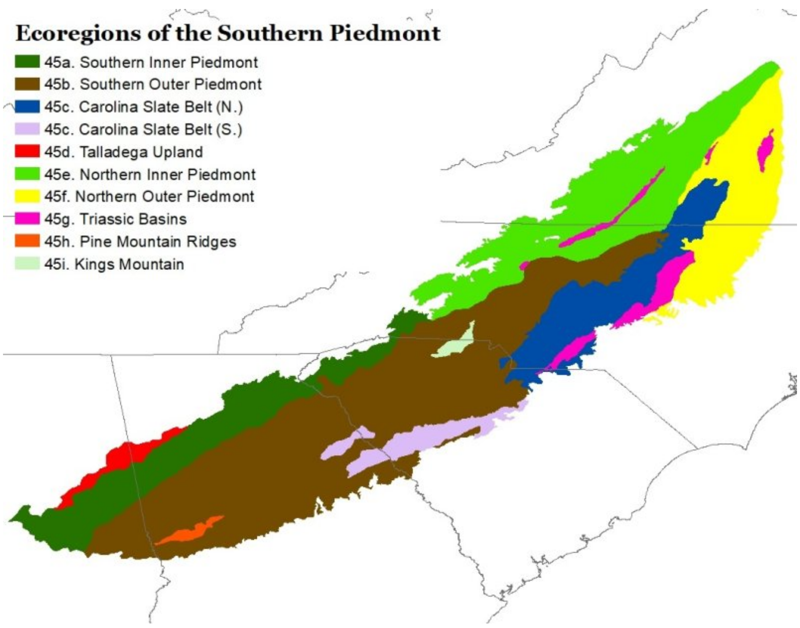

Figure 1. EPA level IV ecoregions of the Southern Piedmont (45).

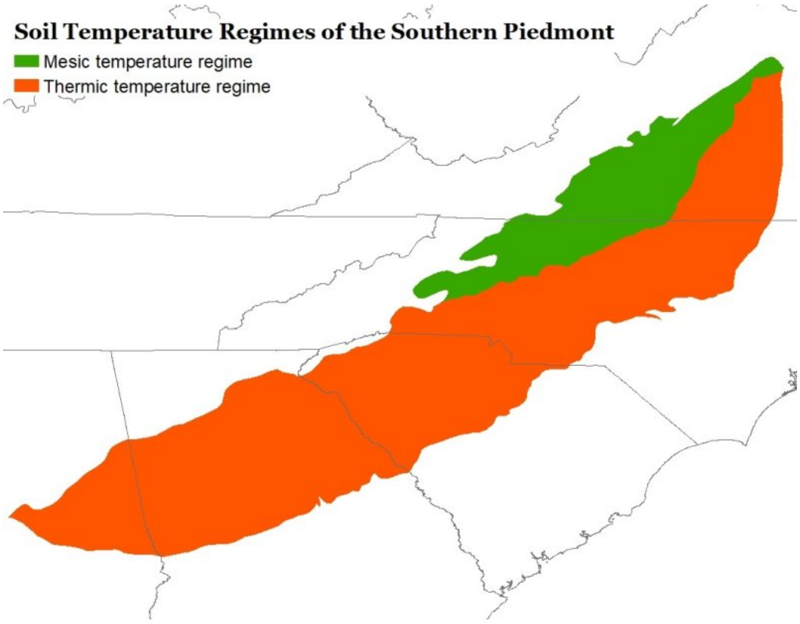

Figure 2. Spatial illustration of soil temperature regimes of the Southern Piedmont.

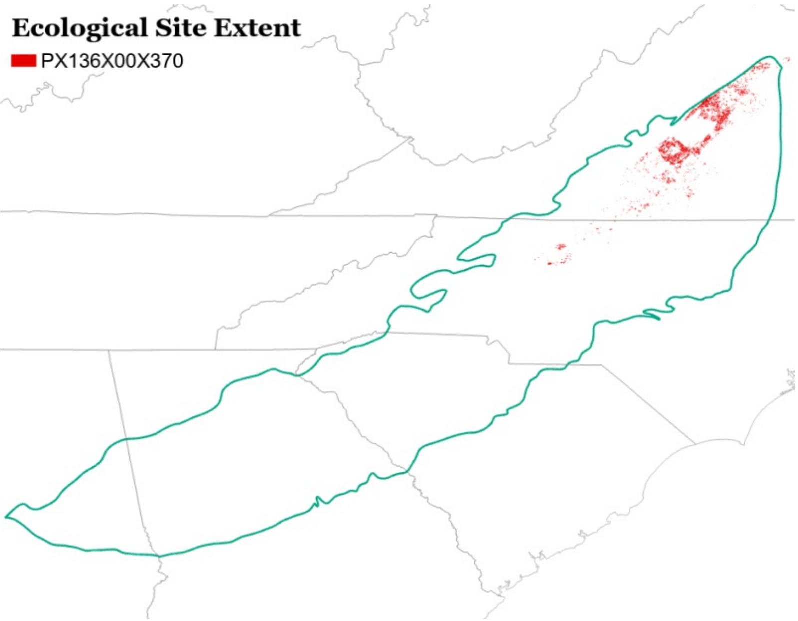

Figure 3. Spatial extent of this ecological site representing the major areas where this site is important on the landscape.

Table 1. Dominant plant species

Tree	(1) *Quercus alba* (2) *Quercus stellata*
Shrub	(1) *Vaccinium* (2) *Gaylussacia baccata*
Herbaceous	(1) *Schizachyrium scoparium* (2) *Pteridium aquilinum*

Legacy ID

F136XY370VA

Physiographic features

This ecological site includes dry, acidic, nutrient-poor uplands, found at low elevations, in the gentler parts of the upper Piedmont plateau, 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.

The landscape of the Northern Inner Piedmont consists of a low, hilly plain to the north and east, with areas of higher elevation and topographic relief becoming more common to the southwest. In general, elevations are highest towards the western boundary and south of the Roanoke river, where the land rises to a broad area of high hills. Areas of lower elevation and topographic relief are generally found east of the Brookneal shear zone, or north of the Roanoke river. In these areas, uplands are generally moderately dissected, with rolling hills and broad interfluves accounting for the majority of the terrain. This ecological site generally sits on the narrower ridges and on short, steep side slopes, as well as on some interfluves underlain by weathering-resistant rock. Elevation decreases dramatically northward, reaching some of the lowest elevations in the MLRA in the northernmost counties in Virginia.

