USDA Natural Resources
Conservation Service

Ecological site QX191X01X504
Limestone Plateau Cloud 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): 191X–High Limestone Plateaus of the Mariana Islands

This MLRA consists of the northern half of Guam and the islands of Saipan), Tinian, Rota, and Aguijan. Topography consists mostly of limestone plateaus. The highest elevations are 1,700 feet (520 meters) on Rota, 1,485 feet (450 meters) on Saipan, 655 feet (200 meters) on Tinian, and 860 feet (260 meters) in the northern part of Guam. The limestone plateaus were uplifted by tectonic activity. Deeply weathered volcanic rock is exposed on some ridges and slopes. Average annual rainfall is 100 inches (2,540 millimeters) on northern Guam and 80 inches (2,030 millimeters) on Saipan, Tinian, Aguijan, and Rota. The rainy season occurs from July through November; the dry season occurs from December through June. Trade winds blow from the northeast. Average annual temperature is 79 degrees F (26 degrees C). Typhoons are frequent. Soils are Alfisols, Andisols, Entisols, Mollisols, or Oxisols. The dominant soil moisture regime is ustic. The soil temperature regime is isohyperthermic. Native vegetation consists of mixed tropical hardwoods; introduced white leadtree or tangantangan trees are abundant. Introduced deer, pigs, goats, and water buffalo are common (USDA-NRCS, 2006). The main human disturbance is clearing land for cultivation. Feral pigs, feral cattle, brown tree snakes, stray dogs (Boonie dogs), and introduced deer are destructive to the native forest (Amand, 2000; CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 191 – High Limestone Plateaus of the Mariana Islands.

Ecological site concept

This ecological site occurs on the island of Rota in the Marianas Islands. It occurs on nearly level to modserately sloping (0 to 15 percent slopes) limestone plateaus at elevations ranging from 1,310 to 1570 feet (400 to 480 meters) (USDA-SCS, 1989).

Soils are shallow, well drained Entisols (lithic ustorthents) in “moist” phases of Luta series that formed in sediment over porous coralline limestone. Soil temperature regimes are isohyperthermic; soil moisture regimes are ustic. Average annual precipitation is 116 inches (2,945 millimeters) and ranges from 113 to 120 inches (2,870 to 3,050 millimeters) (PRISM, 2006). The area is often shrouded in clouds and fog. Water runoff is very low or low; permeability is moderately rapid. Effective rooting depth is 10 to 16 inches (25 to 40 cm). Available water-holding capacity is very low (1 inch) (USDA-SCS, 1989). Most of the area is vegetated by native forest (Amidon et al., 2017; Falanruw et al., 1989; Fosberg, 1960; Liu and Fischer, 2008; Stone, 1970; Wagner and Grether, 1948; Willsey et al., 2019).

Associated sites

QX191X01X505	**Very Low Available Water Capacity Soils on Limestone Plateaus and Escarpments** Soils of QX191X01X505 (The Very Low Available Water Capacity Soils on Limestone Plateaus and Escarpments Ecological Site) formed in porous coralline limestone. Effective rooting depth is 2 to 16 inches; available water holding capacity is very low (1). Most of the area is vegetated by native forest. Soils of Q191X01X504 (The Limestone Plateau Cloud Forest Ecological Site) formed in limestone. Effective rooting depth is 10 to 16 inches and available water holding capacity is also very low (1). Most of the area is vegetated by native forest. Moisture is added to the soil by fog drip, which maintains moist soils.
QX191X01X002	**Moderately Deep Alfic Soils on Volcanic Uplands** Soils of QX191X01X002 (The Moderately Deep Alfic Soils on Volcanic Uplands Ecological Site) formed in residuum derived from andesitic marine tuff and tuffaceous breccia. They are highly weathered Alfisols that have fairly high base saturation, effective rooting depths of approximately 32 inches, surface pH of 6.2 to 6.5, and low available water holding capacity (4 inches). Most of the area is vegetated by grasses, forbs, and mixed forest of introduced and native species. Pacific Island silvergrass or swordgrass (Miscanthus floridulus) is present in some areas. white lead tree or tangantangan (Leucaena leucocephala) is not abundant. Soils of Q191X01X504 (The Limestone Plateau Cloud Forest Ecological Site) formed in fine materials over porous coralline limestone. Effective rooting depth is about 12 inches, surface pH of 7.0 to 7.2; available water holding capacity is very low (1 inch). Most of the area is vegetated by native forest. This ecological site is limited to an area that is often shrouded in clouds and fog. Moisture is added to the soil by fog drip, which maintains the soils in moist condition most of the time.

