USDA Natural Resources
Conservation Service

Ecological site VX164X01X003
Very Poorly Drained Terric Forest

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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): 164X–Humid and Very Humid Steep and Very Steep Mountain Slopes

This MLRA occurs in the State of Hawaii on the islands of Hawaii, Maui, Molokai, Oahu, and Kauai. It consists primarily of deeply dissected mountainous areas. Elevation ranges from sea level to 7000 feet (0 to 2100 meters). Topography is mostly steep, with ridges, gulches, and canyons, as well as areas of plateau. Underlying geology is fractured, basic, igneous rock (mostly basalt) that is slightly to highly weathered. Over this are found deposits of local volcanic ash, tropospheric dust from Asia, and/or organic deposits. Climate is mostly wet tropical. Average annual precipitation typically ranges from 75 to 250 inches (1875 to 6250 millimeters), with extremes of 30 to 450 inches (750 to 11,250 millimeters). Rainfall is well distributed throughout the year with and enhanced rainy season from November through April. Fog drip can add significant amounts of water to the soil. Average annual temperatures range from 53 to 75 degrees F (12 to 24 degrees C), with very little seasonal variation. Soils are mostly Inceptisols, Andisols, and Histosols with isothermic or isomesic soil temperature regimes. Native vegetation consists of moderate stature rainforests, dwarf forests, and stands of uluhe with emergent shrubs and trees.

Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 164 - Humid and Very Humid Steep and Very Steep Mountain Slopes.

Ecological site concept

This ecological site is a rain forest on the wet, high-elevation Alakai plateau on the island

of Kauai. It is within a State lands including Kokee State Park and the Alakai Wilderness Preserve. There is limited access through Kokee State Park. Two much smaller examples occur in inaccessible parts of the Waianae Range on Oahu. Another small example occurs in the Koolau Range on Oahu.

The central concept of the Very Poorly Drained Terric Forest is of very poorly drained, deep soils formed in mucky peat and muck over clay. The surface consists of layers of mucky peat and muck about 32 inches (80 centimeters) deep over gleyed clay to about 51 inches (127 centimeters) depth. The gleyed horizons are continuously saturated and anaerobic; the organic surface horizons are frequently saturated. Vegetation is medium-stature rain forest with closed to open canopy dominated by ohia lehua and olapa. Interspersed within the forest are open bogs. Rainfall ranges from 100 to 450 inches (2540 to 11,430 millimeters), and average annual temperature is 56 degrees F (13 degrees C). Clouds and fog cover the landscape nearly every day.

Associated sites

VX164X01X005	**Somewhat Poorly Drained Organic Surface Forest** The Somewhat Poorly Drained Organic Surface Forest occupies steep slopes on Kauai which adjoin the more level Very Poorly Drained Terric Forest. The two ecological sites share a similar climate, but the Somewhat Poorly Drained Organic Surface Forest sheds water through surface runoff and subsurface flow, has shallower soils, and a much thinner mucky peat surface horizon. Vegetation is similar on both ecological sites and the Somewhat Poorly Drained Organic Surface Forest tends to have a shorter, more open canopy.
VX164X01X401	**Poorly Drained Bog** The Poorly Drained Bog and the Very Poorly Drained Terric Forest both occur on Kauai, but the Very Poorly Drained Terric Forest also occurs in three small locations on Oahu. The Poorly Drained Bog adjoins the extreme eastern boundary of the Very Poorly Drained Terric Forest, and there probably are inclusions of it within the Very Poorly Drained Forest. The ecological sites share a similar climate and elevation, but the Poorly Drained Bog lacks an organic horizon. It has vegetation that is shorter and more open than the Very Poorly Drained Terric Forest.

Similar sites

VX164X01X501	**Sphagnum Peat Dwarf Forest** The Sphagnum Peat Dwarf Forest occurs on Kohala on the island of Hawaii, while the Very Poorly Drained Terric Forest occurs on Kauai and Oahu. Both ecological sites have similar climates. The Sphagnum Peat Dwarf Forest has a surface layer composed of sphagnum, while the Very Poorly Drained Terric Forest has a much thicker surface layer of mucky peat but not sphagnum.