The geologic substrate is typically low in ferromagnesian minerals and high in silica. Parent materials include felsic crystalline rock or fine-grained metasedimentary rock. Common rock types include gneiss, granite, schist, and phyllite. Representative locations are gently sloping to moderately steep, with a representative slope of 7 to 25 percent and a maximum slope of 40 percent (Woods et al. 1999; Griffith et al. 2002).
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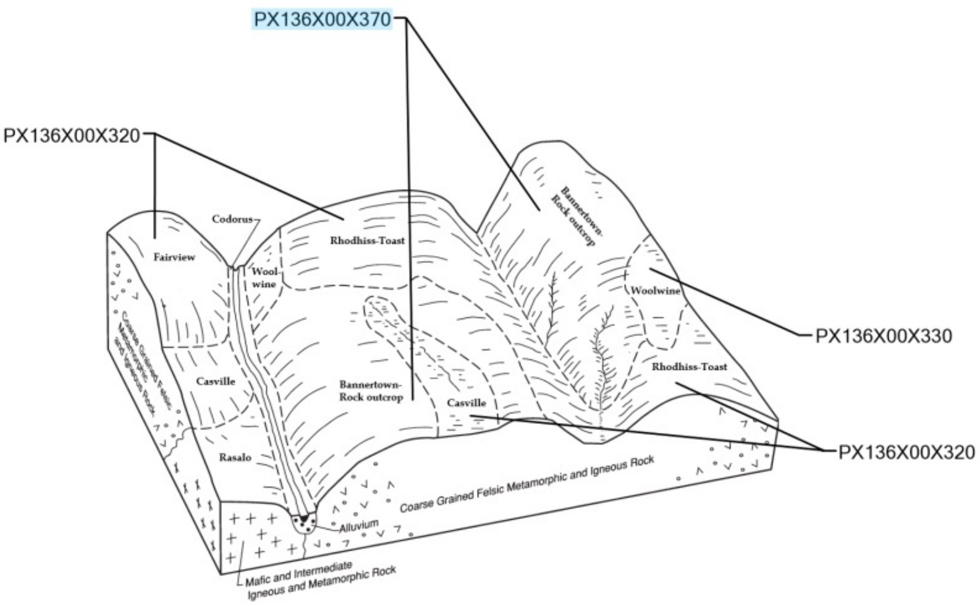


Figure 4. Typical soil-landscape relationships of the Southern Piedmont Felsic Crystalline Soil System. Bannertown soils are associated with this ecological site, depicted here on hillslopes and ridges.

Table 2. Representative physiographic features

Hillslope profile	(1) Backslope (2) Shoulder (3) Summit
Landforms	(1) Piedmont > Hillslope (2) Piedmont > Ridge (3) Piedmont > Interfluve
Runoff class	Medium to high
Flooding frequency	None
Ponding frequency	None
Elevation	70–186 m
Slope	7–25%
Water table depth	183–2,537 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	49–271 m
Slope	2–40%
Water table depth	183–2,537 cm

Climatic features

On this ecological site, the average mean annual precipitation is 45 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)	149-167 days
Freeze-free period (characteristic range)	172-207 days
Precipitation total (characteristic range)	1,118-1,168 mm
Frost-free period (actual range)	137-176 days
Freeze-free period (actual range)	164-222 days
Precipitation total (actual range)	1,067-1,194 mm
Frost-free period (average)	157 days

