USDA Natural Resources
Conservation Service

Ecological site F134XY002TN
Northern Deep Loess Summit

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General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

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 to southern 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 are Tertiary deposits of unconsolidated sand, silt, clay, gravel, and lignite. The soils, mainly Alfisols, formed in the loess mantle. Stream systems of the MLRA typically originate as low-gradient drainageways in the upper reaches that broaden rapidly downstream to wide, level floodplains with highly meandering channels. Alluvial soils, mostly Entisols and Inceptisols, are predominantly silty where loess thickness of the uplands are deepest but grade to loamy textures in watersheds covered by thin loess. Crowley's Ridge, Macon Ridge, and Lafayette Loess Plains are discontinuous, erosional remnants that run north to south in southeastern Missouri - eastern Arkansas, northeastern Louisiana, and south-central Louisiana, respectively. Elevations range from around 100 feet on terraces in southern Louisiana to over 600 feet on uplands in western Kentucky. The steep, dissected uplands are mainly in hardwood forests while less sloping areas are used for crop, pasture, and forage production (USDA, 2006).

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)
-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 Summit is characterized by sinuous, narrow ridgetops and interfluves of the highly dissected Loess Hills (EPA Level IV Ecoregion 74a). Both summit and shoulder positions define the site with slopes ranging from 0 to 12 percent and up to 15 percent, locally. Soils are well drained and formed in loess greater than 4 feet thick. Soil depths vary throughout the site's distribution but loess depths can exceed 90 feet in areas along the edge of the Loess Hills and the adjoining Southern Mississippi River Alluvium (MLRA 131A). The site is recognized for its potential in producing high quality hardwoods. Oaks often dominate the canopy with associates consisting of a broad mixture of southern hardwoods.

Associated sites

F134XY001TN	**Northern Deep Loess Backslope Mesophytic Forest** The Northern Deep Loess Backslope ecological site adjoins the deep loessal summits at the shoulder slope position (slope gradient at approximately 12 to 15 percent).

Similar sites

F134XY107MS	**Southern Deep Loess Summit - PROVISIONAL** The Southern Deep Loess Summit is the southern counterpart to the Northern Deep Loess Summit ecological site. The transitional boundary between the two sites is the northern boundary of the Southern Rolling Hills ecoregion (EPA Level IV, 74c)...as of September 2016.

Table 1. Dominant plant species

Tree	(1) *Quercus alba* (2) *Quercus pagoda*
Shrub	(1) *Ostrya virginiana* (2) *Cornus florida*
Herbaceous	Not specified

Physiographic features

The Northern Deep Loess Summit 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 eventually grade to the undulating Loess Plains (EPA Level IV Ecoregion: 74b).

A western physiographic counterpart to the Loess Hills east of the Mississippi River 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. 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 (3) Interfluve
Flooding frequency	None
Ponding frequency	None
Elevation	200–520 ft
Slope	0–15%
Water table depth	60 in
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 north to south. For the portion of this site east of the Mississippi River, it is 48 to 57 inches (122 to 145 cm). On Crowley's Ridge it is 47 to 51 inches (119 to 130 cm). Maximum precipitation occurs in winter and spring and decreases gradually throughout the summer, except for a moderate increase in midsummer. Rainfall often occurs as high-intensity, convective thunderstorms during warmer periods but moderate-intensity tropical and frontal storms can produce large amounts of rainfall during winter, especially in the southern part of the area. Snowfall generally occurs in the northern portions of the site. Accumulations are typically less than 12 inches (31 cm) 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.

The broad geographic distribution of this site north to south naturally includes much climatic variability with sites farther south having a longer growing season and increased precipitation. These climatic factors likely lead to important differences in overall plant productivity and key vegetation components between the southern and northern portions of this site. As future work proceeds, the current distribution of the Northern Deep Loess Summit, as indicated in this report, will likely be revised with a "central" site interjected between the northern and southern extremes of this MLRA.

