Ecological site F156AY130FL
Subtropical Forested Rocklands of Southern Coast and Islands

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General information

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

MLRA notes

Major Land Resource Area (MLRA): 156A–Florida Everglades and Associated Areas

This area makes up about 7,749 square miles (20,071 square kilometers) and is entirely in Florida. It is located at the southern tip of the State and has shoreline on both the Atlantic Ocean and the Gulf of Mexico. Lake Okeechobee borders the MLRA to the north. Aside from sugar cane plantations in the north, the Everglades National Park, Big Cypress National Preserve, and the Big Cypress Seminole Indian Reservation comprise this area. Historical ditching, berming, and canals prevent natural water flow through this delicate ecosystem. To mitigate this, extensive restoration efforts have been implemented. Urban sprawl from Miami and cities to its north on the Atlantic Ridge has encroached along the eastern boundary of this area. Most of the MLRA has resisted urbanization because of a water table that is at or near the surface, a considerable acreage of unstable organic soils, and its identity as a national treasure.

About one-third of this area is in Native American reservations, national parks, game refuges, or other large holdings. Cypress forests are extensive in the area, but mangrove forests are widespread along the eastern and southern coasts. A large part of the area is open marsh. Much of the area is used for hunting, fishing, and other recreational activities. The cropland in the area is used mainly for winter vegetables, but citrus fruits, avocado, and papaya are grown on the better drained soils. Sugarcane is an important crop on the organic soils south of Lake Okeechobee. The acreage of improved pasture is increasing. Beef cattle are the principal kind of livestock, but dairying is an important enterprise locally. Urbanization is extensive along the eastern coast.

The major soil resource concerns are wind erosion, maintenance of the content of organic matter and productivity of the soils, and management of soil moisture and soil subsidence. Conservation practices on cropland generally include conservation crop rotations, cover crops, nutrient management, pest management, water-control structures, surface drainage systems (field ditches, mains, and laterals), pumping plants, and irrigation water management (including micro irrigation systems and surface and subsurface irrigation systems). Conservation practices on pasture and rangeland generally include prescribed grazing, brush management, pest management, prescribed burning, and watering facilities. Conservation practices on forestland generally include forest stand improvement, firebreaks, pest management, prescribed burning, and management of upland and wetland wildlife habitat.

LRU notes

There is not an official LRU for the MLRA 156A area. For the time being the technical team recommended to add the four terrestrial physiographic provinces ecoregions (Big Cypress, Everglades, Southern Coast and Islands, and Miami Ridge / Atlantic Coastal Strip) and one subaqueous ecoregion (Coastal Marine and Estuarine) on this section. This PES occurs within the Southern Coast and Island ecoregion.

The Southern Coast and Islands Ecoregion, 5 m and below (17 ft and below) in elevation and includes the Ten Thousand Islands and Cape Sable, the islands of Florida Bay, and the Florida Keys. It is an area of mangrove swamps and coastal marshes, coral reefs, various coastal strand type vegetation on beach ridge deposits and limestone rock islands. Although freshwater habitats are limited or non-existent in this region, any freshwater that does occur for periods of time may have great ecological significance. Coastal rockland lakes are small and number, occurring primarily in the Florida Keys. These waters are alkaline, with high mineral content and highly variable salinity levels. The rockland lakes provide important habitat for several kinds of fish, mammals, and birds of the Keys. Reductions in the fresh groundwater lens that floats on the denser saline groundwater can severely affect these lakes.

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: 76 Southern Florida Coastal Plain; 76D Southern Coast and Islands (Griffith, G. E., Omernik, J. M., & Pierson, S. M., 2013)

-Florida Natural Area Inventory, 2010 Edition: Pine Rocklands, Rockland Hammock, Keys Cactus Barren (FNAI ,2010)

-Soil Conservation Service, 26 Ecological Communities of Florida: 9- Everglades Flatwoods, 14- Tropical Hammock (Florida Chapter Soil and Water Conservation Society, 1989)

-NatureServe, 2017: Pinus elliottii var. densa Rockland Woodland Alliance (A0491) - Pinus elliottii var. densa / Coccothrinax argentata - Leucothrinax morrisii Woodland (CEGL003532) "Florida Keys Pine Rockland"

Ecological site concept

The Subtropical Freshwater Forested Rocklands of the Southern Coast and Islands ecological site are flat, poorly to moderately well drained, high elevation communities in the Southern Coast and Islands ecoregion. In this community there is very little soil development and limestone is usually found very near the surface or is often exposed. This ecological site is solely dependent on rainfall and does not regularly flood or is exposed to tidal action but relies on high water tables to maintain reservoirs in solution features of the limestone and to keep humidity levels high. This is a very diverse ecological site and can support over 150 species of temperate and tropical native vegetation. Fires are required to maintain natural diversity of these sites, with changes in management affecting community composition and structure. These are very fragile communities and are susceptible to damage during storm events such as hurricanes, which can cause canopy and sub canopy mortality, as well as being under stress due to prime building sites.

Associated sites

R156AY110FL	**Subtropical Tidal Saline Wetlands of Southern Coast and Islands** The Subtropical Tidal Saline Wetlands of Southern Coast and Islands occur in lower inter- and supra-tidal landscape positions along low-energy coastlines. This may grade into the associated site along larger barrier islands.
R156AY120FL	**Subtropical Keys Tidal Rock Barrens of Southern Coast and Islands** The Subtropical Keys Tidal Rock Barrens of Southern Coast and Islands occur in lower supra-tidal landscape positions immediately adjacent to low-energy coastlines. This may grade into the associated site along larger barrier islands.
R156AY140FL	**Subtropical Coastal Zones of Southern Coast and Islands** The Subtropical Coastal Zones of Southern Coast and Islands occur in lower supra-tidal landscape positions immediately adjacent to high-energy coastlines. This may grade into the associated site along larger barrier islands.

Similar sites

R156AY140FL	**Subtropical Coastal Zones of Southern Coast and Islands** The Subtropical Coastal Zones of Southern Coast and Islands may be confused with the successional stage of the coastal uplands community, a maritime hammock. These are similar in vegetative community structure, but differ by the presence of more tropical species diversity in rockland hammocks. Maritime hammocks will often have a deep soil with shells interspersed while rockland hammock will have a very shallow soil with limestone bedrock at or near the surface.

F156AY020FL	**Subtropical Forested Rocklands of Big Cypress** The Subtropical Forested Rocklands of Big Cypress occurs in a separate mainland ecoregion will have a more mesic moisture regime and are more floristically diverse than this site in the Southern Coast and Islands ecoregion. It will also have lower amounts of urbanization. Resource concerns are reflected differently and require different management needs.
F156AY350FL	**Subtropical Forested Rocklands of Miami Ridge / Atlantic Coastal Strip** The Subtropical Forested Rocklands of Miami Ridge / Atlantic Coastal Strip occurs in a separate mainland ecoregion will have a more mesic moisture regime and are more floristically diverse than this site in the Southern Coast and Islands ecoregion. It will also have greater amounts of urbanization. Resource concerns are reflected differently and require different management needs.
F156AY010FL	**Subtropical Pine Flatwoods and Palmetto Prairie of Big Cypress** The Subtropical Pine Flatwoods and Palmetto Prairies of Big Cypress occur in a separate ecoregion which have lower amounts of urbanization and slightly higher amounts of rainfall and greater elevation. This site has a less diverse open canopy species composition and deeper poorly drained sandy soils which have a subsurface layer that impedes drainage.
F156AY340FL	**Subtropical Pine Flatwoods and Palmetto Prairie of Miami Ridge / Atlantic Coastal Strip** The Subtropical Pine Flatwoods and Palmetto Prairies of Miami Ridge / Atlantic Coastal Strip occur in a separate ecoregion which have greater amounts of urbanization and slightly higher amounts of rainfall and greater elevation. This site has a less diverse open canopy species composition and deeper poorly drained sandy soils which have a subsurface layer that impedes drainage.

Table 1. Dominant plant species

Tree	(1) *Pinus elliottii var. densa* (2) *Bursera simaruba*
Shrub	(1) *Zamia pumila* (2) *Quercus pumila*
Herbaceous	(1) *Andropogon* (2) *Aristida purpurascens*

Physiographic features

This ecological community is found on areas where limestone is at or near the surface, leading to thin organic soil formation. These areas are located on flats and rises above the tidal extent and are influenced primarily by freshwater inputs. These areas are host to many limestone bedrock features such as sinkholes, moats, and outcrops. Development of these features are due to formation and dissolving of cap rocks (crust like upper zones of rock units that become solidified [inundated] through exposure). Biological processes further the dissolution of cap rocks with tree roots penetrating solution holes and crevices in search for better stability and nutrients, creating larger opening and increasing susceptibility to dissolution. Abiotic factors such as fire and wind can further the dissolution by weakening and uprooting shallow rooted trees. In the Southern Coast and Islands ecoregion, these sites occur in the lower portion of the Florida Kays and range from the National Key Deer Refuge and Big Pine Key south to Key West.