Freeze-free period (average)	190 days
Precipitation total (average)	1,143 mm

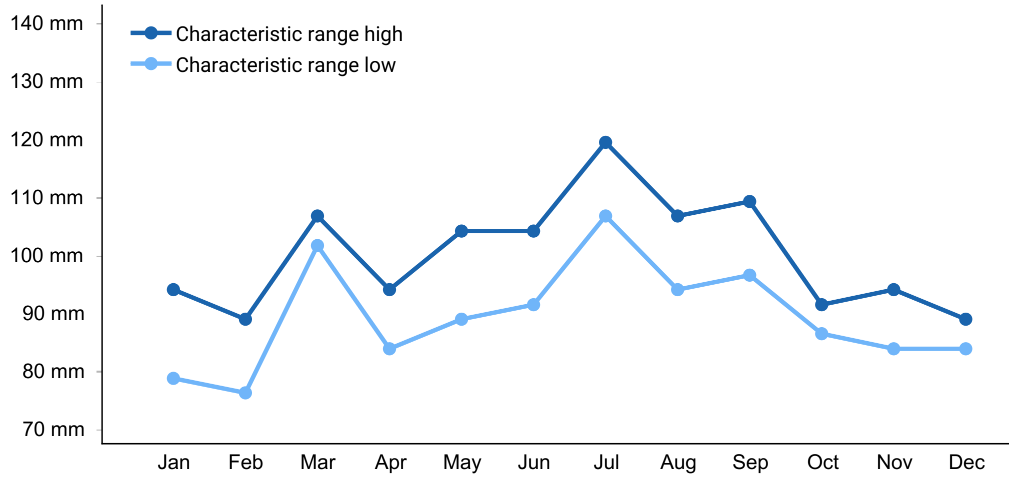


Figure 5. Monthly precipitation range

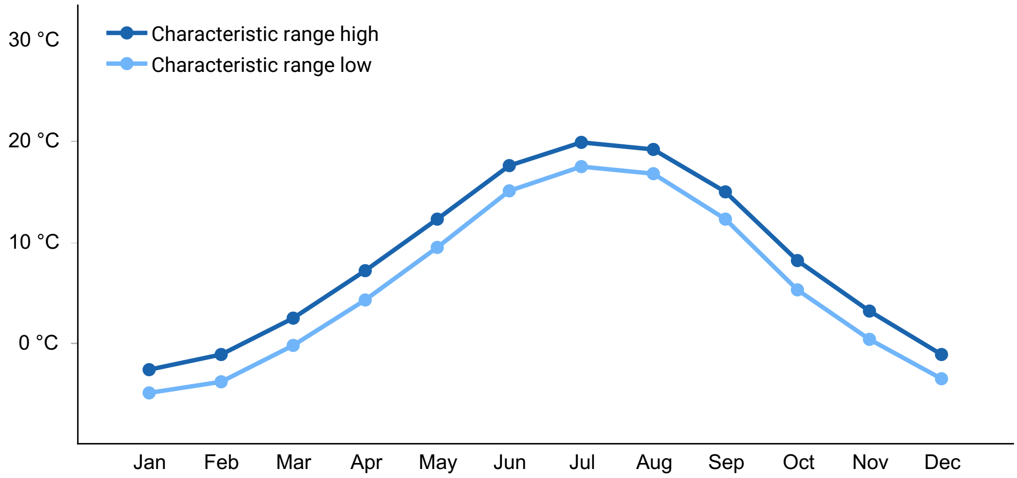


Figure 6. Monthly minimum temperature range

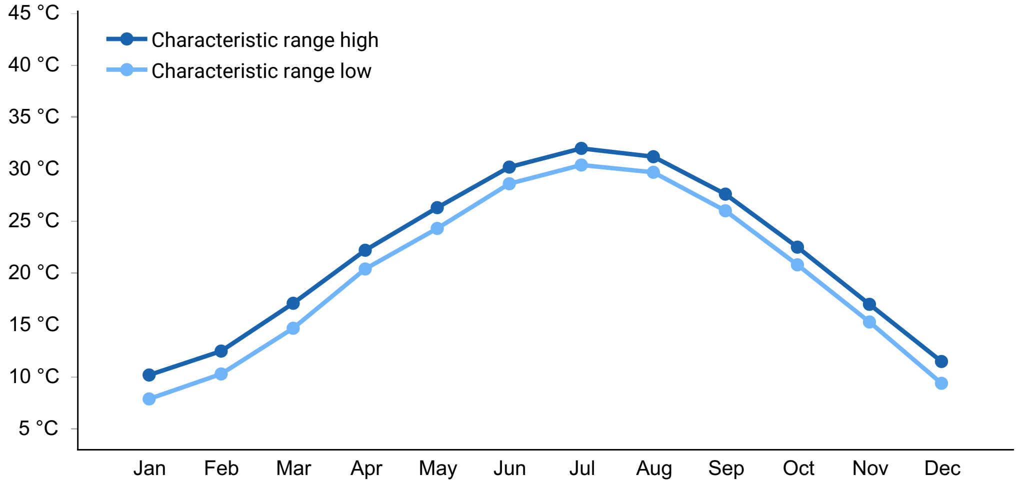


Figure 7. Monthly maximum temperature range

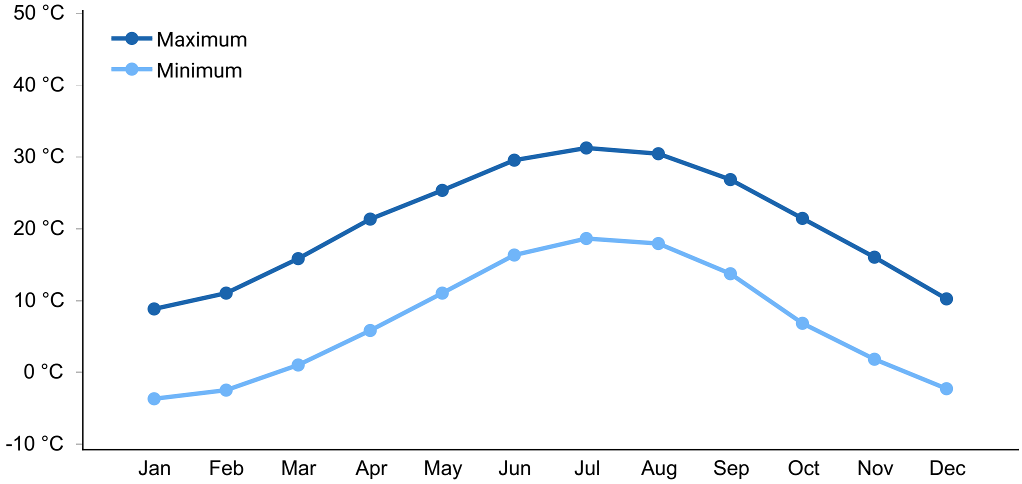


Figure 8. Monthly average minimum and maximum temperature

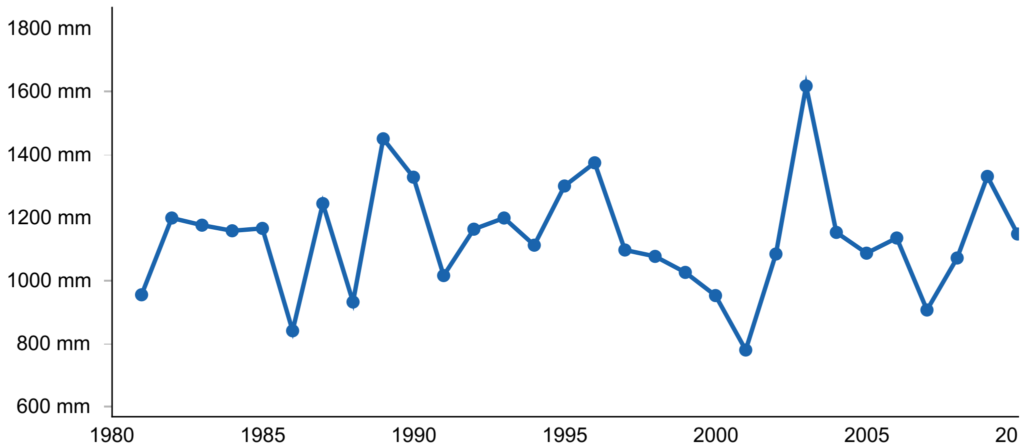


Figure 9. Annual precipitation pattern

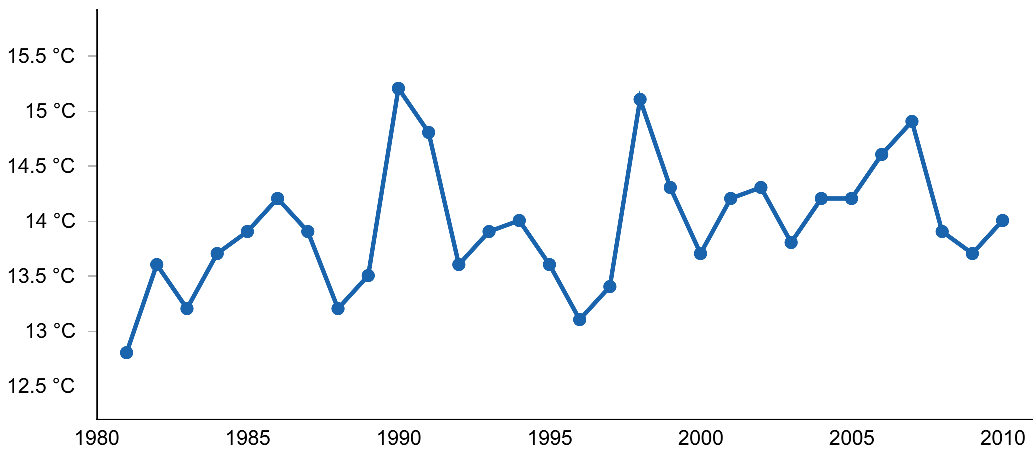


Figure 10. Annual average temperature pattern

Climate stations used

- (1) LOUISA [USC00445050], Louisa, VA
- (2) PALMYRA 3S [USC00446491], Palmyra, VA
- (3) BREMO BLUFF [USC00440993], New Canton, VA
- (4) APPOMATTOX [USC00440243], Appomattox, VA

- (5) BROOKNEAL [USC00441082], Brookneal, VA
- (6) CHATHAM [USC00441614], Chatham, VA
- (7) DANVILLE [USC00442245], Danville, VA
- (8) DANBURY [USC00312238], Danbury, NC
- (9) YADKINVILLE 6 E [USC00319675], East Bend, NC
- (10) MOCKSVILLE 5SE [USC00315743], Mocksville, NC
- (11) LEXINGTON [USC00314970], Lexington, NC
- (12) RURAL HALL [USC00317548], Rural Hall, NC
- (13) SALISBURY [USC00317615], Salisbury, NC
- (14) HIGH POINT [USC00314063], High Point, NC

Influencing water features

This ecological site is not influenced by surface or groundwater features.