VX164X01X001	**Gleyed Soil Forest** The Gleyed Soil Forest occurs on Maui and Molokai; the Very Poorly Drained Terric Forest occurs on Kauai and Ohahu. Both ecological sites share about the same climates and elevations. The Gleyed Soil Forest supports an organic surface horizon which is shallow to an ironstone layer and covered with a layer of peat, while the Very Poorly Drained Terric Forest has a much thicker surface layer of mucky peat with no organic surface horizon. Neither of these sites support Sphagnum moss.

Table 1. Dominant plant species

Tree	(1) *Metrosideros polymorpha* (2) *Cheirodendron trigynum*
Shrub	Not specified
Herbaceous	(1) *Dubautia laxa*

Legacy ID

F164XY003HI

Physiographic features

This ecological site occurs on weathered basaltic lava flows.

Table 2. Representative physiographic features

Landforms	(1) Shield volcano > Lava flow unit
Runoff class	Low
Flooding frequency	None
Ponding frequency	None
Elevation	2,100–5,000 ft
Slope	0–30%
Water table depth	0–13 in
Aspect	W, N

Table 3. Representative physiographic features (actual ranges)

Runoff class	Not specified
Flooding frequency	Not specified
Ponding frequency	Not specified
Elevation	1,500–5,000 ft

Slope	Not specified
Water table depth	Not specified

Climatic features

Summary for this ecological site
Average annual precipitation ranges from about 100 to 450 inches (2540 to 11,430 millimeters). Rainfall occurs throughout the year, with the heaviest precipitation occurring from October through April. Landscapes are shrouded in fog or overcast during much of the day throughout the year, which reduces evapotranspiration and adds additional moisture from condensation of fog on vegetation. Mean annual temperature is about 56 degrees F (13 degrees C). Frost free and freeze free periods are 365 days per year. Kauai is the northernmost of the larger Hawaiian Islands, exposing the island to more mid-latitude frontal weather systems than the other islands.

General principles
Air temperature in the Hawaiian Islands is buffered by the surrounding ocean so that the range in temperature through the year is narrow. This creates “iso-“ soil temperature regimes in which mean summer and winter temperatures differ by less than 6 degrees C (11 degrees F).

The islands lie within the trade wind zone. Significant amounts of moisture are picked up from the ocean by trade winds up to an altitude of more than about 6000 feet (1850 meters). As the trade winds from the northeast are forced up the mountains of the islands their moisture condenses, creating rain on the windward slopes; the leeward sides of the island receive little of this moisture.

Two seasons can be defined during the year: a seven-month winter season from October through April and a five-month summer season from May through September. Summer has warmer temperatures, steadier and stronger trade winds, few widespread rainstorms, and generally lower average monthly rainfall than winter. Differences in rainfall amounts between winter and summer are most marked in low elevation dry areas; wetter areas exhibit less seasonal variation in rainfall.

On the windward sides of the island, cool, moist air at higher elevations descends toward the ocean where it meets the trade winds; this process brings rainfall, often at night, to lower elevation areas.

Extensive low-pressure systems often approach the islands from the west, producing heavy rainstorms that primarily affect the leeward sides, but can envelope the entire island. These major storms occur most frequently between October and March.

Table 4. Representative climatic features

Frost-free period (characteristic range)	365 days
Freeze-free period (characteristic range)	365 days
Precipitation total (characteristic range)	100-450 in
Frost-free period (actual range)	
Freeze-free period (actual range)	
Precipitation total (actual range)	60-450 in
Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	325 in

Climate stations used

- (1) MANOA LYON ARBO 785.2 [USC00516128], Honolulu, HI

Influencing water features

Small headwater streams form within this ecological site. Open bogs and small ponded areas are scattered within the site. The National Wetlands Inventory classifies the forested areas (the ecological site) as forest, seasonally saturated.

Soil features

This ecological site exists on Alakai series soils, which are classified as Clayey, ferrihumic, dysic, isomesic Terric Haplosaprists. This series consists of deep soils that formed in a very poorly drained areas from organic material overlying clay weathered from basaltic lava. The surface horizon consists of mucky peat and muck (sapric materials) about 32 inches (80 centimeters) deep over gleyed clay to about 51 inches (127 centimeters) depth. The gleyed horizons are continuously saturated and anaerobic; the organic surface horizons are frequently saturated. Most roots occur within the upper 32 inches (80 centimeters) of organic soil; roots are few and very fine within the gleyed, mineral clay horizons. The soil temperature regime is isomesic. “Terric” soils in this case refers to ferrihumic soil material, which is “bog iron.” In brief, this is material that formed in place and consists of hydrated iron oxide mixed with organic matter. The iron is either dispersed and soft or cemented into large aggregates. It is saturated with water for more than six months per year, contains 10 percent or more by weight free iron oxide), and has a dark reddish or brownish color that changes little on drying.

