Ecological site F134XY001TN
Northern Deep Loess Backslope Mesophytic Forest

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General information

Approved. An approved ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model, enough information to identify the ecological site, and full documentation for all ecosystem states contained in the state and transition model.

MLRA notes

Major Land Resource Area (MLRA): 134X–Southern Mississippi Valley Loess

The Southern Mississippi Valley Loess (MLRA 134) extends some 500 miles from the southern tip of Illinois southward to Louisiana. This MLRA occurs in Mississippi (39 percent), Tennessee (23 percent), Louisiana (15 percent), Arkansas (11 percent), Kentucky (9 percent), Missouri (2 percent), and Illinois (1 percent). It makes up about 26,520 square miles. Landscapes consist of highly dissected uplands, level to undulating plains, and broad terraces that are covered with a mantle of loess. Underlying the loess mantle are Tertiary deposits of unconsolidated sand, silt, clay, gravel, and lignite. Crowley's Ridge and Macon Ridge, erosional remnants that run north to south in southeastern Missouri - eastern Arkansas and northeastern Louisiana, respectively, have a similar make up. Elevations range from around 100 feet on terraces in southern Louisiana to over 800 feet on uplands in western Kentucky. The soils, mainly Alfisols, formed in the deep loess. The steep, dissected uplands are mainly in hardwood forests while less sloping areas are used for crop, pasture, and forage production.

East of the MS River, this site extends from Wickliffe, Kentucky southward to Vicksburg, Mississippi. West of the MS River, the site is restricted to the southern portions of Crowley's Ridge from about Harrisburg to Helena, Arkansas and the extreme northern portion of Crowley's Ridge (including the Commerce Hills, Hickory Ridge, and a series of smaller hills) in the Missouri "Bootheel".

Classification relationships

All or portions of the geographic range of this site falls within a number of ecological/land classifications including:

-NRCS Major Land Resource Area (MLRA) 134 – Southern Mississippi Valley Loess
-Environmental Protection Agency's Level IV Ecoregion: Bluff Hills, 74a (Griffith et al., 1998; Woods et al., 2002; Chapman et al., 2002; Chapman et al., 2004; Woods et al., 2004; Daigle et al., 2006)
-231H - Coastal Plains-Loess section of the USDA Forest Service Ecological Subregion (McNab et al., 2005)
-US National Vegetation Classification G166. Southern Mesic Beech – Oak – Mixed Deciduous Forest Group (Pyne, 2012)
-LANDFIRE Biophysical Setting 45-46-4713270 and NatureServe Ecological System CES203.481 East Gulf Coastal Plain Northern Loess Bluff Forest (LANDFIRE, 2009; NatureServe, 2013)
-LANDFIRE Biophysical Setting 4513220 and NatureServe Ecological System CES203.079 Southern Crowley's Ridge Mesic Loess Slope Forest and Crowley's Ridge Mesic Loess Slope Forest, respectively (LANDFIRE, 2008; NatureServe, 2011)
-Western Mesophytic Forest Region - Mississippi Embayment Section - Loess Hills (Braun, 1950).

Ecological site concept

The Northern Deep Loess Backslope Mesophytic Forest is characterized by backslope positions on all aspects within a highly dissected landscape. Slopes range from 12 to 80 percent but are typically 20 to 50 percent. The soils of this site formed in loess greater than 4 feet in thickness, are well drained, and generally have base saturations exceeding 60 percent (exceptions do occur). The high water holding capacity of these silty soils creates an incredible medium for plant growth and production. Vegetation of this site is generally represented by a number of forest species that have an affinity for moist environments (i.e., mesophytes).

Similar sites

F134XY108MS	**Southern Deep Loess Backslope - PROVISIONAL** This site is the southern counterpart to the Northern Deep Loess Backslope. The geographical break separating the two sites is the Big Black River, which is also the latitudinal division used by NatureServe in separating their northern and southern loess bluff ecological systems.

Table 1. Dominant plant species

Tree	(1) *Liriodendron tulipifera* (2) *Fagus grandifolia*
Shrub	(1) *Ostrya virginiana* (2) *Asimina triloba*
Herbaceous	(1) *Polystichum acrostichoides* (2) *Carex*

Physiographic features

The Northern Deep Loess Backslope Ecological Site occurs entirely within a distinct physiographic subsection of the Southern Mississippi Valley Loess (MLRA 134). Rising abruptly along the eastern boundary of the Southern Mississippi River Alluvium (MLRA 131A), the Loess Hills occurs as a series of discontinuous sections of steep bluffs and hills that collectively comprise the physiographic subsection. This narrow, east-west belt of highly dissected terrain extends north to south from the Ohio-Mississippi River region in western Kentucky into southeastern Louisiana (Braun, 1950; Bryant, 1993). Gaps and geographic divisions between the respective sections are primarily the result of large streams and rivers flowing westward to join the Mississippi River. Elevations range from 100 to 600 feet above sea level (Hodges, 1995), and local topographic relief often approaches 200 feet between the summits and the adjacent Mississippi River floodplain. This relief differential is accentuated by a stark topography of narrow ridges, vertical bluff faces, steep to nearly vertical backslopes, incised ravines, and narrow drainageways. The abruptness of terrain gradually lessens to the east where the Loess Hills form a rolling pattern.

A western physiographic counterpart to the Loess Hills is Crowley's Ridge of southeastern Missouri and eastern Arkansas (Braun, 1950). Crowley's Ridge is a narrow belt of low, dissected hills that extends roughly 200 miles north to south. Shared characteristics with the bluffs to the east include a loess-cap (but with varying depths) that is underlain by Tertiary deposits of silt, sand, clay, and gravel. Elevation crests over 500 feet above sea level with local topographic relief rising 200 feet above the adjoining alluvial plain (Clark et al., 1974). One notable distinction of its geographic location is that the entire length of Crowley's Ridge is surrounded by the Southern Mississippi River Alluvium (i.e., MLRA 131A; USDA, 2006) and is separated from the Loess Hills to the east by 23 to 50 miles of the vast Mississippi River delta region. Crowley's Ridge is also included in MLRA 134. EPA combines Crowley's Ridge and the bluffs to the east within a single Level IV Ecoregion: the Bluff Hills, 74a (Woods et al., 2004).

All aspects are well represented and included in this ecological site.

Table 2. Representative physiographic features

Landforms	(1) Loess bluff (2) Loess hill
Flooding frequency	None
Ponding frequency	None
Elevation	100–600 ft
Slope	12–80%

Aspect	Aspect is not a significant factor

Climatic features

This site falls under the Humid Subtropical Climate Classification (Koppen System). The average annual precipitation for this site increases from north to south. For the portion of this site east of the Mississippi River, it is 48 to 57 inches (1,219 to 1,448 millimeters). On Crowley's Ridge it is 47 to 51 inches (1,194 to 1,295 millimeters). The maximum precipitation occurs in winter and spring. The precipitation decreases gradually throughout the summer, except for a moderate increase in midsummer. Rainfall occurs primarily as high-intensity, convective thunderstorms, but moderate-intensity tropical storms can produce large amounts of rainfall during winter in the southern part of the area. Snowfall generally occurs in the northern part of the area. Accumulations are generally less than 12 inches (31 centimeters) and generally melt within 3 to 5 days. South of Memphis, winter precipitation sometimes occurs as freezing rain and sleet. The average annual temperature for the portion of this site east of the Mississippi River is 57 to 62 degrees F (13.9 to 18.1 degrees C), increasing from north to south. The average annual temperature for this site on Crowley's Ridge is 57 to 62 degrees F (13.9 to 16.6 degrees C), increasing from north to south. The freeze-free period averages 226 days and ranges from 196 to 253 days, increasing in length from north to south.

Table 3. Representative climatic features

Frost-free period (average)	200 days
Freeze-free period (average)	226 days
Precipitation total (average)	56 in

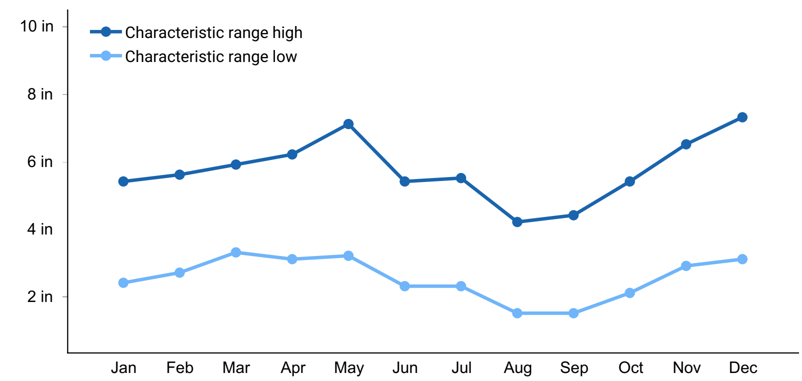

Figure 1. Monthly precipitation range

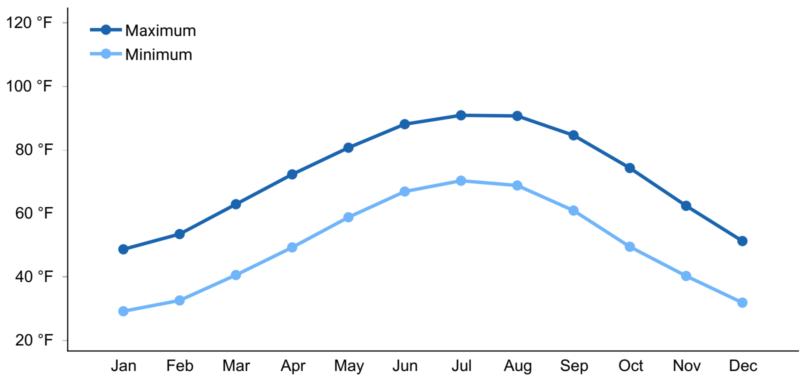

Figure 2. Monthly average minimum and maximum temperature

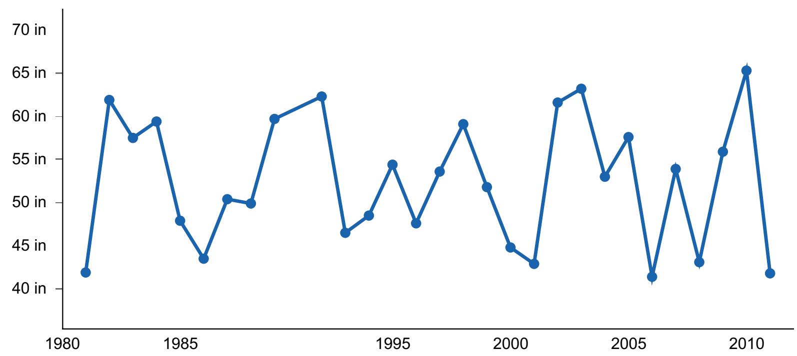

Figure 3. Annual precipitation pattern

Climate stations used

- (1) MARIANNA 2 S [USC00034638], Marianna, AR
- (2) BARDWELL 2 E [USC00150402], Bardwell, KY
- (3) CHARLESTON [USC00221606], Charleston, MS
- (4) HERNANDO [USC00223975], Hernando, MS
- (5) SENATOBIA [USC00227921], Coldwater, MS
- (6) RIPLEY [USC00407710], Ripley, TN
- (7) UNION CITY [USC00409219], Union City, TN
- (8) CAPE GIRARDEAU MUNI AP [USW00003935], Chaffee, MO
- (9) ADVANCE 1 S [USW00093825], Advance, MO
- (10) MEMPHIS [USW00093839], Millington, TN
- (11) HELENA [USC00033242], Helena, AR
- (12) JONESBORO 2 NE [USC00033734], Jonesboro, AR
- (13) NEWBERN [USC00406471], Newbern, TN
- (14) MEMPHIS INTL AP [USW00013893], Memphis, TN
- (15) MADISON 1 NW [USC00034528], Forrest City, AR
- (16) WYNNE [USC00038052], Wynne, AR
- (17) BATESVILLE 2 SW [USC00220488], Batesville, MS
- (18) GRENADA [USC00223645], Grenada, MS
- (19) LEXINGTON [USC00225062], Lexington, MS
- (20) VICKSBURG MILITARY PK [USC00229216], Vicksburg, MS
- (21) MALDEN MUNI AP [USC00235207], Malden, MO
- (22) DYERSBURG III GOLF [USW00003809], Dyersburg, TN
- (23) GREENWOOD LEFLORE AP [USW00013978], Carrollton, MS
- (24) YAZOO CITY 5 NNE [USC00229860], Yazoo City, MS
- (25) COVINGTON 3 SW [USC00402108], Covington, TN

Influencing water features

This site is not influenced by water from a stream or wetland.

Soil features

The parent material of this site is a mantle of highly-erodible loess of eolian origin. The loess is thickest where this site occurs, along the wall of bluffs at the interface of the Mississippi River floodplain, and progressively thins eastward of these bluffs. Underlying this mantle of loess are Tertiary deposits of unconsolidated sand, silt, clay, gravel and lignite, which occasionally surface as prominent horizontal seams along lower backslope positions, exposed bluff walls, stream embankments, and recent landslides and slump events. Crowley's Ridge, a disjunct from the major portion of this ecological site and lying west of the Mississippi River, has a shallower mantle of loess overlying these Tertiary deposits.

