USDA Natural Resources Conservation Service

Ecological site F147XY003PA
Mixed Limestone Upland

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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): 147X–Northern Appalachian Ridges and Valleys

Major Land Resource Area 147 is in the Middle section of the Valley and Ridge Province of the Appalachian Highlands. Characteristic features include folded and faulted parallel ridges and valleys that are carved out of anticlines, synclines, and thrust blocks. The variability of weathering of the underlying bedrock has resulted in resistant sandstone and shale ridges separated by less resistant limestone and shale narrow to moderately broad valleys. The ridges are strongly sloping to extremely steep and have narrow, rolling crests, and the valleys are mainly level to strongly sloping. The Great Valley is a salient feature of the eastern portion and runs the entire length of the MLRA where it is called the Shenandoah Valley in the south. The western side of the MLRA is dominantly hilly to very steep and is rougher and much steeper than the rolling hills to the east. Parts of the northernmost section of the MLRA were subjected to pre-Illinoian glaciation (>770,000 years ago). Anthracite coal underlies some areas in the north and has been mined since the 1700's.

Elevation in MLRA 147 generally ranges from 330 to 985 feet (100 to 300 meters) in the valleys and from 1,310 to 2,625 feet (400 to 800 meters) on the ridges and mountains. It is as high as 2,955 feet (900 meters) on some mountain crests and is nearly 4,430 feet (1,350 meters) on a few isolated, linear mountain ridges. Local relief in the valleys is about 15 to 165 feet (5 to 50 meters). The ridges rise about 660 feet (200 meters) above the adjoining valleys. (USDA, 2006).

Classification relationships

This ecological site is found in Major Land Resource Area 147- Northern Appalachian Ridges and Valleys, 148. MLRA 147 is located within Land Resource Region S - Northern Atlantic Slope Diversified Farming Region (USDA 2006), and in United States Forest Service ecoregion M221 – Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province (Bailey 1995). In addition, MLRA 147 falls within area #67 of EPA Ecoregion Level III – the Ridge and Valley (US EPA, 2013). The Mixed Limestone Ecological Site occurs within 67a, Northern Limestone/Dolomite Valleys of EPA Ecoregion IV (Woods et. al. 1996).

Ecological site concept

The Mixed Limestone Upland Forest occurs throughout MLRA 147 on hills and low ridges within valleys underlain by limestone, dolomite, and calcareous shales and siltstones. This ecological site includes shallow and moderately deep areas that are often intermixed with the deeper soils, due to the karst nature of these landscapes. Limestone bedrock that underlies these areas is typically tilted on end and will weather into pinnacles and sinkholes, often within a few meters of each other. In some areas, limestone outcrops occur on the surface. Depth to bedrock in the deeper soils is typically greater than 40 inches (101 cm) and can quite often be greater than 60 inches (152cm). Under shallower sites, bedrock will occur less than 20 inches (51 cm) from the surface. The soils are relatively high in pH compared to the acidic sandstones and shales in the surrounding higher elevation ridges. Landscapes are well drained, and in some cases water movement through the profile can be quite rapid if there are significant cracks and fissures in the underlying bedrock.

The majority of these areas are cleared for agricultural production. Existing woodlands and forests generally contain *Quercus alba* (White oak), *Quercus muehlenbergii* (Chinquapin oak), *Quercus rubra* (Northern red oak), *Quercus velutina* (Black oak), various Carya spp. (Hickory), Fraxinus Americana (White ash), *Liriodendron tulipifera* (Tuliptree), *Juglans nigra* (Black walnut), and *Acer saccharum* (Sugar maple). *Quercus muehlenbergii* (Chinquapin oak) is indicative of the limestone substrate.

Table 1. Dominant plant species

Tree	(1) *Quercus muehlenbergii* (2) *Quercus alba*
Shrub	(1) *Viburnum prunifolium*
Herbaceous	Not specified

Physiographic features

This ecological site is found on gently rolling hills, slight to steep slopes, and in karst topography within the limestone valleys of MLRA 147. The parent material is limestone, dolomite, with some calcareous shales, siltstones and fine-grained sandstones. This site differs from the hills and mountains of the surrounding higher elevation ridges that are underlain by acidic shales, siltstones, and sandstones, and from similar but steeper landscapes on limestone soils that are shallow to moderately deep. Depth to bedrock in the mixed limestone uplands ecological site is typically greater than 40 inches (101cm) and often is below 60inches (152cm). Shallower sites may have bedrock less than 20 inches (51cm) from the surface. In some areas, limestone crops out at the surface, but generally soils are moderately deep to deep, well drained, and not subject to flooding or ponding.

