USDA Natural Resources
Conservation Service

Ecological site PX136X00X320
Mesic Temperature Regime, Acidic Upland Forest, Moist

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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 cane brakes 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
CEGL008475 *Quercus alba* - *Quercus rubra* - *Carya tomentosa* / *Vaccinium stamineum* / *Desmodium nudiflorum*; CEGL007237 *Quercus rubra* - *Quercus alba* - *Carya glabra* / Geranium maculatum

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 moist acidic uplands on broad ridges, interfluves, hillslopes, and high, old stream terraces. It is geographically restricted to the mesic soil temperature regime portion of the Southern Piedmont, in the northwestern-most part of the MLRA. Soils are typically deep to very deep, well drained Ultisols. Parent materials are typically

residuum derived from acidic igneous or metamorphic rock. Base saturation is less than 35 percent in the subsoil. These site conditions are common and extensive across the Southern Piedmont, often occupying large, contiguous portions of the landscape.

The reference state supports the typical, and historic, acidic oak-hickory forest of the Piedmont. It is a closed to somewhat open canopy forest dominated by species such as white oak (*Quercus alba*), northern red oak (*Quercus rubra*), and other upland oaks, with a much smaller contribution from hickories (Carya spp.) and pines (Pinus spp.), predominantly Virginia pine (*Pinus virginiana*) and shortleaf pine (*Pinus echinata*). Dominant land uses include cropland, pasture and hayland, planted pine, and various urban or suburban uses.

ES CHARACTERISTICS SUMMARY
• Mesic soil temperature regime
• Occurs on Piedmont uplands, on broad ridges, interfluves, hillslopes, and on some high stream terraces, on typical rolling to moderately dissected Piedmont landscapes
• Base saturation: < 35 percent in the subsoil
• Seasonal high water table: usually absent within 72 inches (though the minimum allowable depth is ≥ 40 inches from the soil surface)
• Depth to bedrock: ≥ 40 inches, usually deeper
• 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 greater than or equal to 6 inches
• Soils: deep to very deep, well drained Ultisols

Associated sites

PX136X00X310	**Mesic Temperature Regime, Acidic Upland Forest, Seasonally Wet** Generally found in slightly lower landscape positions. The seasonal high water table is shallower (12-40 inches from the soil surface), supporting a relative increase in obligate or facultative wetland indicator species.
PX136X00X330	**Mesic Temperature Regime, Acidic Upland Forest, Depth Restriction, Dry-moist** Typically in similar landscape positions, but on slightly less stable parts of the landscape (e.g., narrower ridges, steeper hillslopes). Soils are generally shallower to bedrock (< 40 inches) and more droughty, supporting a relative increase in dry-site species, such as black oak (Quercus velutina) and southern red oak (Quercus falcata).
PX136X00X720	**Basic Upland Forest, Moist** The relative soil moisture status is similar, but soils are richer in base cations. Base saturation is greater or equal to 35 percent in the subsoil. Basic indicator species make a much greater contribution to the understory.

Similar sites

PX136X00X820	**Acidic Upland Forest, Moist** The soil temperature regime is thermic, occurring within the native range of loblolly pine (Pinus taeda).

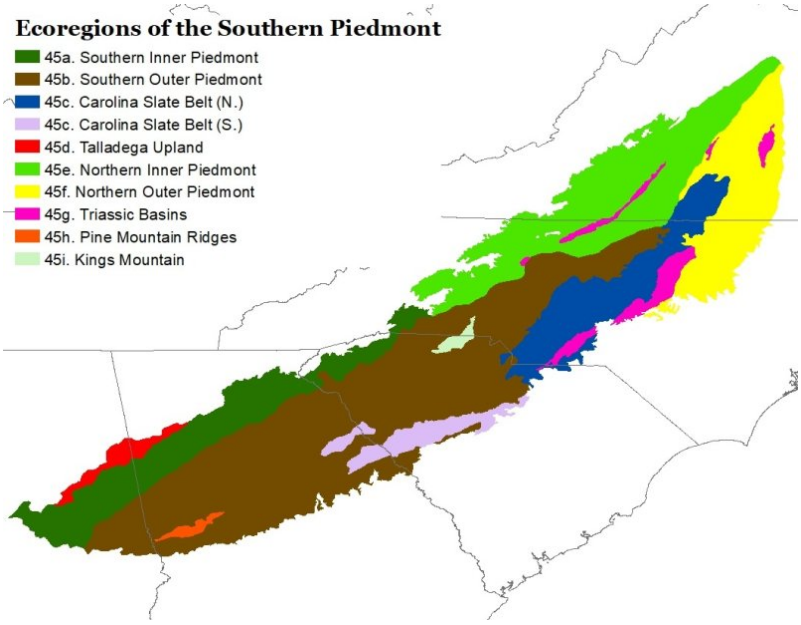


Figure 1. EPA level IV ecoregions of the Southern Piedmont (45).

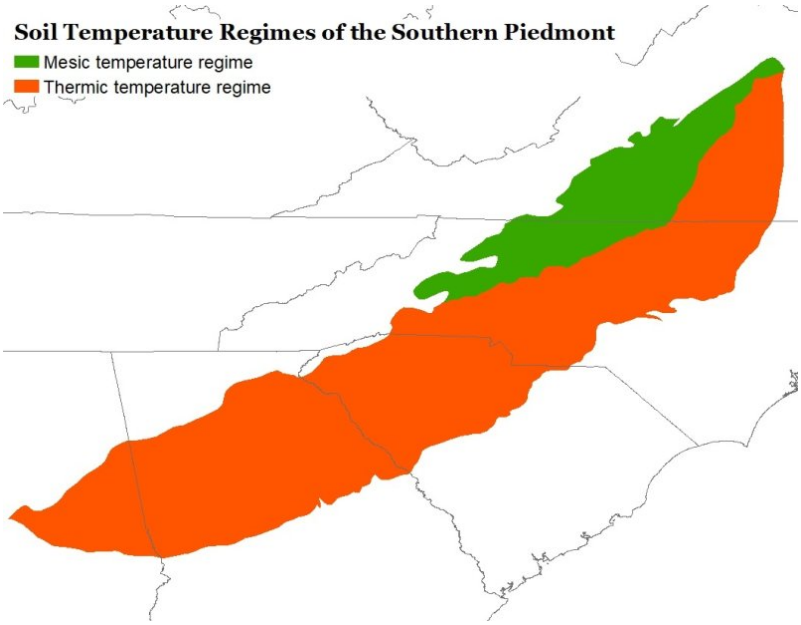


Figure 2. Spatial illustration of soil temperature regimes of the Southern Piedmont.

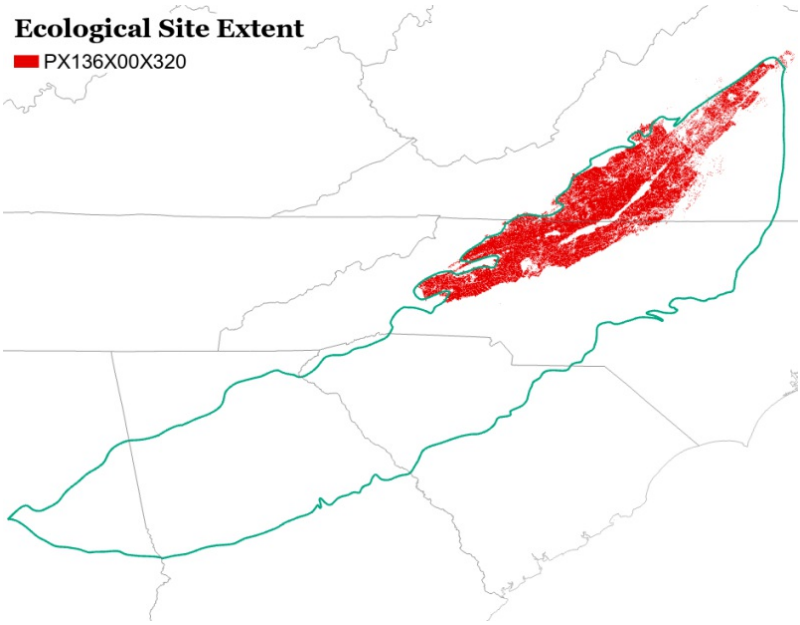


Figure 3. Spatial extent of this ecological site representing the major areas where this site is important on the landscape.