The soils that formed in this loess, and that are principal to this ecological site are the Memphis (Fine-silty, mixed, active, thermic Typic Hapludalfs) and Natchez (Coarse-silty, mixed, superactive, thermic Typic Eutrudepts) series. The Memphis soils exhibit a higher degree of development and are less sloping than Natchez soils. This ecological site is expressed where these soils occur in map units between 12 and 80 percent. Most commonly observed are slopes between 20 and 50 percent. Soil reaction (pH) ranges from strongly acid (5.1-5.5) to moderately alkaline (7.9-8.4). Natchez soils tend to have a higher pH range than Memphis soils. Where higher pH ranges are observed calcium carbonate concentrations are sometimes seen in the lower strata of these soils and are violently effervescent in hydrochloric acid. Base saturations (a measure of a soil’s natural fertility) generally exceed 60 percent, a taxonomic criteria for the Memphis series and an inherent property of the less-weathered Natchez series. Where base saturations do not exceed 60 percent, mainly in western Kentucky, this site is correlated to the Feliciana (Fine-silty, mixed, active, thermic Ultic Hapludalfs) series. Feliciana soils are similar to Memphis soils but have a base saturation of less than 60 percent.

Other miscellaneous areas/soils that are associated with this site are Gullied land, Udorthents, Udults, Brandon and Saffell. Gullied land, where the parent material is silty, are areas where the upper part of soil has been removed due to erosion, scarring the landscape. It is typical to see these areas thickly blanketed with kudzu, but they are capable of supporting vegetation characteristic of this site. Udorthents (the result of mining or other earth-moving activities) and Udults (marine sediments of low fertility), mapped at the Great Group level, are generally found along the lower one-third of backslope positions. They occur as relatively small exposures of raw, undeveloped loess or reddish colored marine sediments, respectively. The Brandon (Fine-silty, mixed, semiactive, thermic Typic Hapludults) and Saffell (Loamy-skeletal, siliceous, semiactive, thermic Typic Hapludults) series support this site where they occur in complex with, or as components of, map units of Memphis, Natchez or Feliciana. Brandon soils developed in a silty mantle, 20 to 40 inches thick, overlying very gravelly or gravelly marine deposits. Saffell soils developed in very gravelly and gravelly sediments of Tertiary age. The low fertility and pH of these Ultisols is presumably masked, through weathering processes, by the higher fertility and pH of the loess parent material as observed in the vegetative community present on these soils.

Figure 5. Natchez soil

Table 4. Representative soil features

Surface texture	(1) Silt loam (2) Silt (3) Silty clay loam
Drainage class	Well drained
Permeability class	Moderate
Surface fragment cover <=3"	0–14%
Surface fragment cover >3"	0%
Subsurface fragment volume <=3" (Depth not specified)	0–59%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

The information presented in this Ecological Site Description (ESD), including the State and Transition Model (STM), was developed using archeological and historical information; published and unpublished scientific reports, inventories, and studies; personal communication with technical experts; and professional experience. The information is representative of a complex set of environmental variables and plant community dynamics. Not all scenarios or biological species associated with this ecological site are represented and included. Key indicator plants, animals, and ecological processes are described to assist with land management decisions and actions.

Plant Community
The Loess Hills are frequently described as supporting rich forests that are starkly different from surrounding plant communities. Most descriptions or characterizations of the forest community emphasize the presence of mesophytes in all life forms and/or levels of community structure (e.g., Braun, 1950 Caplenor et al., 1968; Miller and Neiswender, 1987; Bryant, 1993). However, species associated with drier upland and wetter lowland habitats seem to merge on the deep loessal backslopes where they often form combinations that are difficult to describe. Canopy species that have a relatively high frequency of occurrence in mature, undisturbed stands typically include tuliptree (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), sweetgum (*Liquidambar styraciflua*), white oak (*Quercus alba*), sugar maple (*Acer saccharum* to the north; *Acer floridanum* to the south), cherrybark oak (*Q. pagoda*), northern red oak (*Q. rubra*), Shumard's oak (*Q. shumardii*), black oak (*Q. velutina*), white ash (*Fraxinus americana*), and bitternut hickory (*Carya cordiformis*). Canopy associates occurring at lower frequencies but maintaining local importance include shagbark hickory (*C. ovata*), mockernut hickory (*C. tomentosa*), sassafras (*Sassafras albidum*), black walnut (*Juglans nigra*), black gum (*Nyssa sylvatica*), swamp chestnut oak (*Q. michauxii*), Chinkapin oak (*Q. muehlenbergii*), and sugarberry (C. laevigata). Three additional species occurring locally and at low densities are important indicators of this site: American basswood (*Tilia americana*), cucumber tree (*Magnolia acuminata*), and the mid-story/subcanopy tree, Kentucky yellowwood (*Cladrastis kentukea*), where it naturally occurs. These "indicators" have a broader distribution in North America, but within MLRA 134, they are largely confined to the steep slopes and narrow ravines of this ecological site.

In addition to smaller stems of the preceding canopy species, the understory to mid-story stratum is frequently comprised of hophornbeam (*Ostrya virginiana*), pawpaw (*Asimina triloba*), flowering dogwood (*Cornus florida*), American hornbeam (*Carpinus caroliniana*), slippery elm (*Ulmus rubra*), and redbud (*Cercis canadensis*). The small to tall shrub strata are often well developed, especially on mid- to lower slope positions, and are frequently comprised of spicebush (*Lindera benzoin*), pawpaw (*Asimina triloba*), red buckeye (*Aesculus pavia*), and giant cane (*Arundinaria gigantea*). The ground layer of mature, undisturbed sites is generally rich with native vine and herbaceous taxa. Vines or lianas of this site span multiple height strata and are represented by crossvine (*Bignonia capreolata*), Virginia creeper (*Parthenocissus quinquefolia*), greenbriar, (Smilax spp.), grape (Vitis spp.), and bay starvine (*Schisandra glabra*), where it naturally occurs. Commonly associated forbs include mayapple (*Podophyllum peltatum*), goldenseal (*Hydrastis canadensis*), white snakeroot (*Ageratina altissima*), white baneberry (Actea pachypoda), Jack in the pulpit (*Arisaema triphyllum*), American lopseed (*Phryma leptostachya*), ginseng (*Panax quinquefolius*), richweed (*Collinsonia canadensis*), jumpseed (*Polygonum virginianum*), wreath goldenrod (*Solidago caesia*), and largeflower bellwort (*Uvularia grandiflora*). Ferns comprise a large proportion of the ground cover, which include Christmas fern (*Polystichum acrostichoides*), broad beech fern (*Phegopteris hexagonoptera*), northern maidenhair (*Adiantum pedatum*), lowland bladderfern (*Cystopteris protrusa*), and grapefern (Botrychium spp.).

Variability/Dynamics of Vegetation
The presence and relative abundance of the species listed above can be quite variable, rarely occurring in rigid, predictable patterns and combinations from stand to stand. Still, generalities can be made to predict vegetation response within local environments. Factors influencing composition include: latitude, depth of loess, complexity of surrounding soils, aspect, slope position, and land-use history.

Differences in composition of this site north to south are generally due to natural distributions and species response to habitat disturbances. Some of the more notable examples of species differences north to south involve important oaks and sugar maple. Throughout much of the northern extent of this site, northern red oak, and sugar maple are frequent components. This pattern reverses farther south in Mississippi where Shumard's oak and southern sugar maple (*Acer floridanum*) occur in greater abundances. Additional examples include the entrance of bigleaf magnolia (*Magnolia macrophylla*) and loblolly pine (*Pinus taeda*) as components farther south. However, the presence of loblolly pine is almost always an indicator of former land-use impacts. In fact, loblolly pine was never associated with the historic forest community and was noted as occurring almost exclusively on abandoned farmland (Holmes and Foster, 1908).

Differences in vegetation also occur along a moisture gradient involving depth of loess, aspect, slope gradient, and slope position (Miller and Neiswender, 1987; Hodges, 1995). A higher concentration of oak and hickory may develop and occur in areas where loess depths are shallower, on south- to west-facing slopes, mid- to upper slope positions, and on slopes of lower gradients (12 to 30 percent). Conversely, steep, “protected” backslopes (northwest- to east-facing) and mid- to lower slope positions often support a higher concentration of mesophytes. However, these patterns are not uniform or predictable in every location or situation. Steep, “exposed” slopes occurring within a highly dissected landscape may support a diverse concentration of mesophytes, and some protected slopes have been found to support a local dominance of white oak and even black oak. The degree of dissection of the broader landscape appears to have a tremendous influence on the plant community, and this becomes most evident in undisturbed, mature forests. A continuous, robust canopy across slopes of all aspects appears to contribute to a fairly consistent micro-climate. This moist, shaded environment helps to foster continuation of a forest community that supports similar components, even on opposing slopes. Situations where aspect and slope position appear to exert a greater influence upon vegetation are on exposed slopes that overlook broad floodplains, on low gradient slopes, and along the interface of forest and open areas (i.e., the “edge effect”).

Historic
Archeological evidence indicates that humans have occupied the region for at least 11,000 years (Morse and Morse, 2009). The Mississippi Valley, which includes the Loess Hills and Crowley’s Ridge, provided important resources for human subsistence, and this is evidenced by the discovery of many important cultural sites (see Dye and Cox, 1990; Morse and Morse, 2009). Human populations centered in hamlets, villages, or towns that remained active for several decades would have exerted tremendous influences on the composition and structure of local plant communities. Food, clothing, building, and cultural materials needed for subsistence were cultivated, harvested, and gathered from surrounding environments. Favored mast and fruit producing trees, in addition to numerous shrubs, vines, and herbs, were selectively produced and managed. Plants considered as competitive nuisances may have been culled from local sites or used as fuel or other purposes (Delcourt and Delcourt, 2004).

Archaeological surveys have discovered several prehistoric villages on the bluffs overlooking the Mississippi River floodplain (see Loughridge, 1888; Dye and Cox, 1990; Morse and Morse, 2009), and these centers of occupancy would have necessitated local clearings and intensive subsistence activities. Although the natural community of this site is largely considered a fire-sheltered forest today (LANDFIRE, 2008), historically, the processes may have been different, especially in the immediate vicinity of occupied sites. Some local hillsides were probably cleared of trees and maintained in an herbaceous or open woodland state, which likely necessitated the use of fire as a choice management tool. Overall, areas where Native Americans influenced the development of alternate plant community states were probably localized. Still, this complex backdrop of human subsistence and influences on the surrounding landscape must have contributed to a “shifting mosaic” of biological communities as human populations moved about, increased, and waned. Areas extending beyond Native American communities most likely supported vast forests comprised of trees of extraordinary dimensions.

As the region was being settled, the rich soils of the Loess Hills became an enticement for crop production. In addition to local gardens and food plots for subsistence, cotton emerged as the preferred “money crop” (Hilgard, 1860). Resultantly, the pre-settlement forest and associated plant communities were largely removed by the mid-1800s with activities chiefly focused on the broader ridgetops and low-gradient slopes. However, the lure to expand crop production led to an attempt to cultivate steeper slopes; only the steepest slopes were avoided and left in forest (Hodges, 1995). In addition to cropping pursuits, hillsides were also cleared and converted to pastureland, with grazing often expanding into remaining forests. One notable impact of this practice was the destruction of local cane thickets that clothed the steep hillsides (Hilgard, 1860; Shull 1921). Call (1891) warned of forest composition being altered on Crowley’s Ridge from selective grazing by livestock, in addition to the trampling of vegetation and soil compaction. He specifically mentioned livestock selectively foraging on palatable, “sweet-tasting” mast (e.g., white oaks) and avoiding “bitter-tasting” species (e.g., black and red oaks).

The rapid transformation of the landscape coupled with the erodible nature of the soils led to unheralded impacts that included severe gullying, mass wasting, and altered forest composition on a broad scale. Tenants reportedly abandoned the hilly terrain once local areas were “exhausted” and erosion consumed previously cultivated land (Wailes, 1854). Telltale signs of such past events, today, are often deep gullied chasms supporting eerie spires of free-standing loess deposits, which are typically hidden beneath a dense drapery of kudzu (*Pueraria montana* var. lobata).

Current Concerns and Condition
A close examination of current soil maps reveals thousands of acres of “gullied land” and/or “severely eroded” soil map units within the boundaries of this ecological site. In fact, many of these units comprise a significant proportion of this site’s extent. Yet, given these relatively recent environmental disruptions, a surprising response in vegetation is often observed. A large percentage of the former cropland and pastureland on the hillslopes are now in hardwood forests with many such sites having produced several timber harvests since abandonment. Johnson (1958) emphasized the overall productivity of the Loess Hills by stating “…it is potentially one of the most productive hardwood sites in the nation.” Forests that have reclaimed abandoned farmland often support a much higher percentage of oaks than what may have occurred prior to initial clearing (Clark et al., 1974; Hodges, 1995). For the steep, rugged slopes that were never converted to other uses, a number of timber harvests have been conducted over the past two centuries. A major concern over the current and future forests of this site pertain to the prevailing practice of harvesting superior quality trees of select species and leaving behind unhealthy, defective trees and unmarketable species (i.e., high-grading). This practice has led to shifts in species composition and threatens the overall health and quality of affected stands (Hodges, 1995).