The Southern Coast and Islands ecoregion falls under three major geographic units, the Pliocene series Tamiami Formation, a poorly defined lithostratigraphic unit containing a wide range of mixed carbonate-siliciclastic lithologies and associated faunas occurring at or near the surface. The Pleistocene series Miami Limestone, oolitic facies consisting of white to orangish gray, poorly to moderately indurated, sandy, oolitic limestone (grainstone) with scattered concentrations of fossils and bryozoan facies consisting of white to orangish gray, poorly to well indurated, sandy, fossiliferous limestone (grainstone and packstone). And the Pleistocene series Key Largo Limestone, a white to light gray, moderately to well indurated, fossiliferous, coralline limestone composed of coral heads encased in a calcarenitic matrix. Fossils found in all three geologic formations occur as casts, molds, and original materials. The fossils include corals, mollusks, bryozoans, barnacles, corals, echinoids, foraminifers and calcareous nanoplankton. These formations are highly porous and permeable and are part of the Biscayne Aquifer of the surficial aquifer system (Scott, 2001).

Table 2. Representative physiographic features

Geomorphic position, terraces	(1) Tread

Geomorphic position, flats	(1) Talf (2) Rise
Slope shape across	(1) Linear
Slope shape up-down	(1) Convex (2) Linear
Landforms	(1) Coastal plain (2) Island > Flat (3) Marine terrace > Rise
Runoff class	Low to medium
Flooding duration	Extremely brief (0.1 to 4 hours) to brief (2 to 7 days)
Flooding frequency	Occasional
Ponding frequency	None
Elevation	1–5 m
Slope	0–2%
Ponding depth	0 cm
Water table depth	30–46 cm
Aspect	Aspect is not a significant factor

Climatic features

The climate of MLRA 156A is subtropical, with mild winters and hot wet summers. The average annual precipitation of this MLRA is 37 to 62 inches (950 to 1,565 millimeters). About 60 percent of the precipitation occurs from June through September. Most of the rainfall occurs during moderate intensity, tropical storms that produce large amounts of rain from late spring through early autumn. Late autumn and winter are relatively dry. The average annual temperature of the MLRA is 74 to 78 degrees F (23 to 26 degrees C). The freeze-free period of the MLRA averages 355 days and ranges from 345 to 365 days.

The following tables and graphs consist of specific climate stations found within the range of this ecological site within this MLRA.

Table 3. Representative climatic features

Frost-free period (characteristic range)	365 days
Freeze-free period (characteristic range)	365 days
Precipitation total (characteristic range)	1,092-1,245 mm
Frost-free period (actual range)	365 days
Freeze-free period (actual range)	365 days
Precipitation total (actual range)	1,041-1,397 mm
Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	1,194 mm

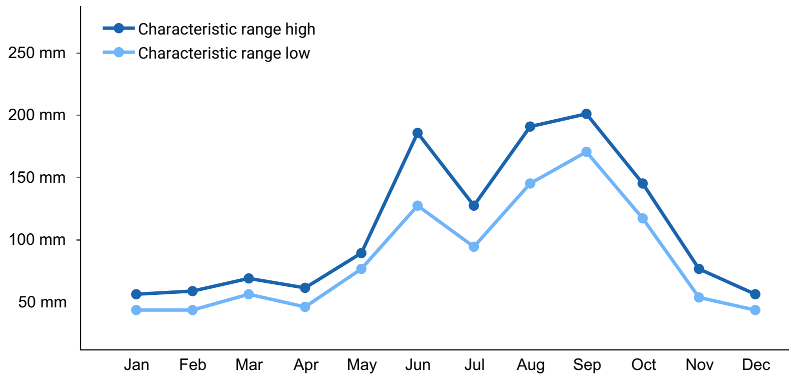


Figure 1. Monthly precipitation range

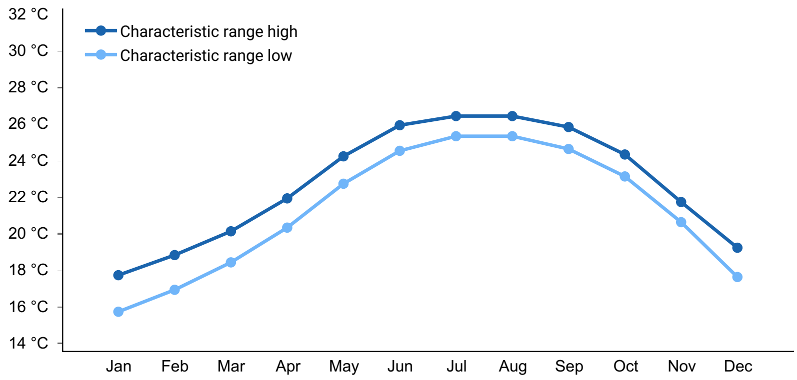


Figure 2. Monthly minimum temperature range

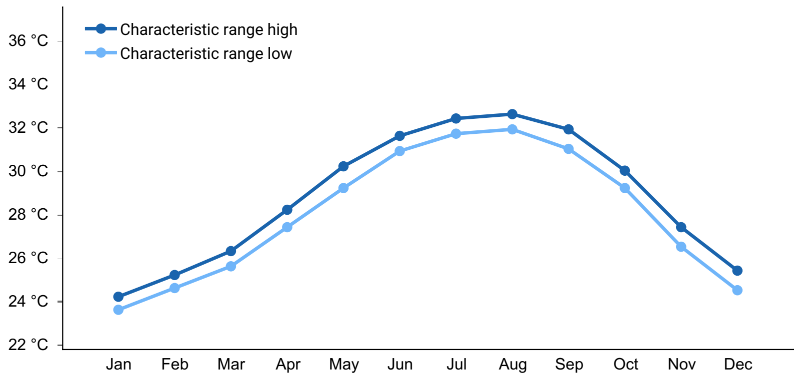


Figure 3. Monthly maximum temperature range

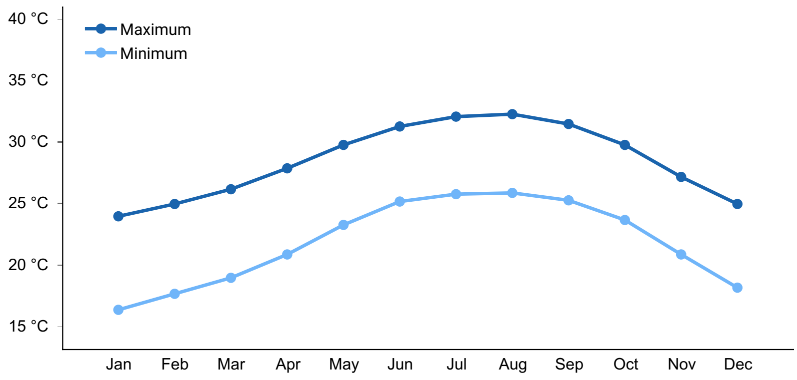


Figure 4. Monthly average minimum and maximum temperature

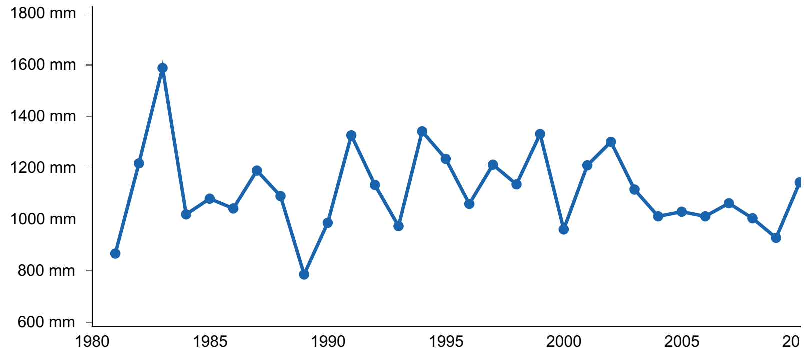


Figure 5. Annual precipitation pattern

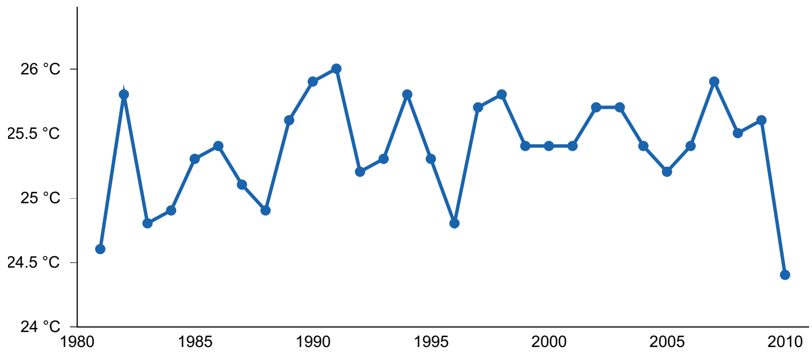


Figure 6. Annual average temperature pattern

Climate stations used

- (1) KEY WEST INTL AP [USW00012836], Key West, FL
- (2) KEY WEST NAS [USW00012850], Key West, FL
- (3) BAHIA HONDA SP [USC00080414], Big Pine Key, FL
- (4) MARATHON AP [USW00012896], Marathon, FL
- (5) CURRY HAMMOCK SP [USC00082046], Marathon, FL
- (6) DUCK KEY [USC00082441], Marathon, FL
- (7) CONCH KEY [USC00081795], Marathon, FL
- (8) ISLAMORADA [USC00084320], Islamorada, FL
- (9) TAVERNIER [USC00088841], Tavernier, FL
- (10) JOHN PENNEKAMP SP [USC00084412], Key Largo, FL
- (11) FLAMINGO RS [USC00083020], Homestead, FL
- (12) EVERGLADES [USC00082850], Naples, FL

Influencing water features

Hydrology of this ecological site is dominated by freshwater inputs via rainfall. Drainage varies according to the porosity of the limestone substrate but is generally very rapid, recharging the Biscayne Aquifer (surficial aquifer) and Floridian Aquifer (deeper subsurface aquifer) during periods of drought. Organic acids may occasionally dissolve the surface limestone causing sinkholes that will promote a moist microclimate from surrounding extreme temperatures, allowing more temperate vegetation. Sinkholes drain readily and will only contain standing water for short periods following heavy rains. The communities within this ecological site are generally dry but may be wet for short periods following heavy rains and storm events, and may have some sites that are very shallowly inundated by very slow-flowing surface water for up to 7 days per year. High intensity storm events may result in storm surges which may injure or kill existing vegetation through prolonged standing saltwater and sediment deposition. Over time, excess salt is diluted by precipitation and flushed from the system, allowing for native vegetation regrowth.