QX191X01X503	**Very Shallow to Moderately Deep Soils on Limestone Plateaus** Soils of QX191X01X503 (The Very Shallow to Moderately Deep Soils on Limestone Plateaus Ecological Site) formed in fine materials over porous coralline or argillaceous limestone. Effective rooting depth is 2 to 20 inches and available water holding capacity is very low to low (2 to 3 inches). Areas not farmed are vegetated by mostly introduced grass, forb, and tree species, with some areas of native upland forest. Tangantangan (Leucaena leucocephala) is abundant in places. Soils of Q191X01X504 (The Limestone Plateau Cloud Forest Ecological Site) formed in fine materials over porous coralline limestone. Effective rooting depth is about 12 inches, surface pH of 7.0 to 7.2; available water holding capacity is very low (1 inch). Most of the area is vegetated by native forest. This ecological site is limited to an area that is often shrouded in clouds and fog. Moisture is added to the soil by fog drip, which maintains the soils in moist condition most of the time.

Table 1. Dominant plant species

Tree	(1) *Hernandia labyrinthica* (2) *Elaeocarpus joga*
Shrub	(1) *Freycinetia reineckei*
Herbaceous	Not specified

Legacy ID

F191XY504MP

Physiographic features

This ecological site occurs on limestone plateaus (USDA-SCS, 1989). The depth to the water table is greater than 72 inches (183 centimeters).

Table 2. Representative physiographic features

Landforms	(1) Plateau
Runoff class	Very low to low
Flooding frequency	None
Ponding frequency	None
Elevation	399–479 m
Slope	0–15%
Water table depth	183 cm
Aspect	Aspect is not a significant factor

Climatic features

Summary for this Ecological Site

Rainfall statistics were determined from PRISM rainfall raster data (PRISM, 2006). Representative (20th and 80th percentiles) values for mean annual precipitation range from 113 to 120 inches (2,870 to 3,050 millimeters) while actual (10th and 90th percentiles) values for mean annual precipitation range from 105 to 121 inches (2,675 to 3,070 millimeters). Extreme values range from 77 to 122 inches (1,955 to 3,100 millimeters). The average annual precipitation is 116 inches (2,945 millimeters) and the median annual average precipitation is 119 inches (3,020 millimeters).

Temperature statistics were determined from PRISM temperature raster data (PRISM, 2006) Representative (20th and 80th percentiles) values for mean annual temperatures is about 75 degrees F (24 degrees C) while actual (10th and 90th percentiles) values for mean annual temperatures are also about 75 degrees F (24 degrees C). Extreme values range from 75 to 79 degrees F (24 to 26 degrees C). The average annual temperature is 75 degrees F (24 degrees C), and the median annual temperature is also 75 degrees F (24 degrees C).

No suitable climate stations are available that are representative of this ecological site. As such the data presented in the climate normals tables below are from the PRISM data above.

General Principles

The climate is uniformly warm and humid throughout the year. Afternoon temperatures typically are about 86 degrees F (30 degrees C); nighttime temperatures are about 68 degrees F (20 degrees C). Relative humidity is 65 to 75 percent in the afternoon to 85 to 100 percent at night. Though temperature and humidity vary only slightly throughout the year, rainfall and wind conditions vary markedly. There are two main seasons, the dry

season from December through June and the rainy season from mid-July to mid-November. Moisture deficit occurs between January and June. Mean annual rainfall ranges from about 98 inches (2,490 millimeters) on the windward (eastern) side of the higher mountains to about 79 inches (2,005 millimeters) along the coast of the western side of the islands. On average, about 15 percent of the annual rainfall occurs during the dry season and 55 percent during the rainy season (Fosberg, 1960; USDA-SCS, 1988; USDA-SCS, 1989).

Throughout the year, the dominant winds are the trade winds that blow from the east or northeast. The trade winds are strongest and most constant during the dry season, when windspeeds of 15 to 25 mph (25 to 40 kph) are common. Coastal areas that have east, and northeast exposures are subject to salt spray and buffeting winds (Fosberg, 1960; USDA-SCS, 1988; USDA-SCS, 1989).

During the rainy season the trade winds may break down and be replaced by a weak, westerly monsoon influence that brings heavy showers or steady and sometimes torrential rains. The islands lie in the path of typhoons from the southeast and east. They bring heavy rains and violent winds that may result in a surge of water onto low-lying coastal areas. They occur most frequently during the latter half of the year. The chance of having one or more typhoons pass close to the islands in any particular year is about once in three years. The chance of having a typhoon move directly across an island is about once in eight years (Fosberg, 1960; USDA-SCS, 1988; USDA-SCS, 1989).

Table 3. Representative climatic features

Frost-free period (characteristic range)	365 days
Freeze-free period (characteristic range)	365 days
Precipitation total (characteristic range)	2,870-3,048 mm
Frost-free period (actual range)	365 days
Freeze-free period (actual range)	365 days
Precipitation total (actual range)	2,667-3,073 mm
Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	2,946 mm

Influencing water features

Number of National Wetland Inventory (NWI) features overlapping ecological site: Freshwater forested/shrub wetlands (30) and freshwater emergent wetlands (24) (USFWS, 2023).