Table 3. Representative climatic features

Frost-free period (average)	200 days
Freeze-free period (average)	226 days
Precipitation total (average)	54 in

Climate stations used

- (1) SENATOBIA [USC00227921], Coldwater, MS
- (2) NEWBERN [USC00406471], Newbern, TN
- (3) HELENA [USC00033242], Helena, AR
- (4) JONESBORO 2 NE [USC00033734], Jonesboro, AR
- (5) MADISON 1 NW [USC00034528], Forrest City, AR
- (6) CHARLESTON [USC00221606], Charleston, MS
- (7) LEXINGTON [USC00225062], Lexington, MS
- (8) RIPLEY [USC00407710], Ripley, TN
- (9) MEMPHIS [USW00093839], Millington, TN
- (10) MALDEN MUNI AP [USC00235207], Malden, MO
- (11) COVINGTON 3 SW [USC00402108], Covington, TN
- (12) DYERSBURG III GOLF [USW00003809], Dyersburg, TN

- (13) MEMPHIS INTL AP [USW00013893], Memphis, TN
- (14) GREENWOOD LEFLORE AP [USW00013978], Carrollton, MS
- (15) MARIANNA 2 S [USC00034638], Marianna, AR
- (16) WYNNE [USC00038052], Wynne, AR
- (17) BARDWELL 2 E [USC00150402], Bardwell, KY
- (18) BATESVILLE 2 SW [USC00220488], Batesville, MS
- (19) GRENADA [USC00223645], Grenada, MS
- (20) VICKSBURG MILITARY PK [USC00229216], Vicksburg, MS
- (21) YAZOO CITY 5 NNE [USC00229860], Yazoo City, MS
- (22) UNION CITY [USC00409219], Union City, TN
- (23) CAPE GIRARDEAU MUNI AP [USW00003935], Chaffee, MO
- (24) ADVANCE 1 S [USW00093825], Advance, MO
- (25) HERNANDO [USC00223975], Hernando, MS

Influencing water features

This site is not influenced by a hydrologic regime. Although rare, inclusions of highly localized depressions have been observed on level, broader interfluves of this site. The presence of such features do not influence the overall characteristics of this ecological site.

Soil features

The parent material of this site is a mantle of highly-erodible loess of eolian origin. East of the Mississippi River, the loess is thickest along the wall of bluffs at the interface of the Mississippi River floodplain and progressively thins eastward. West of the river, the loess is thickest on the southern end of Crowley's Ridge from the area of Wynne to Helena in eastern Arkansas and on the extreme northern end of Crowley's Ridge (including the Commerce Hills, Hickory Ridge, and a series of smaller hills) in southeastern Missouri.

The soils of this site are well drained, have moderate permeability, and consist of silt loam surface horizons with subsoils that range from silt loam to silty clay loam. These soils are not affected by seasonal wetness. The principal soil of this ecological site is the Memphis series (Fine-silty, mixed, active, thermic Typic Hapludalfs). Base saturations (a measure of a soil's natural fertility) generally exceed 60 percent, a taxonomic criteria for the Memphis 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 (USDA, 2016).

Table 4. Representative soil features

Surface texture	(1) Silt loam (2) Silty clay loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderate
Soil depth	80 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	8.4–8.7 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–1 mmhos/cm
Sodium adsorption ratio (0-40in)	0

Soil reaction (1:1 water) (0-40in)	5–6
Subsurface fragment volume <=3" (Depth not specified)	0%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

Background
The Loess Hills are often described as supporting rich, productive forests that are starkly different from surrounding plant communities (Braun, 1950; Miller and Neiswender, 1987; Bryant, 1993). Miller and Neiswender (1989) found the forests of the ecoregion to be more similar to the cove hardwood communities of the Great Smoky Mountains National Park and the Cumberland Plateau than to forests of the adjoining Mississippi Alluvial Valley and Loess Plains. Johnson (1958) declared that the fast-growing trees of the Loess Hills as "…potentially one of the most productive hardwood sites in the nation." Factors contributing to the diversity and productivity of the forest community likely stem from a highly complex and varied topography in addition to very deep, fertile soils that have a high available water capacity (Miller and Neiswender, 1987).