Table 2. Representative physiographic features

Landforms	(1) Valley (2) Hill
Flooding frequency	None
Ponding frequency	None
Elevation	30–914 m
Slope	0–55%
Water table depth	69–152 cm
Aspect	Aspect is not a significant factor

Climatic features

The climate of this region is temperate and humid. The Ridge and Valley Province is not rugged enough for a true mountain type of climate but it does have many of the characteristics of such a climate (Daily 1971). The influence of the high and low topography on air movement causes somewhat greater temperature extremes than are experienced in the Piedmont region to the east. The differences in elevation also affect the length of the frost free season on the ridges verses that in the valleys. The cooler temperatures and the shorter freeze-free periods occur at the higher elevations and in the more northern latitudes. The maximum precipitation occurs from early spring through mid-summer, and the minimum occurs in January and February. The average annual snowfall ranges from 16 to more than 51 inches (40 to 130 centimeters). The average annual temperature is 44 to 57 degrees F (7 to 14 degrees C). A portion of this region that extends from Maryland southward through most of the Shenandoah Valley in Virginia falls within a rain shadow cast by the Appalachian Mountains to the west and the Blue Ridge Mountains to the east. The mountains on either side block moist flowing air from either the east or the west causing the valleys to be drier. Average annual precipitation in this shadow area can average 34 to 36 in/year (86 to 91cm) compared to 40 to 42 in/year (102 - 107 cm) for the rest of the region (PRISM 2013).

Data for mean annual precipitation, frost-free and freeze-free periods and monthly precipitation for this ecological site are shown below. The original data used in developing the tables was obtained from the USDA-NRCS National Water & Climate Center (2015) climate information database for 8 weather stations throughout MLRA 147 in proximity to this ecological site. All climate station monthly averages for maximum and minimum temperature and

precipitation were then added together and averaged to make this table.

Table 3. Representative climatic features

Frost-free period (average)	145 days
Freeze-free period (average)	174 days
Precipitation total (average)	1,041 mm