Soil features

A moist phase of one soil component is associated with this ecological site; Luta (Entisols) (USDA-SCS, 1988; USDA-SCS, 1989). Soil temperature regimes are isohyperthermic; soil moisture regimes are ustic. They are shallow and well drained. The underlying coralline limestone is porous (USDA-SCS, 1989).

Table 4. Representative soil features

Parent material	(1) Limestone
Surface texture	(1) Cobbly clay loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderate
Depth to restrictive layer	25–41 cm
Soil depth	25–41 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0–15%
Available water capacity (0-101.6cm)	2.54 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-25.4cm)	7–7.2
Subsurface fragment volume <=3" (0-101.6cm)	8%
Subsurface fragment volume >3" (0-101.6cm)	13%

Ecological dynamics

The main human disturbance was phosphate mining. Feral pigs, feral cattle, and introduced deer are destructive to the forest (CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

The main natural disturbance is strong storms that can damage or kill vegetation by high

wind speeds. Natural fire is rare in forested areas due to the low amounts of fine fuels on the ground (CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

State and transition model

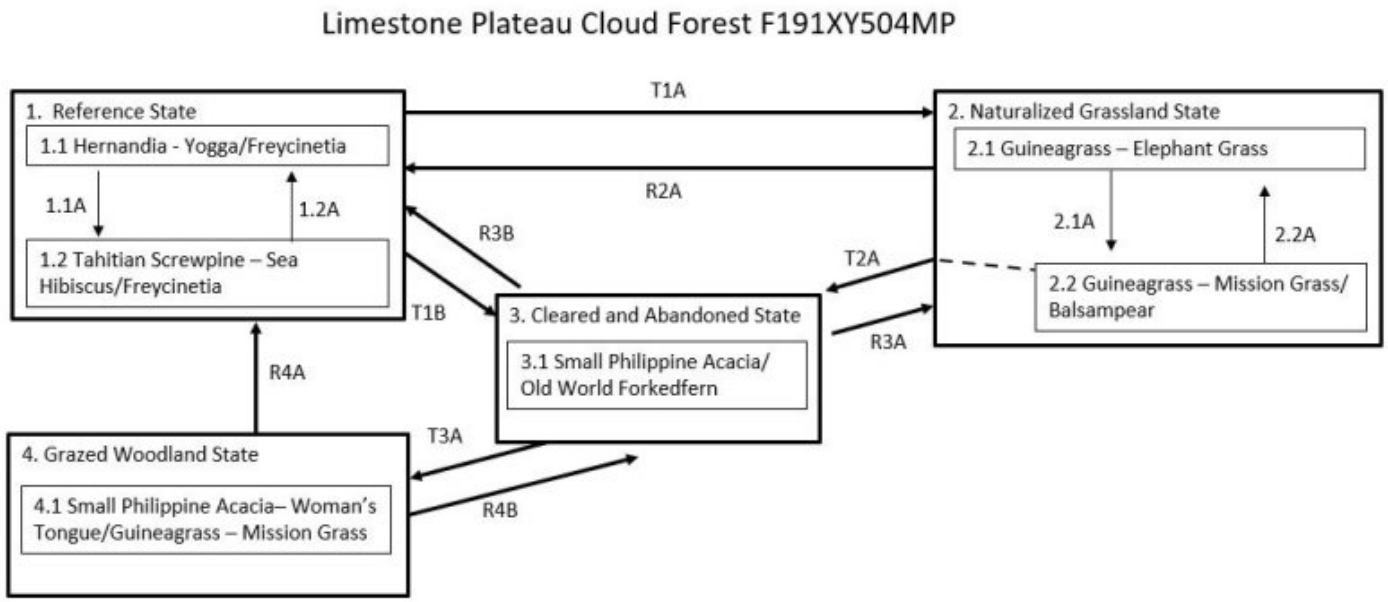

Figure 1. State-and-Transition Model for F191XY504MP (The Limestone Plateau Cloud Forest Ecological Site).

State 1
Reference State

The Reference State (1) has two community phases both consisting of a diverse native forest.

Community 1.1
Hernandia – Yogga/Freycinetia

Dominant canopy species are Elaeocarpus or yogga (*Elaeocarpus joga*), Hernandia (*Hernandia labyrinthica*), chelilai (*Fagraea berteroana* var. galilai), screwpine (Pandanus spp.), Pacific banyan (*Ficus prolixa* var. prolixa), fig (*F. tinctoria*), artocarpus (*Artocarpus mariannensis*), *Pipturus argenteus*, *Guamia mariannae*, and umbrella catchbirdtree (*Pisonia umbellifera*). Shrubs and many ferns inhabit the undergrowth. *Freycinetia reineckei* and alyxia (Alyxia spp.) are common lianas. A liana is a long-stemmed woody vine that is rooted in the soil at ground level and uses trees, as well as other means of vertical support, to climb up to the canopy in search of direct sunlight. Epiphytic ferns and orchids are abundant (Amidon et al., 2017; Falanruw et al., 1989; Fosberg, 1960; Liu and Fischer, 2008; Stone, 1970; Wagner and Grether, 1948; Willsey et al., 2019).

