Ecological site R154XX001FL
Yellow Sands Xeric Uplands

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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): 154X–South-Central Florida Ridge

This MLRA makes up about 7,209 square miles (18,672 square kilometers) and is entirely in Florida. MLRA 154 contains a series of parallel, prominent sandy ridges of Pleistocene marine origin, including the Brooksville and Mount Dora Ridges. These north to south oriented parallel ridges are interspersed with more low lying physiographic provinces, including: upland hills, plains, valleys and gaps (Puri and Vernon 1964).

Many of the soils in this sub-unit are Pleistocene or Holocene sands that are underlain with older, loamy Pliocene marine sediments (Cypresshead formation) or the clayey Miocene marine sediments (Hawthorne formation). A combination of marine depositional events and the dissolution of underlying limestone (karst geology) is responsible for surficial topography throughout Peninsular Florida.

Classification relationships

All portions of the geographical range of this site falls under the following ecological / land classifications including:

-Environmental Protection Agency's Level 3 and 4 Ecoregions of Florida: 75 Southern Coastal Plain; 75c Central Florida Ridges and Uplands (Griffith, G. E., Omernik, J. M., & Pierson, S. M., 2013)

-Florida Natural Area Inventory, 2010 Edition: Sandhill, Scrub, Xeric Hammock (FNAI, 2010)

Ecological site concept

The Yellow Sands Xeric Uplands site occurs in the Floridian Section of the Coastal Plain Province of the Atlantic Plain and is geographically restricted to high sandy ridges of the Central Highlands and Coastal Lowlands of Central Florida. These provinces approximate the emergent portion of the Wicomico shoreline (Puri and Vernon 1964). The larger physiographic landforms of the Central Highlands include ridge systems of Pleistocene origin (Brooksville, Deland, Trail, Mount Dora, Winter Haven, Lake Henry and Lake Wales Ridge ridges), and the Sumter, Polk, Marion, Duval and Lake Uplands. Elevations range from almost sea level along a narrow strip on the western edge of the MLRA 154 to 330 feet on interior hills and ridges.

Geologically, this region is a young marine plain composed of surficial materials consisting of marine sands that are primarily Pliocene or Miocene epochs (2.5 to 23 million years ago) or Pleistocene and Holocene epochs (2.5 million years ago to present) in age. These sandy marine sediments are underlain by Tertiary-age rocks (Oligocene and Eocene epochs – 23 to 56 million years ago) that are dominated by very fine grained limestone and dolomite. Surficial geology is the result of a complex combination of factors ranging from deposition and/or erosion of marine sediments, and the dissolution of underlying carbonate rocks. Fluctuations of ocean levels, offshore currents, wind activity on coastal sediments, and re-deposition are associated with regional dune and ridge systems. Furthermore, the dissolution of underlying carbonate rocks (collectively referred to as karst geology) results in a variety of surficial karstic features. These range in size from karst valleys to smaller, better defined features such as sinkholes or chimneys.

The Cypresshead (Pliocene) and Hawthorne (Miocene) formations are important stratigraphic features that occur below 80 inches throughout most of the site distribution. The Cypresshead formation is composed of siliciclastics that are Pliocene-age sediments from shallow marine, near shore deposits. They are reddish brown to reddish orange, unconsolidated to poorly consolidated loamy sediments. The Hawthorne Formation contains clastic deposits from the Appalachian uplift principally sands, clays, phosphates, and carbonates.

Geomorphic position of the site ranges from summits to toe slopes. Similarly, topography ranges from nearly level to gently rolling. However, areas on dunes, near sinkholes and streams are more sloping. In general, land surface is irregular in the Central Florida Ridges because of the many sinkholes that dot the area.

Associated sites

F154XX002FL	**Xeric Bicolor Sandy Uplands** These are moderately well to excessively drained communities that occur in similar to slightly lower landscape positions within MLRA 154.

F154XA003FL	**Dry Yellow Sands Pine Woodland** These are excessively drained communities that occur in similar landscape positions within MLRA 154.
F154XA004FL	**Moist Sandy Pine-Hardwood Woodlands** These are excessively drained communities that occur in slightly lower landscape positions within MLRA 154.
F154XA009FL	**Moist Basic Pine Uplands** These are well drained communities that occur in slightly lower landscape positions within MLRA 154.

Similar sites

F154XX002FL	**Xeric Bicolor Sandy Uplands** These are moderately well to excessively well drained communities that occur in similar to slightly lower landscape positions within MLRA 154. Soils will be generally white in color or consist of multiple colored layers rather than dominantly yellow throughout. This change influences the soil chemistry, resulting in different natural vegetative communities (dominantly scrub) and corresponding management strategies.
F154XA003FL	**Dry Yellow Sands Pine Woodland** These are excessively drained communities that occur in similar landscape positions within MLRA 154. Soils will be sand generally yellow in color and will have less than 200 centimeters of yellow sand rather than more than 200 centimeters of yellow sand. This change influences the soil chemistry, resulting in different natural vegetative communities (dominantly sandhills) and corresponding management strategies.
R155XY180FL	**Sandy Scrub on Rises, Ridges, and Knolls of Mesic Uplands** These are somewhat poorly to well drained soils that will occur on similar landscape positions on smaller ridgelines within the adjacent MLRA 155. These sites may also occur as newer ridgelines of Pleistocene deposits along coastlines and will commonly be referred to as “coastal scrub” rather than the “interior scrub” of MLRA 154. They will have similar vegetative structure but will differ slightly in native vegetative composition and management strategies. In altered managed states such as pastureland and cropland, this site may produce different production values.
R155XY230FL	**Sandy Scrub on Ridges, Knolls, and Dunes of Xeric Uplands** These are well to excessively well drained soils that will occur on similar to slightly higher landscape positions on smaller ridgelines within the adjacent MLRA 155. These sites may also occur as newer ridgelines of Pleistocene deposits along coastlines and will commonly be referred to as “coastal scrub” rather than the “interior scrub” of MLRA 154. They will have similar vegetative structure but will differ slightly in native vegetative composition and management strategies. In altered managed states such as pastureland and cropland, this site may produce different production values.

Table 1. Dominant plant species

Tree	(1) *Pinus palustris*
Shrub	(1) *Quercus laevis* (2) *Quercus incana*
Herbaceous	(1) *Aristida stricta* (2) *Sorghastrum secundum*

Physiographic features

This ecological site occurs on sandy, excessively drained uplands on marine terraces of coastal plains in central and west-central Florida (Figure 1). Slopes are nearly level to strongly sloping (0 to 20%, but may range up to 40%). The site occurs on ridges and knolls of eolian or marine deposition. Soils are sandy to > 80 inches.

Surface shapes of the site are dominantly convex or linear (up-down) and convex or linear (across). A few areas are concave but the sandy parent materials do not support a change in community type. Despite the slope shape and range of slope, very little surface runoff occurs due to rapid infiltration and permeability.

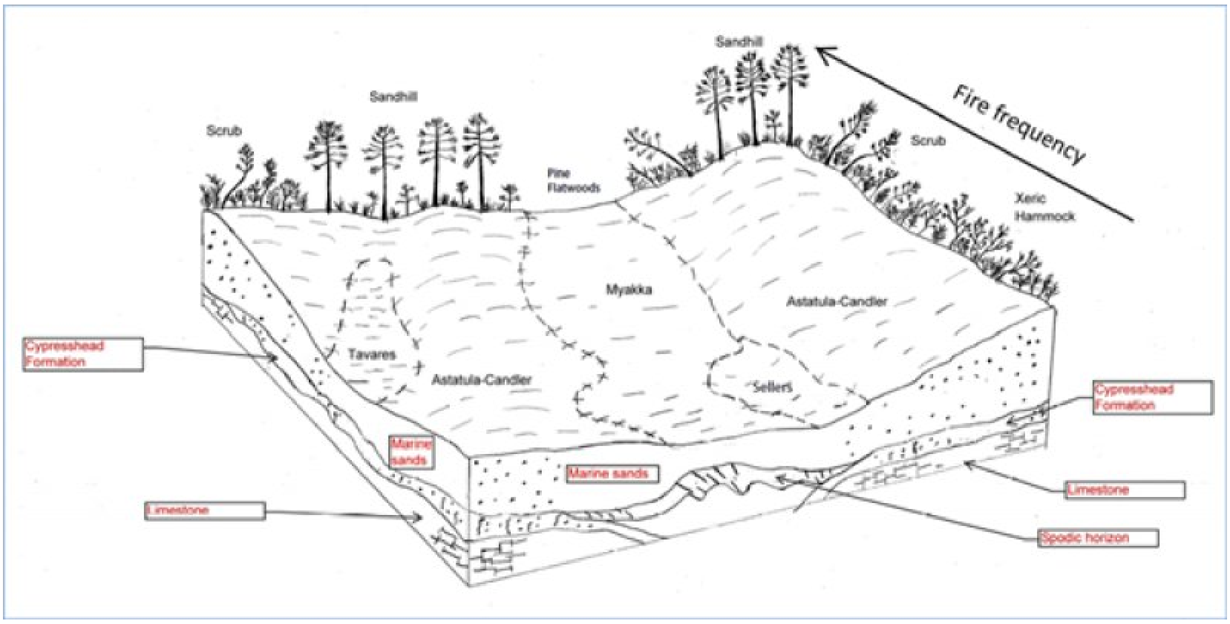

Figure 1. Schematic diagram of landform position and its relations to fire frequency and natural vegetation,

Table 2. Representative physiographic features

Hillslope profile	(1) Summit (2) Shoulder (3) Backslope
Slope shape across	(1) Convex (2) Linear
Slope shape up-down	(1) Convex (2) Linear

Landforms	(1) Marine terrace > Ridge (2) Marine terrace > Knoll
Runoff class	Negligible to low
Flooding frequency	None
Ponding frequency	None
Elevation	15–150 ft
Slope	0–20%
Water table depth	80 in
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Runoff class	Negligible to medium
Flooding frequency	None
Ponding frequency	None
Elevation	7–262 ft
Slope	0–40%
Water table depth	80 in

Climatic features

There is considerable latitudinal climate variation across MLRA 154, which closely approximates the range of the Yellow Sands Xeric Upland Site. MLRA 154 spans three USDA plant hardiness zones in the Florida Peninsula (USDA-ARS). Furthermore, the geographic distribution of the site spans approximately 200 miles north to south in the Florida peninsula, extending across two land divisions known as Land Resource Units (LRU) in MLRA 154. These are labeled 154-1 (North LRU) and 154-2 (South LRU).

The climate is characterized by humid subtropical with long hot summers and mild winters. In the winter months, Canadian air masses move across Peninsular Florida and produce cool, cloudy, rainy weather. Below freezing temperatures are occasional in the northern LRU (154-1), but very rare in the southern LRU (154-2). Overall, there are typically fewer than 30 days of the year with below freezing temperatures in MLRA 154.

Similarly, average temperatures vary considerably from north to south over the range of the site. Annual variations of temperature in 154-1 reflect the distinct seasonal climate. In contrast, the southern portion of this site (154-2) has more uniformity of seasonal temperatures.

Precipitation in MLRA 154 is distributed fairly evenly throughout the year. Average annual precipitation is 45 to 55 inches with June through August being the wettest period. The north (154-1) portion of MLRA 154 receives substantially more precipitation during the winter months compared to the southern (154-2) portion. The 154-1 winter rainfall is associated with winter cold fronts, which tend to disintegrate before reaching 154-2.

Hurricanes and tropical storms affect much of the MLRA 154 region. Catastrophic hurricanes make landfall along the Atlantic coast of Peninsular Florida on the order of two to four times per century. Strong winds and heavy rainfall affects the interior peninsula (MLRA 154); rainfall from hurricanes and tropical systems vary widely but can exceed 20 inches from one storm. Hurricanes are most likely to occur between June and November, and are most common in August and September.

Table 4. Representative climatic features

Frost-free period (characteristic range)	228-365 days
Freeze-free period (characteristic range)	365 days
Precipitation total (characteristic range)	51-53 in
Frost-free period (actual range)	216-365 days
Freeze-free period (actual range)	334-365 days
Precipitation total (actual range)	50-54 in
Frost-free period (average)	314 days
Freeze-free period (average)	358 days
Precipitation total (average)	52 in