Plant communities of this site face additional threats, some of which are newly emerging. Invasive exotic plants are a persistent threat that competes with native species for nutrients and space. The rapid growth rates of some exotics can markedly reduce available space for important native plants. Forests are particularly susceptible to exotic plant invasions following a disturbance, whether the disturbance is from natural causes or human-induced. Some of the more notable and problematic exotic plants observed on this site include princesstree (*Paulownia tomentosa*), tree of heaven (*Ailanthus altissima*), privet (Ligustrum spp.), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), and kudzu.

After centuries of land-use activities, a suite of plant species emerge as important components of this site, especially in mature forests. That list includes the plants indicated above. The majority of these were listed in the early state geologic surveys (e.g., Hilgard, 1860; Loughridge, 1888; Call, 1891) and in more recent surveys and inventories (e.g., Braun, 1950; Caplenor et al., 1968; Clark et al., 1974; Clark, 1977; Miller and Neiswender, 1987; Bryant, 1993). With no example of the presettlement forest remaining intact, reference conditions of this site have been chosen to reflect the native plant species that most frequently occur and that influence the overall structure and characteristics of mature stands.

Following this narrative, a state and transition model is provided that includes the “perceived” reference state and several alternative (or altered) vegetation states that have been observed for the Northern Deep Loess Backslope ecological site. Descriptions of each state, plant community, pathway, and transition follow the model. This model is based on former ecological surveys, current inventories, expert knowledge, and interpretations.

Plant communities will differ across MLRA 134 because of the naturally occurring variability in weather, soils, and aspect. The Reference Plant Community is not necessarily the management goal. The environmental and biological characteristics of this site are complex and dynamic. Accordingly, representative values are presented in a land management context. Species lists are representative, and not all species occurring or potentially occurring are indicated. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

The following diagram suggests pathways that the vegetation on this site might take, given that the modal concepts of climate and soils are met within an area of interest. Specific locations with unique soils and disturbance histories may have alternate pathways that are not represented in the model. This information is intended to show the possibilities in a given set of circumstances.

Above all, this effort is an iterative process. The model and associated information are subject to change as knowledge increases and new information is garnered. Most importantly, local and/or state professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

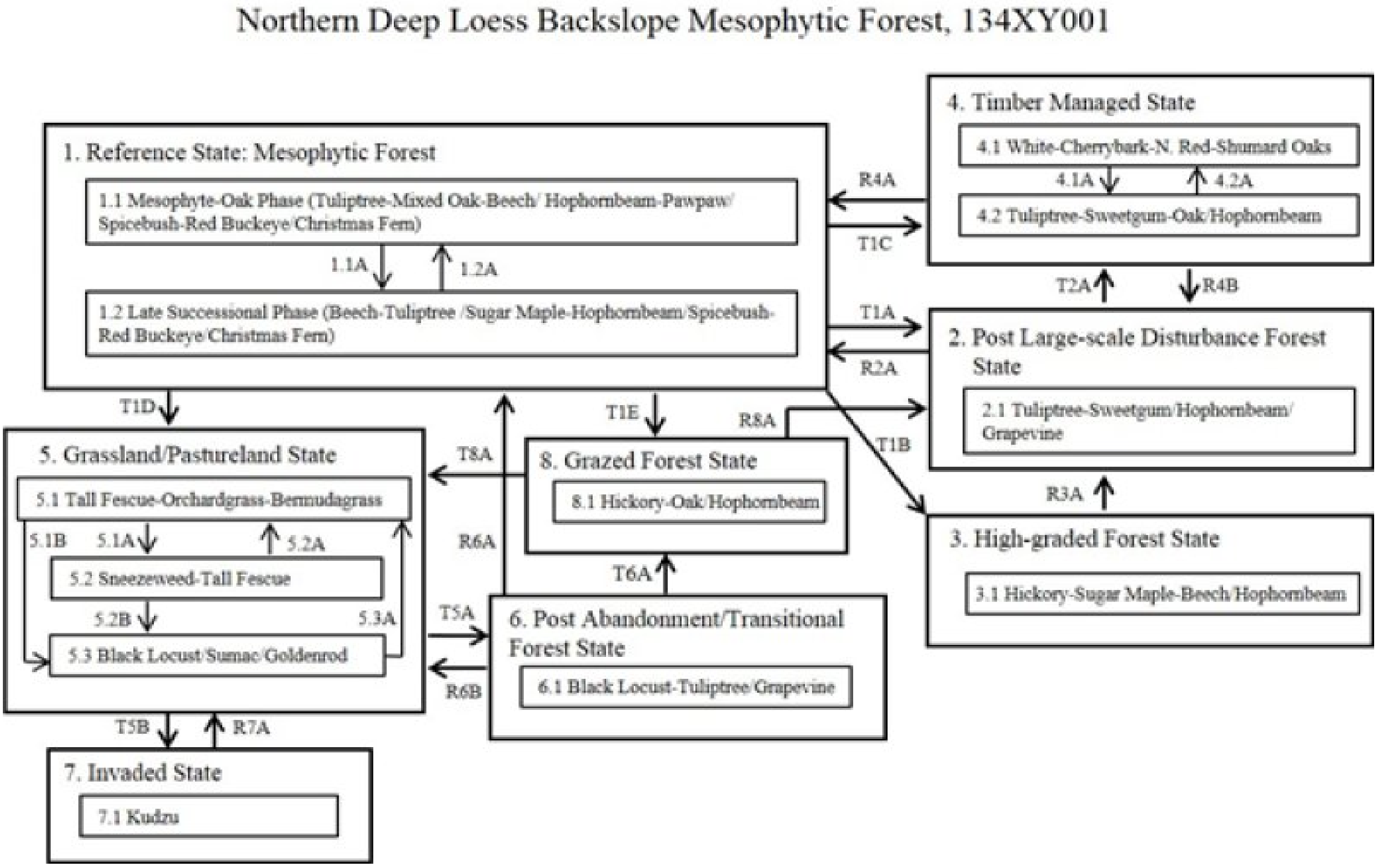

Figure 6. STM

State 1
Reference State: Mesophytic Forest

The pre-settlement forest of this ecological site was largely removed more than 150 years ago (Hodges, 1995). Today, the forests of this site are of two general origins: 1) re-growths from abandoned agricultural lands, pastureland, and formerly cutover/cleared timberland; 2) forests that were never completely cleared but sustained several cuttings of varying intensity. Locations that support “perceived” reference conditions consist of a few areas that have been spared from sustained manipulations for over 50 years. These “conditions” were generated from reviews of several published/unpublished surveys and field observations. Such locations are mainly on public lands (e.g., parks, natural areas, wildlife refuges, etc.), a few privately owned parcels, and an experimental research forest. Although these sites support very large trees, individual tree size is not necessarily an indicator of the reference state. Sites perceived to exhibit reference conditions generally support: 1) a composition consistent with the species reported in historic documents (e.g., state geologic surveys of the 1800s); 2) high species richness, especially in the canopy and subcanopy layers (i.e., no single species dominance); 3) several mesophytic species occuring in multiple height strata and/or life forms (not exclusive to beech and/or sugar maple); 4) well-developed, multi-layered forest; 5) vigorous trees and stands; 6) a low incidence of offsite vegetation (e.g., exotic species and/or native species indicative of other forest types); 7) low incidence of pioneer species that typically distinguish young, transitional forests (note that tuliptree, sweetgum, and other shade-intolerant species typical of older stands, > 75 years, are exceptions). Two community phases are recognized as comprising the reference state. These differing phases are distinguished by the degree of successional stage (development); level or intensity of disturbance; and relative proportion of shade-tolerant vs. shade-intolerant species present in local stands.

Community 1.1
Mesophyte-Oak (Tuliptree-Mixed Oak-Beech/Hophornbeam-Pawpaw/Spicebush-Red Buckeye/Christmas Fern)

Figure 7. Reference State (Phase 1.1)

Figure 8. Community Phase Pathway 1.1A: small, gap scale disturbance

This community phase represents the prevailing successional stage, composition, and structural complexity of stands supporting perceived reference conditions. The primary characteristics that distinguish this phase are the importance and commonality of a mesophyte – oak canopy; mid- to late development seral stage; and re-occurring, gap-scale disturbances. A rich assemblage of plant species characterizes the natural community with mesophytes comprising a major portion of all life forms and structural classes. Important canopy and subcanopy components include tuliptree, American beech, sweetgum, sugar maple, basswood, and cucumber tree. Additional components that are extremely important to the system consist of several oak species including white, northern red, Shumard's, cherrybark, black, chinkapin, swamp chestnut, and water oak. Many additional species of secondary importance occupy positions of the canopy and subcanopy layers such as hickory, white ash, elm, and black gum. Species dominance varies by site, but overall, tuliptree, white oak, and American beech are among the most frequently and consistently encountered species in locations that support reference conditions. The understory is represented by a well-developed tall shrub-sapling layer, small shrub stratum, and a sparse to moderately dense ground layer, all of which attains maximum density and diversity along the mid- to lower slope positions. The lower strata are typically comprised of smaller canopy species in addition to pawpaw, spicebush, red buckeye, giant cane, and several species of vines, forbs, graminoids, and ferns. Following stand-initiating disturbances, beginning characteristics of this phase may become recognizable as early as 50 years on optimum sites (slopes having high soil moisture and high pH), however maximum development likely requires longer periods. Features of older stands often include the scattered presence of standing snags, coarse woody debris, and different size and age distributions of canopy and subcanopy species. An interesting characteristic of this phase is the aggregate presence of several important shade-intolerant to shade-intermediate overstory trees. Among these, tuliptree is one of the most frequently observed canopy components, followed by sweetgum, white ash, white oak, northern red oak, and cherrybark oak. These species are often found in close association with shade-tolerant canopy components such as American beech, sugar maple, basswood, and a number of understory plants. The continued presence and co-existence of species having the full range of tolerances strongly suggests the importance of continual, localized disturbances. Both gap-scale and incomplete stand-scale disturbances likely contribute to the perpetuation of this community phase over longer periods of time. Larger gaps often consist of heavy, downed woody debris and a dense concentration of shrubs, forbs, vines, and released saplings and young trees. Seedlings and saplings of tuliptree and other shade-intolerant species are often common components of larger, forested openings (often > 0.2 acre). Smaller gaps or forest openings may result in the release of suppressed understory components, but the greatest response is often ingrowth or expansion of the surrounding canopy (Oliver and Larson, 1990). Understories of long-term, non-disturbed portions of the stand (i.e., complete canopy closure) are typically comprised of shade-tolerant woody and herbaceous species. The canopy associates that appear to have a tougher time competing in this environment are the oaks. Oak seedlings (< 2 feet tall) are occasional to common components of the ground flora, but there is an alarming paucity of oaks at the taller sapling and small tree strata. Overall, oak recruitment in this phase appears to be poor. Regeneration and continuation of oak likely require disturbances extending beyond the gap-scale, possibly requiring incomplete-stand to stand-initiating disturbances coupled with forces that control potential competitive exclusion of oaks by faster growing shade-intolerant associates. Without reoccurring disturbances that promote oak reproduction and regeneration, this phase will naturally transition to a more shade-tolerant, late successional stage. Prior to reaching that stage, oak break-up, resulting in broader canopy openings, may be rapidly colonized by shade-intolerant mesophytes such as tuliptree with a concomitant release and expansion of a shade-tolerant understory.

Forest overstory. A complex mixture of tolerances from shade intolerant to very tolerant species characterizes the overstory of this community. Dominant and co-dominant canopy trees are often a mixture of mesophytes and oaks. A multitude of species combinations occurs from stand to stand, which is a common characteristic throughout the site’s distribution. Typical overstory species of this community include tuliptree, American beech, sweetgum, sugar maple, basswood, cucumber tree, white oak, cherrybark oak, northern red oak, Shumard’s oak, black oak, chinkapin oak, swamp chestnut oak, bitternut hickory, shagbark hickory, mockernut hickory, white ash, black gum, slippery elm, and occasional occurrences of black walnut, butternut, sassafras, sugarberry, red mulberry and Kentucky coffeetree (Gymnocladus dioicus). In addition to smaller stems of the preceding, the subcanopy is comprised of hophornbeam, American hornbeam, flowering dogwood, pawpaw, redbud, and Kentucky yellowwood.

Mature, undisturbed stands are often comprised of tall, straight hardwoods (> 100 ft.) with robust, overlapping crowns that collectively form a closed-canopy. Conservative estimates of basal area (BA) of these stands frequently range from 110 to 190 ft2/ac. Three height classes of older stands are generally supported with the tallest exceeding 120 feet. Species occurring in multiple height classes will, correspondingly, have multiple entries.

Note that southern sugar maple (Acer floridanum) was not distinguished from sugar maple (Acer saccharum) during field investigations. The latter represents all sugar maple observations on this site.