Table 5. Representative soil features

Parent material	(1) Organic material

Surface texture	(1) Mucky
Family particle size	(1) Clayey
Drainage class	Very poorly drained
Permeability class	Very slow
Depth to restrictive layer	32 in
Soil depth	72 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	8 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	3.5–4.4
Subsurface fragment volume <=3" (0-40in)	2%
Subsurface fragment volume >3" (0-40in)	0%

Ecological dynamics

The information in this ecological site description (ESD), including the state-and-transition model (STM), was developed using archaeological and historical data, professional experience, and scientific studies. The information is representative of a complex set of plant communities. Not all scenarios or plants are included. Key indicator plants, animals, and ecological processes are described to inform land management decisions.

Natural Disturbances
Possible natural disturbances are hurricanes and, in some locations, landslides.

Human Disturbances
This ecological site is nearly inaccessible on foot. There are no roads, and much of the site is surrounded by fences to exclude introduced ungulates.

Humans arrived in the Hawaiian Islands 1200 to 1500 years ago. Their population gradually increased so that by 1600 AD at least 80% of all the lands in Hawaii below about

1500 feet (roughly 500 meters) in elevation had been extensively altered by humans (Kirch 1982)). This ecological site occurs well above that elevation. However, this ecological site may have been affected by factors such as inadvertently introduced plant diseases and seed predation by the introduced Pacific Rat (Athens 1997).

After the arrival of Europeans, documentary evidence attests to accelerated and extensive deforestation, erosion, siltation, and changes in local weather patterns (Kirch 1983) due to more intensive land use, modern tools, and introduction of more plant, animal, and microbe species.

The Polynesians introduced dogs, Pacific rats, and small pigs to the islands. Cattle, sheep, horses, goats, and larger European pigs were introduced in the final decades of the 18th century. These animals ranged free on the islands, becoming very numerous and destructive by the early decades of the 19th century (Henke 1929). The most destructive introduced animals in this remote ecological site have been feral pigs and cattle.

Through the 20th and into the 21st centuries, increases in human populations with attendant land development, as well as accelerated introduction of non-native mammals, birds, reptiles, amphibians, invertebrates, plants, and microorganisms, have brought about dramatic changes to wild ecosystems in Hawaii.

The main disturbances in this ecological site are due to feral pigs, deer, and goats that disturb the soil and directly consume native plants and rats that consume seeds. Some plant species introduced since the arrival of Europeans in Hawaii thrive in this ecological site and can spread rapidly over large areas, competing with native plants. The most abundant invasive plant species are soapbush or Koster's curse (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*), common guava (*Psidium guajava*), kahili ginger or Kahila garland-lily (*Hedychium gardnerianum*), and Australian tree fern or Cooper's cyathea (*Cyathea cooperi*). The forb daisy fleabane or Latin American fleabane (*Erigeron karvinskianus*) is highly invasive. Both sawtooth blackberry (*Rubus argutus*) and West Indian raspberry (*Rubus rosifolius*) are common, as is dogtail (*Buddleja asiatica*). Some common introduced and invasive grass and sedges are common carpetgrass (*Axonopus fissifolius*), Meyen's flatsedge (*Cyperus meyenianus*), and glenwood grass (*Sacciolepis indica*).