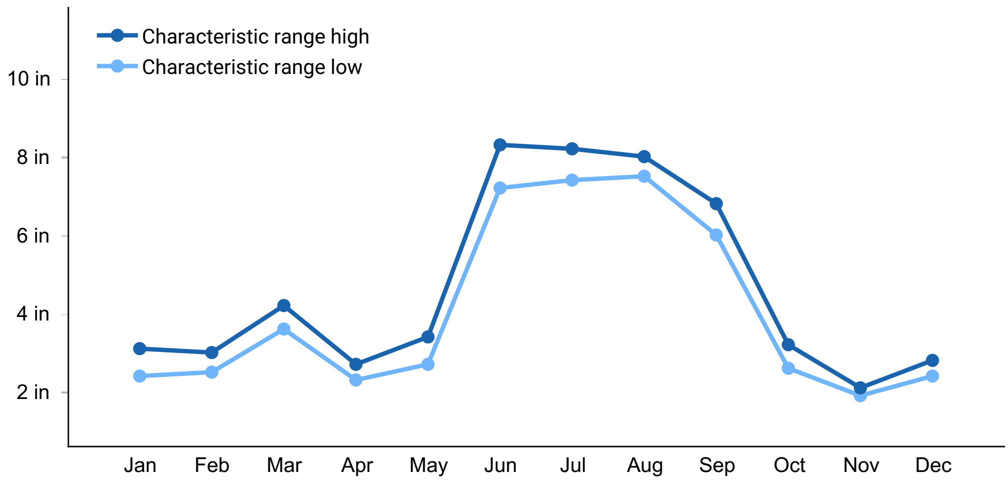

Figure 2. Monthly precipitation range

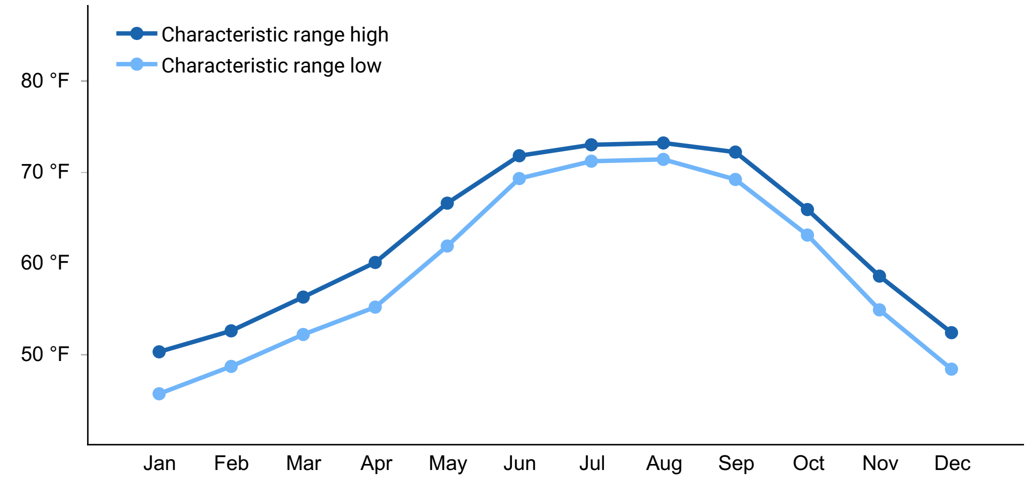

Figure 3. Monthly minimum temperature range

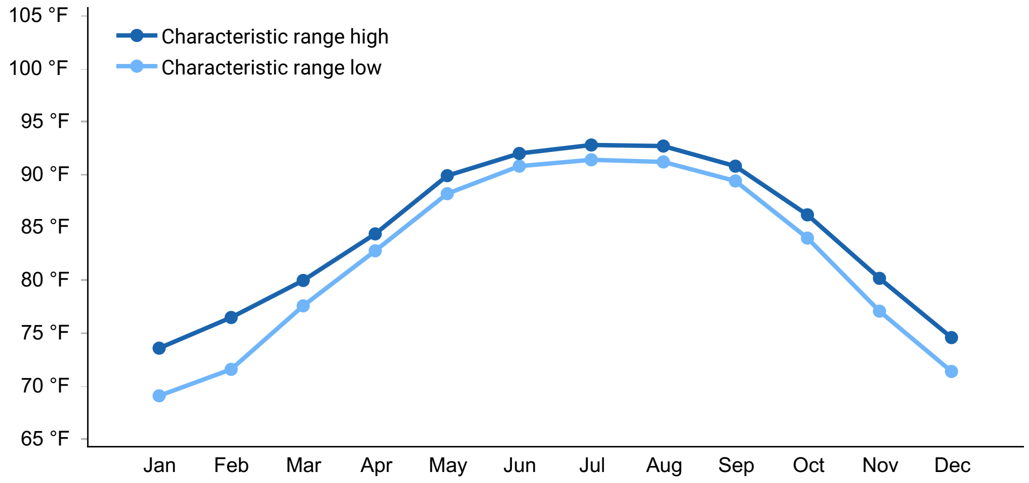

Figure 4. Monthly maximum temperature range

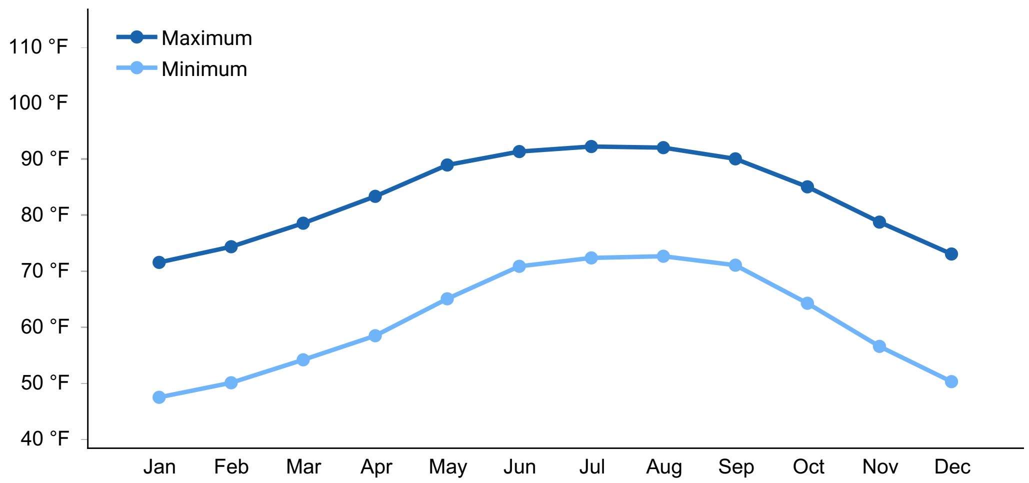

Figure 5. Monthly average minimum and maximum temperature

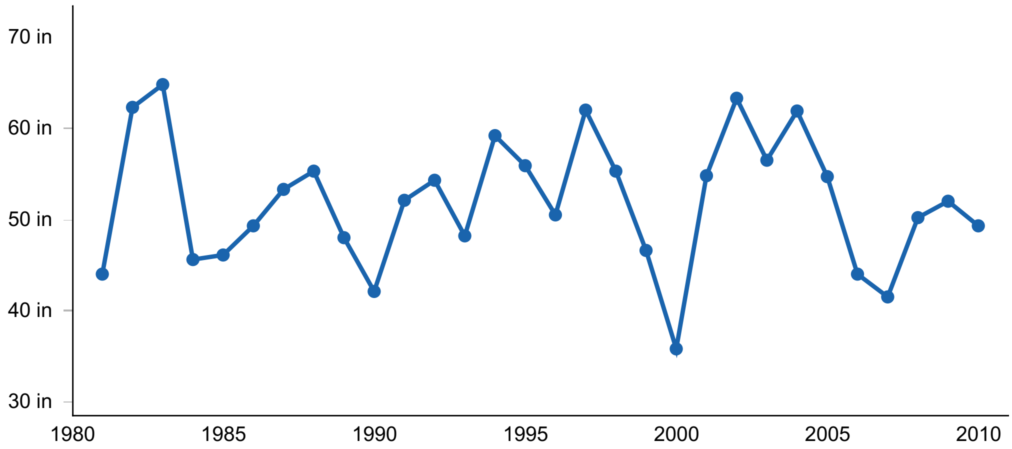

Figure 6. Annual precipitation pattern

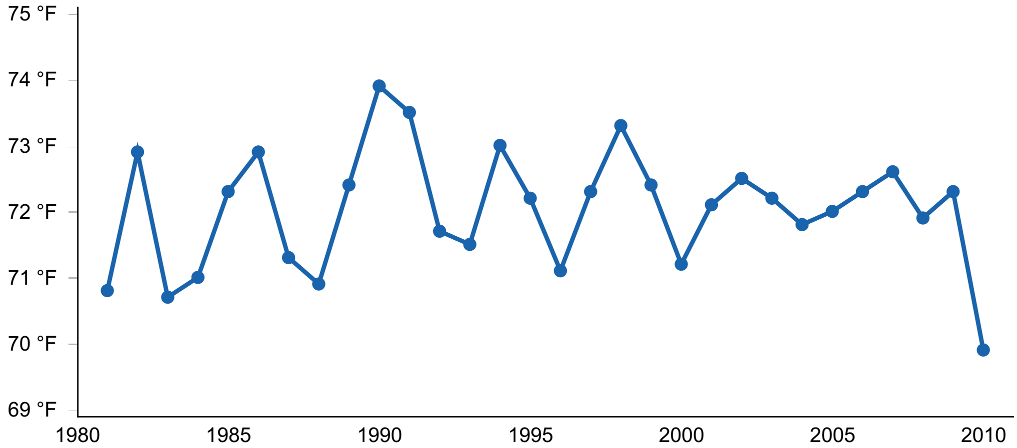

Figure 7. Annual average temperature pattern

Climate stations used

- (1) ARCHBOLD BIO STN [USC00080236], Venus, FL
- (2) AVON PARK 2 W [USC00080369], Avon Park, FL
- (3) MTN LAKE [USC00085973], Lake Wales, FL
- (4) LAKELAND [USW00012883], Lakeland, FL
- (5) CLERMONT 9 S [USC00081641], Clermont, FL
- (6) INVERNESS 3 SE [USC00084289], Inverness, FL
- (7) LAKE ALFRED EXP STN [USC00084707], Haines City, FL
- (8) LISBON [USC00085076], Leesburg, FL
- (9) PLANT CITY [USC00087205], Plant City, FL
- (10) BARTOW [USC00080478], Bartow, FL
- (11) GAINESVILLE 11 WNW [USC00083322], Gainesville, FL
- (12) WINTER HAVEN [USC00089707], Winter Haven, FL
- (13) BROOKSVILLE CHIN HILL [USC00081046], Brooksville, FL
- (14) ORANGE SPRINGS 2SSW [USC00086618], Fort Mc Coy, FL
- (15) SAINT LEO [USC00087851], San Antonio, FL
- (16) TARPON SPGS SEWAGE PL [USC00088824], Tarpon Springs, FL

Influencing water features

This site is situated on soils that have very deep seasonal high water tables (usually > 118 inches [300 centimeters]). Subsurface water flow is dependent on the present of an aquitard (loamy or clayey layer that retards water movement). The presence, depth, and orientation of this water restrictive layer affect subsurface water movement.

Soil features

Typical soils of the Yellow Sands Xeric Uplands site are very deep, sandy marine sediments with little or no soil development to a depth of 80 inches (203 centimeters), although loamy marine sediments may be present at depths greater than 80 inches (203 centimeters). Diagnostic soil series associated with this site are the Astatula and Candler series, which are excessively drained and infertile. Both soil series classify in the Quartzipsamments great group with a hyperthermic temperature regime. The predominant parent materials of Astatula and Candler yellow sands are sandy marine deposits, eolian deposits, or eolian over marine deposits.

Candler sands have weakly developed lamellae (accumulation of oriented silicate clay on or bridging sands and silt grains [see Figure 6]) present in the lower part of the soil profile (below 40 inches [101 centimeters]) and are classified in the Lamellic subgroup. Astatula soils lack lamellae and are in the Typic subgroup. Surface and subsurface texture for both series are fine sand or sand. Sand color is dominantly yellow and comes from small amounts (< 5 %) of silt and clay and/or iron compounds. Organic content of the soils is very low (< 1% in all horizons to 80 inches [203 centimeters]), although surface organic matter can accumulate depending on vegetation and disturbance regimes (see Table 4 for ranges of soil properties). Astatula and Candler soils may have an argillic horizon with loamy textures below 80 inches (203 centimeters) (although this is not recorded in SSURGO map data).

Astatula and Candler yellow sands are excessively drained soils is with rapid or very rapid permeability. Runoff potential ranges from negligible on less sloping areas to moderate on slopes above 18 percent.

Colors of Astatula and Candler surface soils range from very dark gray (10YR 3/1) to light gray (10YR 7/1). Soil reaction (pH 1:1 water) ranges from extremely acid (3.5) to slightly acid (6.5) in surface horizons, and extremely acid (pH 3.5) to neutral (pH 7.3) in subsurface horizons. Soil moisture regimes are udic (moisture control section is not dry in any part for as long as 90 cumulative days in normal years).

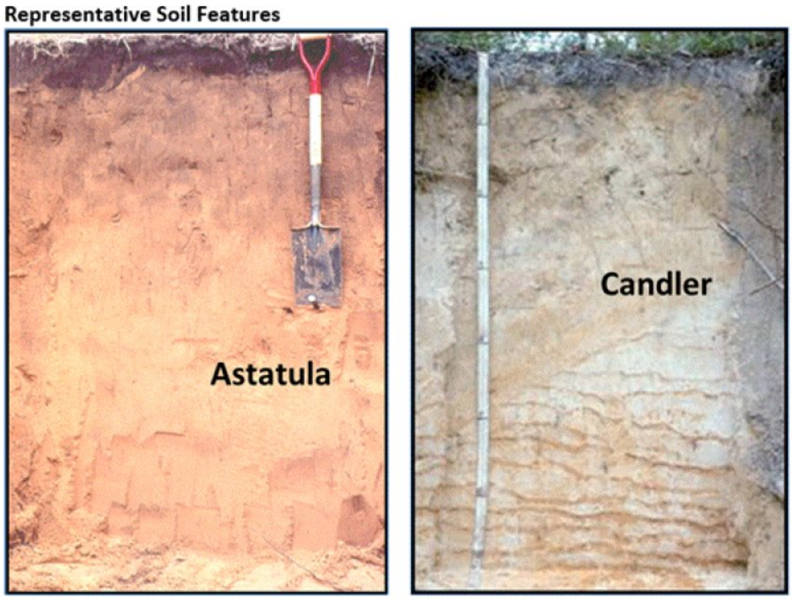

Figure 8. Typical soil profiles of Astatula and Candler sand. Note the lamellae in the lower part of the Candler soil profile.

Table 5. Representative soil features

Parent material	(1) Eolian deposits (2) Marine deposits
Surface texture	(1) Fine sand (2) Sand
Family particle size	(1) Sandy
Drainage class	Excessively drained
Permeability class	Rapid to very rapid
Soil depth	80 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	0.01–1 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–1 mmhos/cm
Sodium adsorption ratio (0-40in)	1
Soil reaction (1:1 water) (0-40in)	4.8–5.6
Subsurface fragment volume <=3" (0-40in)	0%

Subsurface fragment volume >3" (0-40in)	0%

Table 6. Representative soil features (actual values)

Drainage class	Not specified
Permeability class	Not specified
Soil depth	Not specified
Surface fragment cover <=3"	Not specified
Surface fragment cover >3"	Not specified
Available water capacity (0-40in)	0–3.1 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0–4
Soil reaction (1:1 water) (0-40in)	3.5–7.3
Subsurface fragment volume <=3" (0-40in)	0–1%
Subsurface fragment volume >3" (0-40in)	0–2%

Ecological dynamics

Background and Geography of Yellow Sands Xeric Uplands:

This site encompasses a wide range of environmental and floristic conditions. Xeric woodlands of widely spaced longleaf pine (*Pinus palustris*), commonly known as longleaf pine sandhills, were historically widespread on well- to excessively drained sands of the Southeastern Coastal Plain (Myers and White 1987, Myers and Ewel 1990, Frost 1993). Similarly, scrub and xeric hammock vegetation associated with this site is restricted to this geographic region. Similarly, shrublands of xerophytic oaks inhabit excessively drained infertile yellow sands of the Florida Peninsula. This natural community type is known by various names: Florida scrub, sand pine scrub, oak scrub, yellow sands scrubs, oak-hickory scrub, interior scrub, among other names (Abrahamson et al. 1984, Myers and Ewel 1990, Menges 2007, FNAI 2010). Hereafter in this document, it will be referred to as “scrub”. This distribution of this site includes both sandhill and scrub natural community types.

Historical fire regimes of Central Florida xeric uplands were influenced by climate and man. Warmer and drier climate during the post-Pleistocene, coupled with a sharp increase in lightning, created conditions in which large and frequent lightening-ignited fires swept through the flat landscape of the peninsula (Myers and Ewel 1990). It is estimated that lightning caused fires occur at an average rate of more than 1,000 fires/year in prehistoric Florida (Komarek 1964). Before there were man made barriers to fire spread (i.e. roads, settlements, agriculture), fires were able to burn across large landscapes until they were stopped by natural firebreaks such as wetlands and water bodies. In addition, Native Americans used fire for hunting, land clearing, and agriculture (Kalisz et al. 1986, Myers and Ewel 1990).

The geographic extent of Central Florida longleaf pine sandhills and scrubs declined drastically in the 20th century. From 1936 to 1995, the overall geographic distribution of Florida longleaf sandhills declined by over 90% due to conversion to pine plantations, urban development, and agriculture (Kautz 1998). Similarly, the acreage of native scrub vegetation was reduced by 60% since European settlement (Kautz 1998). In particular, sandhills and scrubs on yellow sands suffered the most drastic reduction, as these well drained entisols were favored for citrus cultivation in the 20th century.

Ecological Dynamics of the Site: Natural Vegetation and Succession:

Ecological and community dynamics of this site are complex. In addition to the complexity invoked by natural disturbance regimes, site complexity is related to its broad geographic distribution and concurrent variable environmental and climatic conditions. The non-linear nature of natural succession models for Central Florida xeric uplands is well documented in the literature (Myers 1985, Menges and Hawkes 1998). Accordingly, the State and Transition Model (STM) for this site presented here is complicated, replete with non-linear successional pathways and successional trends linked to regional variation of floristics, soil properties, and natural disturbance regimes.

This site departs from the convention of a single natural community (aka Reference Site) linked to a specific soil map unit component, or set of soil properties (NRCS 2014). Rather, this site includes multiple natural community types at part of its STM: longleaf pine sandhills, scrub, and xeric hammock (as described in FNAI 2010).

The natural communities included in this site run the gamut of stand structure and floristic composition, including open woodlands (aka savanna), dense shrublands, and closed canopy forest. Despite their compositional and structural dissimilarities, sandhills, scrubs and xeric hammocks co-occur on Astatula and Candler sands and fine sands throughout much of MLRA 154 (Kalisz and Stone 1984, Myers 1985, NRCS inventory data 2013). Where historic distributions of scrub and sandhill communities have been studied, the boundaries between these communities fluctuated considerably over time periods on the order of hundreds of years, suggesting the influence of natural disturbance in community regulation (Kalisz and Stone 1984).

With regard to the distribution of xeric upland communities of Central Florida yellow sands, the influence of natural disturbance regimes exceeds that of edaphic properties. In other words, fire is the primary driver of community distribution and ecological dynamics. Relatively predictable fire return intervals will maintain structure and composition in sandhill and scrub communities. Conversely, changes in fire regime, including complete suppression of fire, will affect transition from woodlands with intact herbaceous ground cover to shrub or forest dominated communities (Abrahamson 1984, Myers 1985, Myers 1990, Menges 2007).

Estimates of pre-European settlement fire return intervals vary by author and by region, and there are differences between the north and south portions of the site distribution in MLRA 154. Sandhills of the northern region (LRU 154-1) burned on the order of once per one to five years (Robbins and Myers 1992, Platt 1999, Rodgers and Provencher 1999; Provencher et al. 2001, Glitzenstein et al. 2003). In contrast, fire return intervals of the southern sandhills (LRU 154-2) may have been more variable, with return intervals of two to ten years (Givens et al. 1984, Reinhart and Menges 2004). Fires of pre-European settlement Florida were most frequent in the early to mid-growing season (April through July), the driest period of year with ample lightening activity (Platt 1999).

Sandhill communities are adapted to frequent fire disturbances. Bunchgrasses and other ground cover herbaceous plants provide a matrix fine fuels which encourages fire ignition and spread. Ground fires affect sandhill ecological dynamics in the following ways: preparation of seedbed for germination of longleaf pine and other native sandhill species; stimulation of seed production in many species of grasses and forbs; maintenance of open stand conditions needed for sun-loving plant species; and attenuation of woody and non-native plant spread (Abrahamson 1984, Walker and Peet 1983, Wade and Lundsford 1990, Waldrop et al. 1992, Outcalt et al. 2002, Glitzenstein et al. 2003, Rienhard and Menges 2004). Mature pines and oaks are very resistant to fire injury (Glitzenstein et al. 1995).

In contrast to that of sandhills, estimated historical fire return intervals of yellow sands scrubs are on the order once per 15 to 100 years (Myers 1985; Menges and Hawkes 1998, Menges 2007). Scrub fire periodicity is variable, depending largely on geography, landscape features, land use and climate (Menges and Hawkes 1998, Menges 2007). Scrubs are dominated by evergreen vegetation which has relatively high moisture content. This, coupled with the absence of fine fuels, discourages fire ignition and spread in scrubs. As such, scrubs generally only burn under conditions of extreme drought and heat. These fires are intense and consume most above-ground vegetation, which dramatically changes community structure post-burn (Myers 1990, Menges 2007).