Table 1. Dominant plant species

Tree	(1) *Quercus alba* (2) *Quercus rubra*
Shrub	(1) *Cornus florida* (2) *Vaccinium*
Herbaceous	(1) *Desmodium nudiflorum* (2) *Hexastylis*

Legacy ID

F136XY320VA

Physiographic features

This ecological site is found on broad ridges, interfluves, hillslopes, and high, old stream terraces, in 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.

Representative locations are gently sloping to moderately steep, with a representative slope of 2 to 20 percent and a maximum slope of 45 percent. Though the minimum allowable depth to the seasonal high water table is 40 inches or above in the field, the seasonal high water table is typically 72 inches or greater from the soil surface.

The geologic substrate is is typically acidic igneous or metamorphic rock, which is low in ferromagnesian minerals and high in silica. Representative rock types include felsic crystalline rock, such as granite and gneiss, or fine-grained metasedimentary or metavolcanic rocks such as schist, argillite, and slate. Less typical are highly weathered

mafic intrusive rocks and highly weathered old alluvial sediments. After extensive weathering in a leaching climate, these substrates are functionally similar to those of felsic origin.

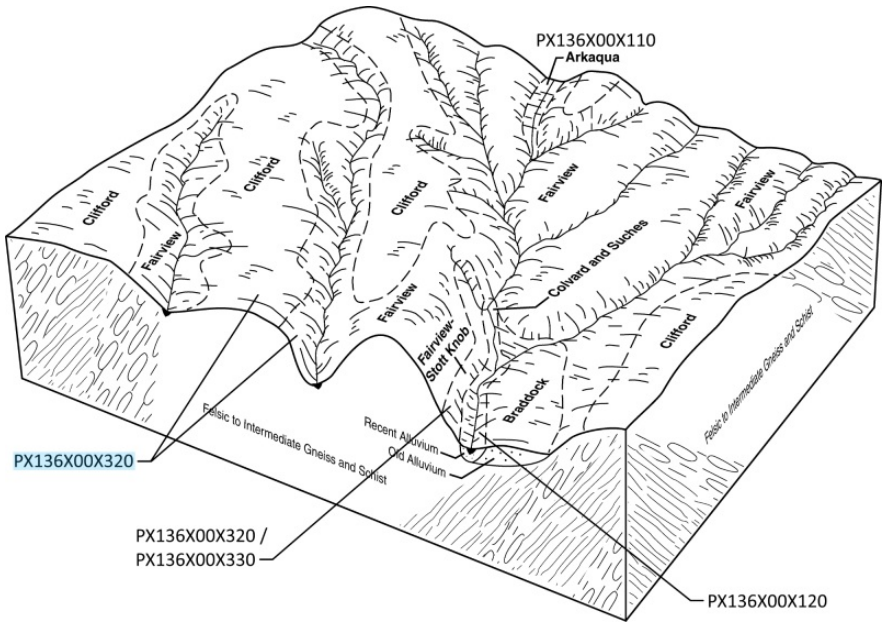


Figure 4. Typical soil-landscape relationships of the Southern Piedmont Felsic Crystalline Soil System. Clifford and Fairview soils are associated with this ecological site, depicted here on gentle hillslopes and interfluves.

Table 2. Representative physiographic features

Hillslope profile	(1) Summit (2) Shoulder (3) Backslope
Landforms	(1) Piedmont > Interfluve (2) Piedmont > Hillslope (3) Piedmont > Ridge
Runoff class	Low to medium
Flooding frequency	None
Ponding frequency	None
Elevation	350–1,200 ft
Slope	2–20%
Water table depth	72–999 in
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Runoff class	Negligible to high
Flooding frequency	None

Ponding frequency	None
Elevation	200–2,000 ft
Slope	2–45%
Water table depth	72–999 in

Climatic features

On this ecological site, the average mean annual precipitation is 46 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)	151-171 days
Freeze-free period (characteristic range)	183-207 days
Precipitation total (characteristic range)	44-47 in
Frost-free period (actual range)	143-181 days
Freeze-free period (actual range)	166-223 days
Precipitation total (actual range)	42-50 in
Frost-free period (average)	160 days
Freeze-free period (average)	194 days
Precipitation total (average)	46 in