State and transition model

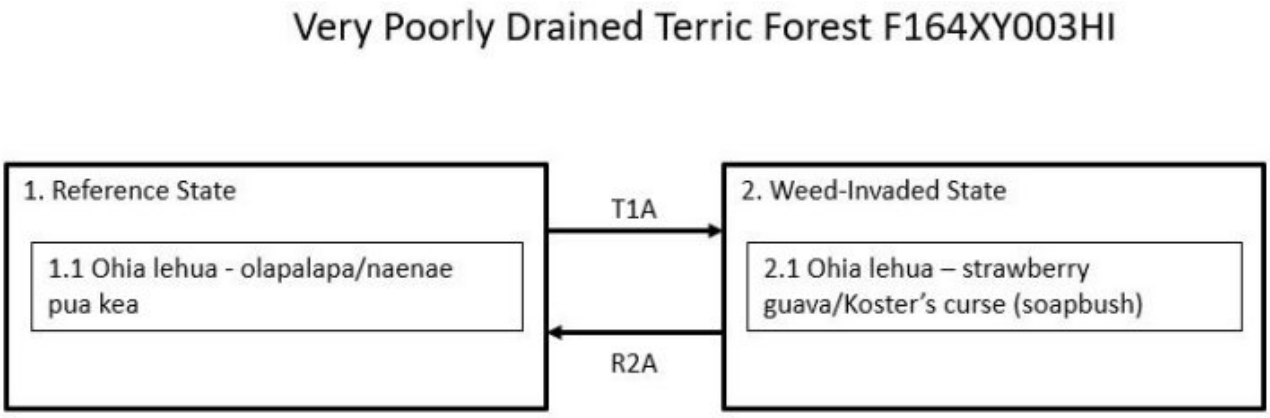

Figure 1. State and Transition Model for the Very Poorly Drained Terric Forest (F164XY003HI).

State 1
Reference State

This state is comprised of one community phase. With disturbance from hurricanes, landslides, or introduced mammals, invasive plants invade the site and native plant species decline in abundance. Invasive plants may invade the site without other disturbances, but the process is much slower.

Community 1.1
Ohia lehua - olapalapa/naenae pua kea

The vegetation of this community phase diverse rainforest of medium stature and open or closed upper canopy. Lichens, mosses, and epiphytes grow on tree trunks and branches. Ferns are abundant and diverse. Ohia lehua (*Metrosideros polymorpha*) and olapalapa or olapa (*Cheirodendron trigynum*) are the dominant overstory tree species. Other common tree genera are Melicope, Myrsine, other Cheirodendron species, other Metrosideros species, Coprosma, and Psychotria. Common shrubs are naenae pua kea (*Dubautia laxa*) and other species of Dubautia, and species of Vaccinium. Tree ferns (Cibotium spp.) also occur. Some species occur on both Kauai and Oahu, while some occur only on one of those islands. Please refer to the accompanying spreadsheet of possible native species.

Dominant plant species

- 'ohi'a lehua (*Metrosideros polymorpha*), tree
- olapalapa (*Cheirodendron trigynum*), tree
- na'ena'e pua melemele (*Dubautia laxa*), other herbaceous

State 2
Weed-Invaded State

This state is comprised of one community phase. It comes into being by gradual invasion of introduced species. Disturbance of the soil and direct damage to native plants by

introduced ungulates, particularly pigs, goats, and deer, will facilitate the transition to this state.

Community 2.1
Ohia lehua - strawberry guava/Koster's curse (soapbush)

The vegetation consists of low to medium stature trees with a diverse understory. Native species are present but have been partially displaced by introduced species. The most common introduced species are soapbush or Koster’s curse (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*), common guava (*Psidium guajava*), kahili ginger or Kahila garland-lily (*Hedychium gardnerianum*), and Australian tree fern or Cooper’s cyathea (*Cyathea cooperi*). The forb daisy fleabane or Latin American fleabane (*Erigeron karvinskianus*) is highly invasive. Both sawtooth blackberry (*Rubus argutus*) and West Indian raspberry (*Rubus rosifolius*) are common, as is dogtail (*Buddleja asiatica*). Some common introduced and invasive grass and sedges are common carpetgrass (*Axonopus fissifolius*), Meyen’s flatsedge (*Cyperus meyenianus*), and glenwood grass (*Sacciolepis indica*).

Dominant plant species

- 'ohi'a lehua (*Metrosideros polymorpha*), tree
- strawberry guava (*Psidium cattleianum*), tree
- soapbush (*Clidemia hirta*), shrub

Transition T1A
State 1 to 2

State 1, the Reference State, transitions to State 2, Weed-Invaded State, by invasion of introduced species. Disturbance by feral deer, goats, and pigs will hasten this process, as will landslides and hurricanes.

Restoration pathway R2A
State 2 to 1

Restoration of State 2 Weed-Invaded State to State 1 Reference State or a facsimile of it may be possible by installing ungulate-proof fence, removing all ungulates, removing introduced plant species, and replanting native species when needed. Long term weed management and fence maintenance would be necessary.

Additional community tables

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DEFINITIONS

Available water capacity: The amount of soil water available to plants to the depth of the first root-restricting layer.