Scrub vegetation is resilient, and rapidly recovers following infrequent fires. There is little change in dominant species composition before or after intense fires, with the exception of sand pine (Abrahamson 1984). Dominant clonal oaks persist and resprout rapidly from underground parts in the post-fire environment (Abrahamson 1984). However, some temporal differences in post-fire oak colonization is apparent in post-fire recovery of Northern region scrubs (154-1). Myrtle oak (*Q. myrtifolia*) growth is most rapid immediately following fire, and sand live oak (*Q. geminata*) growth peaks years after fire (Freeman and Kobziar 2011). Similarly, herbaceous growth and diversity peaks two years following fire, and then dissipates as woody cover increases (Freeman and Kobziar 2011). In contrast, yellow sands scrubs of the Lake Wales Ridge (154-2) show very little compositional turnover following fire (Abrahamson 1984).

Other common scrub plants reseed and colonize amid post-fire conditions (Johnson 1982, Menges and Hawkes 1998). The most notable seeder is the Florida peninsula variety of sand pine (*Pinus clausa* var. clausa). This pine species is short lived (less than 80 years) and has serotinous cones which open after being super-heated. Seeds colonize open ground following intense fires. Sand pine seedlings are shade tolerant, thus able to grow amid dense scrub oak cover (Greenburg et al. 1995, Freeman and Kobziar 2011). Fire return intervals in excess of 80 to 90 years disfavor sand pine regeneration, leading to “oak scrub” lacking pine canopy cover. Conversely, fire return intervals of less than 15 years in scrub may prevent sand pine regeneration, as seedlings are fire intolerant (Myers 1995, Menges and Hawkes 1998).

Changes in fire regimes of Central Florida sandhills affect radical shifts in species composition and abundance. When fire is infrequent (fire return intervals greater than 10 years), woody abundance increases as fire intolerant sand pines and hardwoods invade. This in turn changes the physiognomy and ecological dynamics of the community (Glitzenstein et al. 1995, Platt 1999, Provencher et al. 2000, VanLear et al. 2005). Thick growths of woody plants compete with herbaceous vegetation for light and other resources, and depress regeneration of shade-intolerant longleaf and south Florida slash pines. Herbaceous species richness and abundance is affected by infrequent or absent fire. Typical ground cover of burned yellow sands sandhills contains 20 to 30 species per square meter, many of these interspersed among a matrix of bunchgrass (*Aristida beyrichiana*, *Schizachyrium scoparium*, *Sorghastrum secundum*, Andropogon spp.; Rodgers and Provencher 1999, Carr et al. 2010, Peet 2006). Following period of fire suppression of greater than 10 years, ground cover richness drops to less than 5 species per square meter (Provencher et al. 2001, Varner et al. 2005), and herbaceous species cover is similarly diminished. Concurrently, fire intolerant hardwood species gradually replace longleaf pine and fire tolerant oaks of the over- and mid-stories (i.e. turkey and bluejack oaks). The species composition of invading hardwoods depends on geography, propagule source, and perhaps slight variations in soil fertility and moisture. Where present, clonal oaks will colonized fire suppressed sandhills, leading to scrub vegetation. In other regions of site distribution, laurel oak and other ruderal hardwoods may invade in the absence of fire (Myers and White 1987).

Following long term fire suppression (greater than 80 years), yellow sands sandhills will eventually be replaced by oak dominated closed canopy forests (Givens et al. 1984, Myers 1985, Peroni and Abrahamson 1986, Myers and White 1987, Abrahamson and Abrahamson 1996). In most cases, this is a xeric hammock with sand live oak (*Q.*

geminata) canopy and understory of low growing clonal oaks and other hardwood seedlings (FNAI 2010). Areas isolated from scrub oak colonization may be colonized by laurel and live oaks (*Q. laurifolia* and *Q. virginiana*).

When fire suppressed sandhills do burn, excess woody fuel loads and ground litter encourage hotter and more intense fires which may cause excessive pine mortality (Varner et al. 2005). Smoldering fires in litter accumulations can kill underground plant part and hinder post-fire recovery. For the purposes of ecological restoration of fire suppressed sandhills, the manner and timing of fire reintroduction is very much dependent on the amount of fuel buildup (Varner et al. 2005). Mechanical or chemical hardwood and litter reduction may be necessary prior to reinstitution of fire in some situations.

Similarly, in the absence of fire (fire return interval greater than 100 years) yellow sands scrubs will transition to xeric hammock, as sand live oak overtops other oaks and forms a closed canopy (FNAI 2010). Xeric hammock does not differ much from scrub in terms of floristic composition, although it is structurally distinct from scrub (forest vs. shrubland). The closed canopy, moist ground cover litter, and almost complete absence of herbaceous vegetation of xeric hammock precludes fire spread in all but extremely droughty conditions (Givens et al. 1984, Myers and White 1987). Under these rare circumstances, a very intense canopy fire would kill all above ground vegetation, which would trigger succession to scrub vegetation.

The connection between fire suppression and woody plant invasion in Central Florida sandhills is well documented. However, to date there is no empirical evidence that re-introduction of frequent fire regimes will trigger reverse succession, from scrub or xeric hammock to sandhill, at least not within the scope of this ecological site. Ecological literature suggests that transition from scrub to sandhill is possible with increased fire frequency (Myers 1985, Menges and Hawkes 1998). However, the time frame and conditions necessary for such transition, if at all possible, would exceed the temporal scope considered here.

Wind and water damage associated with hurricanes and strong storms affect the ecological dynamics and vegetation distribution of this site. Strong winds can cause local or widespread pine mortality in sandhills or sand pine scrubs. Although hurricanes usually dissipate before reaching the interior of the peninsula, large storms do affect the region on the order of two to three storms per century. Sand pines are particularly susceptible to wind throw because of their shallow root systems. Similar to catastrophic fire, large scale wind throw may affect transition from late to early successional scrubs on yellow sands. Fire following wind damage may be particularly intense because of the abundance of dead woody fuels.

Other natural disturbances that affect this site include pine and hardwood mortality caused by insects and pathogen. Southern pine beetle (Dendroctonus frontalis; SPB) is a species of bark beetle native to the Southeastern Coastal Plain. Periodically SPB populations increase to epidemic levels and healthy pines are killed as infestations expand. Most susceptible to SPB mortality are densely planted even-aged loblolly and longleaf pine stands, which is common in community timber plantations (Schowalter et al. 1981). Widely space longleaf pines in natural stands are less susceptible to SPB related mortality, and sand pines are generally unaffected.

Biogeography/Regional Variation of the Site:

The Yellow Sand Xeric Uplands Ecological Site has a very wide range of geographic distribution in Peninsular Florida. Accordingly, climatic, abiotic environment and biogeography varies considerably, as does species composition, successional patterns, and ecological dynamics of the site. Furthermore, the biogeography of plant distributions influences regional variation of this site. Northern and southern peninsular floristic variants of yellow sands sandhills are documented in the ecological literature (Myers and White 1987, Menges and Hawkes 1998, USFWS 1999). Furthermore, historical fire regimes differed between the north and south portions of MLRA 154; fire was differently affected by seasonal rainfall and lightening patterns, frontal systems, and prehistoric land uses (Myers and White 1987). Regional variation in floristics, structure and natural disturbance regimes are discussed in the context of the State and Transition model.

Ecological Dynamics of the Site: Soil Properties

The Astatula and Candler soils correlated to this site are acidic, infertile, and of poor productivity. The hot humid climate with abundant precipitation contributes to leaching and increased surface organic matter oxidation in these sands. Soil structure is weakly expressed in the surface layer and absent in the subsoil. Aggregate stability is marginal in the topsoil and aggregates are not present below.

In terms of soil profile morphology, Astatula and Candler soils subtending sandhill and scrub vegetation do not differ between the two plant communities, at least in the northern portion of this sites' distribution (LRU 154-1; Kalisz and Stone 1984b, Crownover et al. 1996). However, yellow sands of sandhill vs. scrub communities do differ in some dynamic properties of surface soil, as observed on the Ocala National Forest (ONF) in LRA 154-1. Astatula soils beneath longleaf pine sandhills have darker hue and thicker A horizon compared to soils subtending scrub or xeric hammock vegetation. These features prompted special designation of “dark surface” Astatula Sands soil map units for the longleaf pine sandhill “islands” of the ONF (Aydelott et al. 1975).

Darker and thicker A horizons of Astatula and Candler sands are associated with frequently burned sandhills with abundant herbaceous ground cover on the ONF (i.e. the northern variant of Phase 1.1 in the current STM). Kalisz and Stone (1984b) attribute these soil features to incorporation of surface detritus and the homogenization of the upper soil resulting from frequent combustion and an active soil-mixing fauna (Kalisz and Stone 1984a). These conditions allow systematic release of fine fuel carbon and nutrients (P, K, etc.). As such, there are slight increases in soil aggregate stability, nutrient availability, and carbon cycling, and this may increase biotic activity. This movement of carbon into the subsoil, and coating of soil particles can provide additional (albeit temporary) cation exchange sites for nutrient retention. Kalisz and Stone (1984b) did not observe increased nutrient availability under longleaf sandhills compared to scrub soils on the ONF. In contrast, higher amounts of phosphorous and higher pH were observed in ONF longleaf sandhill surface soils compared to scrub soils in the mid-1990’s (Crownover et al. 1996). An explanation for these disparate observations of dynamic soil properties is the advent of more frequent growing season burning of ONF sandhills in the late 1980’s (ONF, pers. comm).

As fire return intervals lengthen and woody abundance increases (as in Phases 1.2 and 1.3 of the current STM), carbon and nutrients are held in an undecomposed state in the soil and unavailable for plant use. Similarly, soil aggregate structure, subsoil biotic activity, and nutrient availability are reduced.

In contrast to sandhill soils, Astatula and Candler sands subtending scrub and xeric hammock vegetation in the absence of fire have abundant accumulations of ground litter. Decomposing litter creates surficial organic horizons (Figure 5; Kalisz and Stone 1984b, Varner et al. 2005). Slow release of carbon and nutrients associated with litter decomposition lowers soil pH and accelerates eluviation, which is the major soil forming process under these conditions (Kalisz and Stone 1984b).

Although the dynamics of soil chemistry and soil forming processes have been fairly well studied on the ONF, we do not know if similar fire-mediated soil dynamics occur on Astatula and Candler soils elsewhere in MLRA 154. Further study of these phenomena is warranted in other regions of the site, particularly in the southern extremes (Lake Wales Ridge).

State and transition model

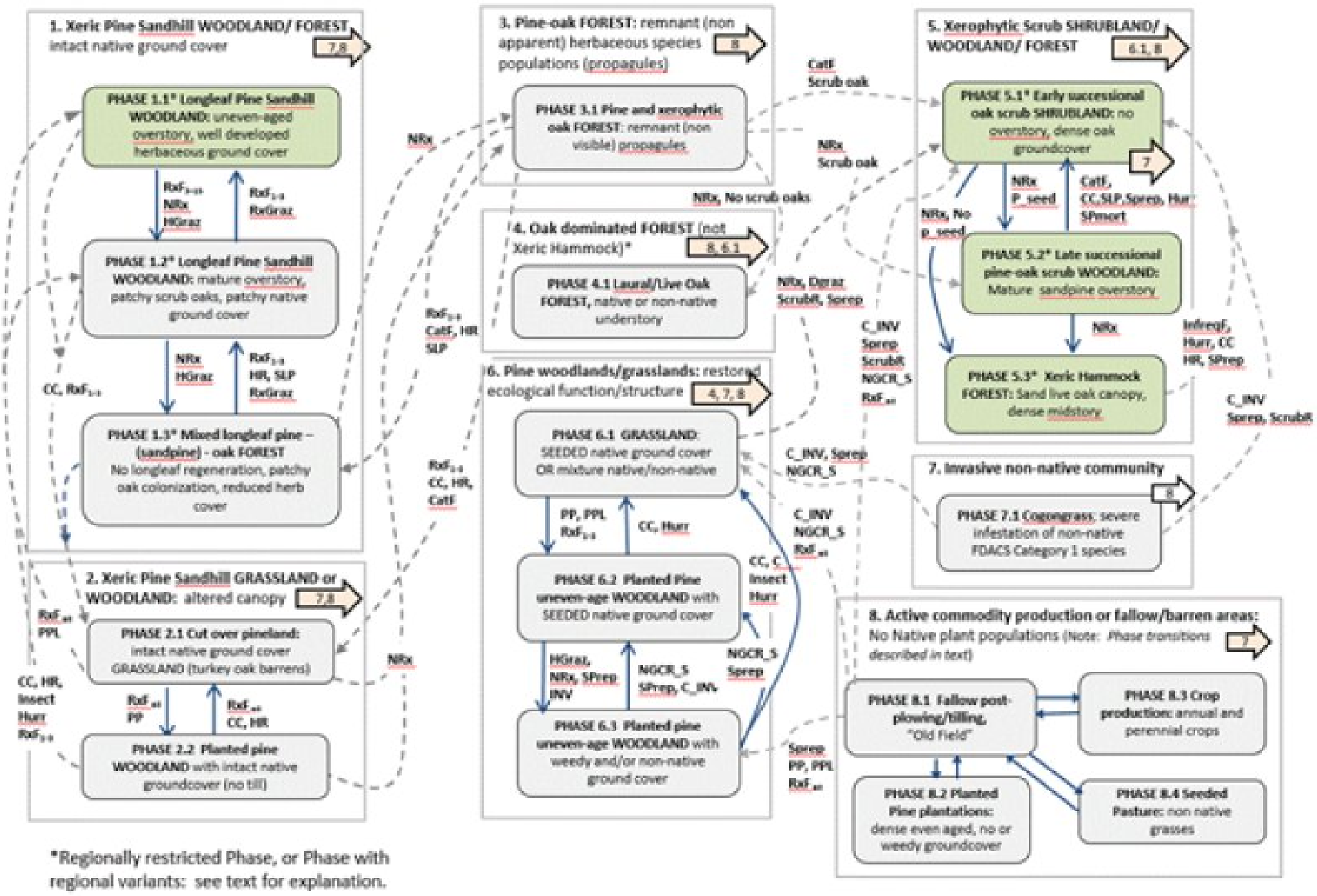

Figure 9. State and Transition Model for this site

RxF_{1-3}	Prescribed fire: frequent return interval (1-3 years)
RxF_{3-15}	Prescribed fire: infrequent return interval (3-15 years)
RxFall	Prescribed fire: all fire return intervals < 20 years
CatF	Infrequent (intense) fire, often stand replacing catastrophic fire
NRx	Fire suppression, or very infrequent non-catastrophic fire (> 20 year return interval)
DGraz	Deferred Grazing
RxGraz	Prescribed Grazing
HGraz	Heavy Intensive Grazing
HR	Hardwood reduction (mechanical and chemical)
PP	Planted Pine (Loblolly, Sand pine, Slash)
PPL	Planted Pine (Longleaf)
CC	Clearcut
Sprep	Site prep (ground penetration)
SLP	Selective logging (pines)
INV	Invasion of noxious non-native plant species
C_INV	Mechanical/chemical control of invasive plant species
NGCR_S	Native ground cover restoration: active seeding
ScrubR	Mechanical reintroduction scrub oak species
Scrub oaks	Propagule availability for colonization
Spmort	Natural mortality of mature Sand Pines (> ~ 70 years old)
Hurr	Hurricane/strong storm winds
No scrub oaks	No seed source for typical scrub oaks, colonization by water and laurel oaks
P_seed	Availability of sand pine seed for Site colonization
No_P_seed	Absence of sand pine seed

4	Transition to **State 4** (Oak dominated Forest/non Xeric Hammock). Transition to this State is only possible in specific regions and environmental conditions of the Site distribution: generally, the northern LRU region without sources of scrub oaks.
6.1	Transition to **Phase 6.1** This includes methods for restoring ground cover vegetation which provide fine fuels and providing wildlife habitat. Treatments include: site preparation (chopping, disking, herbacide application), pre-planting burning, planting bunchgrass from plugs, native grass and forb seeding)
7	Transition to **State 7** (Invasive non-native plant community). Drivers this transition include invasion by noxious non-native plant species (INV); notably, cogongrass.
8	Transition to **State 8** (Commodity production or fallow/barren areas devoid of most native ground cover plant populations). Included are treatments designed to convert land to commodity production of crops or livestock, including: timbering, bulldozing, plowing, planting, irrigation, fertilizing, mowing, chemical applications, among others. In general, State 8 describes conditions where the ground has been tilled.