Three distinct ecological sites are currently recognized in the northern section of the Loess Hills (includes Crowley's Ridge). Each site is largely defined by the landscape position in which it occurs: summits or ridgetops, steep to nearly vertical backslopes, and narrow drainageways. This ecological site, the Northern Deep Loess Summit, is entirely restricted to the highest position on the landscape, the narrow to moderately broad summits.

Historic
The Loess Hills have a long history of human influence. Archeological surveys have discovered several prehistoric sites on the summits of the loess bluffs that overlook the Mississippi River floodplain (see Loughridge, 1888; Dye and Cox, 1990; Morse and Morse, 2009). These centers of occupancy would have necessitated local clearings and intensive subsistence activities. Food, clothing, building, and cultural materials 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. Some local hillsides and especially the intervening ridgetops were cleared of trees and maintained in an herbaceous or open condition. This complex backdrop of human subsistence and influences on the surrounding landscape likely contributed to a "shifting mosaic" of biological communities as human populations moved about, increased, and waned.

As the region was being settled, the rich soils of the Loess Hills became an enticement for crop production. 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 (Hodges, 1994). In addition to cropping pursuits, hillsides were cleared and converted to pastureland, with grazing often expanding into remaining forests. 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. The rapid transformation of the landscape coupled with highly erodible soils led to unheralded impacts that included severe gullying, mass wasting, and altered forest composition on a broad scale.

Today, most of the broader ridges and gently sloping areas remain in some form of active use including pasturage, forest production, orchards, and a limited amount of crop production. However, many of the areas that have been set aside in the public and/or private interest (e.g., parks, refuges, natural areas, and forest preserves) are now heavily forested. With no example of the pre-settlement plant community remaining intact, reference conditions of this site have been arbitrarily chosen to reflect the native plant species that most frequently occur and that influence the overall structure and characteristics of maturing stands. Locations that offer an opportunity to examine "surrogate" reference conditions are relegated to those public and private lands.

Plant Community
Given the landscape position and consistent sun exposure, this site is drier and soils more weathered and acidic than the adjoining moist backslope site. A "drier" association of oaks and hickories tend to develop on this site, especially in areas where the soils are more eroded and where the Loess Hills transition to the Loess Plains. This association is often comprised of a mixture of white oak (*Quercus alba*), black oak (*Q. velutina*), cherrybark oak (*Q.*

pagoda), chinkapin oak (*Q. muehlenbergii*), shagbark hickory (*Carya ovata*), mockernut hickory (*C. tomentosa*), bitternut hickory (*Carya cordiformis*), and occasionally pignut hickory (*C. glabra*). Northern red oak (*Q. rubra*) and Shumard's oak (*Q. shumardii*) are components that are typically found along the edge of the summits and shoulder-slope position. Southern red oak (*Q. falcata*) may appear on sites where land use history was most intense but is largely absent from areas where the loess is thickest and ridgetops the narrowest. In terms of species distribution, abundance, and production, white oak and cherrybark oak are among the most important species of this site (personal observation).

Additional canopy associates of maturing stands often include sweetgum (*Liquidambar styraciflua*), tuliptree (*Liriodendron tulipifera*), white ash (*Fraxinus americana*), black gum (*Nyssa sylvatica*), slippery elm (*Ulmus rubra*), black cherry (*Prunus serotina*), black walnut (*Juglans nigra*), persimmon (*Diospyros virginiana*), and sassafras (*Sassafras albidum*). In addition to smaller stems of the preceding canopy species, the understory to mid-story stratum is frequently comprised of hophornbeam (*Ostrya virginiana*), flowering dogwood (*Cornus florida*), and redbud (*Cercis canadensis*). Many older stands (> 50 years) that have not been manipulated or disturbed are beginning to support higher concentrations of shade tolerant mesophytes such as sugar maple (*Acer saccharum* to the north; *Acer floridanum* to the south) and American beech (Fagus americana) in the understory and midstory layers. Red maple (*Acer rubrum*) may occasionally occur on sites with thinner loess or that were once severely impacted. Farther south, loblolly pine (*Pinus taeda*) becomes an additional component; however the presence of this species is almost always an indicator of former land-use impacts. In fact, pine was never associated with the historic forest community of the Loess Hills and was noted as invading or colonizing abandoned farmland (Holmes and Foster, 1908).