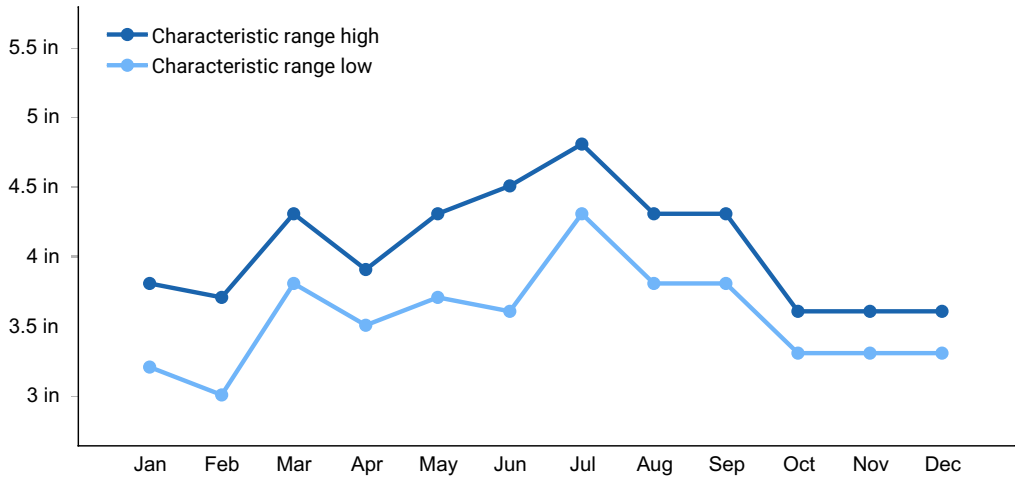


Figure 5. Monthly precipitation range

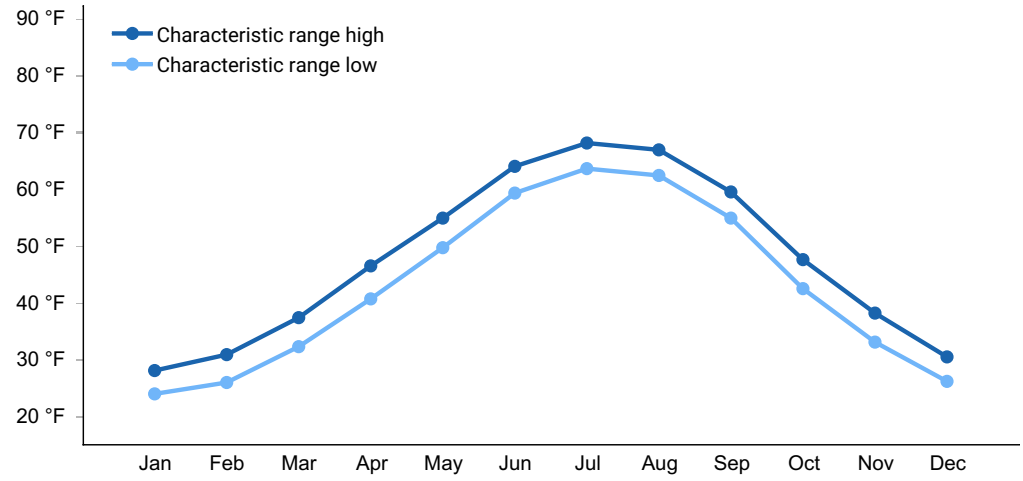


Figure 6. Monthly minimum temperature range

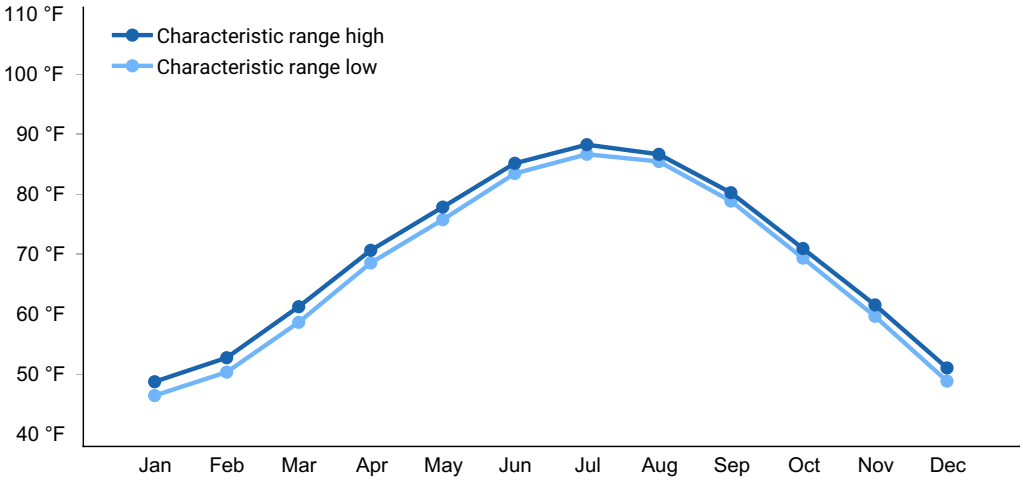


Figure 7. Monthly maximum temperature range

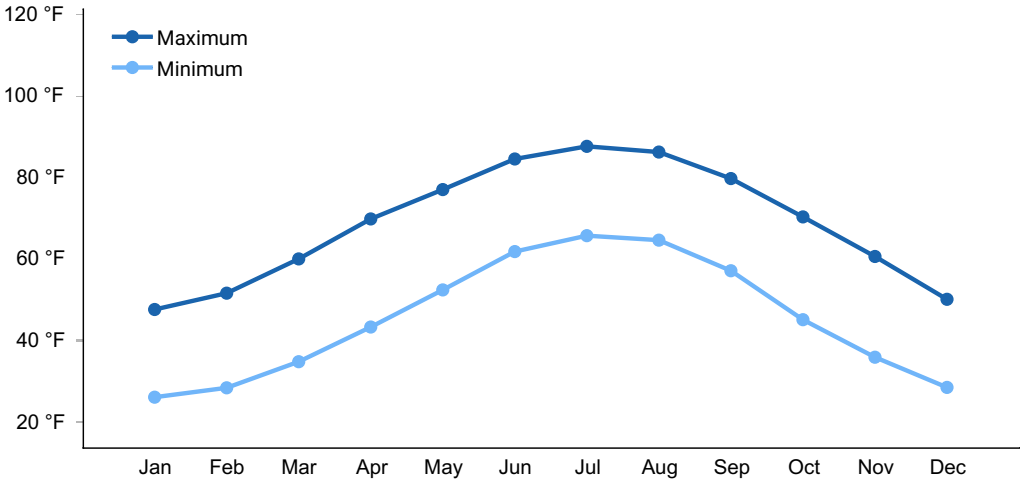


Figure 8. Monthly average minimum and maximum temperature

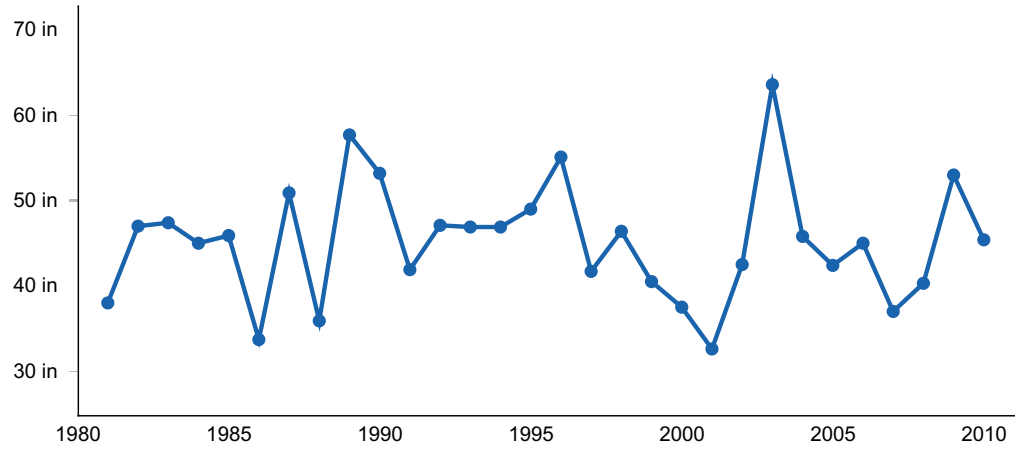


Figure 9. Annual precipitation pattern

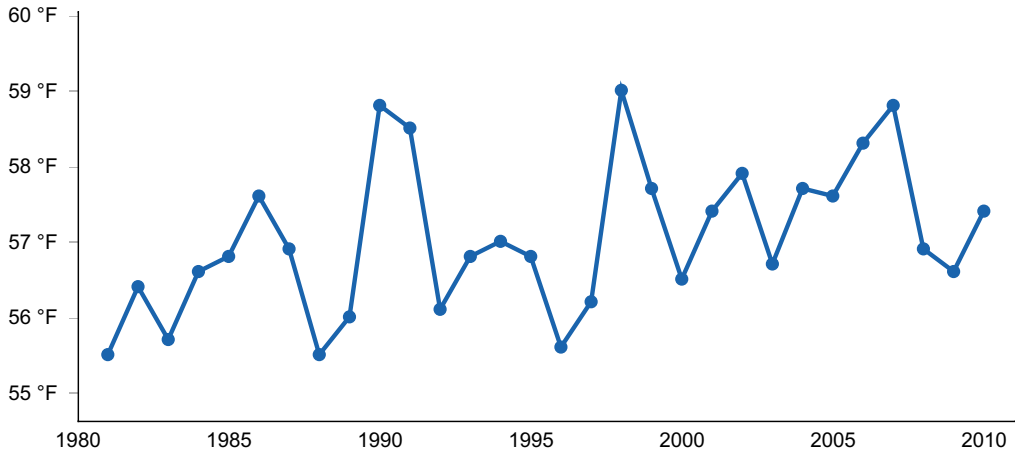


Figure 10. Annual average temperature pattern

Climate stations used

- (1) PIEDMONT TRIAD INTL AP [USW00013723], Greensboro, NC
- (2) HIGH POINT [USC00314063], High Point, NC
- (3) REIDSVILLE 2 NW [USC00317202], Reidsville, NC
- (4) MORGANTON [USC00315838], Morganton, NC
- (5) HICKORY FAA AP [USW00003810], Hickory, NC
- (6) STATESVILLE 2 NNE [USC00318292], Statesville, NC
- (7) SALISBURY [USC00317615], Salisbury, NC
- (8) LEXINGTON [USC00314970], Lexington, NC
- (9) WINSTON SALEM RYNLDS AP [USW00093807], Winston Salem, NC
- (10) YADKINVILLE 6 E [USC00319675], East Bend, NC
- (11) LENOIR [USC00314938], Lenoir, NC
- (12) TAYLORSVILLE [USC00318519], Taylorsville, NC
- (13) W KERR SCOTT RSVR [USC00319555], Wilkesboro, NC
- (14) NORTH WILKESBORO [USC00316256], Wilkesboro, NC
- (15) RURAL HALL [USC00317548], Rural Hall, NC
- (16) DANBURY [USC00312238], Danbury, NC