Figure 10. Legend for transitions and drivers for this site

State 1
Xeric Pine Sandhill WOODLAND / FOREST: intact native ground cover

See Community Phase Narratives

Community 1.1
Longleaf Pine Sandhill WOODLAND: uneven aged overstory, well developed herbaceous groundcover

Figure 11. Phase 1.1 Reference community: Longleaf pine sandhills of the northern LRU 154-1

Figure 12. Phase 1.1 Reference community: Longleaf pine sandhills of the southern LRU 154-2 (along the Lake Wales Ridge)

The pine canopy of the Northern variant of Phase 1.1 consists of widely spaced mature longleaf pines (*P. palustris*) intermixed with patches of regenerating longleaf pine seedlings and saplings. The uneven aged structure is typical of woodlands dominated by long-lived species with erratic but synchronous acorn production over large areas (Platt et al. 1988). Typical Phase 1.1-North pine stands are mosaics of even-aged longleaf pine “cohorts”, with dense patches of pine seedlings distributed in canopy gaps (Platt et al. 1988, Noel et al. 1998). Bare mineral soil and abundant light are required for longleaf pine seed germination, and these conditions are often present in canopy gaps immediately following fire. Midstory vegetation of Phase 1.1-North is generally sparse, consisting of patches of oaks, notably turkey oak (*Quercus laevis*) and sand live oak (*Q. geminata*). Other small statured oaks are often present, although usually in low abundance under conditions of frequent fire. These species include: myrtle oak (*Q. myrtifolia*), Chapman’s oak (*Q. chapmanii*) and bluejack oak (*Q. incana*). Sand post oak (*Q. margaretta*), an oak common in other sandhill communities, is notably infrequent compared to other sandhill communities of Florida (Carr et al. 2010). Chapman's, myrtle and sand live oaks are able to persist for long periods in the ground cover in spite of frequent fires common in the reference site condition. These oak species have clonal life forms which allow horizontal clonal growth via rhizomes, and deep root systems (Abrahamson 1984). Groundcover vegetation of Phase 1.1-North sandhills is dominated by perennial bunch grasses which form a matrix of mostly continuous cover. Numerous plant species are common in the interstitial spaces between grass tussocks (Appendix 2.1). Estimates of Phase 1.1 species richness for the Northern LRU (154.1) are: 68 species /1000 m2 (Carr et al. 2010), and 59 species /400 m2 (ESI field work estimates: n=10, range= 32-87 species). Most ground cover plant species are sparsely distributed grasses and forbs, although low growing sub-shrubs are also significant (Carr et al. 2010; Appendix 2). Wiregrass (*Aristida stricta* var. beyrichiana) is a ubiquitous dominant bunchgrass in Phase 1.1 groundcover. Other common bunchgrasses include lopsided indiangrass (*Sorghastrum secundum*), little bluestem (*Schizachyrium scoparium* var. stoloniferum), pineywoods dropseed (*Sporobolus junceus*) and other bluestem species (*Andropogon ternarius* var. ternarius, *A. gyrans* var. gyrans). The southern variant of Phase 1.1 sandhills (LRU 154.2) differs from the northern variant in species composition and stand structure, as well as in natural disturbance dynamics. These distinctions are well documented in the literature, and Phase 1.1-South sandhills are variously referred to as: scrubby high pine, scrubby sandhills, high pine, turkey oak barrens, and southern ridge sandhills (Abrahamson et al. 1984, Myers and Ewel 1990, Myers and White 1998, USFWS 1999, Corogin 2008). 154-2 yellow sands sandhills differ in stand composition, with South Florida Slash pine (*P. elliottii* var. densa) replacing longleaf pine as the dominant canopy tree. Furthermore, 154-2 sandhills have more shrub cover in the midstory and ground cover, and less herbaceous cover (Abrahamson et al. 1984; Myers and White 1987, Reinhart and Menges 2004). Clonal scrub oaks (myrtle and Chapman's oaks) and saw palmetto (*Serenoa repens*) are common and persistent in southern sandhills, in spite of frequent fire (Myers and White 1987). Florida scrub hickory (*Carya floridana*) and garberia (*Garberia heterophylla*), two Central Florida endemic shrubs, are abundant in southern sandhills, further distinguishing this community from the northern variant. Similarly, some grass species are common in the southern sandhills while uncommon or absent in 154-1, including pinescrub bluestem (*Schizachyrium niveum*) and corkscrew threeawn (*Aristida gyrans*). Furthermore, these sandhills provide habitat for numerous plant species which are narrowly endemic to the Lake Wales Ridge region (see Appendix 3). Ecological dynamics of Phase 1.1 sandhills are intrinsically linked to fire regimes, as frequent fire is necessary for perpetuation of this plant community. Estimates of pre-European settlement fire regimes for yellow sands sandhills vary between the northern and southern regions of MLRA 154. Presettlement fires of the northern sandhills (154-1) were frequent and relatively predictable; fire return intervals are predicted the order of three to four per decade (Jose et al. 2006, Platt 1999, Robbins and Myers 1992, Myers and White 1987). Fire regime of southern Phase 1.1 sandhills were more variable, having been estimated at once every 1 to 10 or 1 to 15 years (Myers 1990, Menges 1999, Reinhart and Menges 2004). The higher shrub and palmetto abundance, coupled with lower herbaceous cover in 154-2 sandhills affect the greater volatility of native fire regimes (Reinhart and Menges 2004). Other natural disturbances contribute to the ecological dynamics of Phase 1.1. Hurricanes and severe storms affect woody stand structure directly, and may impart indirect effects via changes in light availability and available fuels. In addition, storm damage may promote the uneven-aged structure of longleaf pine stands, via blow downs and increased mortality of mature trees. Lightning caused mortality of longleaf pines occurs frequently. Insects and pathogen infestation may kill pines, and on occasion may affect large stands of pines (i.e. southern pine beetle outbreaks, see Ecological Dynamics section).

Table 7. Ground cover

Tree foliar cover	0-25%
Shrub/vine/liana foliar cover	2-40%
Grass/grasslike foliar cover	10-90%
Forb foliar cover	2-25%
Non-vascular plants	0%
Biological crusts	0%
Litter	0-3%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0-20%

Table 8. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0-5%	1-50%	25-95%	2-10%
>0.5 <= 1	0-5%	0-50%	0-25%	0-10%
>1 <= 2	0-5%	0-25%	0%	0%
>2 <= 4.5	0-10%	0-10%	0%	0%
>4.5 <= 13	0-10%	0-10%	0%	0%
>13 <= 40	0-50%	0%	0%	0%
>40 <= 80	0-50%	0%	0%	0%
>80 <= 120	0%	0%	0%	0%
>120	–	–	–	–

Community 1.2

Longleaf Pine Sandhill WOODLAND: mature overstory, patchy scrub oaks, patchy native ground cover

Figure 13. Phase 1.2 Longleaf Pine Sandhill Woodland

Figure 14. Phase 1.2 Longleaf Pine Sandhill Woodland

Phase 1.2 resembles Phase 1.1 in species composition and overstory stand structure. Longleaf pine is the dominant canopy species, and mature longleaf pines are widely spaced throughout and basal area is similar to that of Phase 1.1. However, longleaf pine regeneration is diminished as a result of fire suppression, and the associated unavailability of bare ground and open conditions. Altered fire regimes promote accumulation of pine needles and thickening of surface litter and duff layers which in turn hinders longleaf pine seed germination (Varner et al. 2007). Conversely, oaks and other hardwoods increase in abundance in Phase 1.2, effectively “out competing” young longleaf pines for space and light and becoming prominent in the midstory and ground cover. Seedlings of the more shade tolerant and fire intolerant sand pine (*P. clausa*) may colonize in Phase 1.2 if seed source is available. Similar to Phase 1.1, the northern and southern Phase 1.2 variants may differ in dominant canopy pine species (longleaf pine vs. south Florida pine) and midstory composition. Similar to longleaf, south Florida slash regeneration is linked to post-fire conditions, and mature pines are fire tolerant (although less so than longleaf pine). Compared to the reference site condition, oak abundance of Phase 1.2 is higher. Species of oaks depend on geography and propagule source. In the Northern LRU Phase 1.2, turkey, bluejack and sand live oaks are prominent in the midstory. In addition to these oaks, Florida scrub hickory (*C. floridana*) and saw palmetto are also a prominent in Southern Phase 1.2 midstory. Sand pine may be present in Phase 1.2 sandhills depending on the availability of seed source. Mature pines of Phase 1.2 may have increased susceptibility to insect and pathology mortality, which is aggravated by higher pine density and hardwood encroachment (Palik and Pederson 1996). In addition, fuel accumulations from needle drop and hardwood growth exacerbate fire intensity, which in turn leads to higher pine mortality (Varner et al. 2007). Herbaceous ground cover is sparser and more patchily distributed in Phase 1.2 compared to Phase 1.1. Although the species composition of the ground cover remains similar, shifts in relative species abundances occur in response to increased hardwood encroachment and litter/duff accumulation (Myers 1985; Myers and White 1987). Species richness of Phase 1.2 is lower (mean spp /400 m2 = 44, range: 37-50, n=6; NRCS data 2013), reflecting sparser distribution of herbaceous plant populations due to fire suppression.

Community 1.3
Mixed Longleaf Pine - (Sand Pine) - Oak FOREST: no longleaf regeneration, patchy oak colonization, reduced herb cover

Figure 15. Phase 1.3 Mixed pine-oak Forest

Phase 1.3 describes Longleaf Pine Sandhill Woodlands following long periods of fire suppression (more than 10 years) or longer term alteration of native fire regimes (i.e. decades with occasional fire; fire return interval greater than 5 years). In this phase, increased of woody growth is concurrent with declines in herbaceous ground cover. Transition to pine-oak dominance may be exacerbated by selective logging and/or heavy grazing. Where seed sources are available, shade-tolerant sand pine may colonize. Stand structure in Phase 1.3 is dramatically different from that of Phase 1.1. Denser canopy and sub-canopy conditions attenuate light reaching the forest floor, as well as increases litter and duff accumulation which suppresses natural regeneration. Accordingly, thicker duff layers retain higher organic content and moisture availability (Hiers et al. 2007). Longleaf pine regeneration in Phase 1.3 is non-existent, as the soil surface is inhospitable to seedling germination. The canopy is increasingly even-aged as old longleaf pines die out and are replaced by even-aged sand pine or oak species. Similarly, encroachment of the mid- and under-story by oaks and palmettos is further accelerated from fire suppression, heavy grazing, and available propagule sources. Herbaceous ground cover of Phase 1.3 is significantly reduced in cover and species richness compared to that of Phase 1.1. Many of the small statured, heliophytic and sparsely distributed grass and forb species are extirpated. Patches of herbaceous vegetation remain, particularly in canopy gaps where light does reach the ground. Dominant bunchgrass tussocks may persist in these patches, along with some other remnant herbaceous plants. Small scale species richness is much lower compared to Phase 1.1, reflecting the paucity of small statured plant species relative to woody plant abundance. Increased pine and hardwood density in Phase 1.3 promote pine mortality from insect and pathogen infestations. Mature sand pines are particularly susceptible to wind throw and insect mortality. Furthermore, heavy accumulation of pine and oak leaf litter further suppresses the fine fuels necessary for the spread of low intensity fires.

Pathway 1.1A
Community 1.1 to 1.2

Longleaf Pine Sandhill WOODLAND: uneven aged overstory, well developed herbaceous groundcover

Longleaf Pine Sandhill WOODLAND: mature overstory, patchy scrub oaks, patchy native ground cover

Changes from historic frequent fire to regimes of either infrequent fire or complete fire suppression accelerates hardwood and sand pine encroachment (i.e. transition to Phase 1.2). Continued fire suppression affects transition to Phase 1.3 and eventually States 3 and/or 4. Heavy grazing reduces fine fuels needed to carry frequent low intensity ground fires, which lessens fire spread and accelerates woody plant invasion. In addition, heavy grazing will affect understory vegetation diversity, growth and reproduction, of palatable forbs and grasses. The following drivers contribute to this community pathway: Infrequent fire regimes are generally applied for land management objectives other than natural area conservation and restoration. These include, but not limited to, fuels reduction, forage management, tree plantation management, and site preparation (for crops and plantations). Included here are fire regimes with longer return intervals (> 3 years but < 15 years for LRU 154-1, and > 10 years and < 20 years for LRU 154-2). These prescribed fires generally occur in the dormant season in the southeastern Coastal Plain, although this category of infrequent fire regimes includes dormant and growing season prescribed fires. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. Heavy grazing describes grazing in excess of biomass and compositional recovery capacity of plant species or the plant community. Heavy grazing may affect large shifts in plant composition through loss of populations of palatable plants. Heavy grazing by cattle leads to the decline in palatable grasses such as lopsided indiangrass (*Sorghastrum secundum*), and causes increases in less palatable forage species (e.g. wiregrass, *Aristida stricta* var. beyrichiana). The over-utilization of forage species through heavy grazing can be caused under either continuous or rotational grazing systems.

Pathway 1.2A
Community 1.2 to 1.1

Longleaf Pine Sandhill WOODLAND: mature overstory, patchy scrub oaks, patchy native ground cover

→

Longleaf Pine Sandhill WOODLAND: uneven aged overstory, well developed herbaceous groundcover

Phase 1.2 describes a condition deviated from reference site condition via alteration of historical fire regime. Most plant populations typical of Phase 1.1 sandhills are still present in Phase 1.2, although shifts in relative abundances have occurred. Transition from Phase 1.2 to Phase 1.1 sandhills is possible through the reintroduction of frequent fire, without mechanical or chemical treatments for hardwood reduction. In addition, seasonal and moderate grazing may be reintroduced. Ground cover composition resembling that of Phase 1.1 will occur following one to several prescribed fires, and subsequent restoration of native fire regimes. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1-3 years for the North LRU (154-1) and 1-10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season. Prescribed grazing is the controlled harvest of vegetation with grazing or browsing animals, that are managed with the intent to balance forage production and animal demand to ensure proper utilization of forage species. Management may be continuous or rotational grazing systems, with proper forage/animal balance, composition of forage species will remain stable over extended periods. Regardless of the type of grazing management, deferment of areas or fields for 30 to 90 days during the growing season to allow for seed production, plant recruitment, and mitigation of grazing following other management practices (i.e. prescribed burning, brush management, etc.) is recommended for ground cover restoration.

Pathway 1.2B
Community 1.2 to 1.3

Longleaf Pine Sandhill WOODLAND: mature overstory, patchy scrub oaks, patchy native ground cover

Mixed Longleaf Pine - (Sand Pine) - Oak FOREST: no longleaf regeneration, patchy oak colonization, reduced herb cover

Continued fire suppression will eventually invoke increased hardwood and sand pine encroachment typical of the Phase 1.3. Heavy grazing can further reduce patchy ground cover and fine fuels needed to carry frequent fires, which exacerbates woody encroachment. Drivers that contribute to this transition: Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. Heavy grazing describes grazing in excess of biomass and compositional recovery capacity of plant species or the plant community. Heavy grazing may affect large shifts in plant composition through loss of populations of palatable plants. Heavy grazing by cattle leads to the decline in palatable grasses such as lopsided indiangrass (*Sorghastrum secundum*), and causes increases in less palatable forage species (e.g. wiregrass, *Aristida stricta* var. beyrichiana). The over-utilization of forage species through heavy grazing can be caused under either continuous or rotational grazing systems.

Pathway 1.3A
Community 1.3 to 1.2

Mixed Longleaf Pine - (Sand Pine) - Oak FOREST: no longleaf regeneration, patchy oak colonization, reduced herb cover

Longleaf Pine Sandhill WOODLAND: mature overstory, patchy scrub oaks, patchy native ground cover

Reintroduction of frequent low intensity fires (once every 1 to 3 years) promotes the transition of Phase 1.3 to Phases 1.1 or 1.2. However, mechanical or chemical treatments may be required prior to the reintroduction of fire for the purpose of woody biomass reduction. Depending on the density of oak and sand pine encroachment, selective logging can promote the open aspect of Phase 1.1 stand structure, plus open space for re-colonization of herbaceous ground cover and fine fuels to carry low intensity fires. Other mechanical treatments such as chopping or bulldozing may be used to reduced woody biomass; however, treatments indicated here do not include heavy ground disturbance or penetration which would extirpate native plant populations. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1 to 3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. This practice involves selective removal of pines via mechanical methods, usually for the purpose of improving residual stand conditions. These techniques can promote restoration of stand structure and composition to more uneven-aged conditions, and promote natural regeneration of longleaf pine where seed source is available. In the current model, this treatment does not include “high grading” of pine stands, which is a type of selective logging targeting only the most merchantable trees. Prescribed grazing is the controlled harvest of vegetation with grazing or browsing animals, that are managed with the intent to balance forage production and animal demand to ensure proper utilization of forage species. Management may be continuous or rotational grazing systems, with proper forage/animal balance, composition of forage species will remain stable over extended periods. Regardless of the type of grazing management, deferment of areas or fields for 30 to 90 days during the growing season to allow for seed production, plant recruitment, and mitigation of grazing following other management practices (i.e. prescribed burning, brush management, etc.) is recommended for ground cover restoration.