Soil features

Soils on this ecological site are typically shallow to moderately deep, well drained to somewhat excessively drained Inceptisols or shallow Ultisols. The available water storage capacity of the profile is generally 4 inches or less. The depth to unweathered or partially weathered bedrock is less than 40 inches, but most soils associated with this ecological site are shallower to bedrock. Soils are typically rocky or gravelly. Areas of exposed rock, stones, or boulders may sit at the surface in places. Parent materials are residuum derived from acidic igneous or metamorphic rock, such as granite, gneiss, or schist.

Reaction in the subsoil is typically strongly acid to extremely acid (pH 3.5 to 5.5). In the surface layers, reaction varies with land use and management. Under low input or forested conditions, it generally falls somewhere between pH 3.5 and 6.0. Base saturation is less than 35 percent in the subsoil. These soils are typically in a coarse-loamy or loamy-skeletal particle size family.

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 taxa include: Typic Dystrudepts
Modal soil series include: Devotion, Bannertown
Other soils attributed to this ecological site include Milldraper, Bugley, Bremo, and Blocktown

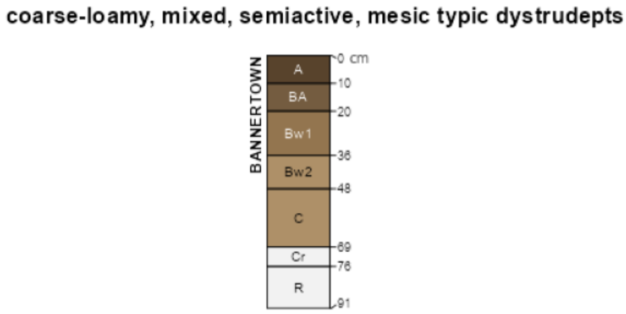


Figure 11. An illustration of a soil profile belonging to the Bannertown series, a representative soil series associated with this ecological site.

Table 5. Representative soil features

Parent material	(1) Residuum–igneous and metamorphic rock
Surface texture	(1) Sandy loam (2) Fine sandy loam (3) Loam (4) Channery, very channery silt loam (5) Gravelly coarse sandy loam (6) Gravelly sandy loam
Family particle size	(1) Coarse-loamy (2) Loamy-skeletal
Drainage class	Well drained to somewhat excessively drained
Permeability class	Rapid
Depth to restrictive layer	46–76 cm
Soil depth	46–76 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-203.2cm)	5.08–7.62 cm
Soil reaction (1:1 water) (0-25.4cm)	3.5–6
Subsurface fragment volume <=3" (0-203.2cm)	6–23%

Subsurface fragment volume >3" (0-203.2cm)	1–16%

Table 6. Representative soil features (actual values)

Drainage class	Well drained to excessively drained
Permeability class	Moderately rapid to rapid
Depth to restrictive layer	28–99 cm
Soil depth	28–99 cm
Surface fragment cover <=3"	0–1%
Surface fragment cover >3"	0–1%
Available water capacity (0-203.2cm)	2.54–10.16 cm
Soil reaction (1:1 water) (0-25.4cm)	3.5–6
Subsurface fragment volume <=3" (0-203.2cm)	0–31%
Subsurface fragment volume >3" (0-203.2cm)	0–37%

Ecological dynamics

U.S. National Vegetation Classification (USNVC) associations that are consistent with reference conditions on this ecological site include CEGL008521 *Quercus alba* - Quercus (coccinea, velutina, montana) / *Gaylussacia baccata*. This concept is closely related to the reference community, but is likely broader than the scope of this ecological site which is limited in extent to the northwestern part of the Southern Piedmont of Virginia and North Carolina. It may or may not approximate stands located in North Carolina, which are reportedly slightly different than their northern counterparts in Virginia. Fieldwork will be needed to quantify expected differences (USNVC 2022).

MATURE FORESTS
The reference state typically supports an open to partially open woodland dominated by upland oaks, with small openings of predominantly herbaceous and low shrub cover, usually where the underlying bedrock is at or near the surface. Vegetation structure can be heterogeneous, with fine-scale differences in tree, shrub, and herb dominance. Canopy cover was likely significantly lower in the past, given a more frequent fire regime.

On account of the shallow effective rootzone and nutrient-poor substrate, trees grow slowly and are of relatively small stature. During periods of heavy precipitation and high winds, windthrow is a common source of natural disturbance, though trees anchored in the crevices of rock often fair better.

Under reference conditions, the canopy is dominated by dry-site oaks, with acid-tolerant flora in the understory. Species diversity is generally low. Important canopy species include white oak (*Quercus alba*), post oak (*Q. stellata*), black oak (*Quercus velutina*), blackjack oak (*Q. marilandica*), southern red oak (*Q. falcata*), and scarlet oak (*Quercus coccinea*), the proportions of which can vary greatly. Chestnut oak (*Q. montana*) can also be important, but it is not usually strongly dominant as it can be in areas of higher elevation and topographic relief. Because of low natural fertility and dry edaphic conditions, hickories (Carya spp.) and oaks more mesophytic than white oak (e.g., northern red oak (*Quercus rubra*)) are generally scarce or absent. Of the hickory species, mockernut hickory (*Carya tomentosa*) is most representative, though it is largely confined to the understory. Pines, including Virginia pine (*Pinus virginiana*), shortleaf pine (*Pinus echinata*), and eastern white pine (*Pinus strobus*), are typically scattered throughout the forest.

The subcanopy layer is generally poorly developed. Understory trees include species common elsewhere on dry acidic uplands, such as sourwood (*Oxydendrum arboreum*), sassafras (*Sassafras albidum*), blackgum (*Nyssa sylvatica*), and flowering dogwood (*Cornus florida*), along with saplings of canopy species. The shrub layer is strongly dominated by members of the heath family, including various blueberries (Vaccinium spp.), black huckleberry (*Gaylussacia baccata*), and mountain laurel (*Kalmia latifolia*), among others. Several species of St. Johnswort (Hypericum spp.) can also be abundant, particularly in woodlands maintained with fire.