Depending on site conditions, the small to tall shrub strata may be represented by spicebush (*Lindera benzoin*), pawpaw (*Asimina triloba*), possumhaw (*Ilex decidua*), and red buckeye (*Aesculus pavia*). The ground layer varies from relatively sparse under high shade to complete coverage within canopy gaps and areas of recent disturbance. Vines or lianas of this site span multiple height strata and are represented by grape (Vitis spp.), crossvine (*Bignonia capreolata*), Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (*Toxicodendron radicans*), Alabama supplejack (*Berchemia scandens*), and greenbrier (Smilax spp.). Herbaceous taxa include mayapple (*Podophyllum peltatum*), jumpseed (*Polygonum virginianum*), white snakeroot (*Ageratina altissima*), green dragon (*Arisaema dracontium*), beaked agrimony (*Agrimonia rostellata*), wild comfrey (*Cynoglossum virginianum*), sedges (Carex spp.), slender woodoats (*Chasmanthium laxum*), and Christmas fern (*Polystichum acrostichoides*), the latter occurring where surface moisture is greatest and shade the heaviest.

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. Factors influencing composition generally include: latitude, depth of loess, complexity of surrounding soils, and land-use history.

Areas of former cropland and pastureland that are now in hardwood forests have produced several timber harvests since initial abandonment. On the most favorable sites where the loess is very deep and land use history relatively mild, potential productivity (i.e., site index) of individual trees can be impressive. Site indices of cherrybark oak, Shumard's oak, sweetgum, and tuliptree reportedly approach a height of 100 feet within 50 years of growth (Broadfoot, 1976).

A major concern over 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, 1994).

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. 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 (*Pueraria montana* var. lobata).

Following this narrative, a "provisional" state and transition model is provided that includes the "perceived" reference state and several alternative (or altered) vegetation states that have been observed and/or projected for the Northern Deep Loess Summit ecological site. This model is based on limited inventories, literature, expert knowledge, and interpretations. Plant communities will differ across MLRA 134 due to natural variability in climate, soils, and physiography. Depending on objectives, the reference plant community may not necessarily be the management goal.

The environmental and biological characteristics of this site are complex and dynamic. As such, 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 within a given set of circumstances and represents the initial steps toward developing a defensible description and model. The model and associated information are subject to change as knowledge increases and new information is garnered. This is an iterative process. Most importantly, local and/or state professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