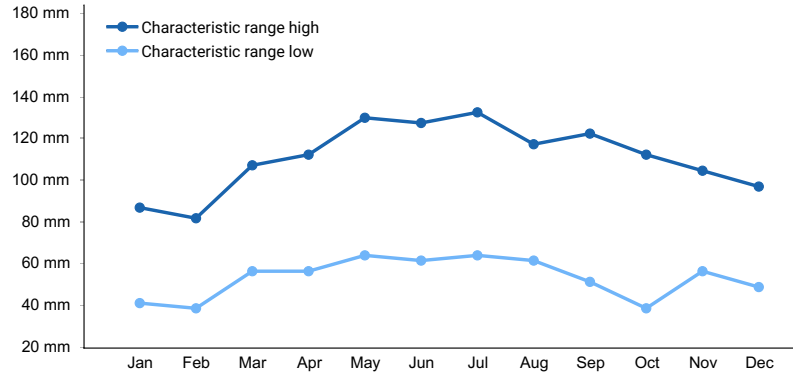


Figure 1. Monthly precipitation range

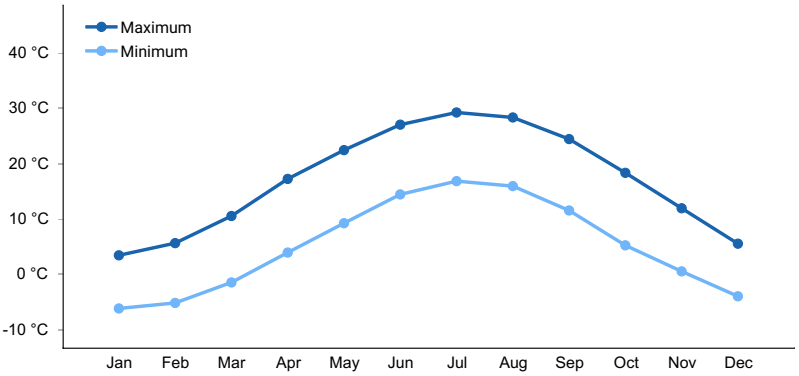


Figure 2. Monthly average minimum and maximum temperature

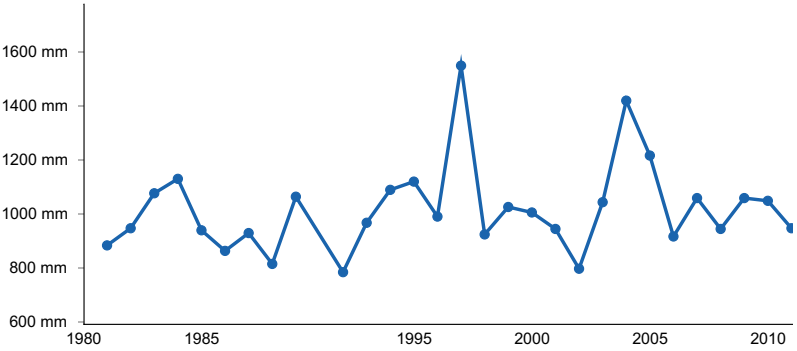


Figure 3. Annual precipitation pattern

Climate stations used

- (1) EVERETT [USC00362721], Everett, PA
- (2) DALE ENTERPRISE [USC00442208], Dayton, VA
- (3) FRANKLIN 2 NE [USC00463215], Franklin, WV
- (4) HAMBURG [USC00363632], Hamburg, PA
- (5) LEWISBURG [USC00364976], Lewisburg, PA
- (6) STATE COLLEGE [USC00368449], State College, PA
- (7) WINCHESTER 7 SE [USC00449186], Winchester, VA

- (8) CHAMBERSBURG 1 ESE [USC00361354], Chambersburg, PA

Influencing water features

This ecological site is not influenced by wetland or riparian water features.

Soil features

The soil series associated with this site are: Wurno, Westmoreland, Webbtown, Watahala, Washington, Vertrees, Vanella, Timberville, Swimley, Swanpond, Ryder, Opequon, Poplimento, Pecktonville, Oaklet, Nollville, Needmore, Morrison, Millheim, Mertz, Lodi, Litz, Hublersburg, Hayter, Hagerstown, Groseclose, Frederick, Frankstown, Faywood, Endcav, Elliber, Edom, Dunmore, Duffield, Christian, Chilhowie, Carbo, Caneyville, Bookwood, Belmont,and Allenwood. They have weathered from limestone, dolomite, calcareous shales, siltstones, sandstones, phyllite, quartzite, and cherty limestone. The soils have developed from bedrock that has weathered in place, called residuum, and in some cases from materials that have moved from upper to lower slope positions, called colluvium, or less commonly, from pre-Illinoian glacial till (>770,000 years before present). Soils data was obtained from the Natural Resources and Conservation Service (NRCS) National Soils Information System database (USDA 2015).

The soils are well drained with the seasonal high water table at 27 to 60 inches (68 to 152cm) depth or deeper. Depth to bedrock varies from less than 20 inches (51cm) to greater than 60 inches (152 cm). Soil surface textures are mostly silt loams and fine sandy loams, but can be silty clay loam if they have undergone extensive erosion. Subsurface textures are clayey. Water movement through the soil profile can be very slow to rapid depending on the underlying bedrock. In areas where the underlying limestone has many fissures and cracks, water movement can be quite rapid. Soil pH is generally around 5.0 to 6.0, but can be higher than 7.0 in the shallowest areas where limestone or calcareous bedrock outcrops are present.

Table 4. Representative soil features

Parent material	(1) Residuum–limestone (2) Colluvium–dolomite (3) Till–calcareous shale
Surface texture	(1) Channery silt loam (2) Very channery silty clay loam (3) Gravelly
Family particle size	(1) Loamy
Drainage class	Moderately well drained to well drained
Permeability class	Very slow to rapid
Soil depth	15–231 cm
Surface fragment cover <=3"	1–9%
Surface fragment cover >3"	1–9%
Available water capacity (0-101.6cm)	2.54–18.54 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	4.6–7.3
Subsurface fragment volume <=3" (Depth not specified)	0–45%

Subsurface fragment volume >3" (Depth not specified)	0–80%

Ecological dynamics

The vegetation groupings described in this section are based on the terrestrial ecological system classification and vegetation associations developed by NatureServe (Comer 2003) and the Natural Heritage Programs of Pennsylvania (Zimmerman et al. 2012), Virginia (Fleming et al. 2013), West Virginia (WVDNR 2014), and Maryland (Harrison 2004). Terrestrial ecological systems are specifically defined as a group of plant community types (associations) that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. They are intended to provide a classification unit that is readily mappable, often from remote imagery, and readily identifiable by conservation and resource managers in the field. A given system will typically manifest itself in a landscape at intermediate geographic scales of tens to thousands of hectares and will persist for 50 or more years. A vegetation association is a plant community that is much more specific to a given soil, geology, landform, climate, hydrology, and disturbance history. It is the basic unit for vegetation classification. Each association will be named by the dominant species that occupy the different strata (tree, sapling, shrub, and herb). Within the NatureServe database, individual vegetation associations are assigned an identification number called a Community Element Global Code (CEGL).