In much of the Virginia Piedmont, mountain laurel is widespread on droughty, nutrient-poor sites, and is not confined to cool, north-facing or otherwise sheltered microsites as it is further south. However, the pervasiveness of mountain laurel in these systems is thought to be due at least in part to fire suppression.

In most contemporary stands, as a result of decades of fire suppression, the herb layer is sparse and species-poor. Grasses and forbs may appear in the vicinity of rock outcrops and in openings, but are usually somewhat sparse elsewhere. In these fire-suppressed woodlands, the herb layer is generally occupied by acid-tolerant subshrubs and ferns, such as western brackenfern (*Pteridium aquilinum*), striped prince's pine (*Chimaphila maculata*), and trailing arbutus (*Epigaea repens*).

In the past, fire-dependent grasses and forbs would have presumably been more important in the herb layer. Grasses such as little bluestem (*Schizachyrium scoparium*) and blackseed speargrass (*Piptochaetium avenaceum*) would have been more abundant, along with characteristic forbs such as Virginia tephrosia (*Tephrosia virginiana*), horseflyweed (*Baptisia tinctoria*), Atlantic pigeonwings (*Clitoria mariana*), greater tickseed (*Coreopsis major*), anisescented goldenrod (*Solidago odora*), and various other composites and leguminous forbs.

DYNAMICS OF NATURAL SUCCESSION AND FIRE ECOLOGY

Historically, oak and oak-pine forests of the Southeast were maintained through recurring fire, either naturally-occurring or introduced by humans. 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 Piedmont uplands, the historical influence of fire on successional dynamics was likely expressed on a continuum, from dry to moist, where moist or sheltered sites were shaped more by gap-driven dynamics and dry or exposed sites more by fire. On intermediate sites, their respective influence on successional dynamics probably fell somewhere in between.

In contemporary upland forests of the Southern Piedmont, an overall shift towards gap-driven successional dynamics (driven largely by windthrow, drought, disease, etc.) has had a homogenizing effect on the upland vegetation of the region, making moist, intermediate, and dry sites more similar to one another than they were in the past.

On this ecological site, contemporary examples tend to have a thick layer of leaf litter and fewer understory grasses and forbs. Dense colonies of ericaceous (heath family) shrubs, vines, and small trees have often grown up in the understory, restricting the growth of true herbaceous species. Over years of fire exclusion, these characteristics have often progressed to such a degree that conditions are no longer conducive to the spread of fire, a phenomenon known as mesophication. In this scenario, when fire is removed for long periods of time, positive feedbacks result in succession toward forest systems that are less apt to burn.

In the past, the routine use of fire by Native Americans, coupled with periodic lightning-induced fires, constrained the growth of understory shrubs and fire-intolerant trees. These fires maintained a more open canopy and promoted a dense herbaceous layer that could efficiently carry fire in future burns. While the historic fire return interval is thought to be relatively similar across most of the Southern Piedmont uplands, drier sites were more prone to fire and hence burned more completely and at higher intensities than moister sites.

Vegetation structure was historically more open throughout the Southern Piedmont uplands, but particularly on drier or more exposed sites. Given the more frequent fire regime of the past, canopy cover was likely more open and more heterogeneous than it is presently, and herb cover higher overall, as per historical accounts and witness tree records.

On the driest uplands of the Piedmont, all but the most fire-tolerant tree species would have been suppressed, and some excluded entirely. Those species with intermediate fire tolerance, including some oaks, pines, and hickories, would have presumably been more abundant on moister or more sheltered sites.

The reduction in the frequency of fires over the past century has allowed shade-tolerant, fire-sensitive trees such as red maple (*Acer rubrum*), American beech (*Fagus grandifolia*), and American holly (*Ilex opaca*) to become more abundant in many upland forests in the Southeast, but they are particularly out of place on dry uplands. Except for in sheltered areas, these thin-barked species would have been largely excluded from the understory of dry upland forests under a more frequent fire regime.

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 (Pinchot and Ashe 1897; Oosting 1942; Peet and Christensen 1980; Schafale and Weakley 1990; Cowell 1998; League 2005; Spira 2011; Fleming 2012; Guyette et al. 2012; Schafale 2012a, 2012b; Vander Yacht et al. 2020; Fleming et al. 2021; Greenberg et al. 2021; Spooner et al. 2021).

SPECIES LIST
Canopy layer: *Quercus alba*, *Quercus stellata*, *Quercus velutina*, *Quercus marilandica*, *Quercus falcata*, *Quercus coccinea*, *Quercus montana*, *Pinus virginiana*, *Pinus echinata*, *Pinus strobus*

Subcanopy layer: *Oxydendrum arboreum*, *Sassafras albidum*, *Nyssa sylvatica*, *Cornus florida*, *Juniperus virginiana*, *Carya tomentosa*, *Carya glabra*, *Castanea pumila*

Vines/lianas: *Vitis rotundifolia*, *Smilax glauca*, *Smilax bona-nox*, *Lonicera japonica* (I)

Shrub layer: *Vaccinium stamineum*, *Vaccinium pallidum*, *Gaylussacia baccata*, *Hypericum hypericoides* ssp. multicaule, *Kalmia latifolia*, *Ceanothus americanus*, *Rosa carolina*, *Hypericum prolificum*, *Hypericum lloydii*, *Yucca filamentosa*, *Yucca flaccida*