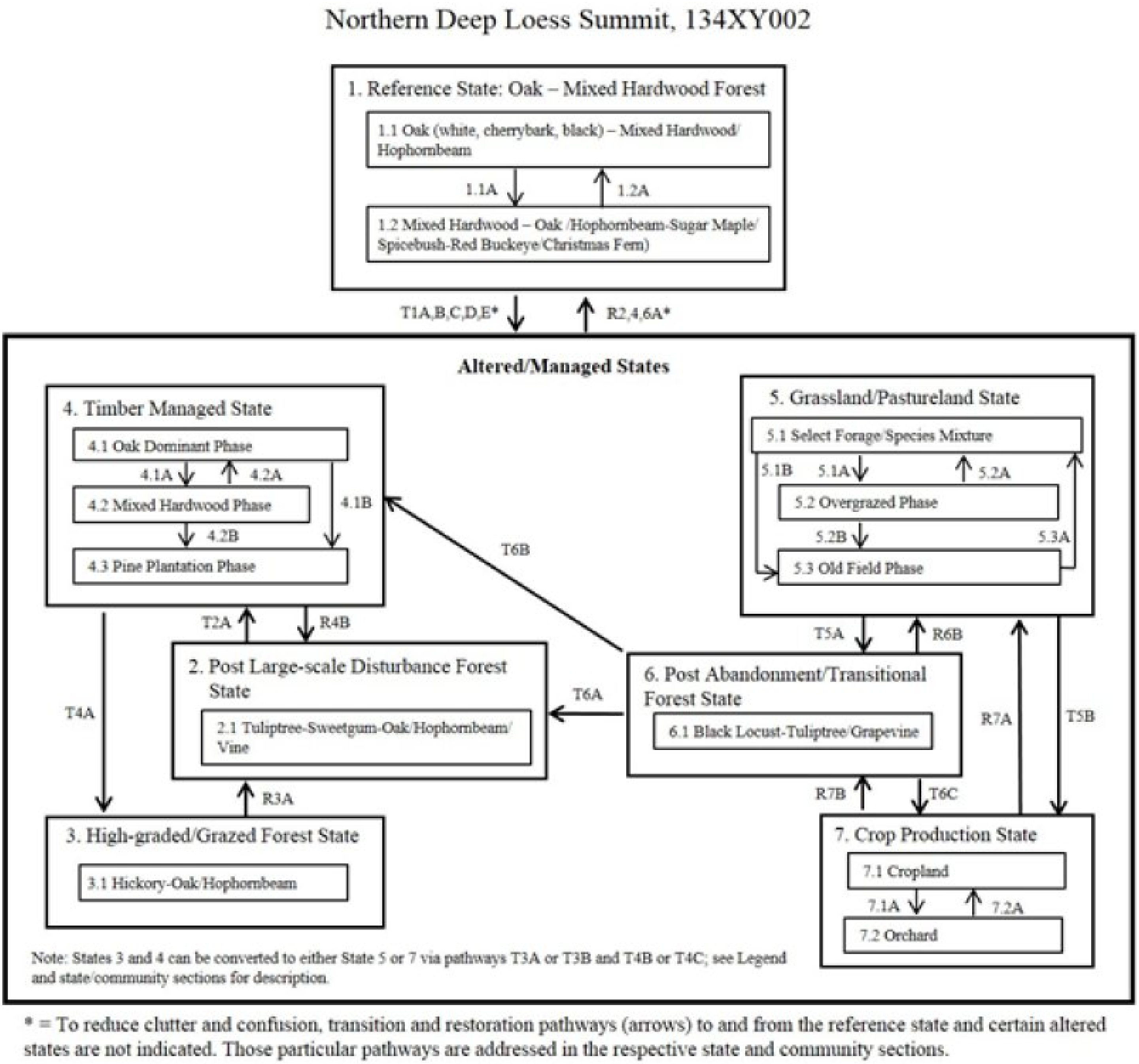

Figure 6. STM - Northern Deep Loess Summit

Pathway	Process/Stressor
1.1A	natural succession over time; disturbance minimal, gap-scale
1.2A	large gap- to incomplete stand-scale disturbance (wind, ice, "possible" low- to mixed-severity fire, uneven-aged management – group selection harvests)
T1A, R3A, R4B, T6A	large-scale stand initiating disturbance (wind, ice, replacement fire, clearcut; State 2)
T1B, T4A	repeated select harvest (high-grading) and/or livestock grazing - uncontrolled access (State 3)
T1C, 4.2A	beginning point uneven-aged stand; goal of oak/mixed hardwood management; timber stand improvements; group selection; competitor control – herbicide and mechanical; or conversion to pine monoculture (State 4)
T1D, T3A, T4B, 5.2A, 5.3A, R6B, R7A	mechanical removal of vegetation; herbicide application; seedbed preparation; planting desired species at appropriate rate (State 5)
T1E, T3B, T4C, T5B, T6C, 7.2A	mechanical removal of vegetation; preparation for cultivation or orchard establishment (State 7)
T2A, T6B	beginning point even-aged stand; establishment of advance oak regeneration (potential planting; competitor control – herbicide/mechanical; TSI); or conversion to pine monoculture (State 4)
R2A, R4A, R6A	natural succession over time (> 50 yrs); may require exotic plant control and reestablishment of missing species (State 1)
4.1A	relaxation of oak management; timber harvests with no competition control
4.1B, 4.2B	conversion to pine monoculture
5.1A	overstocked pasture and/or long-term continual grazing
5.1B, 5.2B	grazing and/or mowing/haying cessation, natural succession
T5A, R7B	natural succession (< 30 yrs) (State 6)
7.1A	site preparation and orchard establishment