Wetland description

NA

Soil features

Soils associate with this ecological site occur in the isohyperthermic soil temperature regime of MLRA 156A. The isohyperthermic soil temperature regime has mean annual soil temperatures of 22 °C (72ºF) or more and a difference between mean summer and mean winter soil temperatures of less than 5 °C (41ºF) at 50 cm (20 inches) below the surface.

Soils in this ecological site are characteristic of limestone bedrock at or near the surface with very little soil development. Small accumulation of acidic nutrient-poor sand, marl, clayey loam, and organic debris may form in depressions and crevices in the rock surface. Along the ecotone to lower communities the thin layer of organic matter may be missing, showing larger areas of exposed limestone bedrock. Drainage varies according to the porosity of the limestone but is generally rapid. Most sites are wet for only short periods following heavy rains but can be shallowly inundated by slow-flowing surface water during the wet season. Soils found in solution holes may contain 30 to 50 percent organic matter. Representative soils include Saddlebunch, Matecumbe, Pennekamp, and Keyvaca.

Table 4. Representative soil features

Parent material	(1) Herbaceous organic material (2) Marl–limestone (3) Residuum–limestone
Surface texture	(1) Very gravelly, gravelly, marly silt loam
Drainage class	Poorly drained to well drained
Permeability class	Moderately rapid to rapid
Depth to restrictive layer	10–43 cm
Soil depth	10–43 cm
Surface fragment cover <=3"	0–10%
Surface fragment cover >3"	10%
Available water capacity (0-43.2cm)	1.78–7.37 cm
Calcium carbonate equivalent (0-43.2cm)	0–90%
Electrical conductivity (0-43.2cm)	1–24 mmhos/cm
Sodium adsorption ratio (0-43.2cm)	1–50
Soil reaction (1:1 water) (0-43.2cm)	7.6–8.2
Subsurface fragment volume <=3" (0-43.2cm)	4–45%
Subsurface fragment volume >3" (0-43.2cm)	1–10%

Ecological dynamics

The information presented in this ecological site description (ESD) and state-and-transition model (STM) were developed using archaeological and historical information, published and unpublished scientific reports, professional experience, consultation with technical experts, and NRCS inventories and studies. The information presented is represented of a complex set of plant community dynamic and environmental variables. Not all scenarios or plants are represented and included. Key indicator plants, animals, and ecological processes are described to help guide land management decisions and actions.

These are upland habitats that are above the coastal zone and are unaffected by daily and seasonal tides. Primarily driven by freshwater inputs from rain, these communities support large amounts of vegetation on thin organic/ marl soil over limestone bedrock and rely on a high-water table to maintain reservoirs. Weak acid from dissolving organic matter can create ongoing erosional processes that dissolves surface limestone forming solution holes, which helps maintain the seasonal high-water table. Small solution holes are frequent in this ecological site. These are highly diverse communities that are influenced by disturbance history, time since latest disturbance, community size, relative isolation from other similar sites, and physical environment (Olmsted 1980).

Pine rocklands are a unique habitat located in south Florida and limited in extent to this MLRA in each ecoregion sub-unit except the Everglades. It is characterized by an open canopy of pines and a patchy understory of tropical and temperate shrubs and palms. This site used to have a much larger extent than what is currently mapped today, but due to urbanization demands their range has reduced greatly. This habitat is maintained regularly by fire which burned on a 3 to 15 year interval, historically started by lightening strikes during summer months, now relied on prescribed fires. While this vegetative community is different from rockland hammock in structure, it is the primary community which succeeds to rockland hammocks after fire exclusion. These sites are usually excluded from flooding, but in areas near the ocean may experience flooding from storm surges. These pine rockland communities are different from the pine flatwood communities seen throughout peninsular Florida by the regular presence of exposed limestone rock throughout the community with very little soil development and the presence of rare plant species endemic to this community.

Rockland hammocks are the dominant forest type in the Florida Keys and often have greater than 120 native tree and shrub species, making up the diverse closed canopy and shrubs layers, in which many species reach their northern extent in Florida. Rockland hammock occurs on a thin layer of highly organic soil covering limestone on high ground that does not regularly flood, but it is often dependent upon a high-water table to maintain reservoirs in solution features of the limestone and to keep humidity levels high. These communities typically have large more mature trees in the interior where there is greater soil development and less disturbances, while the margins can be almost impenetrable in places with dense growth of smaller shrubs, trees, and vines. The tremendous development pressures in the rapidly urbanizing areas where rockland hammock occurs have greatly reduced the extent of this community. Exotic animals that have been introduced destroy and prey on native vegetation that is not adapted to their presence, leading to decline in native species. The dense canopy minimizes temperature fluctuations by reducing soil warming during the day and heat loss at night, creating mesic conditions. Mesic conditions are further maintained by the hammock's rounded profile, which deflects winds, limiting desiccation during dry periods and reducing interior storm damage. Historically rockland hammocks in South Florida evolved with fire in the landscape, fire most often extinguishing near the edges when it encounters the hammock's moist microclimate and litter layer. Rockland hammocks are susceptibly to damage from fire during extreme drought or when the water table is lowered from surrounding development. Extreme fires can cause root mortality and consume the humus layer, causing a succession back to a pine rockland community. Hurricanes and other disturbance events can have negative effects once fragmentation and exotic species become dominant, excessive damage from winds can be amplified due to roads and other development, opening space for exotic species. Severe storms can cause storm surges that can deposit overwash which can kill the understory. Thorn scrub is a community variant of rockland hammocks that occur along the ecotone of this community.

The hammocks on the Florida Keys tend to be drier than those on the mainland because of increased ocean breezes and lowered rainfall. They also have a higher percentage of tropical species in part because many temperate species, such as live oak, swamp bay (*Persea palustris*), sugarberry (*Celtis laevigata*), and coontie, reach their southern limits on the mainland or in the northern Keys. Many tropical tree species within Florida, such as rough strongbark (*Bourreria radula*) and lignum-vitae only occur in rockland hammocks of the Keys. Rockland hammock can be the advanced successional stage of mesic or xeric pine rocklands, especially in cases where rockland hammock is adjacent to flatwoods where hardwood seed rain is high. In such cases, when fire is excluded from adjacent flatwoods for 15 to 50 years it can succeed to rockland hammock vegetation that can retain a relict overstory of pine. Although rockland hammock can reestablish within 50 years after fire, maximum development of structure and diversity probably requires more than 100 fire-free years. Relative stability of hammock boundaries in relation to pine rocklands also suggests that the current vegetation mosaic is similar to the one which has existed during the past (Olmsted 1980). The ecotone between rockland hammock and pine rockland is abrupt when regular fire is present in the adjacent pine dominant community. However, when fire is removed, the ecotone becomes more gradual as hardwoods from the hammock push out into the pineland. Rockland hammock can be distinguished from pine rockland in having a closed, hardwood canopy rather than an open pine canopy. Rockland hammock can have almost the same structure and species composition as the tropical form of maritime hammock. It differs by being on a shallow rock substrate rather than the sand or shell substrate of barrier islands or high energy coasts.

Keys cactus barren is confined to the Florida Keys on limestone bedrock (Key Largo limestone) and is known from only six sites, four on the Upper Keys and two from the southern arm of Big Pine Key which is composed of Key Largo limestone (unlike the rest of Big Pine Key and the other Lower Keys, which are composed of Miami oolite). It occupies larger areas several acres in extent, or may occur as small, scattered patches within the thorn scrub variant of rockland hammock. The natural process giving rise to cactus barrens is not known, but since they occur on sites where the thin layer of organic soil over limestone bedrock is missing, they may have formed by soil erosion following destruction of the plant cover by fire, storm, or artificial clearing. This community is the most threatened by development and is unique only to this niche of Florida, totaling roughly 4.5 ha (11 acres).

Keys cactus barren is often surrounded by the thorn scrub variant of rockland hammock, consisting of low woody species such as buttonwood, blolly (*Guapira discolor*), catclaw blackbead, bayleaf capertree, poisonwood (*Metopium toxiferum*), and brittle thatch palm (Thrinax morrisii), forming a transition to the taller rockland hammock upland community. Prickly pear cacti in the genus Opuntia in this community are vulnerable to attack by the larvae of the cactus moth (Cactoblastis cactorum) which was inadvertently introduced from South America in the mid-1990s. Cactus barrens are vulnerable to development, even on public conservation lands, since their vegetation resembles weedy clearings and disturbed areas. Sites that have shown increasing encroachment of woody species over time may require efforts to maintain the open nature of the habitat, which favors the rare herbaceous species. Invasion by the exotic Brazilian pepper (*Schinus terebinthifolius*) is also a problem on some sites.