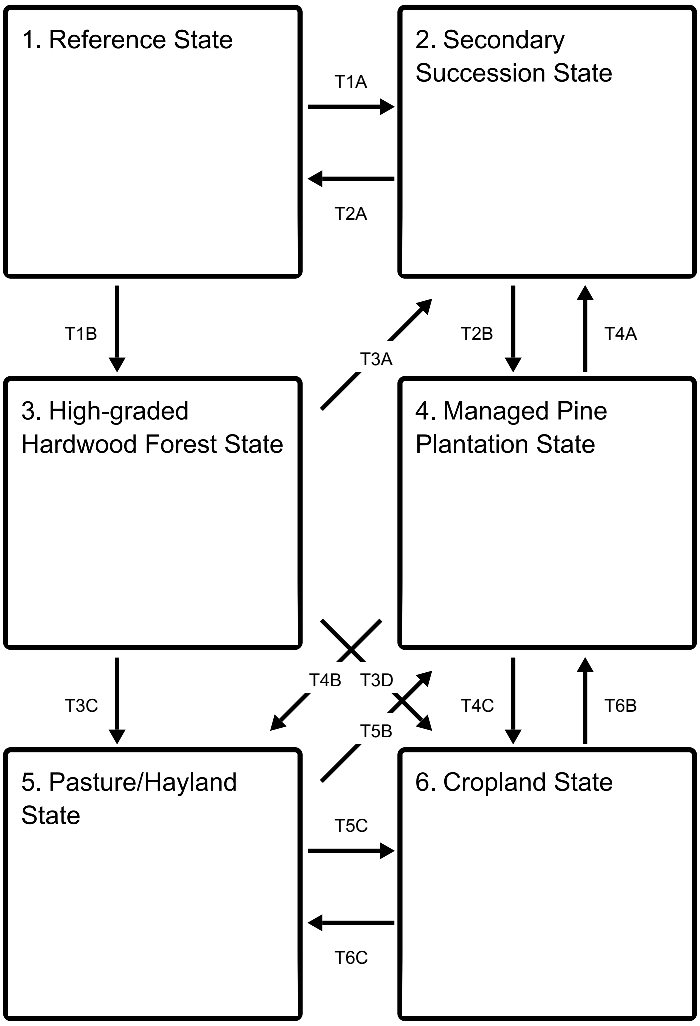
Herb layer - forbs: *Pteridium aquilinum*, *Chimaphila maculata*, *Epigaea repens*, *Asplenium platyneuron*, Cladonia spp., *Tephrosia virginiana*, *Baptisia tinctoria*, *Clitoria mariana*, *Coreopsis major*, *Solidago odora*, *Hieracium gronovii*, *Cunila origanoides*, Lespedeza spp., Desmodium spp., *Symphyotrichum patens*, *Erigeron strigosus*, *Potentilla canadensis*, *Iris verna*, *Solidago pinetorum*, *Desmodium rotundifolium*, *Hieracium venosum*, *Rhynchosia tomentosa*, *Hypericum gentianoides*, *Packera anonyma*, *Rudbeckia hirta*, *Trichostema dichotomum*, Helianthus spp., *Solidago nemoralis*, *Antennaria plantaginifolia*, *Hypoxis hirsuta*, *Uvularia puberula*, *Cypripedium acaule*, *Stylosanthes biflora*, *Solidago erecta*, *Linum intercursum*, *Lespedeza cuneata* (I), *Portulaca oleracea* (I.)

Herb layer - graminoids: *Schizachyrium scoparium*, *Danthonia spicata*, *Piptochaetium avenaceum, Sorghastrum nutans*, Dichanthelium spp., *Carex nigromarginata*, *Saccharum alopecuroides*, *Gymnopogon ambiguus*, *Eragrostis spectabilis*, *Eragrostis hirsuta*, *Eragrostis capillaris*, *Carex albicans*, *Digitaria filiformis*, *Luzula bulbosa*, *Cyperus echinatus*, *Cyperus retrorsus*, *Cyperus retrofractus*,

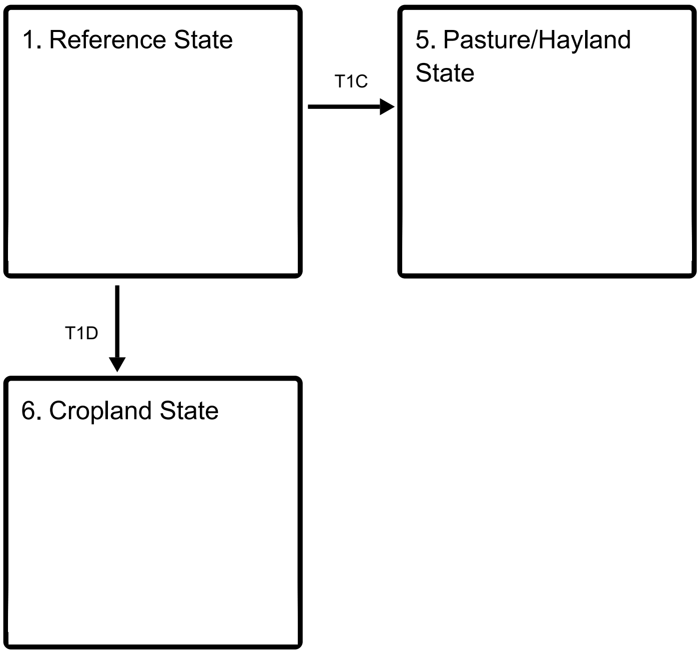
(I) = introduced

State and transition model

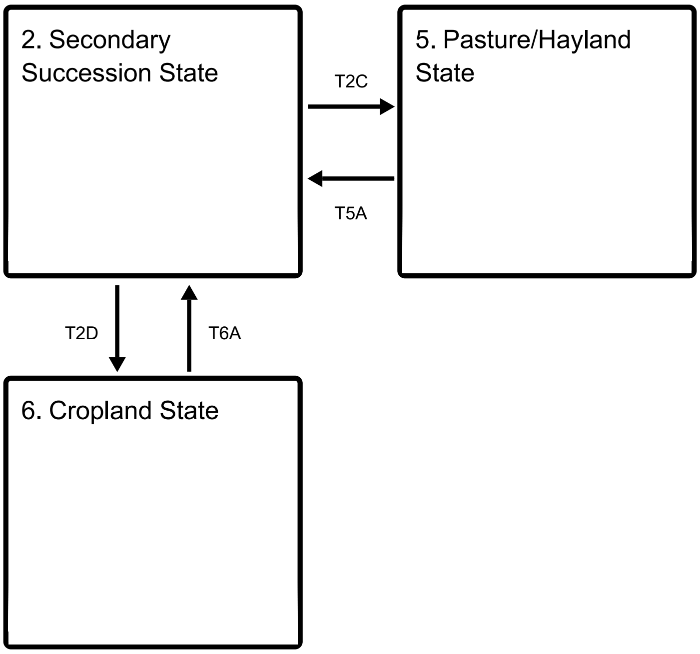
Ecosystem states



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, 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.

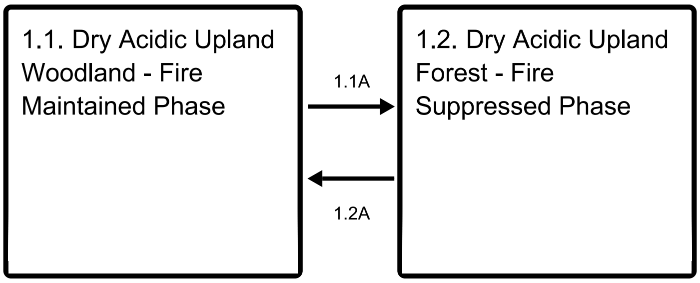
T5C - Seedbed preparation, applications of fertilizer/lime, weed control, and planting of crop or cover crop seed.

T6A - Agricultural abandonment.

T6B - Site preparation and tree planting.