Figure 7. Legend

State 1
Reference State: Oak - Mixed Hardwood Forest

The pre-settlement plant community of this ecological site was largely removed more than 150 years ago, and there are no extant examples of the former system. Based on projections from others, oaks were important components of that community (Hodges, 1995). Structural characteristics are open for debate but there are indications that the Loess Hills had an open physiognomy (see Heineke, 1987). It is possible that portions of this site supported open to moderately open woodland conditions with canopy coverage ranging from 30 to 75 percent. However, the natural fertility and high available water capacity of the deep loess soils of this site foster tremendous plant productivity. Without management actions (e.g., fire) to control vegetation growth, a closed-canopy forest develops rapidly on this site. Following decades of land-use impacts and erosion, the plant community that returned in those areas initially set aside for protection 50 to 80 years ago (e.g., parks, natural areas, and refuges) are often comprised of a large oak component. Associates with oaks include a broad range of hardwoods that respond incredibly well on the fertile, moist soils of this site. Two community phases are currently recognized within the reference state of this ecological site. They are distinguished from one another based on the degree of dominance by oak (Community Phase 1.1) and eventual replacement of oaks by shade tolerant species (Community Phase 1.2).

Community 1.1
Oak (white, cherrybark, black) – Mixed Hardwood/Hophornbeam

This community phase represents the successional stage, composition, and structural complexity of stands supporting perceived reference conditions. Historically, this phase may have been best referred to as an Oak – Mixed Hardwood Woodland community. From a structural perspective, there are very few, if any, appropriate examples of that community type available for observation. Still, the prevailing characteristic of this phase is a large oak component with mixed hardwoods as important community associates. Of the oaks, important species throughout the distribution of the site are generally white, cherrybark, black, northern red oak, Shumard's oak, water, chinkapin, and to a lesser extent, southern red oak. The fertile, moist soils of this site provide an incredible medium for supporting a broad range of additional hardwoods including sweetgum, tuliptree, white ash, hickory, elm, black walnut, black gum, persimmon, and sassafras. Important midstory and understory components often consist of hophornbeam, flowering dogwood, redbud, spicebush, paw paw, and smaller individuals of the preceding canopy trees. Depending on canopy cover (i.e., open vs. closed) and disturbance type and frequency, ground cover will vary from sparse to dense. As individual stands increase in age, 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 hardwoods such as tuliptree, sweetgum, and ash with a concomitant release and expansion of a shade-tolerant understory.

Community 1.2
Mixed Hardwood – Oak/Hophornbeam – Sugar Maple/Spicebush – Red Buckeye/Christmas Fern

This community phase represents a later successional stage of this ecological site and is characterized by the dominance and prevalence of shade-tolerant species throughout midstory and understory strata. 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 midstory and understory where they occur as seedlings, saplings, and subcanopy 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 include greater abundance of sugar maple and even beech in the understory with associates of sweetgum, white ash, blackgum, and bitternut hickory in the canopy. Additional components expected to thrive or persist include hophornbeam, flowering dogwood, pawpaw, red buckeye, and spicebush. Important, shade-intolerant components of Phase 1.1 will likely decrease in abundance 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 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 hardwoods 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.

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 (e.g., oaks) 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, 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

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 – Oak/Hophornbeam/Vine

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.