- (17) MT AIRY 2 W [USC00315890], Mount Airy, NC
- (18) DANVILLE RGNL AP [USW00013728], Danville, VA
- (19) DANVILLE [USC00442245], Danville, VA
- (20) BROOKNEAL [USC00441082], Brookneal, VA
- (21) CHATHAM [USC00441614], Chatham, VA
- (22) STUART [USC00448170], Stuart, VA
- (23) PHILPOTT DAM 2 [USC00446692], Henry, VA
- (24) MARTINSVILLE FLTR PLT [USC00445300], Martinsville, VA
- (25) ROCKY MT [USC00447338], Rocky Mount, VA
- (26) BEDFORD [USC00440551], Bedford, VA
- (27) LYNCHBURG RGNL AP [USW00013733], Lynchburg, VA
- (28) LYNCHBURG #2 [USC00445117], Lynchburg, VA
- (29) TYE RIVER 1 SE [USC00448600], Amherst, VA
- (30) APPOMATTOX [USC00440243], Appomattox, VA
- (31) BREMO BLUFF [USC00440993], New Canton, VA
- (32) PALMYRA 3S [USC00446491], Palmyra, VA
- (33) LOUISA [USC00445050], Louisa, VA

Influencing water features

This ecological site is not influenced by surface or ground water features.

Soil features

Soils on this ecological site are typically deep to very deep, well drained Ultisols. The available water storage capacity of the profile is greater than or equal to 6 inches. While representative soils associated with this ecological site do not have a root restrictive layer, the range of variability includes soils with unweathered or partially weathered bedrock within the rootzone of woody plants, at depths not less than 40 inches from the soil surface. Typically, parent materials are residuum derived from acidic igneous or metamorphic rock, such as granite, gneiss, schist, argillite, etc. Parent materials also include highly weathered mafic intrusive rock and highly weathered old alluvial sediments on high stream terraces not subject to flooding. Soils weathered from these materials are functionally similar to those that formed in acidic residuum.

Reaction in the subsoil is typically strongly acid to very strongly acid (pH 4.5 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 4.5 and 6.0. Base saturation is less than 35 percent in the subsoil.

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: Typic Kanhapludults, Typic Hapludults

Modal soil series include: Clifford, Nathalie, Fairview, Toast, and Poplar Forest
Other soils attributed to this ecological site include Appomattox, Beckham, Bentley, Buckhall, Buffstat, Casville, Colleen, Danripple, Diana Mills, Happyland, Huddleston, Littlejoe, Minnieville, Penhook, Rhodhiss, Tomlin, Westfield, Wintergreen, Yadkin, Yellowbottom, and several others.

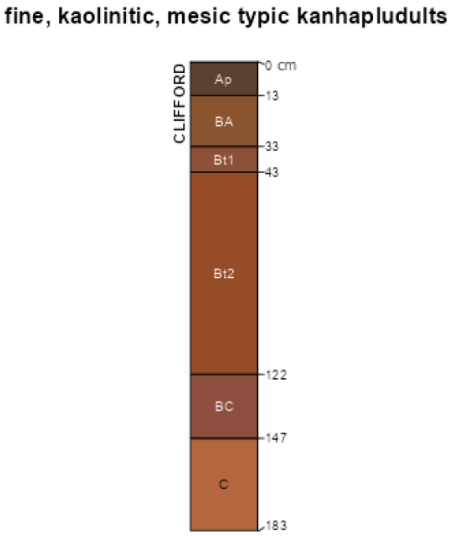


Figure 11. An illustration of a soil profile belonging to the Clifford series, a representative soil series associated with this ecological site.

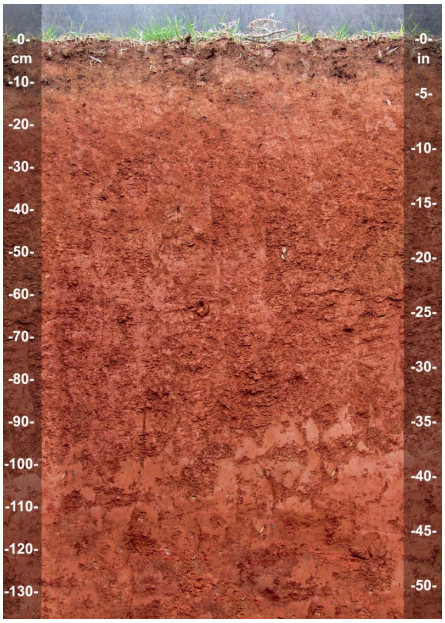


Figure 12. A soil profile of the Clifford series.

Table 5. Representative soil features

Parent material	(1) Residuum–igneous and metamorphic rock

Surface texture	(1) Sandy loam (2) Sandy clay loam (3) Loam (4) Fine sandy loam (5) Clay loam
Family particle size	(1) Fine (2) Fine-loamy
Drainage class	Well drained
Permeability class	Moderate to moderately rapid
Depth to restrictive layer	63–999 in
Soil depth	63–80 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-80in)	8–11 in
Soil reaction (1:1 water) (0-10in)	4.5–6
Subsurface fragment volume <=3" (0-80in)	0–8%
Subsurface fragment volume >3" (0-80in)	0–4%

Table 6. Representative soil features (actual values)

Drainage class	Well drained
Permeability class	Moderately slow to moderately rapid
Depth to restrictive layer	58–999 in
Soil depth	58–80 in
Surface fragment cover <=3"	0–1%
Surface fragment cover >3"	0–1%
Available water capacity (0-80in)	7–13 in
Soil reaction (1:1 water) (0-10in)	4.5–6.5
Subsurface fragment volume <=3" (0-80in)	0–19%
Subsurface fragment volume >3" (0-80in)	0–9%

Ecological dynamics

U.S. National Vegetation Classification (USNVC) associations that are consistent with reference conditions on this ecological site include CEGL008475 *Quercus alba* - *Quercus rubra* - *Carya tomentosa* / *Vaccinium stamineum* / *Desmodium nudiflorum* (USNVC 2022).

MATURE FORESTS
The reference state supports the typical, and historic, acidic oak-hickory forest of the Southern Piedmont. This forest type is arguably the most widespread non-ruderal forest type in the Piedmont, which before European settlement, covered large expanses of the uplands of the MLRA. Although old-growth stands are somewhat uncommon, it is still one of the most prevalent matrix forest types in the Southern Piedmont. It is a closed to somewhat open canopy forest dominated by mesophytic and dry-mesophytic oaks, with a much smaller contribution from hickories and pines, and with occasional dry-site oaks. The vegetation is distinguished from that of drier acidic ecological site concepts by the relative scarcity of dry-site oaks (e.g., *Q. marilandica*, *Q. stellata*, *Q. velutina*, *Q. montana*, *Q. coccinea*, *Q. falcata*, etc.). Several of these species may be present, but they are generally of low cover.