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

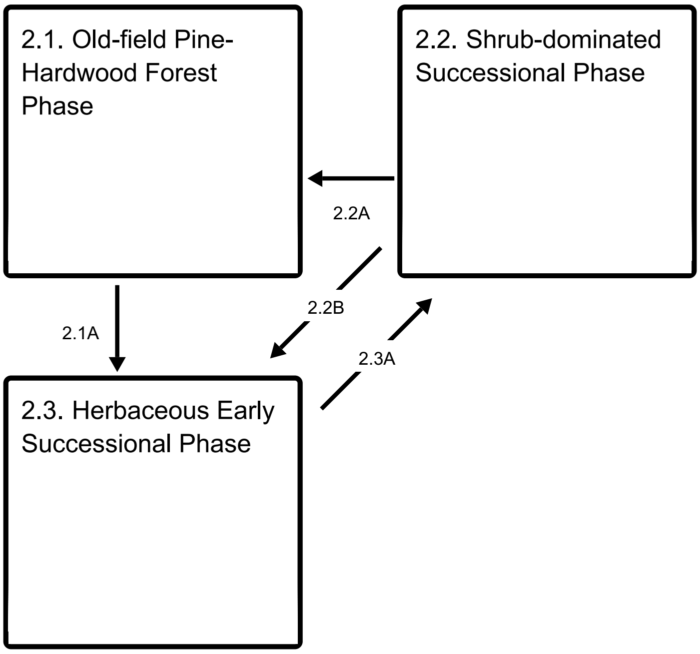
State 1 submodel, plant communities



1.1A - Long-term exclusion of fire.

1.2A - Prescribed burns and selective removals.

State 2 submodel, plant communities



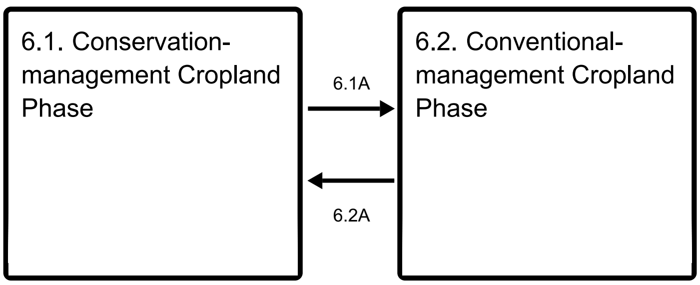
2.1A - Clearcut logging.

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 dry-site oaks, with acid-tolerant flora in the understory. Hickories and oaks more mesophytic than white oak (e.g., northern red oak) are generally scarce or absent in the canopy.

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

Community 1.1
Dry Acidic Upland 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. Species diversity is low. Representative species of the canopy layer include post oak (Quercus stellata), white oak (Quercus alba), blackjack oak (Quercus marilandica), and black oak (Quercus velutina). Canopy cover is lower than in the fire suppressed phase.

Forest understory. Characteristic understory tree species include sourwood (Oxydendrum arboreum), sassafras (Sassafras albidum), blackgum (Nyssa sylvatica), and flowering dogwood (Cornus florida), along with saplings of canopy species.

Common understory shrub species include deerberry (Vaccinium stamineum), Blue Ridge Blueberry (Vaccinium pallidum) and black huckleberry (Gaylussacia baccata).

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

Dominant plant species

- white oak (*Quercus alba*), tree
- post oak (*Quercus stellata*), tree
- shortleaf pine (*Pinus echinata*), tree
- blackjack oak (*Quercus marilandica*), tree

- black oak (*Quercus velutina*), tree
- southern red oak (*Quercus falcata*), tree
- sourwood (*Oxydendrum arboreum*), tree
- sassafras (*Sassafras albidum*), tree
- flowering dogwood (*Cornus florida*), tree
- blackgum (*Nyssa sylvatica*), tree
- deerberry (*Vaccinium stamineum*), shrub
- Blue Ridge blueberry (*Vaccinium pallidum*), shrub
- black huckleberry (*Gaylussacia baccata*), shrub
- St. Andrew's cross (*Hypericum hypericoides ssp. multicaule*), shrub
- winged sumac (*Rhus copallinum*), shrub
- blackberry (*Rubus*), shrub
- Carolina rose (*Rosa carolina*), shrub
- New Jersey tea (*Ceanothus americanus*), shrub
- little bluestem (*Schizachyrium scoparium*), grass
- blackseed speargrass (*Piptochaetium avenaceum*), grass
- poverty oatgrass (*Danthonia spicata*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- splitbeard bluestem (*Andropogon ternarius*), grass
- black edge sedge (*Carex nigromarginata*), grass
- silver plumegrass (*Saccharum alopecuroides*), grass
- bearded skeletongrass (*Gymnopogon ambiguus*), grass
- western brackenfern (*Pteridium aquilinum*), other herbaceous
- Virginia tephrosia (*Tephrosia virginiana*), other herbaceous
- horseflyweed (*Baptisia tinctoria*), other herbaceous
- Atlantic pigeonwings (*Clitoria mariana*), other herbaceous
- greater tickseed (*Coreopsis major*), other herbaceous
- anisescented goldenrod (*Solidago odora*), other herbaceous
- queendevil (*Hieracium gronovii*), other herbaceous
- common dittany (*Cunila origanoides*), other herbaceous
- lespedeza (*Lespedeza*), other herbaceous
- ticktrefoil (*Desmodium*), other herbaceous

Community 1.2
Dry Acidic Upland 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 herb layer is typically sparser. The pine component can have a greater proportion of Virginia pine and the understory usually contains a greater proportion of fire-intolerant species.

Forest overstory. The overstory is dominated by dry-site oaks. Species diversity is low. Representative species of the canopy layer include post oak (Quercus stellata), white oak (Quercus alba), blackjack oak (Quercus marilandica), and black oak (Quercus velutina).

Canopy cover is higher than in the fire maintained phase.

Forest understory. Characteristic understory tree species include sourwood (Oxydendrum arboreum), sassafras (Sassafras albidum), blackgum (Nyssa sylvatica), and flowering dogwood (Cornus florida), along with saplings of canopy species.

Common understory shrub species include deerberry (Vaccinium stamineum), Blue Ridge blueberry (Vaccinium pallidum), black huckleberry (Gaylussacia baccata), and mountain laurel (Kalmia latifolia).