Forest understory. The understory is typically well developed with both density and diversity of plants increasing on mid- to lower-slope positions and on protected slopes. In addition to smaller overstory seedlings and saplings, woody plants include spicebush, pawpaw, red buckeye, and giant cane and occasionally wild hydrangea (Hydrangea arborescens), oak leaf hydrangea (Hydrangea quercifolia), American bladdernut (Staphylea trifolia), and bursting-heart (Euonymus americana). Canopy gaps provide suitable conditions for additional species such as blackberry (Rubus spp.). Vines or lianas of this site span multiple height strata and typically include crossvine, Virginia creeper, greenbrier, grape, poison ivy, and bay starvine where it naturally occurs. The herbaceous layer is fairly species-rich on the best sites and is often comprised of mayapple, goldenseal, bloodroot, yellow fumewort, largeflower bellwort, Jack in the pulpit, green dragon, wild comfrey, white baneberry, American lopseed, ginseng, richweed, beaked agrimony, jumpseed, Virginia snakeroot, wreath goldenrod, sedges, along with several important ferns including Christmas fern, broad beech fern, northern maidenhair, lowland bladderfern, and grapefern.

Table 5. Soil surface cover

Tree basal cover	1-7%
Shrub/vine/liana basal cover	1-5%
Grass/grasslike basal cover	0-3%
Forb basal cover	0.5-4.0%
Non-vascular plants	0-5%
Biological crusts	0%
Litter	29-85%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0-30%
Bedrock	0%
Water	0%
Bare ground	1-23%

Table 6. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	1-10%
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	1-8%
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	1-5%
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	1-4% N*
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	0-3% N*
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-20 per acre
Tree snag count** (hard***)	0-20 per acre

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0-5%	1-20%	0-8%	1-9%
>0.5 <= 1	1-10%	1-20%	0-4%	4-20%
>1 <= 2	0-10%	2-40%	0-4%	0-40%
>2 <= 4.5	1-20%	1-40%	0-4%	0-1%
>4.5 <= 13	10-60%	5-50%	–	–
>13 <= 40	20-65%	–	–	–
>40 <= 80	20-65%	–	–	–
>80 <= 120	50-90%	–	–	–
>120	50-80%	–	–	–

Community 1.2
Late Successional (Beech-Tuliptree/Sugar Maple-Hophornbeam/Spicebush-Red

Buckeye/Christmas Fern)

This community phase represents a late successional stage of this ecological site and is characterized by the dominance and prevalence of shade-tolerant species throughout the forest profile. A concern over the addition of this phase is that few, if any, “intact” examples are known, today. However, isolated patches (possible remnants) possessing perceived characteristics of this phase have been observed in protected, cove-like ravines and on very steep slopes (> 60 percent). Although indisputable examples have not been described or characterized, the inclusion of this phase is largely based on: 1) projections of future community development as interpreted from the concentration of current mid- and understory shade-tolerant components; 2) observations of old, possible remnant forest patches that are dominated by relic shade-tolerant trees. Recognition of this phase is mainly due to a trend occurring in many older stands that have been protected from large, reoccurring disturbances. In these stands, shade-tolerant trees often occupy important positions in the canopy; however, their greatest concentrations are often distributed throughout the understory where they occur as seedlings, saplings, and small trees. Understories dominated by shade-tolerant species are sometimes devoid of shade-intolerant species, with the exception of recent germinations and small seedlings (< 1 feet in height). Disturbances occurring within the community are mainly in the form of smaller, gap-scale openings resulting in the deaths of individual trees and/or small groups of canopy/subcanopy trees (e.g., windthrow events). Gaps of insufficient size ultimately favor “ingrowth” of live canopy trees or canopy accession of shade-tolerant species (Oliver and Larson, 1990). An interpretation of these observations is that future overstory recruitment will largely come from the advancement of smaller, shade-tolerant components. Without the requisite processes for retaining oaks and other shade-intolerant species, slow decline and eventual disappearance of some species may occur at the stand level. Composition of late successional stands likely include greater abundance and dominance of beech and sugar maple with associates of basswood, white ash, cucumber tree, blackgum, and bitternut hickory. Mid- and understory components expected to thrive or persist include American hornbeam, hophornbeam, flowering dogwood, pawpaw, red buckeye, spicebush, and smaller canopy species such as beech and sugar maple. Important, shade-intolerant components of Phase 1.1 will likely decrease in abundance and importance in the late successional stage but may not disappear entirely at the stand level. Large canopy gaps are anticipated to reset conditions for faster growing shade-intolerants such as tuliptree and possibly sweetgum; the former is expected to persist as an important canopy component given its rapid response to disturbance and greater longevity. However, larger-scale disturbances (e.g., incomplete stand- to stand-initiating) on a more frequent rotation may be required for greater oak regeneration. Even then, proliferation of shade-tolerant species and the presence of fast-growing mesophytes may still present recruitment challenges for oaks (Johnson et al., 2009). A community phase pathway (pathway 1.2A below) is recognized for creating conditions more suitable for shade-intolerant species, but the complications just mentioned may require stand-initiating disturbances and pro-active management specifically designed for oak recruitment.

Forest overstory. The overstory is primarily represented by late successional, shade-tolerant and moderately-tolerant species. Beech is often a common to dominant species with diameters well in excess of 30 inches dbh and tree heights of individual stems approaching 120 feet. Sugar maple is an important component occupying subcanopy positions with occasional stems extending into the upper canopy. Additional components of the overstory include tuliptree, basswood, cucumber tree, white oak, northern red oak, bitternut hickory, shagbark hickory, black gum, white ash, and may include occurrences of sweetgum, hackberry or sugarberry, red mulberry, and persimmon. The presence of shade-intolerant species, such as tuliptree, benefit from former gap-scale disturbances. The subcanopy is comprised of smaller stems of beech and sugar maple in addition to hophornbeam, American hornbeam, flowering dogwood, pawpaw, and redbud.

The following lists of overstory and understory components were generated from two small forest patches located on very steep slopes within protected cove and ravine environments. Both sites were considered to best represent this phase based on the prevalence of shade tolerant species. A better understanding of the dynamics and composition of this community phase should develop as protected stands continue to mature.

Forest understory. The understory is typically well developed and mainly comprised of shade tolerant to very tolerant species. Both density and diversity of plants tends to increase on mid- to lower-slope positions and on protected slopes. In addition to smaller overstory seedlings and saplings (especially beech and sugar maple), woody plants include spicebush, pawpaw, and red buckeye, and occasionally bursting-heart. Composition of the vine and herbaceous layers are largely the same shade-tolerant species of Reference Community Phase 1.1.

Pathway 1.1A
Community 1.1 to 1.2

This pathway represents a natural increase in shade-tolerant, late successional species (i.e., increased mesophication) over a long period of time. Disturbance is light, infrequent, and localized – the result of single tree senescence or small group windthrow. The abundance and importance of shade intolerant species declines, overall.

Pathway 1.2A
Community 1.2 to 1.1

This pathway involves larger gap- to incomplete stand-scale disturbances resulting in a reduction of late successional dominance in the overstory and permitting opportunity for shade-intolerant species to resume position in the stand. Potential disturbances include those induced by wind, ice, soil slippage/rotational slumps, low to mixed severity fire, and forest management (e.g., group selection harvests, basal area reduction harvests). Species benefitting from this level of disturbance include tuliptree, sweetgum, white ash, and other shade-intolerant hardwoods. Restoring the oak component, however, may be more problematic. If oaks were rare in the late successional stand, their regeneration in the recovering gaps will also be rare and most likely, nonexistent. Achieving successful oak recruitment ultimately depends upon the presence of advanced oak regeneration prior to the disturbance. Management recommendations for oak recruitment may include timber stand improvement (TSI), planting, and mechanical and chemical treatment of oak competition. Finding the appropriate approach for a given stand and environment necessitates close consultation with trained, experienced, and knowledgeable professionals. It is strongly urged and advised that professional guidance from a forester be secured and a well-designed silvicultural plan developed in advance of any work conducted.

State 2
Post Large-scale Disturbance Forest State

This state is characterized by the regeneration or regrowth of a pre-existing forest stand following a major, stand-replacing disturbance. Scale of the disturbance is at the stand level and is greater than one acre in size (Johnson et al., 2009). Potential types of disturbances include catastrophic windstorms, wildfire, landslides, silvicultural clearcuts, and particularly destructive ice storms. The resulting, even-aged stand (or single-cohort) is set on a new course of development, which is highly dependent upon several critical factors including: the composition and structure of the stand prior to the disturbance; the degree or intensity of the disturbance; size and configuration of the disturbed area; and distance to seed sources. Composition and condition of the forest stand prior to a major disturbance may dictate, in large part, future composition of the regenerating stand. Although colonization by new species is expected soon after the disturbance, many of the pre-existing overstory components are anticipated to occupy position in the new, developing stand – their presence arising mainly from stump or root sprouts, advance regeneration, and germination from the seed bank (Oliver and Larson, 1990). This generality may fail depending upon the intensity of the disturbance and understory structure of the pre-existing stand. Of particular concern, oak regeneration, even in formerly oak-dominated stands, is particularly problematic on this site and may require additional measures before oak dominance is expressed in the new stand (see Beck and Hooper, 1985; Goelz and Meadows, 1995; Lockhart et al., 2010). If the intensity of the disturbance only removed the overstory and damage to the understory strata was light, then understory components of advance regeneration may proliferate in the new opening. This may be a desired condition if managing for an oak shelterwood harvest and subsequent oak recruitment. However, this scenario is particularly problematic in high-graded stands where repeated select cuttings ultimately favored dense concentrations and advancement of hophornbeam, American hornbeam, beech, and sugar maple throughout the understory. Overstory removal would ultimately favor proliferation of the preceding species, further complicating and impeding regeneration of a more diverse stand.

Community 2.1
Tuliptree-Sweetgum/Hophornbeam/Grapevine

Figure 9. Post Large-scale Disturbance Forest State (Phase 2.1)

Soon after overstory removal, numerous species may colonize large openings and influence the dynamics of the site. Initial colonizers are often forbs, graminoids, and vines that may have existed in the seed bank, were forest floor components prior to disturbance, or transported into the site via wind and/or animals. These plants co-exist and compete for space with the sprouts, advance regeneration, and seedlings of the future overstory. Early successional or pioneer species frequently observed include black locust, sumac, greenbrier, grapevine, blackberry, American burnweed (*Erechtites hieraciifolius*), and broomsedge bluestem (*Andropogon virginicus*). Overstory species anticipated to occur during the stand-initiation stage include tuliptree, sweetgum, black locust, white ash, sassafras, oaks, hickories, elm, walnut, black cherry, hackberry, sugarberry, boxelder, redbud along with the residual shade-tolerant species of sugar maple, beech, blackgum, hophornbeam, and flowering dogwood. Composition of the young stand will vary dramatically if the disturbance is a well-designed and implemented shelterwood harvest that favors the advancement of an established oak understory. As the stand grows and canopy closure occurs, vertical stratification begins to develop and dominance is often expressed by the faster growing pioneer species (Oliver and Larson, 1990). Tuliptree often overtops associates in this stage and can dominate large openings, particularly if the species was present in the stand before the disturbance (Beck and Hooper, 1985; Lockhart et al., 2010). Although patterns vary greatly, additional species that may be locally abundant include sweetgum, elm, white ash, and sassafras. Conversely, oak stems are often severely reduced by this stage and those remaining are frequently overtopped by associates, especially tuliptree (Lockhart et al. 2010). Once released, oaks may resume growth and eventually recover position in the canopy. For stands that were highly altered prior to the disturbance (e.g., high-graded), intensive management may be necessary in order to establish a desired composition. Management actions may include controlling undesirable species mechanically and chemically and planting the desired species.

Forest overstory. As reported here, composition of the overstory is generally representative of the developing stand as it transitions from the stand-initiating to the stem exclusion stages. A broad number of species of all tolerances may occur, but shade-intolerant species will often exert dominance early on. Species typical of this state include tuliptree, sweetgum, sassafras, elm, white ash, oaks, hickory, black cherry, hackberry, and boxelder. Canopy heights will vary widely and are entirely dependent on age or successional stage of the developing stand.

Forest understory. The initial stages of development will be comprised of a broad array of woody saplings, seedlings, vines, forbs, and graminoids. Those persisting to canopy closure at the stem exclusion stage may continue to survive in subordinate strata. Species occupying the newly stratified understory will include slower growing shade-tolerant species in addition to some shade-intolerant to moderately-tolerant species that continue to survive in a suppressed condition. Taxa occurring in the lower strata may include smaller stems of sugar maple, beech, blackgum, hophornbeam, pawpaw, spicebush, grapevine, greenbrier, blackberry, and Christmas fern in addition to suppressed oak and hickory.

State 3
High-graded Forest State

Forests in this state have undergone repeated select harvests over time. Actions leading to this condition consist of removing the biggest and best trees of the most desirable species and leaving low-quality trees (damaged and deformed) and undesirable species. This action, conducted repeatedly, can cause tremendous shifts in species composition and can decrease the vigor and health of the residual stand. Without implementing carefully prescribed management actions, species composition of extreme high-graded stands may remain in a highly altered condition for many decades, even after large, stand-replacing disturbances resets “successional opportunity.” Today, this vegetation state probably represents the conditions of many forest stands throughout the distribution of this site. Local stands in which desirable species such as oaks, tuliptree, walnut, sweetgum, cucumber tree, basswood, etc. were repeatedly targeted often results in sites with proportionally more hickory, maple, and beech. Stands where hickory was also targeted often support beech, maple, and disproportionate numbers of other components such as boxelder, hackberry, and sugarberry.