State 3
High-graded/Grazed Forest

Forests in this state have undergone repeated select harvests over time. Actions leading to this condition consist of removing the largest 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, etc. were repeatedly targeted often results in sites with proportionally more hickory, maple, and beech. Stands where hickory was also targeted often support maple, hophornbeam, and disproportionate numbers of other components such as boxelder, hackberry, and sugarberry. Because "overgrazed woods" often consists of components very similar to high-graded stands, uncontrolled livestock access to forests is also included in this state. 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 been high-graded and uncontrolled access by livestock.

Community 3.1
Hickory-Oak/Hophornbeam-Sugar Maple

The vegetation assemblage of a high-graded stand generally consists of a paucity of oaks left in the overstory. However, some oaks, especially red oaks, can be found in heavily grazed forests. Therefore, oak is retained in the community phase name of this ecological site due to the grazing effect. Under high-grading practices, 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 on particularly moist sites. Noticeable characteristics of this condition are a conspicuous reduction of oaks and other valuable hardwoods. Most grazed forests of this site are also managed for timber and many sites likely have been high-graded. 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 likely varies by stand. Occurrences of exotic species such as princesstree may also 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).

State 4
Timber Management

Three 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, the density of oaks relative to other hardwoods, and the establishment of pine 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.). The third and final phase represents the conversion to a pine monoculture (or plantation).

Community 4.1
Oak Dominant

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. Locations that may have a greater chance for success are on sites where loess depths are thinner (e.g., eroded ridgetops near the boundary with the Loess Plains) 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, 1994), 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.

Community 4.2
Mixed Hardwood

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 the moist soils of this 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.

Community 4.3
Pine Monoculture

This community phase represents site conversion to a pine monoculture. Johnson (1958) suggested that the highest ridges and thinnest loess soils were best suited for pine. However, this management option should be relegated to the southern extent of this ecological site in Mississippi. The northern portions of this site are probably best suited to hardwood production. Although pines grow well, the moist, fertile characteristics of loessal soils tend to foster a rapid response of fast growing hardwoods such as tuliptree and sweetgum. Pine stands can be quickly overcome on sites where loess thickness is greatest. Pine monocultures observed on this site in Mississippi revealed serious competition by tuliptree, sweetgum, and white ash. In stands that were examined, tuliptree had topped the pines and were seriously suppressing production. Successful pine production on this site necessitates the implementation of consistent hardwood competition controls (both mechanical and chemical).

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 4.1B
Community 4.1 to 4.3

This pathway represents the conversion of the former oak dominated forest to a pine monoculture or plantation (Phase 4.3). This action requires mechanical removal of all hardwoods, site preparation, herbicide treatment of root sprouts, and planting in pine; loblolly pine should be the preferred species given the productivity of the site. It should be noted that the productivity of this site does favor fast growing hardwoods such as tuliptree and secondarily sweetgum. Pine stands can be overcome quickly by fast growing hardwoods on the deep loess soils of this site.

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.

Pathway 4.2B
Community 4.2 to 4.3

This pathway represents the conversion of the former mixed hardwood forest to a pine monoculture or plantation (Phase 4.3). This action requires mechanical removal of all hardwoods, site preparation, herbicide treatment of root sprouts, and planting in pine; loblolly pine should be the preferred species given the productivity of the site.

State 5
Grassland/Pastureland

This state is representative of sites that have been converted to and maintained in pasture and forage cropland, typically a grass – legume mixture. 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
Select Forage/Species Mixture

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.

Community 5.2
Overgrazed Pasture

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.

Community 5.3
Old Field Phase

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.

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

This state represents a return to forest conditions following the abandonment of pastureland/grassland and cropland 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

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.

State 7
Crop Production

Immediately upon settlement, the fertility of the soils led to rapid land clearing and crop production. Any ridgetop that was wide enough to pull a plow through was cultivated. Beyond subsistent crops, cotton became the cash crop of choice. After tremendous impacts were incurred upon the land, cotton was largely abandoned as a profitable commodity on this site. Today, crops that are often established include corn and soybean, mostly. Agriculture production is generally a minor state or land use on this site due to the narrowness of the ridgetops and the dissected landscape. There are a few orchards that have been established on some of the ridges of the Loess Hills, but this too is relatively minor compared to other land use categories. Of the active orchards that have been observed, peach production may be among the most important.