The Mixed Limestone Upland Ecological Site is located in the Ridge and Valley region of the Appalachian Highlands, an area that has undergone extensive human disturbance since pre and post-European settlement times (Braun, 1950). This ecological site is found on hills and steep to moderately steep slopes, and in karst topography within the limestone valleys of MLRA 147. The parent material is limestone, dolomite, with some calcareous shales, siltstones and fine-grained sandstones.

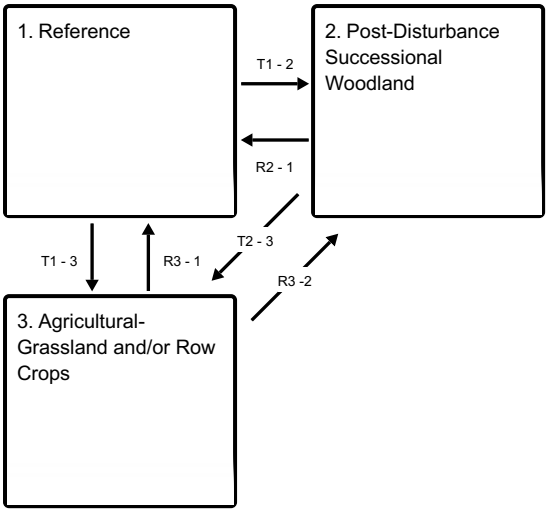
The reference state is a combination of several associations of the Northeastern Interior Dry-Mesic Oak Forest System (CES202.592)and the Central Appalachian Alkaline Glade and Woodland System (CES202.602) as described by NatureServe (NatureServe 2009). The Northeastern Interior Dry-Mesic Oak Forests are one of the most widespread forest systems throughout the northeastern and northcentral U.S. They occur in dry-mesic settings, are typically closed canopy forests, and cover large expanses at low to mid elevations. Particular tree species found on the Limestone Uplands ecological site are *Quercus muehlenbergii* (Chinquapin oak), *Quercus alba* (White oak), *Quercus rubra* (Northern red oak), *Quercus velutina* (Black oak), various Carya spp. (Hickory), Fraxinus Americana (White ash), *Liriodendron tulipifera* (Tuliptree), *Juglans nigra* (Black walnut), and *Acer saccharum* (Sugar maple). *Quercus muehlenbergii* (Chinkapin oak) is indicative of the limestone substrate and will appear where bedrock is closer to the surface, slopes are steeper, and the soil is less weathered resulting in areas of relatively higher pH.

Forests and woodlands occupying the shallowest, steepest, and most convex parts of this ecological site are part of the Appalachian Alkaline Glade and Woodland System. These communities occupy mid-elevation ridges, slopes, and outcrops where soil is thin over calcareous bedrock and forest cover is patchy. *Juniperus virginiana* (Eastern redcedar) is a common tree, filling in areas with the absence of fire. *Quercus muehlenbergii* (Chinquapin oak), Rhus aromatic (Fragrant sumac), *Cercis canadensis* (Eastern redbud), and *Ostrya virginiana* (Hophornbeam) may occur and prairie grasses are the dominant herbs. These may include *Andropogon gerardii* (Big bluestem), *Schizachyrium scoparium* (Little bluestem), and Bouteloua spp. (Grama grass).

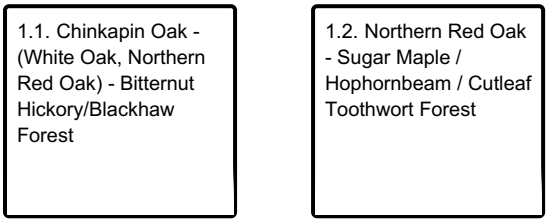
Mature forest stands today may be quite different than those of pre-European settlement. Due to the inherent fertility and good drainage of these limestone derived landscapes, most areas have been converted to agriculture with the exception of some of the steepest, most shallow, or rocky sites. The most common alternative state associated with this ecological site is cropland. In limited areas where cropland has been abandoned, the vegetation community is an invaded successional woodland. Common species are *Juniperus virginiana* (Eastern redcedar), *Robinia pseudoacacia* (Black locust), *Liriodendron tulipifera* (Tuliptree), and *Prunus serotina* (Black cherry). Nonnative species include *Lonicera japonica* (Japanese Honeysuckle), *Berberis thunbergii* (Japanese Barberry), *Alliaria petiolata* (Garlic mustard), and *Microstegium vimineum* (Japanese stiltgrass).