Sinkholes and exposed limestone bedrock can also be found as features within this community. Sinkholes can form in three ways. Dissolution sinkholes form when limestone is dissolved at or near the surface. Ongoing erosional processes result from the chemical and physical actions of underground water, which slowly dissolves the limestone and enlarges these cavities. Subsidence sinkholes, the most common type in Florida, form when the land subsides as limestone beneath is dissolved. These sinkholes develop into bowl-shaped depressions which can be shallow or deep. Collapse sinkholes can form when the water level in an underground cavern is lowered, either naturally (e.g., drought) or unnaturally (e.g., water table drawdown), creating a space between the water level and the roof of the cavern, which can cause a collapse of the roof. These sinkholes form rapidly when the weight of overlying sediments cause a collapse into the underground cavity. Sinkholes are found all throughout the state of Florida, but small dissolution sinkholes are frequent and most well represented in this ecosite, found within rockland hammocks, marl prairies, and pine flatwoods.

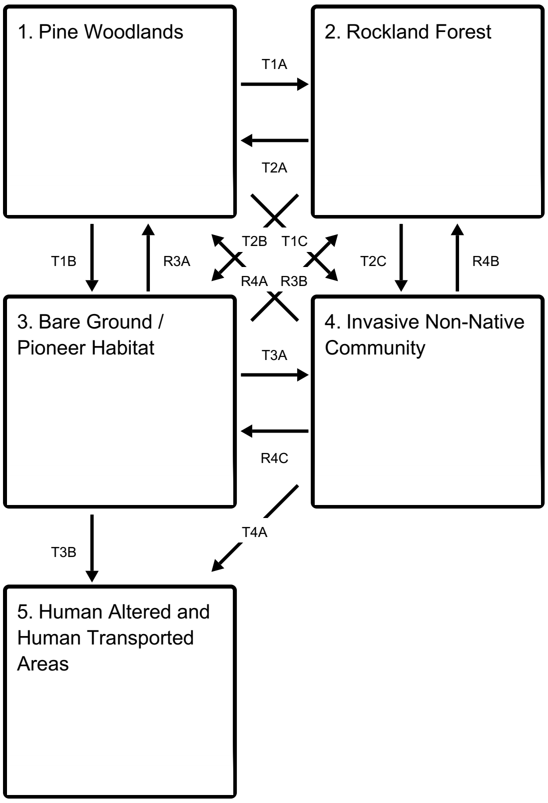
Sinkholes generally have higher relative humidity levels and lower light and temperature readings than the surrounding natural community. Whether they form a complete canopy or not, trees on the upper slopes or rim shelter the sinkhole from intense solar radiation. The depression itself also limits the effects of desiccating winds. Standing water in the bottom of the sinkhole, together with seepage from the surrounding uplands, helps to raise and maintain humidity levels. These conditions also buffer temperature extremes, providing frost-free habitats for cold sensitive species. This often allows for a unique mixture of tropical and temperate flora to exist in many Florida sinkholes. The sheltered habitat of sinkholes is also naturally protected from fires. Sinkholes that develop in fire-maintained communities often develop a hardwood canopy. Sinkholes may occur within most natural community types. In pyrogenic communities, sinkholes may form a natural barrier to fire that allows hardwood species to become established around the edge. Sinkholes drain readily and only contain standing water during, or for short periods following, heavy rains. The size of an individual sinkhole is variable and depends in large part on the local geology and hydrology.

Limestone outcrops are common in areas of karst terrain where the limestone is near the surface. The often-sheltered position of limestone outcrops supports a moist microclimate that moderates temperature extremes, allowing for bryophytic species to grow in the crevices, which help form organic soil over time through decomposition, which can eventually transition into a forested community. These sites occur within geologic features such as solution holes and are terrestrial communities, whereas exposed rocky tidal areas are classified as consolidated substrate.

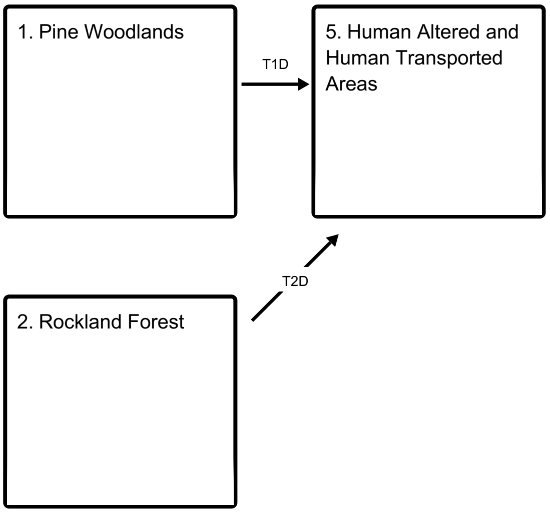
Human activities in the surrounding areas may affect the delicate microclimate of a sinkhole and induce deleterious responses. For example, logging of the surrounding canopy can increase both solar radiation and sedimentation levels. Major soil disturbances in the adjoining uplands could disrupt seepage water sources. Large withdrawals of groundwater could substantially lower water tables and reduce the hydroperiods of sinkholes. Sinkholes are sometimes used as dumpsites. Because sinkholes drain directly to underground aquifers, refuse dumping should be strongly discouraged. Chemical applications, waste treatments, and spills on the surrounding upland require active monitoring to determine their potential impacts and mitigation requirements. Invasive exotic species are sometimes problematic in sinkholes. Their establishment is often facilitated by the shaded, humid environmental conditions. Steep slopes and the presence of sensitive plant and animal species can complicate the treatment of exotic plants. Furthermore, the close connection of sinkholes to aquifers requires especially careful applications of herbicides to avoid groundwater contamination.

State and transition model

Ecosystem states



States 1, 5 and 2 (additional transitions)



T1A - Fire Exclusion for Greater than 50 years

T1B - Extreme Vegetation Killing Fire

T1C - Invasion of Non-Native / Exotic Species

T1D - Human Alteration / Transportation of Materials

T2A - Selective Removal of Hardwood and Pine Species / Reintroduction of Fire

T2B - Extreme Vegetation Killing Fire

T2C - Invasion of Non-Native / Exotic Species

T2D - Human Alteration / Transportation of Materials

R3A - Established Seedbank / Habitat Management / Time

R3B - Established Seedbank / Habitat Management / Time

T3A - Invasion of Non-Native / Exotic Species

T3B - Human Alteration / Transportation of Materials

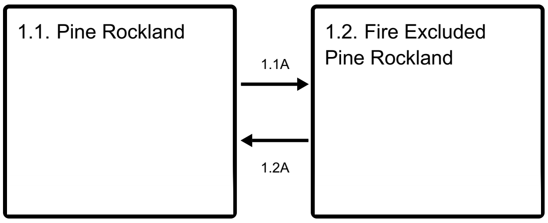
R4A - Mechanical / Biological / Chemical Removal of Species

R4B - Mechanical / Biological / Chemical Removal of Species

R4C - Mechanical / Biological / Chemical Removal of Species

T4A - Human Alteration / Transportation of Materials

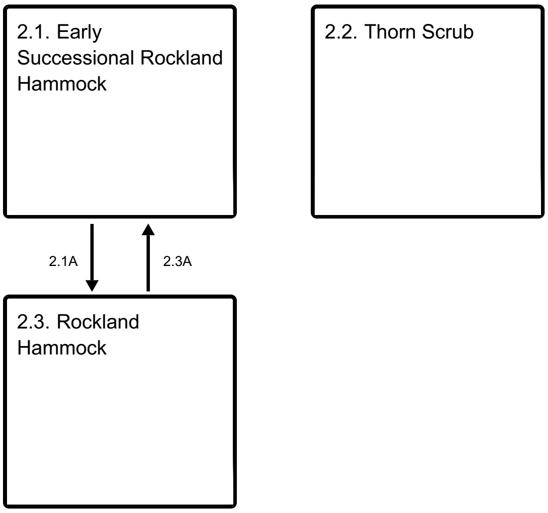
State 1 submodel, plant communities



1.1A - Exclusion of Fire from the System (15 to 50 years)