Community 7.1
Cropland

Corn and soybean.

Community 7.2
Orchard

The principal orchard type observed on this site is peach, although pecan orchards may also occur.

Pathway 7.1A
Community 7.1 to 7.2

Release of cultivation and conversion to or establishment of orchard.

Pathway 7.2A
Community 7.2 to 7.1

Mechanical removal of vegetation and stumps; herbicide treatment of residual plants; and preparation for cultivation.

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. This transition also includes 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.

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). The final option of this pathway is the conversion of the former hardwood forest to a pine monoculture or plantation (Phase 4.3). This action requires mechanical removal of all hardwoods, site preparation, herbicide treatment of root sprouts, and planting in pine; loblolly pine should be the preferred species given the productivity of the site. It should be noted that the productivity of this site does favor fast growing hardwoods such as tuliptree and secondarily sweetgum. Pine stands can be overcome quickly on deep loess soils of this site.

Transition T1D
State 1 to 5

Actions required to convert forests to grassland or forage production include forest clearing, stump removal, herbicide application, seedbed preparation, and the establishment of desired plants.

Transition T1E
State 1 to 7

Actions include mechanical removal of vegetation and stumps; herbicide treatment of residual plants; and preparation for cultivation or orchard establishment.

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).

Conservation practices

Forest Stand Improvement
Invasive Plant Species Control
Forest Management Plan - Applied

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. The final option of this pathway is the conversion of the former hardwood forest to a pine monoculture or plantation (Phase 4.3). This action requires mechanical removal of all hardwoods, site preparation, herbicide treatment of root sprouts, and planting in pine; loblolly pine should be the preferred species given the productivity of the site.

Restoration pathway R3A
State 3 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 T3A
State 3 to 5

Actions include forest clearing, stump removal, herbicide application, seedbed preparation, and the establishment of desired plants.

Transition T3B
State 3 to 7

Actions include mechanical removal of vegetation and stumps; herbicide treatment of residual plants; and preparation for cultivation or orchard establishment.

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. Management activities to aide recovery may include exotic species control and silvicultural treatment.

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 T4A
State 4 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. This transition also includes 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.

Transition T4B
State 4 to 5

Actions include forest clearing, stump removal, herbicide application, seedbed preparation, and the establishment of desired plants.

Transition T4C
State 4 to 7

Actions include mechanical removal of vegetation and stumps; herbicide treatment of residual plants; and preparation for cultivation or orchard establishment.

Transition T5A
State 5 to 6

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

Actions include mechanical removal of vegetation and stumps; herbicide treatment of residual plants; and preparation for cultivation or orchard establishment.

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.

Transition T6A
State 6 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 T6B
State 6 to 4

This pathway represents prescribed management strategies for transitioning an abandoned forest state to one that meets compositional and production objectives. For enhanced oak production (Phase 4.1), actions may include artificial regeneration and reduction of oak competition. Managing for mixed hardwood production (Phase 4.2) may require exotic species control and general timber stand improvement practices. The final option of this pathway is the conversion of the former hardwood forest to a pine monoculture or plantation (Phase 4.3).

Restoration pathway R6B

State 6 to 5

Actions include forest clearing, stump removal, herbicide application, seedbed preparation, and the establishment of desired plants.

Transition T6C
State 6 to 7

Actions include mechanical removal of vegetation and stumps; herbicide treatment of residual plants; and preparation for cultivation or orchard establishment.

Restoration pathway R7A
State 7 to 5

Seedbed preparation and establishment of desired forage/grassland mixture.

Restoration pathway R7B
State 7 to 6

Abandonment of cropland/orchard production and allowing natural succession to proceed to canopy closure of the young, developing forest stand.

Additional community tables

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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	05/12/2025
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:**