Community 3.1
Hickory-Sugar Maple-Beech/Hophornbeam

Figure 10. High-graded Forest State (Phase 3.1)

This vegetation assemblage represents a high-graded condition of this ecological site. Species typically left or avoided during harvests often include hickory, sugar maple, beech, and practically the entire understory. This has resulted in canopies largely comprised of the preceding species along with a dense understory of hophornbeam and American hornbeam. Noticeable characteristics of this condition are a conspicuous reduction of oaks and other valuable hardwoods.

Forest overstory. Various hickories, sugar maple, and beech typically dominate the overstory. Dominant hickories may vary by site and slope position, but in general, shagbark, mockernut, and pignut occupy upper slopes and bitternut is more common along mid- to lower slope positions, although in some sites, the latter is the dominant canopy species throughout. Desirable hardwoods may occur but they are nearly always under-represented. Sporadic occurrences of tuliptree, sweetgum, white oak, northern red oak, black oak, swamp chestnut oak, chinkapin oak, black gum, and occasionally cucumber tree and basswood are among the components that are sometimes present. The midstory may be represented by a high number of stems of hophornbeam, American hornbeam, dogwood, and smaller beech and sugar maple.

Forest understory. The understory of high-graded stands can often appear well developed and structurally complex, which is often comprised of smaller shade-tolerant canopy and midstory trees and understory shrubs. Components of the understory typically include hophornbeam, American hornbeam, spicebush, pawpaw, and smaller stems of sugar maple and beech. Some high-graded stands can support a surprisingly rich ground layer comprised of various graminoids, ferns, forbs, and vines. The exotic and problematic Japanese honeysuckle can be abundant.

State 4
Timber Managed Forest State

Two timber managed phases are included to represent the range of management options and associated outcomes, given their importance and interest by silviculturists, landowners, land managers, and industry. The level of management intensity and the density of oaks relative to other hardwoods distinguish them. The first phase is an oak-centric management approach that promotes oak regeneration and production. Currently, the distribution of an oak-managed system is probably very rare and restricted due to the level of management commitment required for its development, maintenance, and perpetuation. The second phase represents a natural transition from an oak-managed system once specific management actions are relaxed. Incidentally, this phase also represents stands where even-aged methods (e.g., clearcut) and larger group selection harvests are conducted without oak-specific management actions (e.g., TSI, competitor control, oak-shelterwood approach, etc.).

Community 4.1
White-Cherrybark-N. Red-Shumard Oaks

This community phase is considered representative of the most important and widespread oak components of this ecological site. Targeted species of this phase will most likely include white, cherrybark, northern red, and Shumard's oaks. Additional oaks that commonly occur and are sometimes locally abundant or dominant include black, swamp chestnut, chinkapin, and water oak. The specific combination of oaks within a stand will most certainly vary by site, and species may also vary by latitude. Producing and managing for oak-dominated stands on moist, highly productive sites can be extremely challenging. Direct competition with other hardwoods severely limits oak regeneration and may, over time, replace oaks within a stand (Loftis, 2004; Johnson et al., 2009). Disturbance of sufficient magnitude, intensity, and frequency is generally required for reducing this competition and thus allowing for successful oak reproduction and eventually, overstory recruitment (Johnson et al., 2009). For this very reason, consideration of local site factors should be applied into the decision-making process well before management begins. Stands occurring within incised ravines and on very steep slopes of this site should be carefully evaluated. Moist environments such as the preceding will invariably favor exceptional reproduction and growth by all hardwoods, and the management burden to implement effective controls may be too intensive. Locations that may have a greater chance for success are on slopes less than 30 percent and on sites where oaks are already the dominant overstory component. Successful management begins only when there is a competitive source of oak regeneration. This requires a population of well-developed, oak advance reproduction (e.g., seedlings, sprouts, and saplings) beneath the forest canopy (Clark, 1993; Loftis, 2004). Stems five feet tall and greater will have a better chance and a head start for continued growth following subsequent treatments. One approach that leads to advance reproduction in the stand is to implement a silvicultural treatment several years prior to final harvest of the overstory. This involves the removal and control (mechanical and herbicide treatment) of mid-story and understory competition while leaving the upper canopy layer intact. This action alters stand structure and increases the light environment for oak development (Loftis, 2004; Clatterbuck and Armel, 2010). Under this particular method, the final harvest may follow the uniform shelterwood approach, which removes all trees two inches dbh and above (Hodges, 1995), or it may be possible to implement a modified, "shelterwood with reserves" method that leads to a two-aged stand for greater structural complexity (Loftis, 2004). One additional management tool that has been promoted is the use of prescribed fire. However, its use in the promotion of oak-dominated stands has not always achieved the desired results (Clatterbuck and Armel, 2010). The efficacy of prescribed burns to produce and maintain oak stands in the Loess Hills are unknown and untested (Lockhart et al., 2010). [Please consult Johnson et al., (2009) for an exceptional and exhaustive treatment of silvicultural approaches to oak management.] Finding the appropriate approach for a given stand and environment necessitates close consultation with trained, experienced, and knowledgeable forestry professionals. If there is a desire to proceed with this state, it is strongly urged and advised that professional guidance be secured and a well-designed silvicultural plan developed in advance of any work conducted. Implementing careless and unplanned actions can lead to unanticipated ecological consequences that may take decades to undo.

Forest overstory. Overstory composition of a given stand will vary considerably depending on the silvicultural system used and the respective management stage prescribed for that system. Under the shelterwood method, the top canopy layer will largely remain intact immediately following site preparation but the mid-story will have been removed and controlled. The canopy will include mature oaks in addition to other hardwoods typical of this site, possibly including tuliptree, sweetgum, white ash, cucumber tree, and black gum. The manager, however, may have elected to remove tuliptree, and potentially other species, from the canopy years prior in order to reduce or eliminate future seed source. Following final harvest of the canopy (shelterwood approach), the newly developing overstory is anticipated to consist mainly of oaks, which may include a combination of white, cherrybark, northern red, Shumard's, black, swamp chestnut, chinkapin, and/or water oak. A stand comprised entirely of oak on this ecological site is highly improbable. Oaks may dominate but most assuredly other hardwoods will occur in the new stand.

Forest understory. A similar range of contingencies applies for the understory as for the overstory. The central goal in transitioning stands to this management phase requires the presence of oak advance reproduction. The oak component throughout the understory is anticipated to be well represented. Density and/or percent cover should be high enough for effective accession into the overstory strata and representation in the future canopy. The reduction or removal of non-oak understory competition is expected to decrease species richness and overall structural complexity. Herbaceous species may still be broadly represented.

Community 4.2
Tuliptree-Sweetgum-Oak/Hophornbeam

Figure 11. Timber Managed State (Phase 4.2)

This phase represents natural succession of a former oak-managed system following cessation of active management. Components of this phase may differ depending on the silvicultural system utilized, time lapse since last treatment, and the intensity and effectiveness of former competition controls. The species anticipated to occupy position in the transitioning stand include several competitors of oak, such as tuliptree, sweetgum, elm, and ash, along with an increasing presence of shade tolerant midstory and understory components (e.g., sugar maple and hophornbeam). Incidentally, the aforementioned hardwoods frequently dominate former clearcuts and large group selection harvests (e.g., 0.5 to 1.0-acre cuts). Therefore, this phase is also representative of timber harvests resulting in larger clearings. Although oaks generally respond well to even-aged management, the exceptional growth of other hardwoods on this moist site often results in overtopping of oak within a few years of timber operations. Persistent competition control is crucial for effective oak management on this site.

Forest overstory. Overstory composition of this phase is anticipated to consist mainly of a broad mixture of shade-intolerant hardwoods in the overstory and shade-tolerant species becoming established in the understory. Composition ultimately depends on the age of the stand, how long the stand has gone unmanaged, and the type and intensity of former timber management. Without management specifically benefitting oak regeneration, a decrease in oak abundance is anticipated with a concomitant increase in other hardwoods, especially tuliptree, sweetgum, elm, and ash.

Forest understory. Understory composition may vary depending on the type and intensity of former management and the lapse in time since the most recent operation. Younger stands may support a mixture of species ranging from shade-intolerant to tolerant species, including some oak seedlings and saplings. Older stands are anticipated to support disproportionally more shade tolerant species in the understory including sugar maple, beech, hophornbeam, American hornbeam, pawpaw, spicebush, and red buckeye.

Pathway 4.1A
Community 4.1 to 4.2

This pathway represents relaxation or cessation of oak management and maintenance. Over time, the stand will naturally transition toward a mixed hardwood composition with a greater concentration of shade-tolerant species (e.g., sugar maple, beech, and hophornbeam) encroaching through the understory. The transition to a mixed hardwood stand may occur rapidly (in a single cohort) if all competition control is halted before a clearcut or final harvest. Under the latter scenario, tuliptree, if not completely removed and controlled, may rapidly colonize the large opening and dominate the new stand.

Pathway 4.2A
Community 4.2 to 4.1

This pathway represents a return to the managed, oak-dominated system, which necessitates the establishment of oak advance regeneration. Prescribed silvicultural activities may include low thinning (understory and midstory), competition control (mechanical and chemical), crop tree release, and possible planting to aide oak recovery and abundance. Following sufficient advance regeneration, the overstory may be removed or thinned to a residual stand of crop trees depending on overstory composition and the chosen silvicultural approach. Continued efforts to control non-oak competition should be expected and planned.

State 5
Grassland/Pastureland State

This state is representative of hillslopes that have been converted to and maintained in pasture and forage cropland, typically a grass – legume mixture. The steep slopes and erosive soils of this site emphasize the need for diligent and well-planned pasture management. For pastureland, planning or prescribing the intensity, frequency, timing, and duration of grazing can help maintain desirable forage mixtures at sufficient density and vigor (USDA, NRCS, 2010; Green et al., 2006). Overgrazed pastures can lead to soil compaction and numerous bare spots, which may then become focal points of accelerated erosion and colonization sites of undesirable plants or weeds. Establishing an effective pasture management program can help minimize the rate of weed establishment and assist in maintaining vigorous growth of desired forage. An effective pasture management program includes: selecting well-adapted grass and/or legume species that will grow and establish rapidly; maintaining proper soil pH and fertility levels; using controlled grazing practices; mowing at proper timing and stage of maturity; allowing new seedings to become well established before use; and renovating pastures when needed (Rhodes et al., 2005; Green et al., 2006). It is strongly advised that consultation with State Grazing Land Specialists and District Conservationists at local NRCS Service Centers be sought when assistance is needed in developing management recommendations or prescribed grazing practices. Three community phases of this state are currently recognized. They differ in the level of grazing pressure and progression of natural succession should active management and/or grazing cease.

Community 5.1
Tall Fescue-Orchardgrass-Bermudagrass

Figure 12. Grassland/Pastureland State (Phase 5.1)

This community phase represents commonly planted forage species on pasturelands, haylands, and open grasslands. The suite of plants established on any given site may vary considerably depending upon purpose, management goals, and usage (e.g., horses vs. cattle). Most systems include a mixture of grasses and legumes that provide forage throughout the growing season. Cool season forage may include tall fescue (*Schedonorus arundinaceus*), orchardgrass (*Dactylis glomerata*), white clover (*Trifolium repens*), and red clover (*T. pratense*), and warm season forage often consists of bermudagrass (*Cynodon dactylon*), bahiagrass (*Paspalum notatum*), and annual lespedeza (Kummerowia spp.). Several additional plants and/or species combinations may be present depending on the objectives and management approaches of the land manager/owner. Maintaining the select suite of plants for any length of time is improbable in most situations. Both native and non-native plant species will gradually propagate newly established and renovated pastureland and hayland. Over time, a very diverse mixture of species will become established on most sites; some of these may be noxious and highly undesirable.

Forest overstory. The overstory in the grassland state is minimal, consisting mainly of scattered shade trees along the lower slopes.

Forest understory. Species composition of pastures, hayfields, and open areas of this community phase will vary considerably. Newly planted and/or renovated sites will consist mainly of the selected seeding mixtures, which may include tall fescue, orchardgrass, bermudagrass, white clover, and red clover among others. Depending on the amount of time elapsed since planting, a number of native and non-native species may invade the site and co-exist with the selected species.

Community 5.2
Sneezeweed-Tall Fescue

This phase is indicative of overgrazed conditions. In some situations, except the most severe cases, the originally planted species may still be present, but their abundance and density is dramatically reduced, often placing them as minor components of the community. The most abundant species under these conditions are often unpalatable, noxious weeds. The dominant components of this phase will vary from site to site and time of year. In summer, an abundance of sneezeweed (*Helenium amarum*) is often a clear indication of heavy grazing on older, continuously occupied pastures. In spring, hairy buttercup may be the dominant species with local patches of curly dock (*Rumex crispus*) interspersed. Invasions by thistle (Cirsium spp.), foxtail (Setaria spp.), Johnsongrass (*Sorghum halepense*), beefsteak plant (*Perilla frutescens*), and pigweed (Amaranthus spp.) are commonplace and their collective presence in a pasture can significantly reduce available forage. Of the species comprising the original seeding mixture, tall fescue, bermudagrass, and white clover may continue to persist under overgrazed, degraded conditions. Additional characteristics of overgrazed areas include a much higher percentage of bare ground, soil compaction, and erosion of topsoil.