Under reference conditions, oaks are dominant in the canopy. White oak (*Quercus alba*) and northern red oak (*Quercus rubra*) are the principal species, of which white oak is usually more important. The hickory component of the canopy is of much lower cover. Most characteristic are mockernut hickory (*Carya tomentosa*) and pignut hickory (*Carya glabra*). Hickories tend to be much more abundant in the understory. Somewhat moister and cooler landscape positions typically favor a higher cover of northern red oak. This species is comparatively more abundant in the mesic soil temperature regime portion of the MLRA overall.

In mature stands, pines are typically scattered throughout the forest, with Virginia pine (*Pinus virginiana*) and shortleaf pine (*P. echinata*) usually being most important in the mesic soil temperature regime portion of the MLRA, though eastern white pine (*Pinus strobus*) can also be present. Tuliptree (*Liriodendron tulipifera*), though more abundant in the early stages of succession, is also characteristic of mature stands. Like the pine species, it is usually of low cover, colonizing and reproducing chiefly in canopy gaps.

In the subcanopy layer, representative species include flowering dogwood (*Cornus florida*), red maple (*Acer rubrum*), sourwood (*Oxydendrum arboreum*), American holly (*Ilex opaca*), blackgum (*Nyssa sylvatica*), American beech (*Fagus grandifolia*), and hickory (Carya spp.).

The shrub and herb layers are dominated by acid-loving flora, including those of the heath family, however the shrub and herb layers are less acidic in character than in drier and more infertile acidic uplands. Under reference conditions, the shrub layer is typically sparse, with seedlings and saplings of canopy species, or vines, occupying much of the cover.

Characteristic shrub species include deerberry (*Vaccinium stamineum*), Blue Ridge blueberry (*Vaccinium pallidum*), and bursting-heart (*Euonymus americanus*). Characteristic vines include muscadine (*Vitis rotundifolia*) and Virginia creeper (*Parthenocissus quinquefolia*).

Although the herb layer is generally sparse, it can be impressively species-rich under reference conditions, especially where fire has been reintroduced. Low species richness is often the result of long-term overgrazing by large deer populations. Species richness can be increased through effective deer population management, as well as through the reintroduction of regular, low-intensity ground fires.

Typical herbaceous species include nakedflower ticktrefoil (*Desmodium nudiflorum*), littlebrownjug (*Hexastylis arifolia*), Virginia heartleaf (*Hexastylis virginica*), striped prince's pine (*Chimaphila maculata*), crippled cranefly (*Tipularia discolor*), dimpled troutlily (*Erythronium umbilicatum*), downy rattlesnake plantain (*Goodyera pubescens*), and rattlesnakeweed (*Hieracium venosum*). Additional species representative of fire-maintained stands include devil's grandmother (*Elephantopus tomentosus*), hairy bedstraw (*Galium pilosum*), woodland sunflower (*Helianthus divaricatus*), several species of lespedeza (Lespedeza spp.) and ticktrefoil (Desmodium spp.), and an array of grasses and sedges.

DYNAMICS OF NATURAL SUCCESSION AND FIRE ECOLOGY

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. While the historic fire return interval is thought to be relatively similar across most of the Southern Piedmont uplands, moister sites were less prone to fire and hence burned less completely and at lower intensities than drier sites.

Like other moist oak-hickory forests in the region, successional dynamics are thought to be primarily gap-driven, with small-scale natural disturbances such as windthrow, drought, and disease, usually affecting only small portions of the forest at a time. Canopy gaps are readily colonized by early successional herbs and shrubs, and later by pines and opportunistic hardwoods. These localized events are inconspicuous, but cumulatively they help shape the age class distribution, structure, and species composition in these forests.

In the past, regular low-intensity fires would have kept the understory somewhat more open than at present and constrained the growth of fire-intolerant woody species. Periodic severe fires would have likely occurred during unusually dry and windy conditions, presumably resulting in catastrophic tree mortality and stand replacing changes. 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.

A combination of prescribed burns and selective removals can open up the understory and constrain the growth of fire-intolerant ruderal species, thereby restoring the health and vigor of forests that evolved under a more regular fire regime.

YOUNG SECONDARY FORESTS
On relatively undisturbed sites, stands are uneven-aged, with at least some old trees present. In areas that were cultivated in the recent past however, having been left idle for some time, even-aged pine stands dominate the landscape. These rapidly maturing pioneers are replaced by oaks and hickories only as the pines die.

In general, young secondary forests on this ecological site are dominated by Virginia pine (*P. virginiana*), along with opportunistic hardwoods such as sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), and tuliptree (*Liriodendron tulipifera*). Oaks and hickories are usually confined to the understory of young secondary stands. Their growth is temporarily suppressed by the cover of faster growing tree species.

Under a canopy of pines, a shift toward dry-site understory species is often observed. In the Southern Piedmont, old-field pine stands typically exhibit a sparse, xerophytic herb-shrub stratum, resulting from intense competition with the dominant pines, whose roots form a closed network within the upper few inches of soil. Low levels of sunlight and a thick layer of pine litter on the forest floor further suppress herb and shrub development. In such an environment, striped prince's pine (*Chimaphila maculata*), blueberry (Vaccinium sp.), and various other members of the heath family are well-adapted for survival (Billings 1938; Oosting 1942; Peet and Christensen 1980; Skeen et al. 1980; Felix III et al. 1983; Schafale and Weakley 1990; Cowell 1998; 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 rubra*, *Quercus falcata*, *Carya tomentosa*, *Carya glabra*, *Pinus echinata*, *Pinus virginiana*, *Liriodendron tulipifera*, *Quercus velutina*, *Quercus coccinea*, *Pinus strobus*

Subcanopy layer: *Cornus florida*, *Nyssa sylvatica*, Carya spp., *Acer rubrum*, *Diospyros virginiana*, *Fagus grandifolia*, *Oxydendrum arboreum*, *Ilex opaca*, *Prunus serotina*, *Liquidambar styraciflua*,

Vines/lianas: *Vitis rotundifolia*, *Smilax rotundifolia*, *Smilax glauca*, *Parthenocissus quinquefolia*, Loncera japonica (I),

Shrub layer: *Vaccinium stamineum*, *Vaccinium pallidum*, *Euonymus americanus*, *Viburnum acerifolium*, *Ilex opaca*, *Ligustrum sinense* (I), *Elaeagnus umbellata* (I)