Bulk density: the weight of dry soil per unit of volume. Lower bulk density indicates a greater amount of pore space that can hold water and air in a soil.

$CaCO_3$ equivalent: The amount of free lime in a soil. Free lime exists as solid material and typically occurs in regions with a dry climate.

Canopy cover: The percentage of ground covered by the vertical projection downward of the outermost perimeter of the spread of plant foliage. Small openings within the canopy

are included.

Community pathway: A description of the causes of shifts between community phases. A community pathway is reversible and is attributable to succession, natural disturbances, short-term climatic variation, and facilitating practices, such as grazing management.

Community phase: A unique assemblage of plants and associated dynamic soil properties within a state.

Dominant species: Plant species or species groups that exert considerable influence upon a community due to size, abundance, or cover.

Drainage class: The frequency and duration of a water table in a soil. There are seven drainage classes, ranging from “excessively drained” (soils with very rare or very deep water tables) to “well drained” (soils that provide ample water for plant growth but are not so wet as to inhibit root growth) to “very poorly drained” (soils with a water table at or near the surface during much of the growing season that inhibits growth of most plants).

Electrical conductivity (EC): A measure of the salinity of a soil. The standard unit is deciSiemens per meter (dS/m), which is numerically equivalent to millimhos per centimeter (mmhos/cm). An EC greater than about 4 dS/m indicates a salinity level that is unfavorable to growth of most plants.

Isomesic soil temperature regime: A regime in which mean annual soil temperature is 47 degrees F (8 degrees C) or higher but lower than 59 degrees F (15 degrees C) and mean summer and mean winter soil temperatures differ by less than 11 degrees F (6 degrees C) at a specified depth.

Isothermic soil temperature regime: A regime in which mean annual soil temperature is 59 degrees F (15 degrees C) or higher but lower than 72 degrees F (22 degrees C) and mean summer and mean winter soil temperatures differ by less than 11 degrees F (6 degrees C) at a specified depth.

Major Land Resource Area (MLRA): A geographic area defined by NRCS that is characterized by a particular pattern of soils, climate, water resources, and land uses. The island of Hawaii contains nine MLRAs, some of which also occur on other islands in the state.

Makai: a Hawaiian word meaning “toward the sea.”

Mauka: a Hawaiian word meaning “toward the mountain” or “inland.”

Naturalized plant community: A community dominated by adapted, introduced species. It is a relatively stable community resulting from secondary succession after disturbance. Most grasslands in Hawaii are in this category.

Parent material: Unconsolidated and chemically weathered material from which a soil is developed.

pH: The numerical expression of the relative acidity or alkalinity of a soil sample. A pH of 7 is neutral; a pH below 7 is acidic and a pH above 7 is basic.

Reference community phase: The phase exhibiting the characteristics of the reference state and containing the full complement of plant species that historically occupied the site. It is the community phase used to classify an ecological site.

Reference state: A state that describes the ecological potential and natural or historical range of variability of an ecological site.

Restoration pathway: A term describing the environmental conditions and practices that are required to recover a state that has undergone a transition.

Sodium adsorption ratio (SAR): A measure of the amount of dissolved sodium relative to calcium and magnesium in the soil water. SAR values higher than 13 create soil conditions unfavorable to most plants.

Soil moisture regime: A term referring to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa (the crop wilting point) in the soil or in specific horizons during periods of the year.

Soil temperature regime: A defined class based on mean annual soil temperature and on differences between summer and winter temperatures at a specified depth.

Soil reaction: Numerical expression in pH units of the relative acidity or alkalinity or a soil.

State: One or more community phases and their soil properties that interact with the abiotic and biotic environment to produce persistent functional and structural attributes associated with a characteristic range of variability.

State-and-transition model: A method used to display information about relationships between vegetation, soil, animals, hydrology, disturbances, and management actions on an ecological site.

Transition: A term describing the biotic or abiotic variables or events that contribute to loss of state resilience and result in shifts between states.

Udic soil moisture regime: A regime in which the soil is not dry in any part for as long as 90 cumulative days in normal years, and so provides ample moisture for plants. In Hawaii it is associated with forests in which hapuu (tree ferns) are usually moderately to highly abundant.

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Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	12/20/2025
Approved by	Kendra Moseley
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):**

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

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

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

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

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

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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

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

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

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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:**

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17. **Perennial plant reproductive capability:**