State 2
Xeric Pine Sandhill GRASSLAND or WOODLAND: altered canopy

See Community Phase Narratives

Community 2.1
Cut over pineland: intact native ground cover GRASSLAND (turkey oak barrens)

Figure 16. Phase 2.1 Cut over pineland with intact native groundcover

Phase 2.1 describes conditions following removal of pine and hardwood canopy and midstory of Phases 1.1, 1.2, and to some extent, Phase 1.3. This condition is a separate state in light of the considerable energy and expense needed to restore State 1 stand conditions (uneven-aged pine stands with oak midstory). Notably, State 2 is distinguished as having intact native ground cover vegetation which either resembles Phase 1.1 conditions or is restorable to Phase 1.1 conditions with reintroduction of frequent fire. Importantly, groundcover of State 2 has not been subject to ground penetration, i.e. plowing, tilling, disking, etc. Included in Phase 2.1 are old-fields (i.e. clear-cuts, not fallow crop lands) and native pasture lands. There is no canopy or mid-story stand structure in Phase 2.1. However, pine seedlings may be present depending on availability of seed sources. Ground cover diversity and species richness in Phase 2.1 resembles that of State 1 conditions. Because of the lack of soil tilling or plowing, a matrix of bunchgrasses remains in this phase, including wiregrass (*A. beyrichiana*). In addition to native perennial species typical of intact ground cover, native “weedy” plant species are often present. Weedy species colonize following clear cutting or other disturbances of the ground surface (not ground penetration). Residual ground cover following clear cutting may be sparse, depending on pre-cut conditions, and weedy species will often colonize the open spaces. The sudden increase in availability of light and moisture may trigger the rapid expansion of native bunchgrasses, particularly those in the genus Andropogon (bluestems). Frequent fire regimes are still intact in Phase 2.1, as periodic fire is necessary to encourage native ground cover persistence. Although grasses can provide the fine fuels necessary for low intensity ground fires, the absence of longleaf pine needle drop may slightly alter fire intensity and behavior.

Community 2.2
Plant pine WOODLAND with intact native groundcover (no till)

Figure 17. Phase 2.2

Phase 2.2 describes a woodland of planted pine (of any species native to Florida) overtopping intact native ground cover. On these excessively drained yellow sands, plant pine species typically include longleaf and sand pine. Although native ground cover remains intact, Phase 2.2 differs from reference site condition in stand structure (and perhaps overstory composition). Planted pines are generally even-aged and evenly spaced. Fire regimes are affected by Phase 2.2 stand structure. Fire behavior may be affected by heavy needle fall typical of densely planted longleaf pine, invoking hotter fires with greater scorch (Grace and Platt 1995). Alternatively, the paucity of fine fuels provided by grasses and other herbs may depress fire spread. Phase 2.2 has native ground cover vegetation, although the frequency and cover of component species will vary according to overstory density. In general, more densely planted stands will have sparser and patchier ground cover. As planted pines mature, light reaching ground level attenuates and heliophytic plants are replaced by more shade tolerant species. However native plant propagules remain in this densely shaded condition, and plant populations will rebound upon canopy opening (the transition to Phase 3.1 has yet occurred in this phase). In addition, weedy herbaceous species may be present in the ground cover.

Pathway 2.1A
Community 2.1 to 2.2

Cut over pineland: intact native ground cover GRASSLAND (turkey oak barrens)

Plant pine WOODLAND with intact native groundcover (no till)

The transition of Phase 2.1 to 2.2 occurs if native pines are planted (without the use of ground penetrating site preparation methods) and frequent fire regime remains intact. Fire maintains woodland conditions by precluding colonization of oaks and other hardwoods. This indicates all prescribed fire regimes (frequent and infrequent) with fire return intervals less than 15 years. This includes hand and mechanical planting of pine seedlings, as well as some methods which allow the natural reseeding from remnant mature pine trees. Typically, slash (*P. elliottii*) and sand (*P. clausa*) pine seedlings are densely planted in even aged stands for the purpose of pulpwood and saw timber production. Loblolly pine (*P. taeda*) may be planted for commodity production but is infrequent on Central Florida yellow sands.

Pathway 2.2A
Community 2.2 to 2.1

Plant pine WOODLAND with intact native groundcover (no till)

Cut over pineland: intact native ground cover GRASSLAND (turkey oak barrens)

The transition from Phase 2.2 to 2.1 can occur via clear-cut logging of canopy pines coupled with continued prescribed fire. Hardwood reduction treatment may be applied to enhance open, herbaceous-dominated ground cover vegetation. This indicates all prescribed fire regimes (frequent and infrequent) with fire return intervals less than 15 years. This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category.

State 3
Pine-Oak FOREST: remnant (non-apparent) herbaceous species population (propagules)

See Community Phase Narratives

Community 3.1
Pine and Xerophytic Oak FOREST: remnant (non-visible) propagules

Figure 18. Phase 3.1

Phase 3.1 describes a mixed pine-oak forest following a long period of fire suppression (on the order of decades without fire). The basis for distinction of this phase is the presence of native ground cover plant populations which may not readily visible. Importantly, this phase describes fire suppressed conditions in the absence of previous major soil disturbance in the form of plowing, tilling or disking. Canopy pines may include any native pine species; however, longleaf and sand pines are typical of fire suppressed pine-hardwood forests on yellow sands. Slash pines (*P. elliottii*) may be present if they were planted (i.e. successional from Phase 2.2). Canopy oaks may include xerophytic sand live oak, and laurel oak (depending on seed source). Scrub hickory (*C. floridana*) may be a prominent sub-canopy species in LRU 154-2. Clonal scrub oaks (myrtle and Chapman's oaks) may be midstory components, depending on propagule availability. Ground cover vegetation is mainly invisible in Phase 3.1. Occasionally, small sprigs of wiregrass or shade tolerant native plants may be visible, particularly in canopy gaps. Despite the apparent absence of ground cover, dormant propagules persist in this phase and are able to recolonize the site following hardwood reduction and reintroduction of fire. Fuel conditions of this phase have dramatically deviated from those of reference site conditions. There are no fine fuels necessary to carry frequent low intensity ground fires. Under typical weather conditions this phase will not burn. Catastrophic wildfire may occur under extreme drought conditions.

State 4
Oak dominated FOREST (not Xeric Hammock – regionally restricted)

See Community Phase Narratives

Community 4.1
Laurel / Live Oak FOREST: native or non-native understory

Figure 19. Phase 4.1 - Laurel / Live Oak Forest with a variable understory

Phase 4.1 is a closed canopy oak forest with no herbaceous ground cover typical of State 1 sandhills. These conditions follow decades of fire suppression, and develop in regions with no source of scrub oaks and sand pine. Within the geographic range of this site, scrub oaks are infrequent or absent in part of the Northern LRU, including much of the Brooksville Ridge, western Alachua and Marion counties (Figure 1). The canopy of Phase 4.1 is dominated by sand live oak (*Q. geminata*) and laurel oak (*Q. laurifolia*). Southern live oak (*Q. virginiana*) may also occur, although this species is not typically common on excessively drained sands. No pines are present in the canopy or understory. Midstory can be dense or open, mainly harboring oak saplings. Under increasingly shady conditions, plant species typical of more mesic forests can invade the understory, such as cabbage palm (*Sabal palmetto*), cherry laurel (*Prunus caroliniana*), and greenbriar (Smilax spp.). Any native State 1 ground cover populations are extirpated. In addition, hardwoods typical of native longleaf pine sandhill midstory are absent (i.e. turkey and bluejack oaks, scrub hickory). In the absence of herbaceous ground cover vegetation and pine needles, there is no fine fuel to carry fire. Thick litter duff of hardwood leaves can build up and hold considerable moisture which further suppresses fire ignition. Catastrophic fire would only occur in extreme drought conditions, and result in canopy mortality. Similarly, strong winds and saturating rain associated with hurricanes may affect forest canopy.

Laurel oaks have weak root systems (compared to live oaks) and are readily upturned (S. Carr, pers obs.).

State 5
Xerophytic Scrub SHRUBLAND / WOODLAND / FOREST

See Community Phase Narratives

Community 5.1
Early Successional Oak Scrub SHRUBLAND: no overstory, dense oak groundcover

Figure 20. Phase 5.1 : Early Successional Oak Scrub SHURBLAND dominated by clonal oaks, no pine canopy is present

Figure 21. Phase 5.1 : Early Successional Oak Scrub SHURBLAND with abundant sand pine regeneration

Phase 5.1 is characterized by dense growths of scrub oaks (myrtle, Chapman’s, and sand live oaks) and palmetto (saw and scrub palmetto). Canopy is absent in this early successional phase, either because sand pine seed source is unavailable or has not yet colonized the stand following disturbance. The dense establishment of clonal oaks disallows successful colonization of other pine species (longleaf and slash pines) which require abundance light and bare ground for germination. Scrub oaks in this phase reach 3 to 5 feet in height. Herbaceous ground cover of Phase 5.1 is very sparse or completely absent. Where it occurs, ground cover vegetation is patchily distributed. Because of the dominance of a few clonal oaks and paucity of herbaceous species, small scale diversity of Phase 5.1 is very low (average 19 species / 400 m2; range 12-36; n=6: NRCS inventory data 2013). Bunch grasses typical of longleaf sandhills are notably absent (i.e. wiregrass, indiangrass). The diversity and density of herbaceous plants are highest in the years immediately following fire (Menges and Hawkes 1998). Under historical conditions, composition and structure of Phase 5.1 scrub was maintained by fire regimes with return intervals of once every several decades (Myers 1985). Fires do ignite in scrubs in extreme drought conditions, and are typically are very hot and intense. Clonal scrub oaks and palmettos vigorously re-sprout, rapidly re-colonizing the post-fire environment (Abrahamson 1984; Freeman and Kobziar 2011). Recovery of plant diversity and cover occurs within 1 to 5 years following fire, although oak height growth continues for longer periods (Abrahamson 1984; Greenberg 2003; Schmalzer 2003). Non clonal plants, including herbaceous plants, are typically killed in hot fires. Some species which are prolific seeders (such as Florida rosemary), will recolonize post-fire.

Community 5.2
Late Successional Pine - Oak Scrub WOODLAND: mature sand pine overstory

Figure 22. Phase 5.2: Late Successional Pine - Oak Scrub WOODLAND

Figure 23. Phase 5.2: Late Successional Pine - Oak Scrub WOODLAND understory

Phase 5.2 is dominated by dense growths of scrub oaks (Q. myrtifolia, Q. chapmannii, *Q. geminata*) mixed with palmetto (saw and scrub palmetto), and a few other xerophytic hardwood species. Species composition of Phase 5.2 is very similar to that of Phase 5.1; the main difference between these phases is structural. A canopy of mature sand pines is present in Phase 5.2. Shrub growth is very dense and can reach 10 feet in height, although midstory is generally lower in stature under dense pine canopy. Sand pine canopies are typically even-aged, which is an artifact of seedling colonization following intense fire or logging (Laessle 1958). Sand pine canopies range from sparse to very dense. Herbaceous ground cover of Phase 5.2 is very sparse or absent. With prolonged fire exclusion, patches of open ground occur following death of individual oak clones. These patches often support abundant growth of fire intolerant fruticose lichens (members of the genus Cladonia). Dense surface accumulations of pine needles and hardwood leaves are also typical in the prolonged absence of fire. Phase 5.2 describes the late successional conditions of scrub communities which are adapted to infrequent and intense fires, on the order of two to three fires per century (FNAI 2010; Myers 1985). Coarse, woody fuels of Phase 5.2 only carry fire in extreme weather and drought conditions. If fire return interval is less than the typical lifespan of sand pine (60 to 70 years), fires will trigger regeneration of sand pine from serotinous cones. Sand pine can rapidly reseed post-fire conditions.

Community 5.3
Xeric Hammock FOREST: sand live oak canopy, dense midstory

Figure 24. Phase 5.3 Xeric Hammock FOREST: sand live oak canopy, dense midstory

Phase 5.3 describes late successional vegetation resulting from long term fire suppression of former scrub and xeric longleaf pine sandhill communities (FNAI 2010). This phase represents Xeric Hammock, a natural community type recognized by the Florida Natural Areas Inventory (FNAI 2010). Compositionally, Phase 5.3 closely resembles the scrub phases (Phases 5.1 and 5.2) in that the same clonal oak species are dominant (*Q. myrtifolia*, Q. chapmannii, *Q. geminata*). However, this phase is a forest with a closed canopy of sand live oak (*Q. geminata*), overtopping lower growths of clonal scrub oaks and hardwood seedlings. Sand pine is either absent, having failed to regenerate under densely forested conditions, or is present as a few old emergent trees. The mid- and under-story strata are overwhelmingly dominated by scrub oaks and palmetto. Other shrubs are sometimes irregularly distributed, including rusty staggerbush (*Lyonia ferruginea*), sparkleberry (*Vaccinium arboreum*), deerberry (*V. stamineum*), garberia (*Garberia heterophylla*), and Florida rosemary (*Ceratiola ericoides*). Herbaceous ground cover in Phase 5.3 is very sparse or absent. The forest floor is covered with oak leaf litter which holds considerable moisture, creating mesic conditions at ground level and further depressing native herbaceous growth as well as pine germination (FNAI 2010). The Phase 5.2 xeric hammock community itself is fire resistant. Fine fuels are absent, and hardwood litter retains ample moisture which deters fire spread. When fires do occur, they are severe and generally occur in extreme drought conditions. Unlike surface fires, these intense fires consume most standing biomass. In xeric hammocks, clonal oaks quickly re-sprout from extensive rhizome systems, impeding colonization of pines and herbaceous species.

Pathway 5.1A
Community 5.1 to 5.2

Early Successional Oak Scrub SHRUBLAND: no overstory, dense oak groundcover

Late Successional Pine - Oak Scrub WOODLAND: mature sand pine overstory

Fire suppression or very infrequent fire (on the order of once every 50+ years) allows the establishment of sand pine overstory and dense oak midstory, which are typical of Phase 5.2. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. Sand pine can colonize post-fire or fire suppressed conditions if seed source if available. In the absence of seed source, there is no sand pine regeneration.

Pathway 5.2A
Community 5.2 to 5.1

Late Successional Pine - Oak Scrub WOODLAND: mature sand pine overstory

Early Successional Oak Scrub SHRUBLAND: no overstory, dense oak groundcover

Phase 5.2 can transition to Phase 5.1 via natural disturbances of intense fire or strong winds associated with hurricanes or storms which result in sand pine mortality. Clear-cut logging results in canopy reduction which mimics the effects of intense fire and wind. Intense fires can reduce oak cover; however, clonal oaks and palmetto quickly resprout following fire unless extremely hot fire kills underground tissue of oak clones (Abrahamson and Abrahamson 1996). Strong winds are often associated with hurricanes, and occasionally affect large scale landscape disturbance in the Central Florida peninsula. Storm winds of this magnitude occur on the order of several times a century. Sand pine (*P. clausa*) is particularly susceptible to wind generated damage and mortality. Storm related sand pine mortality on a large scale can convert late successional sand pine scrub and xeric hammock to early successional oak scrub. Strong winds may affect other pine woodlands similarly, although longleaf pine sandhill communities are generally invulnerable to severe hurricane damage, in light of widely spaced and uneven aged longleaf pine stands. This category includes the death of mature sand pines due to natural processes. Sand pines typically occur in even aged populations and are short lived (about 70 years). Sand pines weakened by age, insects, and pathogens typically fall over and release seed from heat sensitive cones. This provides a seed source for sand pine germination under conditions conducive for regeneration. This practice involves selective removal of pines via mechanical methods, usually for the purpose of improving residual stand conditions. These techniques can promote restoration of stand structure and composition to more uneven-aged conditions, and promote natural regeneration of longleaf pine where seed source is available. In the current model, this treatment does not include "high grading" of pine stands, which is a type of selective logging targeting only the most merchantable trees. This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. This driver includes wildland fire such as fires ignited by arson, accidents, or lightning. These fires tend to be infrequent (greater than 20 year return interval) and intense due to high fuels accumulation. These are conditions which accelerate wildlife fire ignition and spread and induce stand-replacing fires. Also included in this category are planned prescribed fires designed to mimic high intensity wildland fires. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Pathway 5.2B
Community 5.2 to 5.3

Late Successional Pine - Oak Scrub WOODLAND: mature sand pine overstory

Xeric Hammock FOREST: sand live oak canopy, dense midstory

In the continued absence of fire (greater than100 years); Phase 5.2 scrub will succeed to Phase 5.3 (Xeric Hammock). This occurs when the larger statured sand live oaks overtop the other scrub oaks creating a closed canopy, coupled with the eventual mortality of canopy sand pines and lack of sand pine regeneration. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from greater than 20 years to many decades.