1.2A - Reintroduction of Fire / Maintain Fire Return Interval of 3 to 15 years

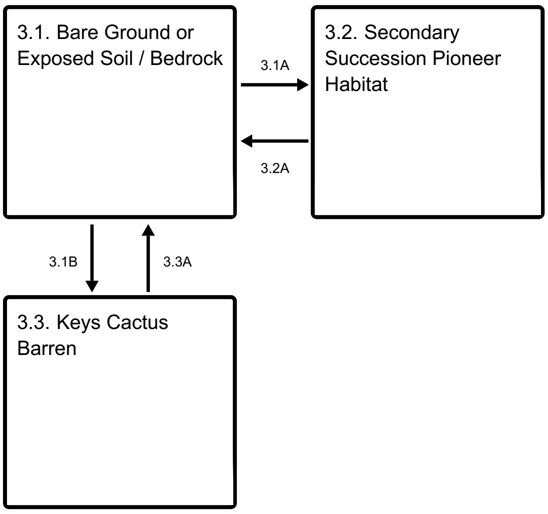
State 2 submodel, plant communities



2.1A - Time, Succession

2.3A - Overstory Mortality Disturbance Event

State 3 submodel, plant communities



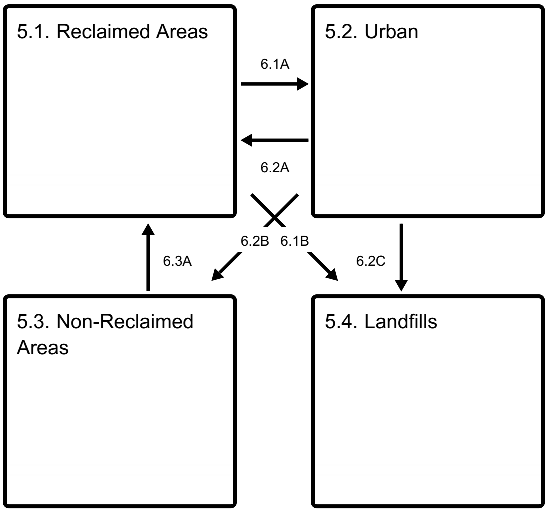
3.1A - Seedbank Establishment

3.1B - Cacti Seedbank Establishment

3.2A - Disturbance Event

3.3A - Disturbance Event

State 5 submodel, plant communities



6.1A - Urban Development

6.1B - Waste Accumulation

6.2A - Land Reclaimation

6.2B - Industrial / Urban Development

6.2C - Waste Accumulation

6.3A - Land Reclamation

State 1
Pine Woodlands

This state depicts forested rocklands consisting of open canopied forests dominated by pine trees. Fire is used to maintain this habitat and will have an open to dense understory of diverse subtropical and temperate species. Exposed limestone rocks can be found throughout the entire area or close to the surface.

Characteristics and indicators. This site is characterized by shallow to exposed bedrock with an open pine woodland similar to pine flatwoods communities. Subtropical species will be present in the understory.

Resilience management. Fire is used to maintain community composition and structure and was historically introduced every 3 to 15 years. In areas of high density urbanization and fragmentation of this habitat, mechanical treatments such as roller chopping or hand removal can be utilized but are less effective than fire treatments.

Dominant plant species

- Florida slash pine (*Pinus elliottii var. densa*), tree
- saw palmetto (*Serenoa repens*), shrub
- wax myrtle (*Morella cerifera*), shrub
- cabbage palmetto (*Sabal palmetto*), shrub
- pineland threeawn (*Aristida stricta*), grass
- arrowfeather threeawn (*Aristida purpurascens*), grass
- lopsided Indiangrass (*Sorghastrum secundum*), grass
- coontie (*Zamia pumila*), other herbaceous
- partridge pea (*Chamaecrista fasciculata*), other herbaceous

Dominant resource concerns

- Sheet and rill erosion
- Subsidence
- Organic matter depletion
- Ponding and flooding
- Salts transported to surface water
- Salts transported to ground water
- Plant productivity and health

- Plant structure and composition

Community 1.1
Pine Rockland

Pine rocklands are open canopied forested dominated by pines with a patchy understory of tropical and temperate shrubs and palms and a rich herbaceous layer of mostly perennial species endemic to south Florida. These communities will exist on very shallow to bedrock soils that are dominantly marl textured. This community is globally impaired and limited in distribution to Big Cypress National Preserve (Monroe and Collier Counties), the Florida Keys, and the southern portion of the Miami Ridge. The pine rocklands in the Florida Keys area will be more xeric due to lower rainfall and has a well developed sub canopy of silver palm, brittle thatch palm, and a higher percentage of tropical shrub species since many temperate species reach their southern limit on the mainland.

Resilience management. Fire is used to maintain community structure and composition with return intervals every 3 to 15 years, and without fire would allow the development of hardwood species to close the canopy transitioning to a rockland hammock. Although hardwood species are a natural component of pine rocklands, an exclusion of fire greater than 50 years will result in a succession to rockland hammock.

Dominant plant species

- Florida slash pine (*Pinus elliottii var. densa*), tree
- Florida silver palm (*Coccothrinax argentata*), shrub
- Key thatch palm (*Leucothrinax morrisii*), shrub
- sweet acacia (*Vachellia farnesiana*), shrub
- smooth strongbark (*Bourreria cassinifolia*), shrub
- Long Key locustberry (*Byrsonima lucida*), shrub
- grannybush (*Croton cascarilla*), shrub
- buttonsage (*Lantana involucrata*), shrub
- mangroveberry (*Psidium longipes*), shrub
- white bully (*Sideroxylon salicifolium*), shrub
- coco plum (*Chrysobalanus icaco*), shrub
- Florida strangler fig (*Ficus aurea*), shrub
- wild banyantree (*Ficus citrifolia*), shrub
- wax myrtle (*Morella cerifera*), shrub
- Guianese colicwood (*Myrsine cubana*), shrub
- redbay (*Persea borbonia*), shrub
- white indigoberry (*Randia aculeata*), shrub
- winged sumac (*Rhus copallinum*), shrub
- cabbage palmetto (*Sabal palmetto*), shrub
- saw palmetto (*Serenoa repens*), shrub
- fewflower holdback (*Caesalpinia pauciflora*), shrub
- smallflower lilythorn (*Catesbaea parviflora*), shrub
- pride of Big Pine (*Strumpfia maritima*), shrub
- threeawn (*Aristida*), grass
- splitbeard bluestem (*Andropogon ternarius*), grass
- crimson bluestem (*Schizachyrium sanguineum var. sanguineum*), grass
- lopsided Indiangrass (*Sorghastrum secundum*), grass
- coontie (*Zamia pumila*), other herbaceous
- partridge pea (*Chamaecrista fasciculata*), other herbaceous
- pineland fern (*Anemia adiantifolia*), other herbaceous
- Bahama brake (*Pteris bahamensis*), other herbaceous
- brackenfern (*Pteridium*), other herbaceous

Community 1.2
Fire Excluded Pine Rockland

This community described a reference pine rockland in which fire has been excluded from the system for greater than 15 years but less than 50 years. This is longer than the naturally accepted fire return interval of 3 to 15 years but less than the 50 year exclusion limit where a rockland hammock gradually develops. Plant composition will be similar to the reference community, but community structure will be different. The shrubs will begin to shade out the understory and accumulate leaf litter, creating a moist environment.

Resilience management. Fire may still be carried through this community and can return to a reference pine rockland if introduced and maintained along a 3 to 15 year return interval.

Dominant plant species

- Florida slash pine (*Pinus elliottii var. densa*), tree
- Key thatch palm (*Leucothrinax morrisii*), shrub
- Florida thatch palm (*Thrinax radiata*), shrub
- seagrape (*Coccoloba uvifera*), shrub
- marlberry (*Ardisia*), shrub
- wild coffee (*Psychotria*), shrub
- blackbead (*Pithecellobium*), shrub
- cabbage palmetto (*Sabal palmetto*), shrub
- wax myrtle (*Morella cerifera*), shrub
- saw palmetto (*Serenoa repens*), shrub
- smallcane (*Lasiacis divaricata*), grass
- basketgrass (*Oplismenus hirtellus*), grass
- eastern poison ivy (*Toxicodendron radicans*), other herbaceous
- greenbrier (*Smilax*), other herbaceous
- medicine vine (*Hippocratea volubilis*), other herbaceous
- redgal (*Morinda royoc*), other herbaceous
- coontie (*Zamia pumila*), other herbaceous
- swordfern (*Nephrolepis*), other herbaceous
- maiden fern (*Thelypteris*), other herbaceous
- airplant (*Tillandsia*), other herbaceous

Pathway 1.1A
Community 1.1 to 1.2

This transition is driven by the exclusion of fire from the community for 15 to 50 years, which allows the establishment of shrubs to enter the midstory and begin a gradual transition to a hammock. This exclusion of fire can be due to high urbanization and fragmentation within the Florida Keys.

Pathway 1.2A
Community 1.2 to 1.1

This transition is driven by the reintroduction of fire into the system, which will assist in maintaining community structure of a reference pine rockland community. Once fire is reintroduced, to maintain a reference pine rockland community a fire return interval of every 3 to 15 years must be maintained to keep hardwoods excluded from growing into the midstory and preventing a possible hammock transition.

State 2
Rockland Forest

This state depicts forested rocklands consisting of closed canopied forests dominated by hardwood species. This is considered the successional stage of pine rocklands, characterized by long periods of time without fire in the system.

Characteristics and indicators. These rockland hammocks are characterized by closed canopy forests with a high diversity of species assemblage. These communities have shaded understories allowing for a dense assemblage of inflammable species and the creation of high moisture conditions creating a cool interior. Leaf litter accumulation will be present on the ground surface and will increase over time.

Dominant plant species

- gumbo limbo (*Bursera simaruba*), tree
- false tamarind (*Lysiloma latisiliquum*), tree
- tietongue (*Coccoloba diversifolia*), tree
- Florida strangler fig (*Ficus aurea*), tree
- live oak (*Quercus virginiana*), tree
- Florida slash pine (*Pinus elliottii var. densa*), tree
- stopper (*Eugenia*), shrub
- cabbage palmetto (*Sabal palmetto*), shrub
- greenbrier (*Smilax*), other herbaceous
- airplant (*Tillandsia*), other herbaceous

Dominant resource concerns

- Sheet and rill erosion
- Plant productivity and health
- Plant structure and composition
- Terrestrial habitat for wildlife and invertebrates

Community 2.1
Early Successional Rockland Hammock

This community describes an early successional rockland hammock in which fire has been excluded from a pine rockland for greater than 50 years, allowing for the shrubs to grow into the overstory and created shaded conditions that will no longer carry ground fires. Species composition will be similar to a rockland hammock but estimates require more than 100 fire free years to have maximum development of hammock structure and diversity. A relict overstory of slash pine may be present, representative of a transitioned pine rockland.