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

Dominant plant species

- white oak (*Quercus alba*), tree
- post oak (*Quercus stellata*), tree
- blackjack oak (*Quercus marilandica*), tree
- black oak (*Quercus velutina*), tree
- southern red oak (*Quercus falcata*), tree
- shortleaf pine (*Pinus echinata*), tree
- Virginia pine (*Pinus virginiana*), tree
- sourwood (*Oxydendrum arboreum*), tree
- blackgum (*Nyssa sylvatica*), tree
- flowering dogwood (*Cornus florida*), tree
- deerberry (*Vaccinium stamineum*), shrub
- Blue Ridge blueberry (*Vaccinium pallidum*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- black huckleberry (*Gaylussacia baccata*), shrub
- cat greenbrier (*Smilax glauca*), shrub
- saw greenbrier (*Smilax bona-nox*), shrub
- poverty oatgrass (*Danthonia spicata*), grass
- rosette grass (*Dichanthelium*), grass
- black edge sedge (*Carex nigromarginata*), grass
- whitetinge sedge (*Carex albicans*), grass
- striped prince's pine (*Chimaphila maculata*), other herbaceous
- trailing arbutus (*Epigaea repens*), other herbaceous
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous
- western brackenfern (*Pteridium aquilinum*), other herbaceous
- cup lichen (*Cladonia*), 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 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. Stands are even-aged and species diversity is low. The canopy is usually dominated by pines, with hardwoods confined mostly to the understory. Species that exhibit pioneering traits are usually most abundant.

Forest overstory. The overstory is typically dominated by pines. Virginia pine (P. virginiana) is the most characteristic species, though shortleaf pine (P. echinata) or eastern white pine (Pinus strobus) can also be important. 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 sassafras (Sassafras albidum), red maple (Acer rubrum), blackgum (Nyssa sylvatica), and eastern redcedar (Juniperus virginiana). Seedlings of oaks are usually present in the understory. These seedlings are released gradually as the forest matures and the pines begin to die off.

In the shrub layer, representative species include various blueberries (Vaccinium spp.), along with several vines.

Dominant plant species

- Virginia pine (*Pinus virginiana*), tree
- shortleaf pine (*Pinus echinata*), tree
- sassafras (*Sassafras albidum*), tree
- red maple (*Acer rubrum*), tree
- blackgum (*Nyssa sylvatica*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- eastern white pine (*Pinus strobus*), tree
- oak (*Quercus*), tree
- blueberry (*Vaccinium*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- sassafras (*Sassafras albidum*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- rosette grass (*Dichanthelium*), grass
- poverty oatgrass (*Danthonia spicata*), grass
- striped prince's pine (*Chimaphila maculata*), other herbaceous
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous
- moccasin flower (*Cypripedium acaule*), other herbaceous
- dwarf cinquefoil (*Potentilla canadensis*), 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 grades into the forested successional phase as tree seedlings become saplings and begin to occupy more of the canopy cover.

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

Dominant plant species

- Virginia pine (*Pinus virginiana*), tree
- sassafras (*Sassafras albidum*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- princesstree (*Paulownia tomentosa*), tree
- winged elm (*Ulmus alata*), tree
- Callery pear (*Pyrus calleryana*), tree
- silktree (*Albizia julibrissin*), tree
- winged sumac (*Rhus copallinum*), shrub
- blackberry (*Rubus*), shrub
- St. Johnswort (*Hypericum*), shrub
- greenbrier (*Smilax*), shrub

- rose (*Rosa*), shrub
- Chickasaw plum (*Prunus angustifolia*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- smooth sumac (*Rhus glabra*), shrub
- broomsedge bluestem (*Andropogon virginicus*), grass
- goldenrod (*Solidago*), other herbaceous
- sericea lespedeza (*Lespedeza cuneata*), other herbaceous
- Indianhemp (*Apocynum cannabinum*), other herbaceous
- aster (*Symphyotrichum*), other herbaceous
- thoroughwort (*Eupatorium*), 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

- greenbrier (*Smilax*), shrub
- St. Johnswort (*Hypericum*), shrub
- broomsedge bluestem (*Andropogon virginicus*), grass
- splitbeard bluestem (*Andropogon ternarius*), grass
- crabgrass (*Digitaria*), grass
- annual fescue (*Vulpia myuros*), grass
- sixweeks fescue (*Vulpia octoflora*), grass
- lovegrass (*Eragrostis*), grass
- thoroughwort (*Eupatorium*), other herbaceous
- Canadian horseweed (*Conyza canadensis*), other herbaceous
- goldenrod (*Solidago*), other herbaceous
- Virginia dwarfdandelion (*Krigia virginica*), other herbaceous
- dwarf cinquefoil (*Potentilla canadensis*), other herbaceous
- poorjoe (*Diodia teres*), other herbaceous
- annual ragweed (*Ambrosia artemisiifolia*), other herbaceous
- aster (*Symphyotrichum*), other herbaceous
- Virginia pepperweed (*Lepidium virginicum*), other herbaceous
- Small's ragwort (*Packera anonyma*), 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
- red maple (*Acer rubrum*), tree
- sourwood (*Oxydendrum arboreum*), tree
- flowering dogwood (*Cornus florida*), tree
- common persimmon (*Diospyros virginiana*), tree
- oak (*Quercus*), tree
- pine (*Pinus*), 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*) and eastern white pine (*Pinus strobus*) 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
- blackgum (*Nyssa sylvatica*), tree
- sassafras (*Sassafras albidum*), tree
- red maple (*Acer rubrum*), tree
- Virginia pine (*Pinus virginiana*), tree
- eastern white pine (*Pinus strobus*), tree
- oak (*Quercus*), tree
- blueberry (*Vaccinium*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- greenbrier (*Smilax*), shrub
- blackberry (*Rubus*), shrub
- St. Johnswort (*Hypericum*), shrub
- black huckleberry (*Gaylussacia baccata*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- rosette grass (*Dichanthelium*), grass
- poverty oatgrass (*Danthonia spicata*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- striped prince's pine (*Chimaphila maculata*), other herbaceous
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous
- moccasin flower (*Cypripedium acaule*), 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.), 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*), dogfennel (*Eupatorium capillifolium*), common sheep sorrel (*Rumex acetosella*), Japanese clover (*Kummerowia striata*), 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*), and black cherry (*Prunus serotina*).

Dominant plant species

- dallisgrass (*Paspalum dilatatum*), grass
- purpletop tridens (*Tridens flavus*), grass
- tall fescue (*Schedonorus arundinaceus*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- hairy crabgrass (*Digitaria sanguinalis*), grass
- Bermudagrass (*Cynodon dactylon*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- smooth crabgrass (*Digitaria ischaemum*), grass
- white clover (*Trifolium repens*), other herbaceous
- Japanese clover (*Kummerowia striata*), other herbaceous
- sericea lespedeza (*Lespedeza cuneata*), other herbaceous
- black medick (*Medicago lupulina*), other herbaceous
- field clover (*Trifolium campestre*), other herbaceous
- narrowleaf plantain (*Plantago lanceolata*), 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. 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
- 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
- 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 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) 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 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) 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.

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	05/20/2025
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):**

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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):**

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

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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:**