Forest overstory. The occasional, pastureland shade tree represents this structural component

Forest understory. Species composition of overgrazed sites varies depending on local conditions. Typically, one to several different unpalatable species will invade and dominate the pasture – crowding out and replacing the originally planted forage mixture. The following species are generally observed in overgrazed sites.

Community 5.3
Black Locust/Sumac/Goldenrod

This phase represents the succession of pastureland and/or open grassland to “old field” conditions. The stage of this phase is the transitional period between a predominantly open, herbaceous field and the brushy stage of a newly initiated stand of trees. Structurally, this phase is characterized as a complex consisting of newly colonized tree seedlings, scattered small saplings, shrubs, and a persistent herbaceous component. Duration of this phase is short-lived and depending on former management, use, and impacts, may last from 3 to 5 years and possibly up to 8 on severely degraded sites. On many old field sites, the early pioneer woody species consists mainly of black locust, followed by scattered stems of tuliptree, sweetgum, elm, hackberry, sugarberry, honeylocust (*Gleditsia triacanthos*), and boxelder. Shrubs are frequently represented by winged sumac (*Rhus copallinum*), smooth sumac (*R. glabra*), elderberry (Sambucus canadensis), and blackberry. Herbaceous species may consist of tall fescue, bermudagrass, goldenrod (Solidago spp.), foxtail (Setaria spp.), purpletop (*Tridens flavus*), croton (Croton spp.), ticktrefoil (Desmodium spp.), dallisgrass (*Paspalum dilatatum*), Carolina horsenettle (*Solanum carolinense*), among many others. This particular phase represents an “at risk” condition for this vegetation state. Allowing a site to undergo continued colonization and development by woody pioneer species will make recovery back to pasture, forage production, or open grassland increasingly difficult. Incidentally, this phase is also the ideal stage for implementing forest management actions to influence and direct species composition of a future stand. As tree species continue to colonize the old field, desired species can easily be retained and undesirable ones culled. This is also the ideal period for planting the preferred crop trees.

Forest overstory. Under the old field condition, the scattered shade trees referenced in the preceding community phases continue to represent this structural component.

Forest understory. Many of the herbaceous species listed and occurring in the preceding community phases may continue to persist in the old field stage. The major difference for this phase is the increased colonization of woody vegetation (i.e., seedlings, shrubs, subshrubs, and vines). The species typically invading old fields include black locust, sassafras, persimmon, elm, sweetgum, tuliptree, plum (Prunus spp.), oaks, hickory, sumac, blackberry, greenbrier, grapevine, Japanese honeysuckle, goldenrod (Solidago spp.), ticktrefoil (Desmodium spp.), and many others.

Pathway 5.1A
Community 5.1 to 5.2

This pathway occurs when pastures are overstocked or continually grazed over long periods.

Pathway 5.1B
Community 5.1 to 5.3

When all management activities are discontinued (e.g., grazing, mowing, etc.), natural succession of the once managed site leads to the “old field” stage.

Pathway 5.2A
Community 5.2 to 5.1

This pathway represents a release of grazing pressures followed by renovation, which generally includes clipping, herbicide application, increasing pH and fertility levels (liming and fertilizing), and reseeding the desired forage at an appropriate rate.

Pathway 5.2B
Community 5.2 to 5.3

Abandonment of grazing with no renovation will lead to succession of the overgrazed pasture to an old field condition. Even with a continuation of grazing, relaxing appropriate management of a pasture over time will allow unpalatable tree, shrub, and vine species to invade an overgrazed site.

Pathway 5.3A
Community 5.3 to 5.1

This pathway represents renovation of the old field condition back to pastureland, forage production, or open grassland. Management activities likely include mechanical removal of the larger, woody vegetation followed by herbicide treatment and establishment of desired seeding mixtures.

State 6
Post Abandonment/Transitional Forest State

This state represents a return to forest conditions following the abandonment of pastureland and grassland management. The developmental stage of this state follows the “old field” condition and begins at canopy closure of the new forest stand. This initiates the stem exclusion period whereby establishment of additional canopy species becomes exceedingly difficult without active management (Oliver and Larson, 1990). Composition of the resulting forest will vary considerably depending on the amount of time the site was previously managed; the intensity of former land use practices; the condition of the land prior to abandonment; and the source and distance of the nearest seed sources. Some pioneer species of the new stand may dominate early on but will be replaced by competitors within the community as the stand matures. Competitive interactions are intense at this stage.

Community 6.1
Black Locust-Tuliptree/Grapevine


Figure 13. Post Abandonment/Transitional Forest State (Phase 6.1)

Species composition of this phase is highly variable depending on local site conditions and the age or stage of stand development. A single community phase is selected to represent the breadth of species combinations that may occur. One of most frequently observed colonizers of abandoned sites is black locust. This species has been observed to dominate newly initiated stands at canopy closure, but its dominance is usually short-lived. In the southern extent of this site, loblolly pine may be among the early colonizing species of some sites and may experience a similar fate as black locust. Once the stand matures and additional hardwood species assert dominance and codominance, black locust and loblolly pine are often reduced to occasional stems or eliminated altogether. Additional hardwoods that may comprise a large proportion of the overstory early on include sassafras, elm, hackberry, sugarberry, boxelder, black cherry, tuliptree, sweetgum, and several important oak species. As the stand matures, shifts in species dominance and codominance often occur. The components that may increase in importance include tuliptree, sweetgum, white ash, elm, oaks, and hickory. However, the presence of oak and hickory may be a special case that depends on nearest seed sources and disturbances at sufficient intensity and frequency to aid their competitive placement in the maturing stand. Most problematic for this phase is the abundance and proliferation that exotic species can have on abandoned sites. The exotic species most commonly observed in newly developing stands include princesstree, tree of heaven, Chinese privet, multiflora rose, Japanese honeysuckle, and, more locally, mimosa, chinaberry, and white mulberry. Depending on the extent of the invasion, exotic plants can significantly alter the natural succession of the stand – impeding it from ever reaching reference conditions.

Forest overstory. Overstory composition will vary considerably depending on site history, condition, and location, and age of the stand. At canopy closure (beginning stage), the dominant species is often black locust with associates including sassafras, persimmon, black cherry, hackberry, sugarberry, boxelder, oak, hickory, and persisting stems of sumac, and plum. Southward in Mississippi, an additional associate of newly established stands may be loblolly pine. As the stand matures, species asserting dominance or occurring in greater importance may include tuliptree, sweetgum, black cherry, hackberry, oak, and hickory. Invasive exotic species that may occur at different stages of development and in different locations include princesstree, tree of heaven, mimosa, and white mulberry.

Historically, several species of oak collectively dominated many post-abandoned open lands, especially on sites with slopes less than 30 percent. Their importance today is best expressed in stands that still support perceived reference conditions. How well oaks respond on future post-abandoned sites is of great concern and remains to be evaluated.

Forest understory. Species comprising the understory include redbud, flowering dogwood, hophornbeam, sugar maple, grapevine, poison ivy, and Virginia creeper. Exotic species often occurring in the understory include Chinese privet and Japanese honeysuckle.

State 7
Invaded State

This state represents the proliferation and dominance by a single species: kudzu. Several exotic species are now commonplace and problematic throughout the distribution of this site, but none compare with kudzu in its ability to displace and impede colonization by other species. When established, this rapidly growing legume effectively forms a single-species state by growing over, covering, and eventually replacing all other forms of vegetation. When allowed to grow into surrounding forests, it can significantly alter the composition and structure of the invaded stand by overshading the canopy and understory components and preventing regeneration of forest species (Forest Invasive Plants Resource Center, Online).

Community 7.1
Kudzu

Figure 14. Invaded State (Phase 7.1)

A well-established kudzu population has a canopy that invariably covers 100 percent of the ground surface and anything else it blankets. Healthy vines can sprawl 50 to 60 feet in all directions within a single growing season (Forest Invasive Plants Resource Center, Online) and can rapidly grow over and cover all stationary life forms and/or structures.

State 8
Grazed Forest State

This state represents uncontrolled access by livestock onto the forested slopes of this ecological site. It does not take into account carefully prescribed and/or managed forms of forest grazing (e.g., agroforestry or silvopasture), which generally has a mutual goal of providing quality forage and productive forest management. The conditions considered and represented here are the extreme cases of long-term forest grazing; this form of uncontrolled access has been referred to as “turning livestock into the woods” (Brantly, 2014). Forest stands that sustain heavy and frequent livestock traffic often have an open understory consisting of few herbaceous plants; low numbers of woody seedlings and shrubs; damaged tree roots; compacted soils; and varying levels of soil erosion. Composition of heavily grazed stands varies depending on the length of time grazing has occurred within the stand, the type(s) of livestock having access (hence, different grazing strategies), former forestry or logging practices, and conditions or composition of the forest prior to grazing. A single community phase is selected to represent the breadth of conditions that may be anticipated in stands having uncontrolled access by livestock.

Community 8.1
Hickory-Oak/Hophornbeam

Figure 15. Grazed Forest State (Phase 8.1)

Most grazed forests of this site are also managed for timber and many sites likely have been high-graded to some extent. Examples of grazed stands that have been examined typically supported a disproportionate amount of hickory, sugar maple, and beech relative to other hardwoods; however, this pattern varied by stand. Some locations supported northern red oak, cucumber tree, basswood, and even butternut (*Juglans cinerea*) among the hickory, sugar maple, and beech. Occurrences of exotic species such as princesstree also appeared to increase in grazed sites, especially in recent canopy gaps. Based on studies elsewhere and observations in grazed stands of this site, forest regeneration is very limited, particularly where livestock traffic and frequency is high. The canopy species known to have high livestock preference include tuliptree, black locust, white ash, white oak, and sassafras. The species apparently having a lower preference are the hickories, some of the red oaks, hophornbeam, American hornbeam, and pawpaw (Biswell and Hoover, 1945; Johnson, 1952; USDA-SCS, 1992). Preferential foraging on seedlings and saplings over long periods can lead to tremendous shifts in future canopy composition. The most palatable forage within forest stands are often the herbaceous understory plants, and those are typically targeted first (Johnson, 1952). The forests of this site are generally closed-canopied; hence, the availability of suitable herbaceous forage is often thinly distributed. What little is present is quickly consumed and sometimes depleted from a site. The combined effects of trampling, browsing woody plants, and foraging on the herbaceous layer often results in a high percentage of bare soil, exposed roots, and an open understory. Furthermore, overstory trees occurring in stands with high livestock traffic grow more slowly over time (Johnson, 1952).

Forest overstory. The length of time and intensity of grazing may ultimately determine overstory composition. Overstory species occurring in grazed forests may include hickory, various oaks, tuliptree, white ash, sweetgum, sugar maple, beech, black cherry, walnut, princesstree, honeylocust, hophornbeam, American hornbeam, and flowering dogwood, among others.

Forest understory. Depending on the type of livestock (cattle, goats, sheep), grazing intensity, and level of livestock traffic, understories can be startling depauperate. Woody vegetation that escaped trampling may consist of pawpaw, hophornbeam, American hornbeam, red buckeye, and dogwood. Very few, if any, herbaceous species may be present with the exception of an occasional Christmas fern.

Transition T1A
State 1 to 2

This pathway represents a large-scale, stand replacing disturbance, which may be caused by a catastrophic windstorm (e.g., straight-line winds, tornado), ice storm, severe fire, landslide, or a silvicultural clearcut. For this stressor to occur, most or all of the overstory must be removed or destroyed. A few residual trees may persist, but overall, the disturbance must be intensive enough, at least one acre or larger (Johnson et al., 2009), that a new, even-aged stand is created.

Transition T1B
State 1 to 3

Repeated selective harvesting or high-grading of stands over time can cause shifts in species composition, structure, and overall health of affected stands. High-grading occurs when the most desirable trees of select species are repeatedly removed leaving behind inferior, low quality stems and undesirable species.

Transition T1C
State 1 to 4

This pathway consists of prescribed silvicultural activities specifically designed to meet stand compositional and production objectives. For increasing oak recruitment and production (transitioning to Phase 4.1), achieving a level of oak advance regeneration in the stand is a necessity. Activities may include release cuttings through a combination of low and high thinning, mechanical and chemical control of competition, and artificial regeneration (i.e., planting) of sites with low oak presence. For management of a mixed hardwood system (less intensive approach), this pathway represents a variety of uneven-aged silvicultural methods, which may include group selection and/or single tree selection harvests (all classes/condition; avoid “high-grading”). Of caution, uneven-aged methods on this productive site will likely favor Phase 4.2, which may result in disproportionately more shade-intolerant mesophytes (group selection) or shade-tolerant overstory and understory components (single tree selection).

Transition T1D
State 1 to 5

Actions required to convert forests to pasture or forage production include forest clearing, stump removal, herbicide application, seedbed preparation, and the establishment of desired plants. Decisions to convert forestland to pastureland on this site should be made carefully with erosion controls planned and deployed before, during, and after conversion activities. This site is extremely susceptible to erosion. The decision to proceed with this action should be done so in close communication with and guidance from local NRCS Service Centers.