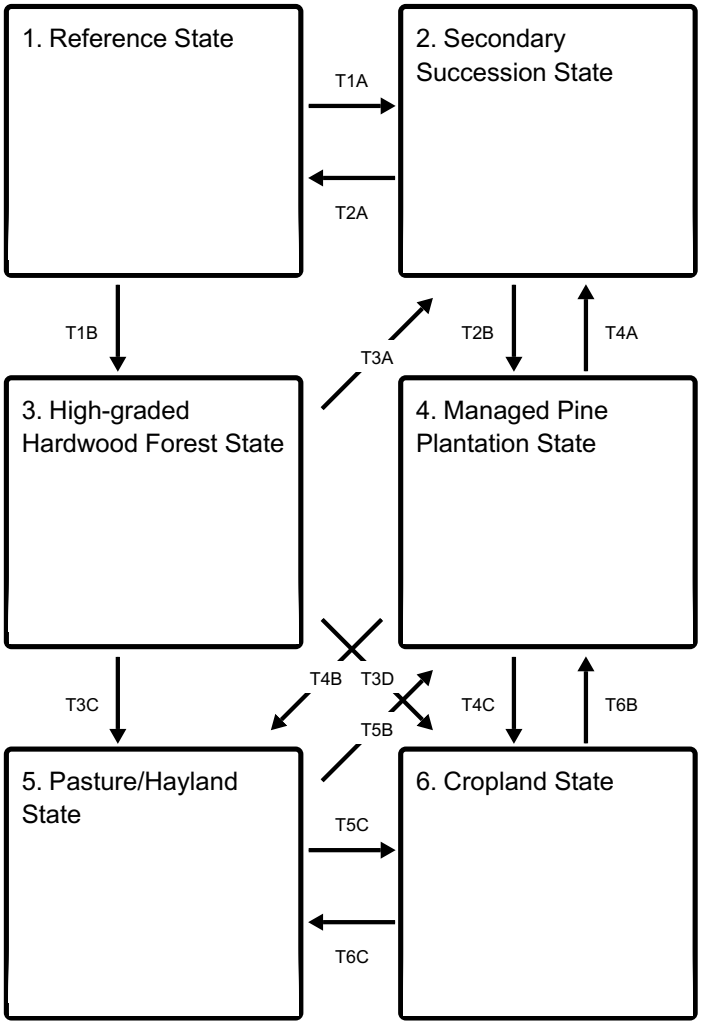
Herb layer - forbs: *Desmodium nudiflorum*, *Hexastylis arifolia*, *Hexastylis virginica*, *Chimaphila maculata*, *Asplenium platyneuron*, *Tipularia discolor*, *Erythronium umbilicatum*, *Elephantopus tomentosus*, *Goodyera pubescens*, *Hieracium venosum*, *Helianthus divaricatus*, *Galium pilosum*, *Hypoxis hirsuta*, *Aristolochia serpentaria*, *Cypripedium acaule*, Desmodium spp., Lespedeza spp., *Helianthus divaricatus*

Herb layer - graminoids: Dichanthelium spp., *Danthonia spicata*, Carex spp. (cephalophora, albicans, digitalis, hirsutella, laxiflora)

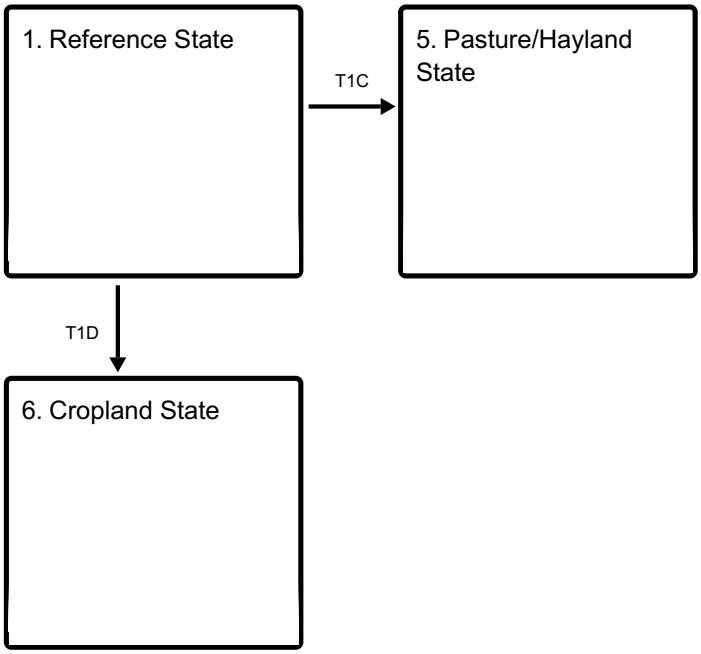
(I) = introduced

State and transition model

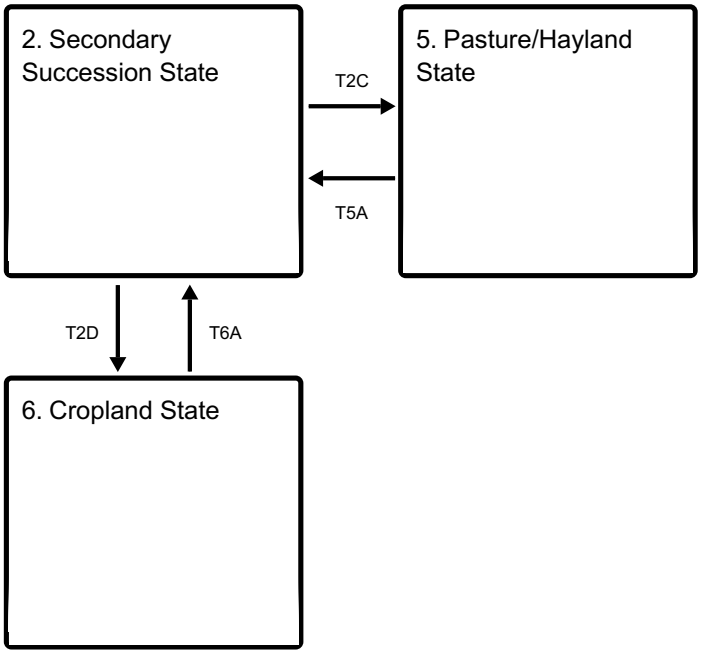
Ecosystem states



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.

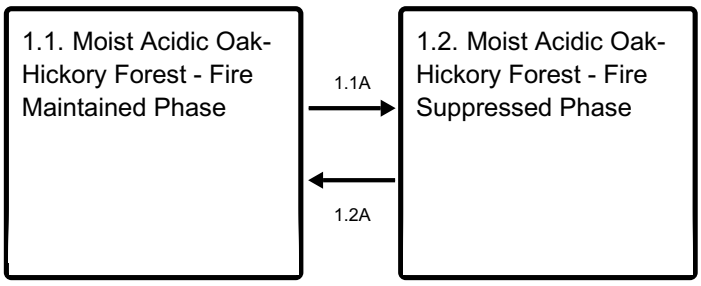
T5C - Seedbed preparation, applications of fertilizer/lime, weed control, and planting of crop or cover crop seed.

T6A - Agricultural abandonment.

T6B - Site preparation and tree planting.

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

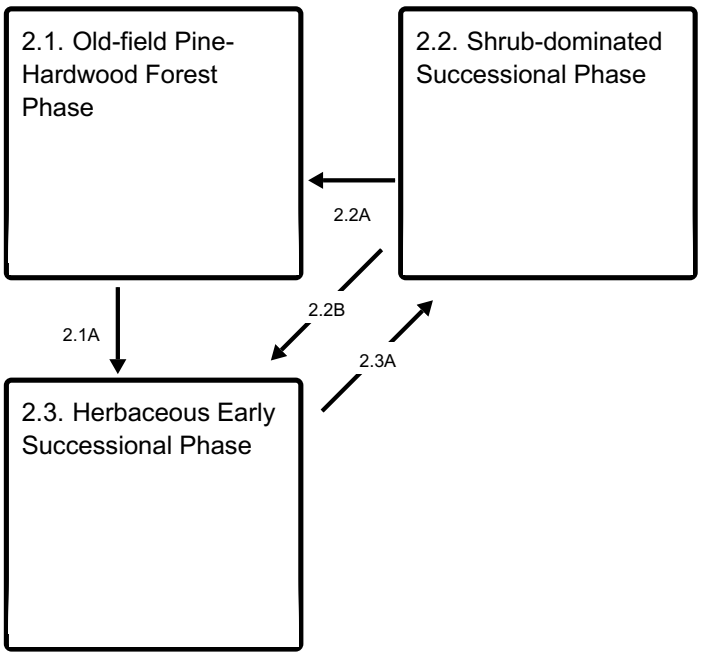
State 1 submodel, plant communities



1.1A - Long-term exclusion of fire.