State and transition model

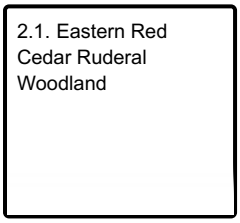
Ecosystem states



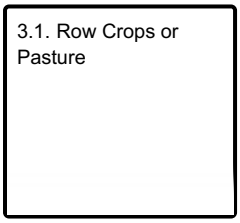
State 1 submodel, plant communities



State 2 submodel, plant communities



State 3 submodel, plant communities



State 1
Reference

The reference state is a combination of several associations of the Northeastern Interior Dry-Mesic Oak Forest System (CES202.592) and the Central Appalachian Alkaline Glade and Woodland System (CES202.602) as defined by NatureServe (NatureServe 2009). Due to the long history of human activity, the associations listed below may in reality reflect the current naturalized, minimally managed state rather than the historic, pre-European settlement condition. Due to the heterogeneity and the broadness of this provisional ecological unit, the vegetation associations listed below are not intended to cover every situation nor the full range of conditions and species.

There are no transition pathways designated between the communities in the reference state because the differences in vegetation are more controlled by landscape position than management or disturbance.

Community 1.1
Chinkapin Oak - (White Oak, Northern Red Oak) - Bitternut Hickory/Blackhaw Forest

Quercus muehlenbergii - Quercus (alba, rubra) - *Carya cordiformis* / *Viburnum prunifolium* Forest The Chinquapin Oak - (White Oak, Northern Red Oak) - Bitternut Hickory / Blackhaw Forest, also known as the Southern Appalachian Limestone Rich Cove Forest (CEGL004793 - NatureServe 2017), is dominated by a mixture of *Quercus muehlenbergii* (Chinkapin oak), other oaks, particularly *Quercus alba* (White oak) and *Quercus rubra* (Red oak), and several hickories, *Carya cordiformis* (Bitternut hickory), *Carya glabra* (Pignut hickory), and *Carya ovalis* (Red hickory). Fraxinus Americana (White ash), *Liriodendron tulipifera* (Tuliptree), *Acer saccharum* (Sugar maple), *Quercus velutina* (Black oak), *Ulmus rubra* (Slippery elm), Tilia Americana (American basswood), and *Juglans nigra* (Black walnut) may also be present in the canopy. Disturbed stands may have a higher proportion of Fraxinus Americana (White ash), *Celtis occidentalis* (Common hackberry), and other early-successional species in the overstory. The relatively open subcanopy may contain *Acer saccharum* (Sugar maple), *Aesculus flava* (Yellow buckeye), and *Juniperus virginiana* (Eastern redcedar), as well as smaller individuals of *Fraxinus americana* (White ash) and Carya spp. (Hickory). *Viburnum prunifolium* (Blackhaw), *Cercis canadensis* (Eastern redbud), *Cornus florida* (Flowering dogwood), *Ulmus rubra* (Slippery elm), *Ostrya virginiana* (hophornbeam), *Viburnum prunifolium* (Blackhaw), and *Asimina triloba* (Pawpaw) are present as tall shrubs or small trees. Low shrubs include Rhus aromatic (Fragrant sumac), *Dirca palustris* (Eastern palustris), *Staphylea trifolia* (American bladdernut), and *Toxicodendron radicans* (Poison ivy). Herbs present include *Ageratina altissima* (White snakeroot), *Amphicarpaea bracteata* (American hogpeanut), *Asclepias quadrifolia* (Fourleaf milkweed), *Bromus pubescens* (Hairy woodland brome), *Brachyelytrum erectum* (Bearded shorthusk), *Circaea lutetiana* (Broadleaf enchanter's nightshade), Collinsonia Canadensis (Richweed), *Dichanthelium boscii* (Bosc's panicgrass), *Dioscorea quaternata* (Fourleaf yam), *Desmodium glutinosum* (Pointedleaf ticktrefoil), *Elymus hystrix* (Eastern bottlebrush grass), *Euphorbia mercurialina* (Mercury spurge), Eurybia divaricate (White wood aster), *Galium circaezans* (Licorice bedstraw), *Geranium maculatum* (Spotted geranium), *Hexastylis arifolia* (Littlebrownjug), *Houstonia longifolia* (Longleaf summer bluet), *Hydrophyllum virginianum* (Eastern waterleaf), *Maianthemum racemosum* (*Maianthemum racemosum*), *Oxalis grandis* (Great yellow woodsorrel), Packera obovate (Roundleaf ragwort), *Polystichum acrostichoides* (Christmas fern), *Sanicula odorata* (Clustered blacksnakeroot), Sanguinaria Canadensis (Bloodroot), *Sedum ternatum* (Woodland stonecrop), *Thaspium barbinode* (Hairyjoint meadowparsnip), Viola x palmata (Early blue violet), and *Viola pubescens* (Downy yellow violet). Some small patches of *Arundinaria gigantea* (Giant cane) are also present in stands at the southern end of the range. This association is potentially widespread across the Ridge and Valley province. However, this region has a long and extensive history of settlement and agriculture. As a result, few high-quality occurrences of this community exist, and most contemporary stands have been impacted by multiple disturbances, including clearing, cutting, and grazing. Moreover, the fertile soils occupied by this community are particularly prone to invasion by aggressive introduced weeds, whose abundance degrades the quality of many existing stands.