Resilience management. Gap succession is the main driver for this community and is often seen as windthrow during high energy storm events such as hurricanes. This community also requires time to transition to a rockland hammock and is estimated more than 100 fire free years to mature.

Dominant plant species

- Florida slash pine (*Pinus elliottii var. densa*), tree
- gumbo limbo (*Bursera simaruba*), tree
- false tamarind (*Lysiloma*), tree
- false mastic (*Sideroxylon foetidissimum*), tree
- Florida strangler fig (*Ficus aurea*), tree
- Florida fishpoison tree (*Piscidia piscipula*), tree
- paradisetree (*Simarouba glauca*), tree
- white bully (*Sideroxylon salicifolium*), tree
- live oak (*Quercus virginiana*), tree
- poisonwood (*Metopium toxiferum*), tree
- West Indian mahogany (*Swietenia mahagoni*), tree
- stopper (*Eugenia*), shrub
- thatch palm (*Thrinax*), shrub
- marlberry (*Ardisia*), shrub
- Seminole balsamo (*Psychotria nervosa*), shrub
- cabbage palmetto (*Sabal palmetto*), shrub
- seagrape (*Coccoloba uvifera*), shrub
- greenbrier (*Smilax*), shrub
- smallcane (*Lasiacis divaricata*), grass
- basketgrass (*Oplismenus hirtellus*), grass
- airplant (*Tillandsia*), other herbaceous
- swordfern (*Nephrolepis*), other herbaceous
- maiden fern (*Thelypteris*), other herbaceous

Community 2.2

Thorn Scrub

This community is a variant of a rockland hammock that is found only within the Florida Keys. It occurs along the ecotone of rockland hammocks or within openings of rockland hammocks. It is dominated by low-statured scrubby spiny species. It has also been referred to as "Keys hammock thicket", "transitional thorn woodland", or "cactus scrub". Much is still unknown about this community variant and requires further study on ecological stressors and successional patterns. This variant is more commonly seen in the southern Florida Keys in hammocks with lower, more scrubby, xeric species compositions.

Dominant plant species

- saffron plum (*Sideroxylon celastrinum*), shrub
- blackbead (*Pithecellobium*), shrub
- hog plum (*Prunus umbellata*), shrub
- button mangrove (*Conocarpus erectus*), shrub
- beeftree (*Guapira discolor*), shrub
- Key thatch palm (*Leucothrinax morrisii*), shrub
- poisonwood (*Metopium toxiferum*), shrub
- smooth devil's-claws (*Pisonia rotundata*), shrub

Dominant resource concerns

- Plant productivity and health
- Plant structure and composition

Community 2.3
Rockland Hammock

Rockland hammocks are very diverse tropical hardwood forests and considered the successional stage to pine rocklands. Limestone bedrock is very near the surface and often exposed. These communities can have greater than 120 native tree and shrub species present, many of which are at the northern extent of their native range. Organic acids from the decomposition of leaf litter can cause dissolving in the limestone bedrock forming solution holes, which may hold water and help maintain high humidity within the hammock. These will occur in limited extent in the Florida Keys area and will be distinguished from the rockland hammocks in the Big Cypress and Miami Ridge ecoregions. The hammocks in the Florida Keys tend to be drier than those on the mainland because of increased ocean breezes and lowered rainfall. These will also have a higher percentage of tropical species due to many species reaching their northern extent on the the southern tip of Florida. In the Keys, there will be slight structural changes to hammocks varying from north to south due to changes in geology, ground water salinity and rainfall. The northern Keys will have taller, more developed tree canopies (>35 ft in height) due to more permeable limestone and slightly higher rainfall. In the southern Keys the hammocks will have lower scrubby, xeric forms with species 20 ft tall or less, and will have higher abundance of the thorn scrub variant.

Dominant plant species

- live oak (*Quercus virginiana*), tree
- swamp bay (*Persea palustris*), tree
- rough strongbark (*Bourreria radula*), tree
- lignum-vitae (*Guaiacum*), tree
- gumbo limbo (*Bursera simaruba*), tree
- tietongue (*Coccoloba diversifolia*), tree
- false tamarind (*Lysiloma*), tree
- false mastic (*Sideroxylon foetidissimum*), tree
- Florida strangler fig (*Ficus aurea*), tree
- West Indian mahogany (*Swietenia mahagoni*), tree
- Florida poisontree (*Metopium*), tree
- Florida slash pine (*Pinus elliottii var. densa*), tree
- stopper (*Eugenia*), shrub
- Key thatch palm (*Leucothrinax morrisii*), shrub
- Florida thatch palm (*Thrinax radiata*), shrub
- sea torchwood (*Amyris elemifera*), shrub

- marlberry (*Ardisia*), shrub
- Seminole balsamo (*Psychotria nervosa*), shrub
- cabbage palmetto (*Sabal palmetto*), shrub
- coontie (*Zamia pumila*), shrub
- seagrape (*Coccoloba uvifera*), shrub
- sugarberry (*Celtis laevigata*), shrub
- greenbrier (*Smilax*), other herbaceous
- airplant (*Tillandsia*), other herbaceous

Dominant resource concerns

- Subsidence
- Ground water depletion
- Salts transported to surface water
- Plant productivity and health
- Plant structure and composition

Pathway 2.1A
Community 2.1 to 2.3

This transition is driven by time which causes the early succession community to mature into a rockland hammock. While the early successional community can form as soon as 50 years in the absence of fire, it is estimated to need an additional 50 years of a fire free system, for more than 100 years total of being fire free to have maximum development of structure and species diversity.

Context dependence. This often occurs when a rockland hammock is fragmented due to urbanization.

Pathway 2.3A
Community 2.3 to 2.1

This transition is driven by a disturbance event which may return a rockland hammock back to an early succession phase. Overstory mortality may create canopy gaps which would allow for the rapid growth of species as they compete for light availability. Many different factors may cause overstory mortality in a rockland hammock, including, but not limited to, windthrow, crown fires, selective logging, or tree fall by weathering limestone.

State 3
Bare Ground / Pioneer Habitat

This state depicts a community that lacks vegetation. This is most often associated with extreme fires that will cause high mortality rates within a vegetative community. This state will also describe the secondary succession pioneer habitat that will become established if left undisturbed.

Characteristics and indicators. It is characteristic of herbaceous and succulent species found on exposed bedrock with little to no soil development.

Dominant resource concerns

- Subsidence
- Salts transported to surface water
- Salts transported to ground water
- Plant productivity and health
- Plant structure and composition

Community 3.1
Bare Ground or Exposed Soil / Bedrock

This community describes an area in which a disturbance event has cleared or killed the existing vegetative community, leaving behind the bare ground or exposed soil or bedrock. Disturbance events may include wildfires which kill existing vegetation or windthrow from storm events such as hurricanes. In the Keys, habitats which are in close proximity to the ocean may become flooded by extreme storm events, leading to die off from high salinity levels.

Community 3.2
Secondary Succession Pioneer Habitat

This community described a secondary succession pioneer habitat where a disturbance has taken place and cleared the soil, but is still able to support plant growth due to an existing or introduced seedbed. Rapid colonization will begin from herbaceous species, shrubs, and climbing species as well as seedlings from pioneer tree species. Over time it will transition into either a pine rockland or rockland hammock depending on available seedbank and if managed properly for those habitats. If left unmanaged, this community will have large amounts of invasive species throughout the community.

Resilience management. Once a seedbank is established this secondary succession pioneer community can transition to either a rockland hammock or pine rockland, dependent on what was the existing community. Maintenance of that habitat will be required to reflect natural conditions.

Community 3.3
Keys Cactus Barren

This is an open, herbaceous community with scattered shrubs on exposed limestone bedrock or areas with little soil or leaf litter in the Florida Keys. Primary vegetation are wide varieties of herb and succulent species which include cacti, agave, and several rare herbs. This is a very limited site and is only known from six sites which vary primarily in the degree of shrub and cacti cover.

Resilience management. The natural process giving rise to this community is not yet known, but it hypothesized that the thin layer of organic soil over limestone bedrock is missing, they may have formed via erosion following destruction of the plant cover by fire, storm, or artificial clearing. This is a highly endangered community and is most threatened by development.

Dominant plant species

- gumbo limbo (*Bursera simaruba*), tree
- button mangrove (*Conocarpus erectus*), tree
- boxleaf stopper (*Eugenia foetida*), shrub
- catclaw blackbead (*Pithecellobium unguis-cati*), shrub
- Spanish lady (*Opuntia triacantha*), shrub
- false sisal (*Agave decipiens*), shrub
- triangle cactus (*Acanthocereus tetragonus*), shrub
- bindweed dwarf morning-glory (*Evolvulus convolvuloides*), other herbaceous
- Yucatan flymallow (*Cienfuegosia yucatanensis*), other herbaceous
- skyblue clustervine (*Jacquemontia pentanthos*), other herbaceous
- indigo (*Indigofera*), other herbaceous

Pathway 3.1A
Community 3.1 to 3.2

This transition is driven by seedbank establishment, in where existing seeds are present in the remaining soil and begin to grow, creating an secondary succession pioneer habitat which represents the reference communities of State 1 or 2.