1.2A - Prescribed burns and selective removals.

State 2 submodel, plant communities



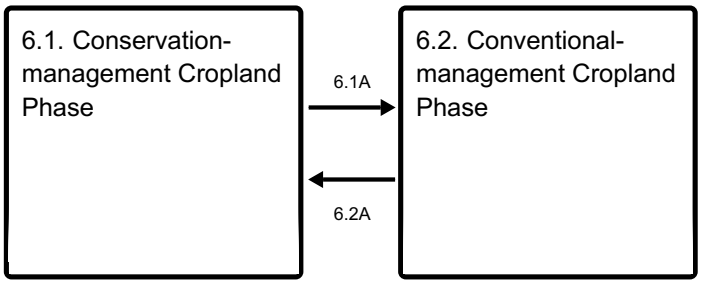
2.1A - Clearcut logging.

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 mesophytic and dry-mesophytic oaks, with a much smaller contribution from hickories and pines, and with occasional dry-site oaks.

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
Moist Acidic Oak-Hickory Forest - Fire Maintained Phase

This is a closed to somewhat 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 oaks. Representative species include white oak (Quercus alba) and northern red oak (Quercus rubra). Hickories and pines make a smaller contribution to the canopy. Representative hickory species include pignut hickory (Carya glabra) and mockernut hickory (Carya tomentosa).

Forest understory. Representative understory tree species include flowering dogwood (Cornus florida), sourwood (Oxydendrum arboreum), blackgum (Nyssa sylvatica), and hickory (Carya spp.)

Representative understory shrub species include deerberry (Vaccinium stamineum), Blue Ridge blueberry (Vaccinium pallidum), bursting-heart (Euonymus americanus), and mapleleaf viburnum (Viburnum acerifolium).

Dominant plant species

- white oak (*Quercus alba*), tree
- northern red oak (*Quercus rubra*), tree
- southern red oak (*Quercus falcata*), tree
- pignut hickory (*Carya glabra*), tree
- mockernut hickory (*Carya tomentosa*), tree
- shortleaf pine (*Pinus echinata*), tree
- flowering dogwood (*Cornus florida*), tree
- blackgum (*Nyssa sylvatica*), tree
- common persimmon (*Diospyros virginiana*), tree
- sourwood (*Oxydendrum arboreum*), tree
- deerberry (*Vaccinium stamineum*), shrub
- Blue Ridge blueberry (*Vaccinium pallidum*), shrub
- bursting-heart (*Euonymus americanus*), shrub
- mapleleaf viburnum (*Viburnum acerifolium*), shrub
- blackberry (*Rubus*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- rosette grass (*Dichanthelium*), grass
- poverty oatgrass (*Danthonia spicata*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- oval-leaf sedge (*Carex cephalophora*), grass
- whitetinge sedge (*Carex albicans*), grass
- splitbeard bluestem (*Andropogon ternarius*), grass
- little bluestem (*Schizachyrium scoparium*), grass
- nakedflower ticktrefoil (*Desmodium nudiflorum*), other herbaceous
- littlebrownjug (*Hexastylis arifolia*), other herbaceous
- dimpled troutlily (*Erythronium umbilicatum*), other herbaceous
- crippled cranefly (*Tipularia discolor*), other herbaceous
- lespedeza (*Lespedeza*), other herbaceous
- ticktrefoil (*Desmodium*), other herbaceous
- devil's grandmother (*Elephantopus tomentosus*), other herbaceous

- woodland sunflower (*Helianthus divaricatus*), other herbaceous
- hairy bedstraw (*Galium pilosum*), other herbaceous
- Virginia snakeroot (*Aristolochia serpentaria*), other herbaceous

Community 1.2
Moist Acidic Oak-Hickory Forest - Fire Suppressed Phase

This is a 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. The pine component can have a greater proportion of Virginia pine and the understory usually contains a greater proportion of fire-intolerant species. The herbaceous understory is typically sparse.

Forest overstory. The overstory is dominated by oaks. Representative species include white oak (Quercus alba) and northern red oak (Quercus rubra). Hickories and pines make a smaller contribution to the canopy. Representative hickory species include pignut hickory (Carya glabra) and mockernut hickory (Carya tomentosa).

Forest understory. Representative understory tree species include flowering dogwood (Cornus florida), sourwood (Oxydendrum arboreum), blackgum (Nyssa sylvatica), and hickory (Carya spp.), along with fire-intolerant species such as American beech (Fagus grandifolia), American holly (Ilex opaca), and red maple (Acer rubrum).

Representative understory shrub species include deerberry (Vaccinium stamineum), Blue Ridge blueberry (Vaccinium pallidum), bursting-heart (Euonymus americanus), American holly (Ilex opaca), and mapleleaf viburnum (Viburnum acerifolium).

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

Dominant plant species

- white oak (*Quercus alba*), tree
- northern red oak (*Quercus rubra*), tree
- southern red oak (*Quercus falcata*), tree
- pignut hickory (*Carya glabra*), tree
- mockernut hickory (*Carya tomentosa*), tree
- Virginia pine (*Pinus virginiana*), tree
- flowering dogwood (*Cornus florida*), tree
- American holly (*Ilex opaca*), tree
- red maple (*Acer rubrum*), tree
- American beech (*Fagus grandifolia*), tree
- deerberry (*Vaccinium stamineum*), shrub
- Blue Ridge blueberry (*Vaccinium pallidum*), shrub
- bursting-heart (*Euonymus americanus*), shrub
- American holly (*Ilex opaca*), shrub
- muscadine (*Vitis rotundifolia*), shrub

- roundleaf greenbrier (*Smilax rotundifolia*), shrub
- cat greenbrier (*Smilax glauca*), shrub
- Virginia creeper (*Parthenocissus quinquefolia*), shrub
- mapleleaf viburnum (*Viburnum acerifolium*), shrub
- oval-leaf sedge (*Carex cephalophora*), grass
- slender woodland sedge (*Carex digitalis*), grass
- nakedflower ticktrefoil (*Desmodium nudiflorum*), other herbaceous
- littlebrownjug (*Hexastylis arifolia*), other herbaceous
- Virginia heartleaf (*Hexastylis virginica*), other herbaceous
- dimpled troutlily (*Erythronium umbilicatum*), other herbaceous
- crippled cranefly (*Tipularia discolor*), other herbaceous
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous
- striped prince's pine (*Chimaphila maculata*), other herbaceous
- downy rattlesnake plantain (*Goodyera pubescens*), 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
Old-field Pine-Hardwood Forest Phase

This forested 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 pines, though opportunistic hardwoods can also be important, particularly in the early stages of tree establishment. Species that exhibit pioneering traits are usually most abundant.

Forest overstory. The overstory is typically dominated by 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 red maple (Acer rubrum), blackgum (Nyssa sylvatica), eastern redcedar (Juniperus virginiana), and American beech (Fagus grandifolia). 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 and the pines begin to die off.

In the shrub layer, representative species include American holly (Ilex opaca), various blueberries (Vaccinium spp.), and several vines.