Transition T1E
State 1 to 8

This pathway represents uncontrolled access by livestock and impacts from sustained, selective grazing and browsing. Impacts from continual grazing and uncontrolled access can result in the removal of palatable understory components, alteration of species composition in current and future stands, conditions for exotic plant invasions, and soil compaction and erosion.

Restoration pathway R2A
State 2 to 1

This pathway represents a return to reference conditions through natural succession, if the disturbance occurred within a reference community. Depending upon objectives and stand condition, management activities to aide recovery may include exotic species control and silvicultural treatment that benefits oak regeneration and establishment (e.g., TSI practices such as crop tree release, low thinning, and cull removal). Restoring a highly altered stand (e.g., high-graded or heavily grazed) to reference conditions will require intensive management including mechanical and chemical treatment of undesirables, multiple follow-up TSI practices, and establishment of missing components (i.e., planting).

Transition T2A
State 2 to 4

This pathway represents the development of an even-aged stand that is prescribed to meet compositional and production objectives. For oak production (Phase 4.1), actions may include a final shelterwood harvest or crop tree harvest; artificial regeneration may be required for increasing oak abundance. Additional actions will likely include mechanical removal and herbicide treatment of oak competition. Development of a stand following a silvicultural clearcut, with no additional management actions, will favor expansion of mixed hardwoods (Phase 4.2). The latter will most likely result in disproportionately more non-oak hardwoods; oak response could be very poor depending on local site conditions.

Restoration pathway R3A
State 3 to 2

This pathway represents a large-scale, stand-initiating disturbance, which effectively removes most or all of the pre-existing overstory. Disturbances may include catastrophic windstorms, severe wildfire, silvicultural clearcut, and slope failure or landslide. For restoration of a severely high-graded stand to be effective, the intensity of the disturbance must be great enough to also damage or destroy most, if not all, of the pre-existing understory. Disturbances that only remove the overstory and not the shade-tolerant understory may promote an unintentional explosion of growth by the latter, further inhibiting reproduction of more desirable shade-intolerant and moderately-tolerant species. Desirable species that were depleted from high-graded stands may need to be planted if natural seeding and reproduction are no longer possible.

Restoration pathway R4A
State 4 to 1

Natural succession over a period of time may transition a former timber-managed stand to one supporting reference conditions. Based on observations of some reference stands, a period greater than 50 years may be required. Some question remains whether a return to reference conditions will occur in every situation, especially since some components may have been selectively culled from the stand. This scenario most likely applies to the rarer components of the community (e.g., Kentucky yellowwood). Overall, resiliency of the community appears to be quite high given the amount of impacts the site has sustained over the past 200 years.

Restoration pathway R4B
State 4 to 2

This pathway represents a large-scale, stand-initiating disturbance, which effectively removes most or all of the pre-existing overstory. Disturbances may include a catastrophic windstorm, severe wildfire, slope failure or landslide, and silvicultural management (even-aged). If the disturbance is a prescribed management action, method of harvest will depend upon current timber objectives and future stand composition and production goals. For continued oak management (Phase 4.1), silvicultural actions may include shelterwood or crop tree harvest in addition to competition control (mechanical and herbicide). For mixed hardwood management, silvicultural action may simply be a clearcut.

Transition T5A
State 5 to 6

This pathway involves abandonment of grassland/pastureland management and allowing natural succession to proceed beyond the old field stage to canopy closure of the young, developing forest stand.

Transition T5B
State 5 to 7

This transition represents proliferation and dominance of an invasive species, kudzu. Most situations where this transition has occurred are on gullied and severely eroded land – the effects of which occurred long ago when early attempts at farming and pasturing on steep slopes led to rapid gullying and in some cases, mass wastage. Kudzu was established in an attempt to control erosion. This transitional pathway is actively occurring as kudzu patches continue to expand over both open areas and along the margins of adjoining forests.

Restoration pathway R6A
State 6 to 1

This pathway represents natural succession back to perceived reference conditions. The period required for this transition to take place likely varies by location and is dependent upon local site conditions. Ages extrapolated from reference stands on a few protected sites (e.g., parks, refuges, etc.) suggest that a return interval to reference conditions may require more than 50 years; some of the examined stands have been protected for at least 75 years. In some cases, a return to the reference state may not be possible without considerable management effort. That effort may involve exotic species control and the reestablishment of components considered characteristic of the reference state. If planting is deemed necessary, local conditions of the transitional forest must be assessed and informed decisions made on which species to plant and where specific tree species should be planted in relation to the slope profile or position.

Restoration pathway R6B
State 6 to 5

Actions required to convert forests to pasture or forage production include forest clearing, herbicide application, seedbed preparation, and the establishment of desired plants. Decisions to convert forestland to pastureland on this site should be made carefully with erosion controls planned and deployed before, during, and after conversion activities. This site is extremely susceptible to severe erosion and soil loss. The decision to proceed with this action should be done so in close communication with and guidance from local NRCS Service Centers.

Transition T6A
State 6 to 8

This pathway represents uncontrolled access by livestock and subsequent grazing and browsing. Selective foraging of palatable species can result in the reduction and loss of certain community associates and create shifts in species composition of affected stands. Some grazed forests today likely developed through this pathway as early cropland pursuits were abandoned and livestock were allowed to graze through reverting stands.

Restoration pathway R7A
State 7 to 5

The establishment of, or a return to, pastureland or open grassland conditions following a previous kudzu infestation may be possible in some areas. Successful actions will require relentless efforts that include one or more of the following methods: mowing, prescribed grazing (cattle and goats), prescribed burning, digging, disking, and intensive herbicide application. Because many areas covered in kudzu are gullied chasms with vertical sidewalls, mechanical smoothing of these land irregularities will be necessary before planting in preferred seed mixtures and restoration to take place. In some extreme cases, restoration attempts could result in greater erosion and worsening of local conditions. Please consult with District and Soil Conservationists at local NRCS Field Offices for advice and guidance on land smoothing and/or restoration attempts on severely eroded/gullied areas.

Restoration pathway R8A
State 8 to 2

Large-scale, stand-initiating disturbances effectively remove the pre-existing overstory and resets site conditions to an early seral stage. Disturbances may include catastrophic windstorms, icestorms, silvicultural clearcut, and slope failure or landslide. Depending on the level of former livestock impacts, there may be very little advance regeneration available for rapid forest development. Pioneers may consist of hardy species capable of establishment on compacted soils, which often includes exotic species. Actions may require control of undesirable species and planting desirable forest species. Natural succession and site-based forest management over time may result in a diverse mix of overstory and understory species.

Transition T8A
State 8 to 5

Actions required to convert forests to pasture or forage production include forest clearing, herbicide application, seedbed preparation, and the establishment of desired plants. Decisions to convert forestland to pastureland on this site should be made carefully with erosion controls planned and deployed before, during, and after conversion activities. This site is extremely susceptible to severe erosion and soil loss. The decision to proceed with this action should be done so in close communication with and guidance from local NRCS Service Centers.

Additional community tables

Table 8. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
cherrybark oak	QUPA5	*Quercus pagoda*	Native	70–130	0–85	18.1–45	–

American beech	FAGR	*Fagus grandifolia*	Native	65–114	10–65	21.3–26.2	–
white oak	QUAL	*Quercus alba*	Native	50–120	4–65	18–39.8	–
sweetgum	LIST2	*Liquidambar styraciflua*	Native	60–137	2–40	15–26.8	–
American beech	FAGR	*Fagus grandifolia*	Native	70–135	0–40	28–38	–
tuliptree	LITU	*Liriodendron tulipifera*	Native	60–148	2–40	28–44	–
Shumard's oak	QUSH	*Quercus shumardii*	Native	75–120	5–40	19.9–43.1	–
American beech	FAGR	*Fagus grandifolia*	Native	20–80	4–40	10–19.2	–
sugar maple	ACSA3	*Acer saccharum*	Native	30–79	4–40	9.5–16.5	–
tuliptree	LITU	*Liriodendron tulipifera*	Native	50–120	2–40	15–26.1	–
hophornbeam	OSVI	*Ostrya virginiana*	Native	5–40	2–40	1–3	–
American beech	FAGR	*Fagus grandifolia*	Native	6–35	2–40	6	–
sugar maple	ACSA3	*Acer saccharum*	Native	5–35	2–40	2–5	–
northern red oak	QURU	*Quercus rubra*	Native	65–112	10–25	19.6–37.6	–
American basswood	TIAM	*Tilia americana*	Native	55–110	0–25	27.1	–
cucumber tree	MAAC	*Magnolia acuminata*	Native	47–120	0–20	23.6–37.9	–
black oak	QUVE	*Quercus velutina*	Native	–	0–20	18.5–39.5	–
chinquapin oak	QUMU	*Quercus muehlenbergii*	Native	–	0–20	14–28.8	–
white ash	FRAM2	*Fraxinus americana*	Native	80–142	0–20	16.9–42.1	–
slippery elm	ULRU	*Ulmus rubra*	Native	45–100	0–20	18.1–25	–
water oak	QUNI	*Quercus nigra*	Native	65–120	0–20	26.6	–
bitternut hickory	CACO15	*Carya cordiformis*	Native	65–100	5–20	18.9–27.2	–
mockernut hickory	CATO6	*Carya tomentosa*	Native	45–100	0–20	25.7	–
hophornbeam	OSVI	*Ostrya virginiana*	Native	27–70	2–20	4–8	–
Kentucky yellowwood	CLKE	*Cladrastis kentukea*	Native	30–70	0–20	13–17.8	–
pawpaw	ASTR	*Asimina triloba*	Native	4–40	0–20	2–4	–
slippery elm	ULRU	*Ulmus rubra*	Native	25–70	0–10	6.1–10	–
slippery elm	ULRU	*Ulmus rubra*	Native	–	0–10	2–4.1	–
blackgum	NYSY	*Nyssa sylvatica*	Native	30–60	0–10	8	–
bitternut hickory	CACO15	*Carya cordiformis*	Native	45–67	0–10	7–9.3	–
mockernut hickory	CATO6	*Carya tomentosa*	Native	40–70	0–10	8–15	–
American basswood	TIAM	*Tilia americana*	Native	35–75	0–10	9.2–14.2	–
white oak	QUAL	*Quercus alba*	Native	35–80	0–10	11.5	–
northern red oak	QURU	*Quercus rubra*	Native	30–80	2–10	6–11	–
black oak	QUVE	*Quercus velutina*	Native	40–70	0–10	12.4	–
Shumard's oak	QUSH	*Quercus shumardii*	Native	30–77	0–5	6	–
swamp chestnut oak	QUMI	*Quercus michauxii*	Native	40–80	0–5	11.7	–
blackgum	NYSY	*Nyssa sylvatica*	Native	–	0–5	17.7–	–

						18.1	
shagbark hickory	CAOV2	*Carya ovata*	Native	–	0–5	16.6	–
shagbark hickory	CAOV2	*Carya ovata*	Native	16–40	0–5	6	–
shagbark hickory	CAOV2	*Carya ovata*	Native	–	0–5	14	–
white ash	FRAM2	*Fraxinus americana*	Native	30–70	0–5	6.5–10	–
Kentucky yellowwood	CLKE	*Cladrastis kentukea*	Native	18–33	0–5	4–8	–
sassafras	SAAL5	*Sassafras albidum*	Native	35–70	0–5	10.5	–
bitternut hickory	CACO15	*Carya cordiformis*	Native	13–40	0–5	1.5–4	–
American hornbeam	CACA18	*Carpinus caroliniana*	Native	4–40	0–5	2–6	–
American elm	ULAM	*Ulmus americana*	Native	30–60	0–5	8	–
flowering dogwood	COFL2	*Cornus florida*	Native	6–32	0–5	1–3	–
sweetgum	LIST2	*Liquidambar styraciflua*	Native	40–75	0–4	6–9.7	–
cucumber tree	MAAC	*Magnolia acuminata*	Native	30–60	0–2	6	–
eastern redbud	CECA4	*Cercis canadensis*	Native	4–20	0–2	1.5–3	–
black walnut	JUNI	*Juglans nigra*	Native	–	0–2	–	–
butternut	JUCI	*Juglans cinerea*	Native	–	0–2	–	–
Kentucky coffeetree	GYDI	*Gymnocladus dioicus*	Native	–	0–2	–	–
bigleaf magnolia	MAMA2	*Magnolia macrophylla*	Native	–	0–2	–	–
mockernut hickory	CATO6	*Carya tomentosa*	Native	16–35	0–2	2–4	–
sugarberry	CELA	*Celtis laevigata*	Native	16–40	0–2	5.1	–
tuliptree	LITU	*Liriodendron tulipifera*	Native	24–40	0–2	6	–
white ash	FRAM2	*Fraxinus americana*	Native	13–40	0–2	2–4	–
cucumber tree	MAAC	*Magnolia acuminata*	Native	30–60	0–2	6	–
American basswood	TIAM	*Tilia americana*	Native	16–40	0–2	2–4	–
red mulberry	MORU2	*Morus rubra*	Native	16–40	0–1	5	–
pignut hickory	CAGL8	*Carya glabra*	Native	–	–	–	–
black cherry	PRSE2	*Prunus serotina*	Native	–	–	–	–
Vine/Liana							
summer grape	VIAE	*Vitis aestivalis*	Native	20–70	1–10	–	–
eastern poison ivy	TORA2	*Toxicodendron radicans*	Native	1–70	0–5	–	–
muscadine	VIRO3	*Vitis rotundifolia*	Native	12–30	0–5	–	–
bay starvine	SCGL7	*Schisandra glabra*	Native	1–20	0–2	–	–
Virginia creeper	PAQU2	*Parthenocissus quinquefolia*	Native	4–40	0–2	–	–