Context dependence. The seedbank must be preexisting in the remaining soil or must be deposited via natural or anthropogenic means.

Pathway 3.1B
Community 3.1 to 3.3

This transition is driven by seedbank establishment, in where existing cacti seeds are present in the remaining soil and begin to grow, creating a cactus barren. Maintenance of this community is still widely unknown.

Context dependence. The seedbank must be preexisting in the remaining soil or must be deposited via natural or anthropogenic means.

Pathway 3.2A
Community 3.2 to 3.1

This transition is driven by a disturbance event which destroys the secondary succession pioneer habitat back to exposed ground. This may be from abiotic factors such as hurricane events or by wildfires which will destroy the regrowth. In the Florida Keys, habitats in close proximity to the ocean may become flooded during extreme storm events, causing die off of species due to high salinities.

Pathway 3.3A
Community 3.3 to 3.1

This transition is driven by a disturbance event which destroys the secondary succession pioneer habitat back to exposed ground. This may be from abiotic factors such as hurricane events or by wildfires which will destroy the regrowth. In the Florida Keys, habitats in close proximity to the ocean may become flooded during extreme storm events, causing die off of species due to high salinities.

State 4
Invasive Non-Native Community

This state consists of Florida Department of Agriculture and Consumer Services (FDACS) Non-Native Category 1 Species list . More information on these species list can be found: https://www.fdacs.gov/content/download/63140/file/Florida%E2%80%99s_Pest_Plants.pdf or by contacting the UF / IFAS Center for Aquatic and Invasive Plants (http://plants.ifas.ufl.edu/), the UF / IFAS Assessment of Non-native Plants in Florida's Natural Areas (https://assessment.ifas.ufl.edu/), or the FWC Invasive Plant Management Section (http://myfwc.com/wildlifehabitats/invasive-plants/). This community will not represent every possibility of invasive species but rather the most common in these areas.

Characteristics and indicators. Non-Native species include species that exist outside of Florida's natural range and are introduced to the state via people, weather events, or any other means.

Resilience management. This state can be found as a part of any other state and can completely replace the native habitat if not properly managed. Restoration to natural communities after exotic non-native invasion includes practices such as mechanical and chemical removal.

Dominant resource concerns

- Subsidence
- Concentration of salts or other chemicals
- Nutrients transported to surface water
- Plant productivity and health
- Plant structure and composition

State 5
Human Altered and Human Transported Areas

These areas include soils that were intentionally and substantially modified by humans for an intended purpose, commonly for terraced agriculture, building support, mining, transportation, and commerce. The alteration is of sufficient magnitude to result in the introduction of a new parent material (human-transported material) or a profound change in the previously existing parent material (human-altered material). They do not include soils modified through standard agricultural practices or formed soils with unintended wind and water erosion. When a soil is on or above an anthropogenic landform or microfeature, it can be definitely be associated with human activity and is assigned to a unique taxa, usually found as an "Urban land complex" within that communities' natural soil properties (e.g., Pennekamp gravelly muck-Urban land complex, 0-2% slopes, extremely stony).

Characteristics and indicators. Evidence of these areas include soils with manufactured items (e.g. artifacts) present in the profile, human altered-materials (e.g., deeply excavated or deeply plowed soil) or human-transported material (e.g., fill), and position on or above anthropogenic landforms (e.g., flood-control levees) and microfeatures (e.g., drainage ditches). Detailed criteria regarding the identification of anthropogenic (artificial) landforms, human-altered materials, and human-transported material are in the "Keys to Soil Taxonomy" (Soil Survey Staff, 2014).

Dominant resource concerns

- Compaction
- Ponding and flooding
- Seasonal high water table
- Emissions of greenhouse gases (GHGs)
- Objectionable odors
- Plant productivity and health
- Plant structure and composition

Community 5.1
Reclaimed Areas

Reclaimed areas are areas that have been modified through anthropogenic means that are restored to a natural or second-hand natural community. Areas that can be reclaimed are any intensity urban areas, and may be required to be reclaimed after urban use (e.g., active mines must be reclaimed). These practices include the identification, removal, and stockpiling soil materials before altering the land, and revegetation and replacement of soil materials after altering the land. This also applies to nearby urban areas that have been adversely affected by the anthropogenic activities.

Community 5.2
Urban

This urban community consists of development for human use. Urban areas include a variety of land uses, e.g., inner city or urban core, industrial and residential areas, cemeteries, parks, and other open spaces; the overall function which may benefit the quality of human life. These often form an urban soil mosaic, where the natural landscape has been fragmented into parcels with distinctive disturbance and management regimes and, as a result, distinctive characteristic soil properties. Within this community there are three different levels of urbanization, based off population dynamics, residential density, and intensity of development. These are labeled as low-intensity, medium-intensity, and high-intensity urban areas, which can eventually be split apart into its own separate state. Low-intensity urban areas may consist of single dwelling homes with little impact on the surrounding community which still somewhat represents the natural community (e.g., represents natural landscape, hydrology, and vegetation) , other examples of this are urban parks, cemeteries, or campgrounds with little urban development. Medium-intensity urban areas consist of larger urban dwellings with some natural features, but have been modified to meet urban needs (e.g., towns). High-intensity urban areas are areas of heavily modified areas with complete alterations of the natural landscape, hydrology, and vegetation to support a very large population, which once constructed is permanently altered (e.g., metropolis areas/ active mines).

Community 5.3
Non-Reclaimed Areas

Non-reclaimed areas are areas that have been modified through anthropogenic means that are unable to be restored to a natural or second-hand natural community. Areas that cannot be reclaimed are areas under active mining status or mined areas before the Phosphate Land Reclamation Act in 1975, which leaves shut down operations alone. These areas also include fallow mines that have been flooded and are now permanent bodies of water.

Community 5.4
Landfills

This is an anthropogenic site for the disposal of waste material. It includes manufactured layers (artificial, root limiting layer below the soil surface) that are representative of human altered and human transported sites. These layers are often alternative between natural fill material and geotextile liners, asphalt, concrete, rubber or plastic that are built up and can rise above the surrounding landscape by 30 meters or more often impeding water, gas, or roots from moving through the profile.

Pathway 6.1A
Community 5.1 to 5.2

This shift in communities is driven by clearing and developing the land for the desired community.

Pathway 6.1B
Community 5.1 to 5.4

This transition is driven by the deposition of manufactured layers along with anthropogenic waste which is consistently built upon.

Pathway 6.2A
Community 5.2 to 5.1

This transition is driven by the revegetation, reestablished hydroperiods, and replacement of displaced soil materials after altering the land.

Pathway 6.2B
Community 5.2 to 5.3

This transition is driven from heavy industrial or urban development which causes the land to become non-reclaimable. This transition is rare due to the many environmental laws and regulations that must be followed when developing.

Pathway 6.2C
Community 5.2 to 5.4

This transition is driven by the deposition of manufactured layers along with anthropogenic waste which is consistently built upon.

Pathway 6.3A
Community 5.3 to 5.1

This transition is driven by the revegetation, reestablished hydroperiods, and replacement of displaced soil materials after altering the land.

Transition T1A
State 1 to 2

This state transition is driven by an exclusion of fire from the system for greater than 50 years. The absence of fire for this amount of time will allow the understory shrub species to mature and grow in the overstory. This will shade out the understory, losing species diversity and accumulating organic matter over time, creating a cool, moist interior, which helps exclude fire from the area.

Constraints to recovery. As the shrubs grow into the overstory they will shade the understory creating more moist conditions in which fire is unable to pass through. If this state is surrounded by pine rocklands which have a regular fire return interval, there will be a sharp ecotone between these two states. If fire has been excluded from the reference state then there will be a gradual transition into the rockland hammock.

Context dependence. The absence of fire from these systems are largely due to the high levels of urbanization and fragmentation along the Florida Keys.

Transition T1B

State 1 to 3

This transition is driven by an extreme fire which removes all of the existing vegetation, leaving behind bare soil or exposed bedrock.

Constraints to recovery. An existing seedbank must be present in the soil and enough time must be allowed for the establishment of the native species to grow. During the growth of these species proper management must be taken to ensure there is no undesirable invasive or exotic species that become established.

Context dependence. An extreme fire can occur due to high buildup of organic matter (leaf litter) in the understory and presence of ladder fuels into the overstory.

Transition T1C
State 1 to 4

The invasion of non-native or exotic species can be driven by a multitude of different environmental factors such as changes in natural hydroperiods or in fire regimes. Typically once a change in one of the two factors mentioned above occurs, non-native or exotic invasive species become established and begin to compete with native species for habitat and nutrients.

Constraints to recovery. Recovery from non-native or exotic invasive species may be difficult due to many adaptations which allow them to survive and outcompete in intolerable conditions. Localized knowledge for each species must be known for best removal of it without harming the native environment, and often different treatments must be applied over one given area.

Context dependence. Growth of non-native and exotic invasive species can be rapid following a change in a natural stressor such as fire frequency or natural hydroperiods which might have once kept the invasive species at bay.

Transition T1D
State 1 to 5

This transition is driven by the alteration and/ or transportation of materials via anthropogenic means.