Dominant plant species

- Virginia pine (*Pinus virginiana*), tree
- red maple (*Acer rubrum*), tree
- shortleaf pine (*Pinus echinata*), tree
- blackgum (*Nyssa sylvatica*), tree
- American beech (*Fagus grandifolia*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- tuliptree (*Liriodendron tulipifera*), tree
- sassafras (*Sassafras albidum*), tree
- oak (*Quercus*), tree
- hybrid hickory (*Carya*), tree
- American holly (*Ilex opaca*), shrub
- muscadine (*Vitis rotundifolia*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- roundleaf greenbrier (*Smilax rotundifolia*), shrub
- Virginia creeper (*Parthenocissus quinquefolia*), shrub
- eastern poison ivy (*Toxicodendron radicans*), shrub

- blueberry (*Vaccinium*), shrub
- Chinese privet (*Ligustrum sinense*), shrub
- littlehead nutrush (*Scleria oligantha*), grass
- striped prince's pine (*Chimaphila maculata*), other herbaceous
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous
- sparselobe grapefern (*Botrychium biternatum*), other herbaceous
- moccasin flower (*Cypripedium acaule*), 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. Species composition varies considerably from location to location. Non-native species usually occupy some portion of the vine or shrub cover in most examples.

Dominant plant species

- Callery pear (*Pyrus calleryana*), tree
- princesstree (*Paulownia tomentosa*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- winged elm (*Ulmus alata*), tree
- tree of heaven (*Ailanthus altissima*), tree
- black cherry (*Prunus serotina*), tree
- silktree (*Albizia julibrissin*), tree
- Chickasaw plum (*Prunus angustifolia*), tree
- black locust (*Robinia pseudoacacia*), tree
- blackberry (*Rubus*), shrub
- rose (*Rosa*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- winged sumac (*Rhus copallinum*), shrub
- autumn olive (*Elaeagnus umbellata*), shrub
- greenbrier (*Smilax*), shrub
- grape (*Vitis*), shrub
- Chinese privet (*Ligustrum sinense*), shrub
- eastern poison ivy (*Toxicodendron radicans*), shrub
- Johnsongrass (*Sorghum halepense*), 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 wild lettuce (Lactuca spp.), sericea lespedeza (*Lespedeza cuneata*), vetch (Vicia spp.), dock (Rumex spp.), yellow crownbeard (*Verbesina occidentalis*), dwarf dandelion (*Krigia virginica*), Indianhemp (*Apocynum cannabinum*), beggarticks (Bidens spp.), slender yellow woodsorrel (*Oxalis dillenii*), Queen Anne's lace (*Daucus carota*), morning-glory (Ipomoea spp.), garden cornflower (*Centaurea cyanus*), dwarf cinquefoil (*Potentilla canadensis*), common mullein (*Verbascum thapsus*), evening primrose (Oenothera spp.), hairy cat's ear (*Hypochaeris radicata*), spiny sowthistle (*Sonchus asper*), 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
- broomsedge bluestem (*Andropogon virginicus*), grass
- hairy crabgrass (*Digitaria sanguinalis*), grass
- smooth crabgrass (*Digitaria ischaemum*), grass
- southern crabgrass (*Digitaria ciliaris*), grass
- Japanese bristlegrass (*Setaria faberi*), grass
- Johnsongrass (*Sorghum halepense*), grass
- annual bluegrass (*Poa annua*), grass
- American burnweed (*Erechtites hieraciifolius*), other herbaceous
- American pokeweed (*Phytolacca americana*), other herbaceous
- Canada goldenrod (*Solidago altissima*), other herbaceous
- Canadian horseweed (*Conyza canadensis*), other herbaceous
- annual ragweed (*Ambrosia artemisiifolia*), other herbaceous
- aster (*Symphyotrichum*), other herbaceous
- thoroughwort (*Eupatorium*), 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 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

- red maple (*Acer rubrum*), tree
- American beech (*Fagus grandifolia*), tree
- American holly (*Ilex opaca*), tree
- blackgum (*Nyssa sylvatica*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- flowering dogwood (*Cornus florida*), tree
- oak (*Quercus*), tree
- hybrid hickory (*Carya*), 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
- red maple (*Acer rubrum*), tree
- blackgum (*Nyssa sylvatica*), tree
- sweetgum (*Liquidambar styraciflua*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- Virginia pine (*Pinus virginiana*), tree
- black cherry (*Prunus serotina*), tree
- flowering dogwood (*Cornus florida*), tree
- American beech (*Fagus grandifolia*), tree
- oak (*Quercus*), tree
- hybrid hickory (*Carya*), tree
- American holly (*Ilex opaca*), shrub
- blueberry (*Vaccinium*), shrub
- grape (*Vitis*), shrub
- Japanese honeysuckle (*Lonicera japonica*), shrub
- greenbrier (*Smilax*), shrub
- blackberry (*Rubus*), shrub
- St. Johnswort (*Hypericum*), shrub
- autumn olive (*Elaeagnus umbellata*), shrub
- rosette grass (*Dichanthelium*), grass
- littlehead nutrush (*Scleria oligantha*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- striped prince's pine (*Chimaphila maculata*), other herbaceous
- ebony spleenwort (*Asplenium platyneuron*), other herbaceous
- sericea lespedeza (*Lespedeza cuneata*), other herbaceous
- moccasin flower (*Cypripedium acaule*), other herbaceous
- aster (*Symphyotrichum*), other herbaceous
- thoroughwort (*Eupatorium*), 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. Soil Fertility and pH Management: Like overgrazing and excessive foot traffic, inadequate soil fertility and pH management can lead to invasion from several common weeds of pastures and hayfields. Species indicative of poor soil fertility and/or suboptimal pH on this ecological site include broomsedge bluestem (*Andropogon virginicus*), sweet vernalgrass (*Anthoxanthum odoratum*), dogfennel (*Eupatorium capillifolium*), Japanese clover (*Kummerowia striata*), common sheep sorrel (*Rumex acetosella*), and Carolina horsenettle (*Solanum carolinense*), among others. Most of these weedy invaders do not compete well in dense, rapidly growing pastures and hayfields. By maintaining soil fertility and pH, managing grazing to favor desirable forage species, and clipping behind grazing rotations when needed, forage grasses and forbs can usually outcompete weedy invaders. Brush Encroachment: Brush encroachment can be problematic in some pastures, particularly near fence lines where there is often a ready seed source. Pastures subject to low stocking density and long-duration grazing rotations can also be susceptible to encroachment from woody plants. Shorter grazing rotations of higher stocking density can help alleviate pressure from shrubs and vines with low palatability or thorny stems. Clipping behind grazing rotations, annual brush hogging, and multispecies grazing systems (cattle with or followed by goats) can also be helpful. Common woody invaders of pasture on this ecological site include rose (Rosa spp.), blackberry (Rubus spp.), saw greenbrier (*Smilax bona-nox*), Japanese honeysuckle (*Lonicera japonica*), common persimmon (*Diospyros virginiana*), eastern redcedar (*Juniperus virginiana*), black cherry (*Prunus serotina*), and Chinese privet (*Ligustrum sinense*).

Dominant plant species

- tall fescue (*Schedonorus arundinaceus*), grass
- dallisgrass (*Paspalum dilatatum*), grass
- orchardgrass (*Dactylis glomerata*), grass

- perennial ryegrass (*Lolium perenne*), grass
- purpletop tridens (*Tridens flavus*), grass
- Johnsongrass (*Sorghum halepense*), grass
- hairy crabgrass (*Digitaria sanguinalis*), grass
- broomsedge bluestem (*Andropogon virginicus*), grass
- Bermudagrass (*Cynodon dactylon*), grass
- sweet vernalgrass (*Anthoxanthum odoratum*), grass
- Kentucky bluegrass (*Poa pratensis*), 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
- 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-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) 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) herbicide application, 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):**

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

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

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

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

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

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

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

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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):**

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

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

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

17. **Perennial plant reproductive capability:**