Pathway 5.3A
Community 5.3 to 5.1

Xeric Hammock FOREST: sand live oak canopy, dense midstory

Early Successional Oak Scrub SHRUBLAND: no overstory, dense oak groundcover

A single catastrophic fire or a series of hot fires could convert Phase 5.3 to early successional scrub (Phase 5.1) if the fire is hot enough to kill the oak overstory. Similarly, other natural disturbances which remove the sand live oak canopy will affect transition to Phase 5.1. These include strong winds associated with hurricanes and storms. Mechanical treatments can affect transition of Phase 5.3 to early successional scrub (Phase 5.1) via canopy reduction. These include clearing of canopy sand live oaks and mechanical chopping to reduce oak cover. This driver includes wildland fire such as fires ignited by arson, accidents, or lightning. These fires tend to be infrequent (greater than 20 year return interval) and intense due to high fuels accumulation. These are conditions which accelerate wildlife fire ignition and spread and induce stand-replacing fires. Also included in this category are planned prescribed fires designed to mimic high intensity wildland fires. This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. Strong winds are often associated with hurricanes, and occasionally affect large scale landscape disturbance in the Central Florida peninsula. Storm winds of this magnitude occur on the order of several times a century. Sand pine (*P. clausa*) is particularly susceptible to wind generated damage and mortality. Storm related sand pine mortality on a large scale can convert late successional sand pine scrub and xeric hammock to early successional oak scrub. Strong winds may affect other pine woodlands similarly, although longleaf pine sandhill communities are generally invulnerable to severe hurricane damage, in light of widely spaced and uneven aged longleaf pine stands.

State 6
Pine WOODLANDS / GRASSLANDS: restored ecological function / structure

See Community Phase Narratives

Community 6.1
GRASSLAND: SEEDED native ground cover OR mixture native / non-native

Figure 25. Phase 6.1: GRASSLAND: SEEDED native ground cover OR mixture native / non-native

Figure 26. Phase 6.1: GRASSLAND: SEEDED native ground cover OR mixture native / non-native

Phase 6.1 describes a grassland of seeded native gound cover species, OR a mixture of native and non-native herbaceous species. Notably, this phase describes conditions where native propagules have been extirpated following long term fire suppression and/or extensive soil disturbance associated with commodity land uses. In this phase, native ground cover plant populations are purposefully re-established on site. There is no canopy or midstory in this phase, as these have typically been removed to create a grassland. Low growing sprouts of clonal oaks and other hardwoods may persist in the understory, depending on conditions prior to site clearing. Re-introduction of native plant populations, coupled with natural colonization of various weedy native and non-native species, creates herbaceous ground cover in Phase 6.1 which superficially resembles that of reference site conditions. However, the full complement of ground cover composition typical of Phase 1.1 remains incomplete. Perennial grasses and forbs with seed dispersal mechanisms not conducive to colonization of distant and disturbed sites are notably absent (i.e. big seeded species which rely on animal and gravity dispersal, and long lived clonal species). To date, there are no examples of whole scale reintroduction of Phase 1.1 native ground cover on Yellow Sands of Central Florida (S. Carr, pers. obs.). However, there are examples of restored ground cover containing common bunch grasses such as wiregrass and Indiangrass, either seeded or planted, mixed with a partial compliment of predominantly wind-dispersed native and non-native herbaceous species. The current STM does not include pathways from State 6 to State 1 at this time, until techniques are developed for restoration of the whole compliment of reference site native ground cover populations. Phase 6.1 is a grassland community with restored ecological function and restored habitat for some wildlife species. Specifically, restoration of native bunchgrasses provides fine fuels for frequent ground fires and is necessary for restoration of ecological site dynamics. Once established, the bunch grass matrix provides habitat suitable for establishment of other native plant populations, either from artificial seeding or natural recruitment. Phase 6.1 grasslands may provide suitable habitat for ground nesting birds and small mammals (see Wildlife interpretations). Furthermore, the open nature of Phase 6.1 coupled with the availability of native forage provides habitat for the gopher tortoise (Gopherus polyphemus), a terrestrial turtle listed as a threatened species in Florida. Gopher tortoise burrows provide habitat for over 350 commensal species (FWC 2014). Following the establishment of grasslands, fine fuels can carry low intensity ground fires. Fire frequencies of two to three decades (or more frequent) are necessary to discourage woody plant encroachment and maintain herbaceous native populations.

Community 6.2
Planted Pine Uneven - Age WOODLAND with SEEDED native ground cover

Phase 6.2 describes longleaf pine woodlands with "restored ecological structure and function". Specifically, this phase describes a woodland community that is restored following extirpation of native ground cover via either long term fire suppression and/or ground disturbance. Phase 6.2 is distinguished by the presence of native ground cover which was established via seeding and/or planting. Accordingly, Phase 6.2 woodlands approximate reference site conditions in stand structure and wildlife habitat suitability (i.e. for native songbirds, fossorial animals, game species, etc.). Similar to Phase 1.1, pine woodland structure of Phase 6.2 is uneven-aged, with patches of regenerating pine seedlings and saplings. Depending on precursor conditions, fire frequency and propagule availability, oaks species may be present in the mid- and understory. Oaks may be present in the midstory and/or understory, depending on precursor community conditions and availability of propagule sources. Despite the resemblance of stand structure, Phase 6.2 woodlands do not fully resemble reference site conditions (Phase 1.1) in species composition, relative species abundance or diversity. At the time of this report, there is no known example of restored ground cover vegetation that is specific to Astatula and Candler soils, which approximates the full complement of native species presence and relative abundance. In particular, restored sandhill woodland would need to resemble the small scale diversity of reference site conditions. Although there are examples of ground cover restoration following soil disturbance and fire suppression on Entisols, these examples are in regions other than MLRA 154/155 (i.e. the Florida Panhandle). Dominant ground cover species can be reintroduced to the Site, as is part of Phase 6.2 conditions. In this manner, fine fuels necessary for frequent fires are established, which further promotes the re-colonization of native plant species. Furthermore, reintroduced native ground cover and fire regime maintains open aspect and ground cover necessary for suitable habitat for many rare and endemic animals such as the gopher tortoise, indigo snake, gopher frog, red-cockaded woodpecker, and numerous ground nesting birds. The practice of planting native wiregrass plugs is common on xeric sands of MLRA 154, particularly on public and private lands managed for conservation and endangered species habitat (A. Barkdoll, pers. comm.). Wiregrass planting is often preceded by mechanical and/or chemical site preparation to reduce dominance of non-native and weedy ground cover vegetation. After a single growing season, ground cover of mainly planted wiregrass is sufficient to carry a ground fire (D. Printiss, pers. comm.). In addition to wiregrass, other native ground cover species may be introduced via seeding (D. Gordon and D. Printiss, pers. comm.). It is possible that populations of most plant species typical of Phase 1.1 could be established over time with repeated seeding and consistent burning. However, as stated above, there is currently no example of this specific to Yellow Sands of Central Florida.

Community 6.3
Planted Pine Uneven – Age WOODLAND with weedy and / or non-native ground cover

Figure 27. Phase 6.3: Planted Pine Uneven – Age WOODLAND with weedy and / or non-native ground cover

Similar to Phase 6.2, this phase describes restored pine stand structure with ground cover suitable for spread of frequent fires. This difference in this phase is the composition of the ground cover. Phase 6.3 ground cover can be a mixture of non-native grasses and weedy native/non-native species. This condition particularly describes old pastures or fallow fields that have been managed for uneven age pine structure for wildlife habitat. Ground fires are possible in these conditions, but do not mimic the fire behavior and intensity of native ground cover fuels. Phase 6.3 longleaf pine woodlands approximate the uneven-aged structure and density of State 1 sandhill conditions, with longleaf pine regeneration present to some degree. Midstory oaks may be present depending on previous site conditions and propagule availability. Phase 6.3 ground cover consists of non-native and/or weedy native plant species. Often, non-native pasture grasses dominate the ground cover, including bermudagrass (*Cynodon dactylon*), and bahiagrass (*Paspalum notatum*). In addition, weedy native and non-native species are typical of disturbed sites, such as bluestems (Andropogon spp.), dog fennel (*Eupatorium capillifolium*), Natal grass (*Melinis repens*), torpedograss (*Panicum repens*), etc.

Pathway 6.1A
Community 6.1 to 6.2

The transition from Phase 6.1 to Phase 6.2 requires pine planting and continued application of prescribed fire. In this transition, pines are planted and managed to eventually resemble Phase 1.1 woodland stand structure: an uneven aged mixture of pines. Although any native pine species (except sand pine) can be managed for this reason, longleaf pines are best suited for uneven aged stand structure on these excessively drained yellow sand soils. Frequent prescribed fire is necessary to perpetuate the ground cover established in Phase 6.1. This includes hand and mechanical planting of pine seedlings, as well as some methods which allow the natural reseeding from remnant mature pine trees. Typically, slash (*P. elliottii*) and sand (*P. clausa*) pine seedlings are densely planted in even aged stands for the purpose of pulpwood and saw timber production. Loblolly pine (*P. taeda*) may be planted for commodity production but is infrequent on Central Florida yellow sands. This includes hand and mechanical planting of longleaf pine seedlings, as well as methods which promote natural reseeding from remnant mature longleaf pine trees. Prescribed burning for site preparation and post-planting management is generally linked to this practice. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1 to 3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season.

Pathway 6.2A
Community 6.2 to 6.1

Transition to Phase 6.1 can occur if canopy pines are removed, either from clear-cut logging or natural disturbances including catastrophic fire, extremely strong winds, and pine mortality due to insects. This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Strong winds are often associated with hurricanes, and occasionally affect large scale landscape disturbance in the Central Florida peninsula. Storm winds of this magnitude occur on the order of several times a century. Sand pine (*P. clausa*) is particularly susceptible to wind generated damage and mortality. Storm related sand pine mortality on a large scale can convert late successional sand pine scrub and xeric hammock to early successional oak scrub. Strong winds may affect other pine woodlands similarly, although longleaf pine sandhill communities are generally invulnerable to severe hurricane damage, in light of widely spaced and uneven aged longleaf pine stands.

Pathway 6.2B
Community 6.2 to 6.3

Phase 6.2 can transition to Phase 6.3 under conditions that encourage the replacement of native ground cover with weedy and/or non-native species. Land management practices include over-grazing, seeding of pasture grasses, invasion of non-native species (not including invasion by noxious plant species such as Cogongrass as described by transition to State 6). Similarly, reduction of fire frequency (or fire suppression) may encourage colonization of non-native or weedy plant species. This condition describes grazing in excess of biomass and compositional recovery capacity of plant species or the plant community. Heavy grazing may affect large shifts in plant composition through loss of populations of palatable plants. Heavy grazing by cattle leads to the decline in palatable grasses such as lopsided indiangrass (*Sorghastrum secundum*), and causes increases in less palatable forage species (e.g. wiregrass, *Aristida stricta* var. beyrichiana). The over-utilization of forage species through heavy grazing can be caused under either continuous or rotational grazing systems. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. Invasive plant species will colonize natural xeric sandhill and scrub, as well as successional and cultural states, including abandoned crop and grove lands, clearings and old fields. In particular, there are four species common to Central Florida Yellow sands which are recognized by the Florida Exotic Pest Plant Council as “Category 1” species: lantana (*Lantana camara*), natal-grass (*Melinis repens*), ceasar’s weed (*Urena lobata*) and cogongrass (*Imperata cylindrica*). These invasive species displace native populations and change plant community dynamics and ecological functions. Cogongrass is a highly clonal species which forms dense naturalized populations that extirpate local native plant populations. Furthermore, cogongrass is rapidly expanding in geographic and environmental range in the southeastern Coastal Plain, and is difficult and expensive to eradicate.

Context dependence. Heavy Intensive Grazing, Site Prep (ground penetration), Fire Suppression (or very infrequent non-catastrophic fire [more than 20 yr. return interval]), Invasion of Noxious Non-Native Plant Species

Pathway 6.3A
Community 6.3 to 6.1

Planted Pine Uneven – Age WOODLAND with weedy and / or non-native ground cover

GRASSLAND: SEEDED native ground cover OR mixture native / non-native

The transition from Phase 6.3 to 6.1 occurs when pine canopy is removed, either via mechanical means (clear-cut logging) or natural disturbance (catastrophic fire, wind, pine mortality from insect attack). In addition, transition to Phase 6.1 may involve planting of native ground cover species and increased fire frequency. Non-native and undesirable vegetation may need to be controlled in preparation for native ground cover planting. Site preparation may involve chemical treatments targeting undesirable herbaceous or woody plants. Mechanical treatments such as disking or tilling may be applied to prepare a seed bed for planting native species. This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Strong winds are often associated with hurricanes, and occasionally affect large scale landscape disturbance in the Central Florida peninsula. Storm winds of this magnitude occur on the order of several times a century. Sand pine (*P. clausa*) is particularly susceptible to wind generated damage and mortality. Storm related sand pine mortality on a large scale can convert late successional sand pine scrub and xeric hammock to early successional oak scrub. Strong winds may affect other pine woodlands similarly, although longleaf pine sandhill communities are generally invulnerable to severe hurricane damage, in light of widely spaced and uneven aged longleaf pine stands. Large scale pine mortality is caused by periodic epidemics of insect infestation. The southern pine beetle is the most common insect responsible for large scale mortality of southern pine species.

Pathway 6.3B
Community 6.3 to 6.2

Transition from Phase. 6.3 to 6.2 involves treatments for native ground cover establishment, without removal of overstory pines. This category includes practices for native ground cover restoration which involve re-introduction of native plant seed or other propagules. Mechanical and chemical applications may be required for site preparation and seedling establishment. In cases where the ground cover is dominated by exotic grasses, frequent herbicide or fire treatment may be necessary. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. This includes all treatments which target invasive plant populations for the purpose of eradication or containment. Invasive plant control is often a part of natural area restoration, but can also be applied to improve wildlife habitat, rangeland, forestry and croplands. Mechanical treatments such as hand clearing, disking, and raking are generally applied to smaller infestations (0.25 acre). Chemical treatments include direct and indirect herbicide applications on small and larger areas. Fire may also control spread of invasive plant populations but is not included in this category.

State 7
Invasive Non-Native Community

See Community Phase Narratives

Community 7.1
Cogongrass; severe infestation of non-native FDACS Category 1 species

Figure 28. Phase 7.1: Cogongrass; severe infestation of non-native FDACS Category 1 species

Phase 7.1 describes a condition where a single noxious non-native species has invaded and dominated the site. In the excessively drained Yellow sands of MLRA 154, by far the most common noxious invasive plant species is cogongrass (*Imperata cylindrica*; (MacDonald 2004)). This highly clonal grass spreads rapidly by underground rhizomes and windblown seeds, forming dense circular patches which can become very large (on the order of 100’s of acres). Cogongrass grows vigorously in full sunlight and thrives on acidic, nutrient-poor soils and droughty conditions such as those of Astatula and Candler soils (MacDonald 2004). Furthermore, cogongrass is a prolific seed producer, and readily invades following soil disturbances. (Yager, Miller, and Jones 2010). Once clones are established, rapid cogongrass growth will extirpate native ground cover plant populations. In addition to its competitive advantage over native vegetation for space and resources, cogongrass may be allelopathic in some situations (Brook 1989, Bryson and Carter 1993). A cogongrass invested pine stand may have mature pines present, with stand structure resembling that of State 1 or State 6 longleaf pine woodlands. Similarly, cogongrass can occur as pure grasslands or mixed with a few remnant hardwood trees or shrubs. Cogongrass infestations of commodity lands can damage crops directly by yield reduction and suppressed growth from competition for nutrients and moisture, and cause (Seth 1970). Cogongrass is very poor forage (Coile and Shilling 1993, Colvin et al. 1993), and cogongrass invasion lowers the forage quality of pasture lands. Cogongrass is a fire adapted species which burns readily and intensely. Furthermore, it thrives in post-fire conditions where it colonizes rapidly clonally and from seed. Cogongrass fueled fires are up to 20% hotter than natural ground fires of native pinelands (MacDonald 2004). These hot fires may deter any pine or hardwood regeneration. In the Southeastern U.S., cogongrass does not have any natural herbivore enemies, nor any known pathogens.

State 8
Active commodity production or fallow / barren areas: no native plant populations

All Phases of State 8 (except Phase 8.1) describe commodity land uses of the Yellow Sands Xeric Uplands site. Commodity crops common on the xeric sands of this site include a variety of annual and perennial crops, the most notable of which is citrus. Other crops common on excessively drained yellow sands include horticultural ornamentals, vineyards, and some row crops. In the southern portion of MLRA 154 sod farms are occasionally present on these soils. Pine plantations which are managed for community production of pulpwood or saw timber are included in State 8. Longleaf and slash pine are typically grown commercially on these soils. Additionally, improved pastures of bahiagrass (or other sod forming grass species) are included in State 8. All Phases of State 8 describe conditions following ground penetrating soil disturbance, to the degree that native ground cover is mostly absent. Generally these phases are characterized by the complete extirpation of native ground cover populations, including seed banks and dormant propagules, although native weedy species may persist (mostly annual species). Depending on the severity and frequency of ground disturbance, soil profile characteristics in the upper part of the soil may be altered.

Community 8.1
Fallow: post – plowing / tilling, “old field”

Figure 29. Phase 8.1: Fallow abandoned citrus grove

Figure 30. Phase 8.1: Fallow field

Phase 8.1 describes a non-production condition of “fallow fields”, generally following land conversion, or crop or pasture abandonment. Ground cover of this phase includes weedy native and non-native plants. If soils were recently tilled, most plants will be annual, predominantly wind dispersed weeds. If the previous land use was improved pasture or plantation with sod grass, bahia or centipede grass may predominate.