Community 1.2
Northern Red Oak - Sugar Maple / Hophornbeam / Cutleaf Toothwort Forest

Quercus rubra - Acer saccharum / *Ostrya virginiana* / *Cardamine concatenata* Forest The Northern Red Oak - Sugar Maple / Hophornbeam / Cutleaf Toothwort Forest, also known as the Central Appalachian Rich Red Oak - Sugar Maple Forest (CEGL008517-NatureServe 2017), occupies moderately moist slopes with various aspects, broad crests, and occasionally high alluvial terraces at low and middle elevations. Elevation ranges from less than 300 to 1146 m (<1000-3760 feet). Middle slope positions are typical, but stands also occur on lower and upper slopes. This forest association occurs in small to large patches. *Acer saccharum* (Sugar maple), *Quercus rubra* (Northern red oak), and, to a lesser extent, Carya spp. (Hickory) are the dominant trees in closed-canopy stands. *Carya glabra* (Pignut hickory) and *Carya ovata* (Shagbark hickory) are the two most frequent hickories, but *Carya cordiformis* (Bitternut hickory), Carya tomentosa (Mockernut hickory), and *Carya ovalis* (Red hickory) are also present in some stands. Fraxinus Americana (White ash), *Liriodendron tulipifera* (Tuliptree), *Quercus alba* (White oak), Quercus prinus (Chestnut oak), *Quercus velutina* (Black oak), *Fagus grandifolia* (American beech), *Quercus muehlenbergii* (Chinkapin oak), and *Tilia americana* (American basswood) each attain importance in a subset of stands. Understory layers contain substantial reproduction of *Acer saccharum* (Sugar maple) and moderate representation of the other major canopy species. The shrub layer is usually very open, with much of its cover contributed by tree saplings; *Ostrya virginiana* (Hophornbeam) is the most constant and abundant small tree/shrub,

while *Cornus florida* (Flowering dogwood), Cercis Canadensis (Eastern redbud), and *Hamamelis virginiana* (American witchhazel) are more locally important understory species. Herbaceous growth is usually not lush and frequently exhibits patch-dominance by one to a few species.