Transition T2A
State 2 to 1

This transition is driven by the selective removal or hardwood and pine species to transition the community structure back to a pine rockland state. Once community structure and composition is to the desired criteria a regular fire return interval must be established every 3 to 15 years.

Constraints to recovery. This is a very costly and time consuming process.

Transition T2B
State 2 to 3

This transition is driven by an extreme fire which removes all of the existing vegetation, leaving behind bare soil or exposed bedrock.

Constraints to recovery. An existing seedbank must be present in the soil and enough time must be allowed for the establishment of the native species to grow. During the growth of these species proper management must be taken to ensure there is no undesirable invasive or exotic species that become established.

Context dependence. An extreme fire can occur due to high buildup of organic matter in the understory and presence of ladder fuels into the overstory.

Transition T2C
State 2 to 4

The invasion of non-native or exotic species can be driven by a multitude of different environmental factors such as changes in natural hydroperiods or in fire regimes. Typically once a change in one of the two factors mentioned above occurs, non-native or exotic invasive species become established and begin to compete with native species for habitat and nutrients.

Constraints to recovery. Recovery from non-native or exotic invasive species may be difficult due to many adaptations which allow them to outcompete and survive in intolerable conditions. Localized knowledge for each species must be known for best management of it it without harming the natural habitat, and often different treatments must be applied over one given area.

Context dependence. Growth of non-native and exotic invasive species can be rapid following a change in a natural stressor such as fire frequency or natural hydroperiods which might have once kept the invasive species at bay.

Transition T2D
State 2 to 5

This transition is driven by the alteration and/ or transportation of materials via anthropogenic means.

Restoration pathway R3A
State 3 to 1

This restoration strategy to reestablish a pine rockland community cannot be done without an established seedbank. This seedbank may be preexisting in the soil or may be planted via human restoration. Once the seedbank is established the area must continually undergo habitat management to ensure there is no presence of undesirable invasive or exotic species over time.

Context dependence. Maintenance of a pine rockland habitat includes regular fire return intervals every 3 to 15 years to prevent hardwood inclusion into the system, if fire is not present in the system this may gradually transition to a rockland hammock.

Restoration pathway R3B
State 3 to 2

This restoration strategy to reestablish a rockland hammock community cannot be done without an established seedbank. This seedbank may be preexisting in the soil or may be planted via human restoration. Once the seedbank is established the area must continually undergo habitat management to ensure there is no presence of undesirable invasive or exotic species over time.

Context dependence. Maintenance of a rockland hammock habitat includes the absence of fire from the system for greater than 50 years while the hammock undergoes development.

Transition T3A
State 3 to 4

The invasion of non-native or exotic species can be driven by a multitude of different environmental factors such as changes in natural hydroperiods or in fire regimes. Typically once a change in one of the two factors mentioned above occurs, non-native or exotic invasive species become established and begin to compete with native species for habitat and nutrients.

Constraints to recovery. Recovery from non-native or exotic invasive species may be difficult due to many adaptations which allow them to survive and outcompete in intolerable conditions. Localized knowledge for each species must be known for best removal of it without harming the native environment, and often different treatments must be applied over one given area.

Context dependence. Growth of non-native and exotic invasive species can be rapid following a change in a natural stressor such as fire frequency or natural hydroperiods which might have once kept the invasive species at bay.

Transition T3B
State 3 to 5

This transition is driven by the alteration and/ or transportation of materials via anthropogenic means.

Restoration pathway R4A
State 4 to 1

Mechanical, biological, and chemical removal strategies include removing the non-native and exotic invasive species through various mechanisms. Localized knowledge for individual non-native or exotic invasive species is needed for specific management. Sometimes introduction of fire regimes may prevent or stop the growth of non-native or exotic invasive species, but many species are fire tolerant. Mechanical removal might include roller chopping, harvesting, or cutting and removal of invasive species. Chemical removal might include aerial dispersal from planes, or basal bark injection treatments.

Context dependence. Mechanical, biological, and chemical removal of non-native and exotic invasive species is a time dependent process, with both removal types taking long times to be considered effective.

Restoration pathway R4B
State 4 to 2

Mechanical, biological, and chemical removal strategies include removing the non-native and exotic invasive species through various mechanisms. Localized knowledge for individual non-native or exotic invasive species is needed for specific management. Sometimes introduction of fire regimes may prevent or stop the growth of non-native or exotic invasive species, but many species are fire tolerant. Mechanical removal might include roller chopping, harvesting, or cutting and removal of invasive species. Chemical removal might include aerial dispersal from planes, or basal bark injection treatments.

Context dependence. Mechanical, biological, and chemical removal of non-native and exotic invasive species is a time dependent process, with both removal types taking long times to be considered effective.

Restoration pathway R4C
State 4 to 3

Mechanical, biological, and chemical removal strategies include removing the non-native and exotic invasive species through various mechanisms. Localized knowledge for individual non-native or exotic invasive species is needed for specific management. Sometimes introduction of fire regimes may prevent or stop the growth of non-native or exotic invasive species, but many species are fire tolerant. Mechanical removal might include roller chopping, harvesting, or cutting and removal of invasive species. Chemical removal might include aerial dispersal from planes, or basal bark injection treatments.

Context dependence. Mechanical, biological, and chemical removal of non-native and exotic invasive species is a time dependent process, with both removal types taking long times to be considered effective.

Transition T4A
State 4 to 5

This transition is driven by the alteration and/ or transportation of materials via anthropogenic means.

Additional community tables

Animal community

Rockland hammocks provide habitat for a variety of wildlife, with few species that live exclusively in the hammocks, but many animals take advantage of the relatively cool interior and slightly higher elevation provided by the hammock. Many birds use the hammocks as stops that provide food and rest for both migratory and resident birds. Pine rocklands are similar in species composition to hammocks, with many species utilizing this area as a wildlife corridor. This habitat is also critical for mammals and reptiles for food, water, shelter and space. Species include:

Birds: Migratory birds include the Kirtlands warbler (Dendroica kirtlandii), oven¬bird (Seiurus aurocapillus), solitary vireo (Vireo solitarius), and gray kingbird (Tyrannus dominicensis). Resident birds include the threatened, white-crowned pigeon (Columba leucocephala), black-whiskered vireo (Vireo atiloquus), mangrove cuckoo (Cocczyus minor), great crested flycatcher (Myiarchus crinitus), cardinal (Cardinalis cardinalis), smooth billed anis (Crotophaga ani), red-bellied woodpecker (Melanerpes carolinus), pine warbler (Dendroica pinus), Bald eagle (Haliarryis leucocephalus), white-eyed vireo (Vireo griseus), and carolina wren (Thryothorus ludovicianus).

Mammals: The Florida Key deer (Odocoileus virginianus clavium), Key Largo cotton mouse (Peromyscus gossypinus allapaticola), Key Largo woodrat (Neotoma floridana smallii), marsh rabbit (Sylvilagus palustris), Gray squirrel (Sciurus carolinensis), Everglades mink (Mustela vison), Key Vaca raccoon (Procyon lotor auspicatus), and Mangrove fox squirrel (Sciurus niger avicennia).

Reptiles: Common species include brown anole (Anolis sagrei), southeastern five-lined skink (Eumeces inexpectatus) eastern indigo snake (Drymarchon corais couperi), red rat snake (Elaphe guttata guttata), Florida Keys mole skink (Eumeces egregius egregius), Florida brown snake (Storeria dekayi victa), rim rock crowned snake (Tantilla oolitica), and Florida ribbon snake (Thamnophis sauritus sackeni).

Amphibians: Common species include eastern narrow mouthed toad (Gastrophryne carolininsis), greenhouse frog (Eleutherodactylus planirostris), southern leopard frog (Rana sphenocephala), and southern toad (Bufo terrestris).

Hydrological functions

This community gets most of its freshwater through rainfall with the majority (roughly 75%) occurring between June and October. Rainfall generally percolates quickly through the soil, maintain fresh water or low salinity “lenses” below these communities.

Recreational uses

These sites are mainly used for recreation areas such as parks and hiking trails, as well as other uses such as bird watching and other natural activities. Because many of the species dependent on this community are state or federally threatened, hunting is not found. Occasionally poaching of Key Deer is seen and is punishable under violations of the Endangered Species Act.

Wood products

This site is generally protected and not under scrutiny of the commercial wood industry. Large old growth species such as pine, mastic, mahogany, and other species were selectively harvested for shipbuilding in the 1800s. Many sites were logged again in the early 1900s for development, leading to the total destruction of the ecological community. Due to their toxic effect to humans poisonwood has been largely removed from these forests (Outcalt, 1997).

Other products

This site is not recommended for rangeland. Due to the upland nature of the sites, these are prime spots for urban development making these habitats recede rapidly. However, large areas have been acquired and are no longer threated by development. In the Florida Keys, much of the remaining rockland hammock habitat remains in private ownership and is threated by development.

Inventory data references

Information presented was derived from NRCS clipping data, current and historical literature, field observations, and personals contacts with local, state and federal partners. This is a provisional level ESD and is subject to change as more information becomes available, for any questions please contact your local NRCS office.

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Acknowledgments

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Dry Tortugas National Park Staff
Southwest Florida Water Management District
Florida Natural Areas Inventory

Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	05/12/2025
Approved by	Charles Stemmans
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

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

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

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

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

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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

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

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

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that**

become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:

17. **Perennial plant reproductive capability:**