Community 8.2
Planted Pine Plantations: dense even aged, no or weedy ground cover

Figure 31. Phase 8.2 Tree Plantation

Phase 8.2 describes commercial pine plantations. Tree species grown for commodity production on Astatula and Candler sands in Central Florida include slash and longleaf pines. Sand pine is generally not grown for commercial harvest. Pine plantations are usually very densely planted and even aged stands. Mechanical and chemical site preparation generally precedes mechanical planting of pine seedlings. Herbicides are often applied before and after planting to control competing vegetation. Ground cover and midstory vegetation of pine plantations is usually sparse or absent, depending largely on the age of the plantation. The ground is typically covered with needle fall following canopy closure.

Community 8.3
Crop Production: annual and perennial crops

Figure 32. Phase 8.3: Citrus grove

Phase 8.3 describes croplands. Included in this category are annual and perennial croplands (i.e. fruit and ornamental orchards, sod farms, etc). Citrus is the most common perennial community crop of Astatula and Candler soils, mostly confined to the Southern LRU. Other commercial crops of this region include corn, truck crops, ornamental (trees and ferns). Management for agricultural crops includes mechanical and chemical treatments for soil tilling and vegetation manipulations.

Community 8.4
Seeded Pasture: nonnative grasses

Phase 8.4 describes pastures with established non-native turf grasses, which support livestock production, or horse farms. Sod grasses almost completely replace native perennial sandhill species. Some hardwood oak species may persist in the under- and mid-story, depending on the degree of land clearing.

Pathway 8.1A
Community 8.1 to 8.2

Fallow: post – plowing / tilling, "old field"

Planted Pine Plantations: dense even aged, no or weedy ground cover

This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. This includes hand and mechanical planting of pine seedlings. Typically, slash (*P. elliottii*) and sand (*P. clausa*) pine seedlings are densely planted in even aged stands for the purpose of pulpwood and saw timber production. Loblolly pine (*P. taeda*) may be planted for commodity production but is infrequent on Central Florida yellow sands. This includes hand and mechanical planting of longleaf pine seedlings, as well as methods which promote natural reseeding from remnant mature longleaf pine trees. Prescribed burning for site preparation and post-planting management is generally linked to this practice.

Pathway 8.1B
Community 8.1 to 8.3

Fallow: post – plowing / tilling, "old field"

Crop Production: annual and perennial crops

This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Pathway 8.1C
Community 8.1 to 8.4

This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. Prescribed grazing is the controlled harvest of vegetation with grazing or browsing animals, that are managed with the intent to balance forage production and animal demand to ensure proper utilization of forage species. Management may be continuous or rotational grazing systems, with proper forage/animal balance, composition of forage species will remain stable over extended periods. Regardless of the type of grazing management, deferment of areas or fields for 30 to 90 days during the growing season to allow for seed production, plant recruitment, and mitigation of grazing following other management practices (i.e. prescribed burning, brush management, etc.) is recommended for ground cover restoration.

Pathway 8.2A
Community 8.2 to 8.1

Planted Pine Plantations: dense even aged, no or weedy ground cover

Fallow: post – plowing / tilling, "old field"

This phase may occur immediately following land conversion such as plowing or tilling, where the land is left absent form active crop production. Fallow fields may be made fallow following the abandonment of the field / crop. Depending on the previous land use, plants may consist of annual or perennial crops interspersed with weedy species.

Pathway 8.3A
Community 8.3 to 8.1

Crop Production: annual and perennial crops

Fallow: post – plowing / tilling, "old field"

This phase may occur immediately following land conversion such as plowing or tilling, where the land is left absent form active crop production. Fallow fields may be made fallow following the abandonment of the field / crop. Depending on the previous land use, plants may consist of annual or perennial crops interspersed with weedy species.

Pathway 8.4A
Community 8.4 to 8.1

This phase may occur immediately following land conversion such as plowing or tilling, where the land is left absent form active crop production. Fallow fields may be made fallow following the abandonment of the field / crop. Depending on the previous land use, plants may consist of annual or perennial crops interspersed with weedy species.

Transition T1A
State 1 to 2

Removal of native longleaf pine canopy via clear-cut or heavy selective logging will convert State 1 to Phase 2.1 (cutover pineland with native ground cover grassland). As the transition to Phase 2.1 only involves stand alteration, the presence of continuous native ground cover continues to support frequent ground fires. Transition to Phase 2.1 followed by fire suppression accelerates the transition to hardwood dominated shrubland and forest (Phases 5.1, 3.1). Canopy removal under these condition may result in a recovery of ground cover populations as light and nutrients are suddenly available. The following contributes to this Transition: This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1 to 3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season. Infrequent fire regimes are generally applied for land management objectives other than natural area conservation and restoration. These include, but not limited to, fuels reduction, forage management, tree plantation management, and site preparation (for crops and plantations). Included here are fire regimes with longer return intervals (> 3 years but < 15 years for LRU 154-1, and > 10 years and < 20 years for LRU 154-2). These prescribed fires generally occur in the dormant season in the Southeastern Coastal Plain, although this category of infrequent fire regimes includes dormant and growing season prescribed fires.

Transition T1B
State 1 to 3

Continued fire suppression will eventually cause Phase 1.3 to succeed State 3. State 3 represents the site condition after more than 20 years of fire suppression (the length of fire suppression depends on geography, local environmental conditions, and availability of colonizing oak species). This transition is complete when these oaks dominate the mid-story and herbaceous ground cover is not visible (see description for Phase 3.1). Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades.

Transition T1C
State 1 to 7

Cogongrass may invade State 1 depending on seed/propagule availability and the presence of local disturbances. However, the shady conditions of Phase 1.3 may deter cogongrass establishment (MacDonald 2004, Yager et al. 2010). Invasive plant species will colonize natural xeric sandhill and scrub, as well as successional and cultural states, including abandoned crop and grove lands, clearings, and old fields. In particular, there are four species common to Central Florida which are recognized by the Florida Exotic

Pest Plant Council as “Category 1” species: lantana (*Lantana camara*), natal-grass (*Melinis repens*), ceasar’s weed (*Urena lobata*) and cogongrass (*Imperata cylindrica*). These invasive species displace native populations and change plant community dynamics and ecological functions. Cogongrass is a highly clonal species which forms dense naturalized populations that extirpate local native plant populations. Furthermore, cogongrass is rapidly expanding in geographic and environmental range in the southeastern Coastal Plain and is difficult and expensive to eradicate.

Transition T1D
State 1 to 8

Conversion of State 1 to commodity land uses (State 8) generally involves removal of native ground cover via ground penetrating treatments. A number of treatments can be used for this, including disking, racking, plowing and herbicide application. Following conversion, other treatments may include: mowing, site prep, tree, or crop planting, seeding of non-native pasture grasses. Many land conversion activities may contribute to this transition: This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Restoration pathway R2A
State 2 to 1

Phase 2.2 can transition to Phase 1.1 or 1.2 through the restitution of uneven-aged structure of longleaf pine stands and native regimes of frequent low intensity fire. Silvicultural treatments used to manipulate stand structure include selective logging of canopy pines, which creates regeneration space for longleaf pine seedlings. Eventually this practice can produce a mosaic of uneven-aged “cohorts”. If longleaf pine is not present in Phase 2.2, it would need to be reintroduced via logging of existing stand followed by longleaf planting (i.e. via Phase 2.1). This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. Large scale pine mortality is caused by periodic epidemics of insect infestation. The southern pine beetle is the most common insect responsible for large scale mortality of southern pine species. Strong winds are often associated with hurricanes, and occasionally affect large scale landscape disturbance in the Central Florida peninsula. Storm winds of this magnitude occur on the order of several times a century. Sand pine (*P. clausa*) is particularly susceptible to wind generated damage and mortality. Storm related sand pine mortality on a large scale can convert late successional sand pine scrub and xeric hammock to early successional oak scrub. Strong winds may affect other pine woodlands similarly, although longleaf pine sandhill communities are generally invulnerable to severe hurricane damage, in light of widely spaced and uneven aged longleaf pine stands. This includes hand and mechanical planting of longleaf pine seedlings, as well as methods which promote natural reseeding from remnant mature longleaf pine trees. Prescribed burning for site preparation and post-planting management is generally linked to this practice. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1 to 3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season.

Transition T2A
State 2 to 3

Depending on propagule availability, sand pine and scrub oaks may colonize heavily shaded planted pine woodlands. Fire suppression would encourage the transition to State 3.1 (Pine-oak Forest). Herbaceous ground cover attenuates with continued fire suppression. Eventually, ground cover populations are extirpated and replaced by woody vegetation. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from > 20 years to many decades.

Transition T2B
State 2 to 7

Cogongrass may invade State 2 depending on seed/propagule availability and the presence of local disturbances. Invasive plant species will colonize natural xeric sandhill and scrub, as well as successional and cultural states, including abandoned crop and grove lands, clearings, and old fields. In particular, there are four species common to Central Florida which are recognized by the Florida Exotic Pest Plant Council as "Category 1" species: lantana (*Lantana camara*), natal-grass (*Melinis repens*), ceasar's weed (*Urena lobata*) and cogongrass (*Imperata cylindrica*). These invasive species displace native populations and change plant community dynamics and ecological functions. Cogongrass is a highly clonal species which forms dense naturalized populations that extirpate local native plant populations. Furthermore, cogongrass is rapidly expanding in geographic and environmental range in the southeastern Coastal Plain and is difficult and expensive to eradicate.

Transition T2C
State 2 to 8

Conversion of State 2 to commodity land uses (State 8) generally involves removal of native ground cover via ground penetrating treatments. A number of treatments can be used for this, including disking, racking, plowing and herbicide application. Following conversion, other treatments may include: mowing, site prep, tree, or crop planting, seeding of non-native pasture grasses. Many land conversion activities may contribute to this transition: Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Restoration pathway R3A
State 3 to 1

A combination of hardwood reduction and reintroduction of fire can affect succession to Phase 3.1, as long as dormant propagules and off-site seed sources exist and are able to recolonize the site. This sort of “passive” ground cover restoration is thought to be possible only if prior land use precluded ground disturbance such as plowing or disking. Transition from Phase 3.1 to Phase 1.3 may occur with selective logging and hardwood control (mechanical or chemical), especially if pine canopy is retained in an effort to restore stand structure. Reinstitution of frequent fire regimes will facilitate ground cover recovery, and eventually may encourage restoration of Phase 1.1 conditions. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1-3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season. This driver includes wildland fire such as fires ignited by arson, accidents, or lightning. These fires tend to be infrequent (more than 20 year return interval) and intense due to high fuels accumulation. These are conditions which accelerate wildlife fire ignition and spread and induce stand-replacing fires. Also included in this category are planned prescribed fires designed to mimic high intensity wildland fires. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. This practice involves selective removal of pines via mechanical methods, usually for the purpose of improving residual stand conditions. These techniques can promote restoration of stand structure and composition to more uneven-aged conditions, and promote natural regeneration of longleaf pine where seed source is available. In the current model, this treatment does not include “high grading” of pine stands, which is a type of selective logging targeting only the most merchantable trees.

Transition T3A
State 3 to 2

A combination of hardwood reduction and reintroduction of fire can affect succession to Phase 2.1, as long as dormant propagules and off-site seed sources exist and are able to recolonize the Site. This sort of “passive” ground cover restoration is thought to be possible only if prior land use precluded ground disturbance such as plowing or disking. Transition to 2.1 involves total removal of canopy, either by clear-cutting and hardwood reduction, or catastrophic wildfire. Following canopy removal, frequent low intensity fire is necessary to encourage ground cover recovery. Reinstitution of frequent fire regimes will facilitate ground cover recovery, and eventually may encourage restoration of Phase 1.1 conditions. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1 to 3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season. This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. This driver includes wildland fire such as fires ignited by arson, accidents, or lightning. These fires tend to be infrequent (more than 20 year return interval) and intense due to high fuels accumulation. These are conditions which accelerate wildlife fire ignition and spread and induce stand-replacing fires. Also included in this category are planned prescribed fires designed to mimic high intensity wildland fires.

Transition T3B
State 3 to 4

In the continued absence of fire, and the absence of colonizing scrub oaks, a closed canopy forest of laurel oak (*Q. laurifolia*) and sand live oak can prevail. These forests are more common in the northern LRU (154.1) following decades of fire suppression. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This “driver” (absence of scrub oaks) represents situations where scrub oaks (and other typical scrub plant species) are not available to colonize the site, thus succession in the absence of fire follows an alternative path. The Yellow Sands considered in this site are geographically widespread throughout Central Florida, and occur in regions without scrub oaks (Carr, pers. obs). Other oaks may eventually colonize the site, including water oaks (*Quercus nigra*), laurel oak (*Q. laurifolia*) and live oak (*Q. virginiana*).

Transition T3C
State 3 to 5

In the absence of hardwood reduction and frequent fire, Phase 3.1 will transition either to a scrub shrubland or a closed canopy forest, depending on the influence of infrequent fire and colonization of oak species. The latter also depends on geography. Transition to Phase 5.1 (early successional oak scrub) can follow a high intensity fire which severely reduces pine-oak canopy. In the presence of colonizing scrub oak (myrtle, Chapman's and sand live oak), low oak scrub will develop. If complete fire suppression continues and scrub oaks are present, late successional scrub may dominate as scrub oaks dominate the midstory suppressing growth of other hardwood and pine species. Shade tolerant sand pine can germinate under these conditions if seed source is present. This driver includes wildland fire such as fires ignited by arson, accidents, or lightning. These fires tend to be infrequent (more than 20 year return interval) and intense due to high fuels accumulation. These are conditions which accelerate wildlife fire ignition and spread and induce stand-replacing fires. Also included in this category are planned prescribed fires designed to mimic high intensity wildland fires. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades.

Transition T3D
State 3 to 8

Conversion of State 3 to commodity land uses (State 8) generally involves removal of native ground cover via ground penetrating treatments. A number of treatments can be used for this, including disking, racking, plowing and herbicide application. Following conversion, other treatments may include: mowing, site prep, tree, or crop planting, seeding of non-native pasture grasses. Many land conversion activities may contribute to this transition: This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Transition T4A
State 4 to 6

The forest canopy of State 4 can be removed via clearcutting and other mechanical and chemical hardwood reduction techniques. If left fallow, weedy herbaceous plants will colonize (Phase 6.1), followed by advantageous hardwoods. Frequent burning may retard reforestation of the site; however, in the absence of fine fuels of native ground cover, reintroduction of ground fires is difficult. Restoration of some elements of native ground cover may be accomplished to transition from Phase 4.1 to Phase 6.1 (with native ground cover). Treatments to affect this transition include canopy removal, mechanical and/or chemical hardwood control, and site preparation in the form of light mechanical chopping and/or burning. Following this, native grasses can be reintroduced to the site via seeding or planting of plugs. Successful establishment of native bunchgrasses (wiregrass, Indian grass) has been observed on Entisols similar to Astatula and Candler, specifically in the Florida Panhandle (TNC, unpublished data). Similarly, other native herbaceous species have been restored via seeding on similar soils in other regions. However, we currently do not know the full potential of ground cover composition restoration using these techniques. Furthermore, we do not have any example of such restoration (from seeding and plantings) specific to these soil types in this MLRA. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1 to 3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season. This category includes practices for native ground cover restoration which involve re-introduction of native plant seed or other propagules. Mechanical and chemical applications may be required for site preparation and seedling establishment. In cases where the ground cover is dominated by exotic grasses, frequent herbicide or fire treatment may be necessary.

Transition T4B
State 4 to 8

Conversion of State 4 to commodity land uses (State 8) generally involves removal of native ground cover via ground penetrating treatments. A number of treatments can be used for this, including disking, racking, plowing and herbicide application. Following conversion, other treatments may include: mowing, site prep, tree or crop planting, seeding of non-native pasture grasses. Many land conversion activities may contribute to this transition: This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Transition T5A
State 5 to 6

State 5 can be converted to Phase 6.1 (grassland of seeded native or mixture native/non-native species). For this, the dense growths of clonal scrub oaks would have to be eradicated through mechanical and chemical means. Clonal oaks are exceptionally difficult to remove, requiring more than just repeated burning (J. Hinchee, pers comm.). Repeated chemical treatments may be necessary to deter re-sprouting. Herbaceous ground cover may be established via seeding or planting, although success of these treatments is unknown (see discussion in previous section). This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1 to 3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season. This category includes practices for native ground cover restoration which involve re-introduction of native plant seed or other propagules. Mechanical and chemical applications may be required for site preparation and seedling establishment. In cases where the ground cover is dominated by exotic grasses, frequent herbicide or fire treatment may be necessary. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category.