Community 1.3
Chinkapin Oak - Eastern Redbud/Roundleaf Ragwort Woodland

Quercus muehlenbergii - Cercis canadensis / *Packera obovata - Lithospermum canescens* Woodland The Chinquapin Oak - Eastern Redbud / Roundleaf Ragwort - Hoary Puccoon Woodland, also known as the Chinquapin Oak Limestone Woodland (CEGL006231; NatureServe 2017), occurs on moderate to steep south- or southwest-facing slopes on shallow, dry, stony soils derived from limestone or dolomite bedrock. Trees are generally widely spaced and relatively short, 3-10 m (10 to 33 ft). *Quercus muehlenbergii* (Chinkapin oak), i is the dominant tree, with associates including Cercis Canadensis (Eastern Redbud), *Juniperus virginiana* (Eastern redcedar), *Celtis tenuifolia* (Dwarf hackberry), Fraxinus Americana (White ash), and *Ostrya virginiana* (Hophornbeam) usually present. Shrubs are often of sparse cover but may include *Rhus aromatica* and Rosa sp. (Rose species). *Cornus florida* (Flowering dogwood) may be a common woody associate in West Virginia and Pennsylvania. The herbaceous layer is patchy but may be quite diverse. Graminoids include *Bouteloua curtipendula* (Sideoats grama), *Carex eburnea*n (Bristleleaf sedge), *Elymus hystrix* (Eastern bottlebrush grass), *Carex pensylvanica* (Pennsylvania sedge), *Poa compressa* (Canada compressa), *Danthonia spicata* (Poverty oatgrass). Associated forbs include *Anemone virginiana* (Tall thimbleweed), *Symphyotrichum undulatum* (Wavyleaf aster), *Symphyotrichum oblongifolium* (Aromatic aster), *Asclepias verticillata* (Whorled milkweed), *Houstonia longifolia* (Longleaf summer bluet), *Penstemon hirsutus* (Hairy beardtongue), Viola spp. (Violet), *Antennaria plantaginifolia* (Pussytoes), *Phlox subulata* (Moss phlox), *Lithospermum canescens* (Hoary puccoon), *Cynoglossum officinale* (Gypsyflower), *Allium cernuum* (Nodding onion), *Solidago ulmifolia* (Elmleaf goldenrod), *Solidago arguta* var. harrisii (Harris' goldenrod), *Packera obovata* (Roundleaf ragwort), Blephilia ciliate (Downy pagoda-plant), *Galium pilosum* (Hairy bedstraw), *Arabis lyrata* (Lyrate rockcress), Heuchera Americana (American alumroot), *Draba ramosissima* (Branched draba), *Pycnanthemum incanum* (Hoary mountainmint), Aquilegia Canadensis (Red columbine), *Helianthus divaricatus* (Woodland sunflower), *Scutellaria ovata* (Heartleaf skullcap), *Silene caroliniana* ssp. pensylvanica (Pennsylvania catchfly), *Sisyrinchium mucronatum* (Needletip blue-eyed grass), *Minuartia michauxii* (Michaux's stitchwort), *Euphorbia corollata* (Flowering spurge), *Paronychia montana* (Mountain nailwort), and *Paronychia virginica* (Yellow nailwort).

State 2
Post-Disturbance Successional Woodland

Community 2.1
Eastern Red Cedar Ruderal Woodland

Juniperus virginiana Ruderal Forest The Eastern Red-cedar Ruderal Forest, also known as the Northeastern Ruderal Red-cedar Forest (CEGL006024 - NatureServe 2017) is a broadly defined old-field early-successional community occurring in a variety of environmental settings in the northeastern states. Canopy closure and height are variable, as are shrub and herbaceous associates. *Juniperus virginiana* (Eastern red-cedar) dominates the canopy layer. Common associates, typically occurring as scattered individuals, may include *Pinus strobus* (Eastern white pine), *Acer rubrum* (Red maple), *Liriodendron tulipifera* (Tuliptree), Quercus spp. (Oak), and *Prunus serotina* (Black cherry). Shrub cover varies, with the most forested stands having little or no shrub cover. Exotic shrubs such as Elaeagnus umbellate (Autumn olive), *Lonicera morrowii* (Morrow's honeysuckle), *Ligustrum vulgare* (European privet), and *Rosa multiflora* (Multiflora rose) are characteristic, along with Rubus spp. (Blackberry). Herbaceous cover likewise varies. Common species in the more open-canopy stands include old-field denizens such as *Schizachyrium scoparium* (Little bluestem), *Festuca rubra* (Red fescue), *Anthoxanthum odoratum* (Sweet vernalgrass), *Agrostis gigantea*n (Redtop), *Andropogon virginicus* (Broomsedge bluestem), *Elymus repens* (Quackgrass), Solidago rugose (Wrinkleleaf goldenrod), *Solidago gigantea*n (Giant goldenrod), *Euthamia graminifolia* (Flat-top goldentop), *Monarda fistulosa* (Wild bergamot), *Toxicodendron radicans* (Poison ivy), *Achillea millefolium* (Common yarrow), and *Daucus carota* (Queen Anne's lace). In dense forest stands, herbs may be absent or limited to scattered shade-tolerant species such as *Alliaria petiolata* (Garlic mustard) and *Allium vineale* (Wild garlic), and *Dennstaedtia punctilobula* (Eastern hayscented fern). These forests are often young and result from the colonization of old agricultural fields by *Juniperus virginiana* (Eastern redcedar) over native and exotic forbs and grasses. These stands may eventually succeed to other forest types as mid- and late-successional

canopy species colonize and subsequently overtop the Juniperus. Some abandoned old fields may become dominated by *Robinia pseudoacacia* (Black locust) with similar associated woody species as above.