Table 9. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
sedge	CAREX	*Carex*	Native	0–0.5	1–10
longleaf woodoats	CHSE2	*Chasmanthium sessiliflorum*	Native	0.5–2	0–5
white bear sedge	CAAL11	*Carex albursina*	Native	0–0.5	0–3

rosette grass	DICHA2	*Dichanthelium*	Native	0–0.5	0–1
Forb/Herb					
Canadian wildginger	ASCA	*Asarum canadense*	Native	0–0.5	0–10
beaked agrimony	AGRO3	*Agrimonia rostellata*	Native	0–1	0–5
white snakeroot	AGAL5	*Ageratina altissima*	Native	0.5–2	0–5
goldenseal	HYCA	*Hydrastis canadensis*	Native	0.5–1	0–5
Jack in the pulpit	ARTR	*Arisaema triphyllum*	Native	0.5–1.5	0–5
wild yam	DIVI4	*Dioscorea villosa*	Native	0.5–2	0–3
Canadian woodnettle	LACA3	*Laportea canadensis*	Native	0.5–2	0–3
wild comfrey	CYVI	*Cynoglossum virginianum*	Native	0–1	0–3
richweed	COCA4	*Collinsonia canadensis*	Native	0.5–2	0–3
mayapple	POPE	*Podophyllum peltatum*	Native	0–1	0–3
Canadian blacksnakeroot	SACA15	*Sanicula canadensis*	Native	0–1	0–3
white baneberry	ACPA	*Actaea pachypoda*	Native	0.5–2	0–2
green dragon	ARDR3	*Arisaema dracontium*	Native	0.5–1.5	0–2
bloodroot	SACA13	*Sanguinaria canadensis*	Native	0–0.5	0–2
violet	VIOLA	*Viola*	Native	0–0.5	0–1
Virginia snakeroot	ARSE3	*Aristolochia serpentaria*	Native	0.5–1	0–1
wreath goldenrod	SOCA4	*Solidago caesia*	Native	0.5–2	0–1
yellow fumewort	COFL3	*Corydalis flavula*	Native	0–0.5	0–1
wild blue phlox	PHDI5	*Phlox divaricata*	Native	0–1.5	0–1
yellow passionflower	PALU2	*Passiflora lutea*	Native	0–2	0–0.5
Canadian honewort	CRCA9	*Cryptotaenia canadensis*	Native	0.5–1	0–0.5
American lopseed	PHLE5	*Phryma leptostachya*	Native	0.5–1.5	0–0.5
licorice bedstraw	GACI2	*Galium circaezans*	Native	0–1	0–0.5
beechdrops	EPVI2	*Epifagus virginiana*	Native	0–0.5	0–0.5
American bellflower	CAAM18	*Campanulastrum americanum*	Native	0.5–2	0–0.5
white avens	GECA7	*Geum canadense*	Native	0–1	0–0.5
ticktrefoil	DESMO	*Desmodium*	Native	0–1	0–0.1
downy yellow violet	VIPU3	*Viola pubescens*	Native	0–1	0–0.1
American ginseng	PAQU	*Panax quinquefolius*	Native	0.5–1	0–0.1
largeflower bellwort	UVGR	*Uvularia grandiflora*	Native	0–1	0–0.1
crippled cranefly	TIDI	*Tipularia discolor*	Native	0–1	0–0.1
longstyle sweetroot	OSLO	*Osmorhiza longistylis*	Native	0–1	0–0.1
smooth Solomon's seal	POBI2	*Polygonatum biflorum*	Native	0.5–1.5	0–0.1
bloody butcher	TRRE5	*Trillium recurvatum*	Native	0–1	–
widowsfrill	SIST	*Silene stellata*	Native	0–2	–
Fern/fern ally					
Christmas fern	POAC4	*Polystichum acrostichoides*	Native	0–1	1–50
lowland bladderfern	CYPR4	*Cystopteris protrusa*	Native	0–0.5	0–20
broad beechfern	PHHE11	*Phegopteris hexagonoptera*	Native	0–1	0–5
northern maidenhair	ADPE	*Adiantum pedatum*	Native	0–2	0–2
silver false spleenwort	DEAC4	*Deparia acrostichoides*	Native	0.5–2	0–0.5
rattlesnake fern	BOVI	*Botrychium virginianum*	Native	0–0.5	0–0.1

Shrub/Subshrub					
red buckeye	AEPA	*Aesculus pavia*	Native	2–6.5	1–50
giant cane	ARGI	*Arundinaria gigantea*	Native	2–6	3–25
northern spicebush	LIBE3	*Lindera benzoin*	Native	1–5	3–25
American bladdernut	STTR	*Staphylea trifolia*	Native	4–13	0–10
wild hydrangea	HYAR	*Hydrangea arborescens*	Native	1.5–5	0–10
oakleaf hydrangea	HYQU3	*Hydrangea quercifolia*	Native	1.5–5	0–10
giant cane	ARGI	*Arundinaria gigantea*	Native	0–2	1–5
northern spicebush	LIBE3	*Lindera benzoin*	Native	0–1	1–5
bursting-heart	EUAM9	*Euonymus americanus*	Native	0–1	0–3
blackberry	RUBUS	*Rubus*	Native	1–3	0–3
American beautyberry	CAAM2	*Callicarpa americana*	Native	1–4.5	0–3
American beautyberry	CAAM2	*Callicarpa americana*	Native	0–1	0–1
bursting-heart	EUAM9	*Euonymus americanus*	Native	0.5–5	0–1
red buckeye	AEPA	*Aesculus pavia*	Native	0–2	0–1
American witchhazel	HAVI4	*Hamamelis virginiana*	Native	2–6	0–1
American holly	ILOP	*Ilex opaca*	Native	0–2	0–0.5
American witchhazel	HAVI4	*Hamamelis virginiana*	Native	0–1	0–0.1
possumhaw	ILDE	*Ilex decidua*	Native	–	–
Tree					
American beech	FAGR	*Fagus grandifolia*	Native	2–13	0–60
pawpaw	ASTR	*Asimina triloba*	Native	0.5–4.5	2–40
pawpaw	ASTR	*Asimina triloba*	Native	2–13	0–40
pawpaw	ASTR	*Asimina triloba*	Native	0–1	0–20
sugar maple	ACSA3	*Acer saccharum*	Native	3–13	2–20
American beech	FAGR	*Fagus grandifolia*	Native	0–1	0–10
sugar maple	ACSA3	*Acer saccharum*	Native	0.5–4.5	0–10
white ash	FRAM2	*Fraxinus americana*	Native	0.5–4.5	0–10
hophornbeam	OSVI	*Ostrya virginiana*	Native	2.5–13	1–10
hophornbeam	OSVI	*Ostrya virginiana*	Native	1–4.5	1–10
white oak	QUAL	*Quercus alba*	Native	0–1	0–5
American beech	FAGR	*Fagus grandifolia*	Native	1–4.5	0–5
cherrybark oak	QUPA5	*Quercus pagoda*	Native	0–1	0–3
bitternut hickory	CACO15	*Carya cordiformis*	Native	0.5–4.5	0–2
common hackberry	CEOC	*Celtis occidentalis*	Native	0.5–4.5	0–2
American hornbeam	CACA18	*Carpinus caroliniana*	Native	2.5–13	0–2
American hornbeam	CACA18	*Carpinus caroliniana*	Native	0.5–4.5	0–1
American hornbeam	CACA18	*Carpinus caroliniana*	Native	0–1	0–1
eastern redbud	CECA4	*Cercis canadensis*	Native	0.5–4.5	0–1
sugar maple	ACSA3	*Acer saccharum*	Native	0–1	0–1
flowering dogwood	COFL2	*Cornus florida*	Native	3–13	0–1
bitternut hickory	CACO15	*Carya cordiformis*	Native	0–1	0–1
cucumber tree	MAAC	*Magnolia acuminata*	Native	1.5–4.5	0–1
mockernut hickory	CATO6	*Carya tomentosa*	Native	3–13	0–1

mockernut hickory	CATO6	*Carya tomentosa*	Native	5–13	0–1
sugarberry	CELA	*Celtis laevigata*	Native	–	0–1
Kentucky yellowwood	CLKE	*Cladrastis kentukea*	Native	4–13	0–1
white ash	FRAM2	*Fraxinus americana*	Native	0–1	0–1
hophornbeam	OSVI	*Ostrya virginiana*	Native	0–1	0–1
blackgum	NYSY	*Nyssa sylvatica*	Native	1–4.5	0–0.5
blackgum	NYSY	*Nyssa sylvatica*	Native	0–1	0–0.5
northern red oak	QURU	*Quercus rubra*	Native	1–4.5	0–0.5
northern red oak	QURU	*Quercus rubra*	Native	0–1	0–0.5
red mulberry	MORU2	*Morus rubra*	Native	–	0–0.5
sassafras	SAAL5	*Sassafras albidum*	Native	0–1	0–0.5
American basswood	TIAM	*Tilia americana*	Native	1–4.5	0–0.5
American elm	ULAM	*Ulmus americana*	Native	1–4.5	0–0.5
slippery elm	ULRU	*Ulmus rubra*	Native	1–4.5	0–0.5
slippery elm	ULRU	*Ulmus rubra*	Native	0–1	0–0.5
hybrid hickory	CARYA	*Carya*	Native	0–1	0–0.5
sweetgum	LIST2	*Liquidambar styraciflua*	Native	0–1	0–0.1
water oak	QUNI	*Quercus nigra*	Native	0–1	0–0.1
black cherry	PRSE2	*Prunus serotina*	Native	0–1	0–0.1
red mulberry	MORU2	*Morus rubra*	Native	0–1	0–0.1
tuliptree	LITU	*Liriodendron tulipifera*	Native	–	0–0.1
tuliptree	LITU	*Liriodendron tulipifera*	Native	0–0.5	0–0.1
Vine/Liana					
Virginia creeper	PAQU2	*Parthenocissus quinquefolia*	Native	0–2	1–25
eastern poison ivy	TORA2	*Toxicodendron radicans*	Native	0–2	0.5–25
grape	VITIS	*Vitis*	Native	0–2	0–10
muscadine	VIRO3	*Vitis rotundifolia*	Native	1–4.5	0–10
muscadine	VIRO3	*Vitis rotundifolia*	Native	0–1	0–5
crossvine	BICA	*Bignonia capreolata*	Native	0–2	0.1–5
roundleaf greenbrier	SMRO	*Smilax rotundifolia*	Native	2–4.5	0–5
bay starvine	SCGL7	*Schisandra glabra*	Native	0–13	0–5
roundleaf greenbrier	SMRO	*Smilax rotundifolia*	Native	0–2	0–3
bristly greenbrier	SMTA2	*Smilax tamnoides*	Native	0–2	0–1
saw greenbrier	SMBO2	*Smilax bona-nox*	Native	0–2	0–1
summer grape	VIAE	*Vitis aestivalis*	Native	0–1	0–1
Japanese honeysuckle	LOJA	*Lonicera japonica*	Introduced	0–1	0–1
Nonvascular					
Bryophyte (moss, liverwort, hornwort)	2BRY	*Bryophyte (moss, liverwort, hornwort)*	Native	0–0.1	0.5–20

Table 10. Representative site productivity

Common Name	Symbol	Site Index Low	Site Index High	CMAI Low	CMAI High	Age Of CMAI	Site Index Curve Code	Site Index Curve Basis	Citation
tuliptree	*LITU*	90	120	90	139	–	–	–	
white oak	*QUAL*	80	110	62	81	–	–	–	

Inventory data references

Information presented in this report was generated from a series of low-intensity reconnaissance (40 sites) and medium- to high-intensity inventories. Moderate and high intensity sampling were conducted by utilizing a series of sampling approaches including point sampling (variable radius forest plots) and fixed-area plot inventories (20 x 20 m) that included species identification and tabulation; ocular estimates of cover per species by vertical stratum; stem counts per species by stratum; and verification and/or description of soils. A culmination of these efforts was the development of the community states and phases and their associated attributes. Site index data, per select tree species, were graciously provided by the Ozark – St. Francis National Forest. Additionally, ECS-5 plots of the appropriate soil, species, county, and slope percentage were considered.

Inventories of varying intensity were conducted throughout the range of this site, which included 40 low-intensity sites, 17 medium-intensity plots, and 6 high-intensity surveys.

Type locality

Location 1: Shelby County, TN	
Latitude	35° 20′ 30″
Longitude	90° 3′ 7″
General legal description	Locality occurs within Meeman-Shelby Forest State Park, TN. Soils are Natchez; aspect 170 d (S); slope 47%; vegetation considered standard for the site. Although S-facing, mesophytes were well represented including large beech, tuliptree, and sugar maple.

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Contributors

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Approval

Matthew Duvall, 3/20/2025

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	05/10/2025
Approved by	Matthew Duvall
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

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

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

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

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

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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

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

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

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

17. **Perennial plant reproductive capability:**