Transition T5B
State 5 to 7

Invasion of State 5 by cogongrass (transition to State 7) is possible, particularly following ground disturbance from logging or site preparation. Invasive plant species will colonize natural xeric sandhill and scrub, as well as successional and cultural states, including abandoned crop and grove lands, clearings, and old fields. In particular, there are four species common to Central Florida which are recognized by the Florida Exotic Pest Plant Council as “Category 1” species: lantana (*Lantana camara*), natal-grass (*Melinis repens*), ceasar’s weed (*Urena lobata*) and cogongrass (*Imperata cylindrica*). These invasive species displace native populations and change plant community dynamics and ecological functions. Cogongrass is a highly clonal species which forms dense naturalized populations that extirpate local native plant populations. Furthermore, cogongrass is rapidly expanding in geographic and environmental range in the southeastern Coastal Plain and is difficult and expensive to eradicate.

Transition T5C
State 5 to 8

Conversion of State 5 to commodity land uses (State 8) generally involves removal of native ground cover via ground penetrating treatments. A number of treatments can be used for this, including disking, racking, plowing and herbicide application. Following conversion, other treatments may include: mowing, site prep, tree or crop planting, seeding of non-native pasture grasses. Many land conversion activities may contribute to this transition: This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Hardwood reduction includes mechanical and chemical treatments designed to reduce hardwood biomass and stem densities. The flush of available resources following hardwood reduction treatments generally favors growth of pines and herbaceous ground cover. Mechanical hardwood reduction treatments include chopping, felling, shearing, “anchor chaining”, and disking. Selective and non-selective herbicides are often used for reduction of hardwoods in the understory and midstory strata. Fire and weather events also affect hardwood reduction, but these are not explicitly included in this category. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Transition T6A
State 6 to 4

State 6 can transition to Phase 4.1 (Oak dominated forest) in the absence of fire and clonal oaks. This state transition is regionally specific to the Northern parts of MLRA 154. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This “driver” (absence of colonizing scrub oaks) represents situations where scrub oaks (and other typical scrub plant species) are not available to colonize the site, thus succession in the absence of fire follows an alternative path. The Yellow Sands considered in this site are geographically widespread throughout Central Florida and occur in regions without proximate scrub oaks (Carr, pers. obs). Other oaks may eventually colonize the site, including water oaks (*Quercus nigra*), laurel oak (*Q. laurifolia*) and live oak (*Q. virginiana*).

Transition T6B
State 6 to 5

State 6 can may be converted to Phase 5.1 (early successional scrub) if scrubs oak species either colonize the site naturally (available propagule source) or are reintroduced via planting. The success of scrub restoration on yellow sands is uncertain (but see Schmalzer et al). If scrub oak clones become established, regime of infrequent fire would be required to maintain early successional habitat. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This refers to the deferment of livestock grazing for a period of greater than one full growing season. Deferment of cattle grazing predominantly benefits grass species. Deferment of goat grazing predominantly benefits “browse” species such as small shrubs and low statue trees, and deferment of sheep grazing predominantly benefits forbs and grass species. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. Reintroduction of scrub oak and other woody species populations typical of Central Florida scrub communities, for the purpose of scrub restoration. Scrub oaks include myrtle oak (Quercus mytifolia), sand live oak (*Q. geminata*), and Chapman’s oak (Q. chapmannii). Other species include saw palmetto (*Serenoa repens*), scrub palmetto (*Sabal etonia*), and fetterbush (Lyonia spp.).

Transition T6C
State 6 to 7

Depending on propagule availability, invasion of cogongrass can affect the transition to

State 7. Invasive plant species will colonize natural xeric sandhill and scrub, as well as successional and cultural states, including abandoned crop and grove lands, clearings, and old fields. In particular, there are four species common to Central Florida which are recognized by the Florida Exotic Pest Plant Council as “Category 1” species: lantana (*Lantana camara*), natal-grass (*Melinis repens*), ceasar’s weed (*Urena lobata*) and cogongrass (*Imperata cylindrica*). These invasive species displace native populations and change plant community dynamics and ecological functions. Cogongrass is a highly clonal species which forms dense naturalized populations that extirpate local native plant populations. Furthermore, cogongrass is rapidly expanding in geographic and environmental range in the southeastern Coastal Plain and is difficult and expensive to eradicate.

Transition T6D
State 6 to 8

Conversion of State 6 to commodity land uses (State 8) generally involves removal of native ground cover via ground penetrating treatments. A number of treatments can be used for this, including disking, racking, plowing and herbicide application. Following conversion, other treatments may include: mowing, site prep, tree, or crop planting, seeding of non-native pasture grasses. Many land conversion activities may contribute to this transition: This includes clear-cut logging natural or planted of pine stands. In MLRA 154, clear-cut logging generally involves mechanical means of cutting, stacking, and hauling logs. Heavy equipment such as feller-bunchers and skidders can affect soil conditions via compaction and ground disturbance. Clear-cutting directly affects plant community composition and function through soil disturbance, alteration of canopy conditions and available resources, such as light and available moisture. Other logging methods that result in significant canopy removal are included under this description, such as seed tree logging. These methods involve removal of the majority of mature canopy pines, with a few residual trees left to serve as seed sources. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Transition T7A
State 7 to 5

Transition from Phase 7.1 to any other State first requires control and reduction of cogongrass. Fire alone will not control spread of cogongrass. Rather, fire stimulates cogongrass growth and seed production. Repeated tillage throughout a growing season may be sufficient to contain cogongrass spread if the infestation is small (i.e. under 0.25 acres). However, this treatment is insufficient and cost ineffective for larger well-established infestations. In these situations, a combination of burning followed by repeated chemical applications has been found effective (Byrd 2007). Two active herbicide ingredients found to affect cogongrass growth are glyphosate and imazapyr (Byrd 2007). If cogongrass control is achieved, planting and site preparation followed by restitution of fire regimes may allow re-establishment of native ground cover and transition to Phase 5.1. This includes all treatments which target invasive plant populations for the purpose of eradication or containment. Invasive plant control is often a part of natural area restoration, but can also be applied to improve wildlife habitat, rangeland, forestry and croplands. Mechanical treatments such as hand clearing, disking, and raking are generally applied to smaller infestations (0.25 acre). Chemical treatments include direct and indirect herbicide applications on small and larger areas. Fire may also control spread of invasive plant populations, but is not included in this category. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management. Reintroduction of scrub oak and other woody species populations typical of Central Florida scrub communities, for the purpose of scrub restoration. Scrub oaks include myrtle oak (Quercus mytifolia), sand live oak (*Q. geminata*), and Chapman's oak (Q. chapmannii). Other species include saw palmetto (*Serenoa repens*), scrub palmetto (*Sabal etonia*), and fetterbush (Lyonia spp.) Prescribed fire (Rx fire) is fire purposefully ignited to accomplish defined land management objectives such as woody fuel reduction and stimulation of herbaceous growth. Fire regimes denoted here are intended to mimic pre-settlement natural fire regimes of frequent, low intensity ground fires with return intervals between 1 to 3 years for the North LRU (154-1) and 1 to 10 years for LRU 154-2 (see Ecological Dynamics section). This driver includes frequent fires in the growing as well as dormant season.

Transition T7B
State 7 to 6

Transition from Phase 7.1 to any other State first requires control and reduction of cogongrass. Fire alone will not control spread of cogongrass. Rather, fire stimulates cogongrass growth and seed production. Repeated tillage throughout a growing season may be sufficient to contain cogongrass spread if the infestation is small (i.e. under 0.25 acres). However, this treatment is insufficient and cost ineffective for larger well-established infestations. In these situations, a combination of burning followed by repeated chemical applications has been found effective (Byrd 2007). Two active herbicide ingredients found to affect cogongrass growth are glyphosate and imazapyr (Byrd 2007). If cogongrass control is achieved, planting and site preparation followed by restitution of frequent fire regimes may allow re-establishment of native ground cover and transition to Phase 6.1. This category includes practices for native ground cover restoration which involve re-introduction of native plant seed or other propagules. Mechanical and chemical applications may be required for site preparation and seedling establishment. In cases where the ground cover is dominated by exotic grasses, frequent herbicide or fire treatment may be necessary. This includes all treatments which target invasive plant populations for the purpose of eradication or containment. Invasive plant control is often a part of natural area restoration, but can also be applied to improve wildlife habitat, rangeland, forestry and croplands. Mechanical treatments such as hand clearing, disking, and raking are generally applied to smaller infestations (0.25 acre). Chemical treatments include direct and indirect herbicide applications on small and larger areas. Fire may also control spread of invasive plant populations, but is not included in this category. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Transition T7C
State 7 to 8

Conversion of State 7 to commodity land uses (State 8) generally involves removal of native ground cover via ground penetrating treatments. A number of treatments can be used for this, including disking, racking, plowing and herbicide application. Following conversion, other treatments may include: mowing, site prep, tree, or crop planting, seeding of non-native pasture grasses. Cogongrass control is necessary for transition to commodity land uses. Many land conversion activities may contribute to this transition: This includes all treatments which target invasive plant populations for the purpose of eradication or containment. Invasive plant control is often a part of natural area restoration, but can also be applied to improve wildlife habitat, rangeland, forestry and croplands. Mechanical treatments such as hand clearing, disking, and raking are generally applied to smaller infestations (0.25 acre). Chemical treatments include direct and indirect herbicide applications on small and larger areas. Fire may also control spread of invasive plant populations but is not included in this category. Periods of 20 years or more without fire can affect significant changes in vegetation structure and composition. Fire suppression encourages increased growth of oaks and other hardwoods, as well as the attenuation of natural longleaf pine regeneration and native ground cover growth. This driver represents periods of fire suppression from more than 20 years to many decades. This land use practice, as practiced in commodity plantation management, generally proceeds mechanical or hand planting of seedlings. However, site prep treatments may precede planting for natural community restoration, field crop production, and wildlife management. Specific treatments may involve ground penetration and soil disturbance, such as disking, roller chopping, shearing, raking, etc. In general, ground penetration of site preparation for forest management is not as severe as tilling and plowing for crop management.

Transition T8A
State 8 to 5

Transitions among the Phases of State 8 are affected by land use and land conversion practices (i.e. land clearing, raking, disking, planting, chemical treatments). Although not specified in the STM diagram (Figure 5), transitions are possible between all phases. Some transitions involved conversion to the “Phase 8.1” fallow field phase as an intermediary step. Depending on the severity of site and soil disturbances, State 8 phases may be restored to natural or semi-natural conditions, including early successional scrub (Phase 5.1). Transition from State 8 to early successional scrub (Phase 5.1) may involve clearing, site preparation, and chemical control of undesirable non-native vegetation. Of key importance is the establishment of scrub oaks and palmetto, the dominant scrub plant species.

Transition T8B
State 8 to 6

Transitions among the Phases of State 8 are affected by land use and land conversion practices (i.e. land clearing, raking, disking, planting, chemical treatments). Although not specified in the STM diagram (Figure 5), transitions are possible between all phases. Some transitions involved conversion to the “Phase 8.1” fallow field phase as an intermediary step. The transition from State 8 to Phase 6.3 can be achieved by clearing non-native woody vegetation and planting pine. Depending on initial conditions, the midstory and understory would be vegetated with residual pasture or crop species, and/or weedy plants. Chemical and mechanical treatments may be needed to maintain conditions needed for successful pine establishment, coupled with the institution of periodic fire. Transition to Phase 6.2 would involve the additional step of native ground cover vegetation restoration and re-introduction of native fire regimes.

Transition T7C
State 8 to 7

Transitions among the Phases of State 8 are affected by land use and land conversion practices (i.e. land clearing, raking, disking, planting, chemical treatments). Although not specified in the STM diagram (Figure 5), transitions are possible between all phases. Some transitions involved conversion to the “Phase 8.1” fallow field phase as an intermediary step. All phases can transition to State 7 if noxious non-native plants (i.e. cogongrass) colonize the site. Particularly susceptible are State 8 Phases with little or no overstory and ground disturbance.

Additional community tables

Table 9. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
sand live oak	QUGE2	*Quercus geminata*	Native	–	0–67	–	–
longleaf pine	PIPA2	*Pinus palustris*	–	–	7.5–37.5	–	–
myrtle oak	QUMY	*Quercus myrtifolia*	Native	–	0–37	–	–
Lacey oak	QULA	*Quercus laceyi*	Native	–	0–37	–	–
Darlington oak	QUHE2	*Quercus hemisphaerica*	Native	–	0–37	–	–
sand post oak	QUMA13	*Quercus margaretta*	Native	–	0–17	–	–
bluejack oak	QUIN	*Quercus incana*	Native	–	0–8	–	–

Table 10. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
Beyrich threeawn	ARBE7	*Aristida beyrichiana*	Native	–	2–85
lopsided Indiangrass	SOSE5	*Sorghastrum secundum*	Native	–	0–8
pineywoods dropseed	SPJU	*Sporobolus junceus*	Native	–	0–8
Shrub/Subshrub					
gopher apple	LIMI5	*Licania michauxii*	Native	–	0–17
saw palmetto	SERE2	*Serenoa repens*	Native	–	0–17
scrub palmetto	SAET	*Sabal etonia*	Native	–	0–2

Hydrological functions

The surface hydrology of this site is highly dependent on underlying soil characteristics and sub-surface geology. The very deep sands allow rapid internal transmission of rainfall to the aquifer and reduces the overall impact of rainfall on surface topography. The underlying and highly permeable karstic limestone is responsible for a significant portion of surface topography. Many surficial sinkhole depressions, sinkhole lakes (where sinkholes intersect the aquifer), springs, and other topographic features are karst related. Another important hydrologic surface feature that occurs in limited extent within this site is floodplains. The extent of floodplain landforms are limited due to the soil properties and geology beneath the site. Porous sandy soils and karstic limestone bedrock increases infiltration and has rapid or very rapid saturated hydraulic conductivity which reduces surface runoff. Therefore, floodplain development is restricted by lack of surface runoff and is limited in extent.

Hydrologic functions (infiltration and runoff) associated with different phases within this site are highly dependent on species densities, duff layer, and overall site management. The soils associated with this site are very deep, sandy, and have rapid or very rapid permeability. With optimum management, infiltration can be maximized, and runoff reduced.

Typically, Phase 1.1 has a dense cover of wiregrass which has a fibrous root system which holds the soil in place and macropores that allows better infiltration and less runoff. With the reduction in fire frequency, the transition to Phase 1.2 and 1.3 reduces the density of wiregrass with more exposed soil surface which accelerates runoff and erosion.

With the community state movement from a grass and forb based understory to a shrub dominated phase; more surface soil is exposed to the effects of rainfall. Typically, lower densities of plant species increase the amount of exposed surface soil and corresponding root system dynamics that hold the soil in situ. However, in dense scrub (Phase 5.1 and 5.2) or xeric hammock (Phase 5.3), the shrub density and accompanying leaf litter may overcome some of the loss of the grass and forb understory. After a catastrophic fire, the soil surface is highly exposed to the effects of rainfall with increased runoff and reduced infiltration.

Commodity oriented plant communities (State 8) should be managed to maximize infiltration and reduce runoff by implementing appropriate soil and water conservation practices. The local Soil and Water Conservation District or USDA-Natural Resources Conservation Service offices should be contacted to determine the best management plan for each specific phase.

Recreational uses

Recreational uses of this site vary depending on location. Typically, areas in close proximity to urbanized areas are playgrounds, picnic areas, or golf courses and are the primary recreational uses. In contrast, natural areas are typically used for hunting, bird watching, camping, paths and trails, and off-road vehicle trails.

The xeric soils of this site have limitations for most recreational uses. Most limitations are due to internal soil factors such as sandy textures (too sandy) and droughty (low available water capacity). External soil factors, such as slope, are a restriction when the slope is in excess of 8 percent.

These soils are fragile when subjected to overuse since droughtiness affects plant growth and viability. Overuse will stress plants and contribute to a loss of ground cover and an increase in erosion, especially on more sloping portions of the site. Paths and trails should be designed to follow slope contours whenever possible.

Inventory data references

MLRA 154 field data sheets: vegetation of sampled sites
2012 FL
Alachua, Putnam, Marion, Citrus, Levy, Polk, Lake Counties

MLRA 154 field data sheets: pedon descriptions 2012 FL Alachua, Putnam, Marion, Citrus, Levy, Polk, Lake

Carolina Vegetation Survey data 22 (not all soil verified) 2000-2008FL Putnam, Marion, Lake, Alachua, Citrus

Ocala National Forest vegetation and soil field data 1996 FL
Marion, Lake

Type locality

Location 1: Marion County, FL	
General legal description	Riverside Island, Ocala National Forest (Astatula Sand)
Location 2: Polk County, FL	
General legal description	Tiger Creek Preserve, (Astatula Sand)
Location 3: Citrus County, FL	
General legal description	Citrus Tract, Withlacoochee State Forest (Candler Fine Sand)

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Rangeland health reference sheet

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

Author(s)/participant(s)	Pete Deal
Contact for lead author	Susan Carr Ecological Site Inventory Specialist NRCS-USDA
Date	09/06/2015
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:**

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

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

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

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

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

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

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

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are**

expected to show mortality or decadence):

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:**