State 3
Agricultural-Grassland and/or Row Crops

Community 3.1
Row Crops or Pasture

The agricultural state is planted either to row crops like corn and soybeans, or in managed pastures of non-native forages. Non-native grasses may include cool season species such as *Schedonorus arundinaceus* (Tall fescue), Phleum pretense (Timothy), and *Dactylis glomerata* (Orchardgrass). Other species included *Sorghum halepense* (Johnsongrass), Setaria spp. (Foxtails), Panicum spp. (Panic grass), Amaranthus spp. (Amaranth), *Taraxacum officinale* (Common dandelion), and *Cirsium arvense* (Canada thistle). The majority of the Limestone Upland ecological site is in agricultural production.

Transition T1 - 2
State 1 to 2

Historically logged and cleared; possibly plowed, pastured, and grazed. Long term succession; no longer grazed.

Transition T1 - 3
State 1 to 3

Clearcutting; tillage; conversion to agricultural land; fertilizer and lime application; active management.

Restoration pathway R2 - 1
State 2 to 1

Remove understory, plant native seeds and seedlings, eliminate and manage nonnative species, implement a prescribed fire plan. Return to the reference or post logged minimally managed state may require a very long term series of costly management options and stages. Many species may need to be planted or seeded to restore the system. Herbivory can be a problem as well as competition from faster growing species. Depending on the existing seed bank and the proximity of a mature forest from which to recruit seeds, ruderal forests may regain a mixed forest stand. Nevertheless, sites that have been cleared and tilled have significant soil disturbance which may include compaction, erosion, loss of native soil structure, loss of soil organic matter, disruption of soil microorganisms, all which affect the soil's nutrient availability and water holding capacity (Duiker and Myers, 2005). These characteristics favor recolonization by plant species that have wind dispersed seeds (verses those that propagate through underground roots called rhizomes, or which have heavy seeds that stay near the parent tree), are shade intolerant, have rapid to moderate growth rates, and drought tolerance (Dyer, 2010). Aggressive control of nonnative species and invasive species will be ongoing. The following conservation practices from the Natural Resources Conservation Service Field Office Technical Guide can be used for restoration efforts (FOTG-USDA): Brush Management-314; Critical Area Planting-342; Early Successional Habitat Development-647; Fence-382; Forest Stand Improvement-666; Herbaceous Weed Control-315; Tree/Shrub site Preparation-490; Upland Wildlife habitat management-645.

Conservation practices

Brush Management
Critical Area Planting
Fence
Tree/Shrub Site Preparation
Tree/Shrub Establishment
Upland Wildlife Habitat Management
Early Successional Habitat Development/Management

Forest Stand Improvement
Herbaceous Weed Control

Transition T2 - 3
State 2 to 3

Clearcutting; tillage; conversion to agricultural land; fertilizer and lime application; active management.

Restoration pathway R3 - 1
State 3 to 1

Cease agricultural management, exclude grazing, plant native seeds and seedlings, eliminate and manage nonnative and aggressive species, implement prescribed fire plan. Return to the reference or post logged minimally managed state may require a very long term series of costly management options and stages. Many species may need to be planted or seeded to restore the system. Herbivory can be a problem as well as competition from faster growing species. Depending on the existing seed bank and the proximity of a mature forest from which to recruit seeds, ruderal forests may regain a mixed forest stand. Nevertheless, sites that have been cleared and tilled have significant soil disturbance which may include compaction, erosion, loss of native soil structure, loss of soil organic matter, disruption of soil microorganisms, all which affect the soil's nutrient availability and water holding capacity (Duiker and Myers, 2005). These characteristics favor recolonization by plant species that have wind dispersed seeds (verses those that propagate through underground roots called rhizomes, or which have heavy seeds that stay near the parent tree), are shade intolerant, have rapid to moderate growth rates, and drought tolerance (Dyer, 2010). Aggressive control of nonnative species and invasive species will be ongoing. The following conservation practices from the Natural Resources Conservation Service Field Office Technical Guide can be used for restoration efforts (FOTG-USDA): Brush Management-314; Critical Area Planting-342; Early Successional Habitat Development-647; Fence-382; Forest Stand Improvement-666; Herbaceous Weed Control-315; Tree/Shrub site Preparation-490; Upland Wildlife habitat management-645.

Conservation practices

Brush Management
Critical Area Planting
Fence
Tree/Shrub Site Preparation
Tree/Shrub Establishment
Upland Wildlife Habitat Management
Early Successional Habitat Development/Management
Forest Stand Improvement
Herbaceous Weed Control

Restoration pathway R3 -2
State 3 to 2

Cease agricultural management, exclude grazing, and allow long term succession.

Conservation practices

Fence

Additional community tables

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Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
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:**

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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:

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

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

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

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

17. **Perennial plant reproductive capability:**