Dominant plant species

- (*Hernandia labyrinthica*), tree

- (*Elaeocarpus joga*), tree
- (*Freycinetia reineckei*), shrub

Community 1.2
Tahitian Screwpine – Sea Hibiscus/Freycinetia

Storm damage to dominant overstory trees allows fast-growing or abundant subdominant species to temporarily become more abundant. Some typical species include Tahitian screwpine (*Pandanus tectorius*), sea hibiscus (*Hibiscus tiliaceus*), and *Freycinetia reineckei* (CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

Dominant plant species

- Tahitian screwpine (*Pandanus tectorius*), tree
- sea hibiscus (*Hibiscus tiliaceus*), tree
- (*Freycinetia reineckei*), shrub

Pathway 1.1A
Community 1.1 to 1.2

Community phase 1.1 may shift to phase 1.2 by damage from powerful storms.

Pathway 1.2A
Community 1.2 to 1.1

Community phase 1.2 reverts to phase 1.1 by regrowth of the original dominant species if given enough time between strong storm events. Browsing and grazing by introduced ungulates may inhibit this process by destruction of tree seedlings.

State 2
Naturalized Grassland State

The Naturalized Grassland State (2) consists of two community phases consisting mostly of introduced grass species.

Community 2.1
Guineagrass – Elephant Grass

Guineagrass (*Urochloa maxima*) is the main grass species; elephant grass (*Pennisetum purpureum*) may also be abundant. These large grasses are very competitive, excluding many other species. Some leguminous forbs may be present, including calopo (*Calopogonium mucunoides*), flor de conchitas or centre (*Centrosema pubescens*), Sarawak bean (*Vigna hosei* Syn. Dolichos hosei), bonavist-bean or lablab (*Lablab purpureus* ssp. purpureus Syn. Dolichos lablab), Hawai'i ticktrefoil (*Desmodium*

sandwicense Syn. D. uncinatum), and greenleaf ticktrefoil (*D. intortum*) (CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

Dominant plant species

- guineagrass (*Urochloa maxima*), grass
- elephant grass (*Pennisetum purpureum*), grass

Community 2.2
Guineagrass – Mission Grass/Balsampear

Guineagrass (*Urochloa maxima*) is still common but has been heavily grazed, leaving openings for other species such as mission grass (*Pennisetum polystachion*) to invade the site. Unpalatable forbs such as balsampear (*Momordica charantia*) are common. Other possible common, but not abundant, species are romerillo (*Bidens alba*), scaly swordfern (*Nephrolepis hirsutula*), Philippine ground orchid (*Spathoglottis plicata*), monarch fern (*Phymatosorus scolopendria*), climbing hempvine (*Mikania scandens*), Jack in the bush (*Chromolaena odorata*), and Canadian horseweed (*Conyza canadensis*) (CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

Dominant plant species

- guineagrass (*Urochloa maxima*), grass
- mission grass (*Pennisetum polystachion*), grass
- balsampear (*Momordica charantia*), other herbaceous

Pathway 2.1A
Community 2.1 to 2.2

Community phase 2.1 will shift to phase 2.2 by overgrazing, which allows invasion by unpalatable grass and forb species.

Pathway 2.2A
Community 2.2 to 2.1

Community phase 2.2 will revert to phase 2.1 with properly managed grazing, which allows desirable species to gradually regain dominance, and possible spot weed control.

State 3
Cleared and Abandoned State

The Cleared and Abandoned State (3) consists of one community phase dominated by weedy, mostly introduced species.

Community 3.1

Small Philippine Acacia/Old World Forkedfern

Common species in this community phase are small Philippine acacia (*Acacia confusa*) and Old World forkedfern (*Dicranopteris linearis*). Guineagrass (*Urochloa maxima*) is still present in patches. Other abundant species may be mission grass (*Pennisetum polystachion*), giant false sensitive plant (*Mimosa diplotricha*), scaly swordfern (*Nephrolepis hirsutula*), Philippine ground orchid (*Spathoglottis plicata*), monarch fern (*Phymatosorus scolopendria*), climbing hempvine (*Mikania scandens*), Jack in the bush (*Chromolaena odorata*), and Canadian horseweed (*Conyza canadensis*) (CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

Dominant plant species

- small Philippine acacia (*Acacia confusa*), tree
- Old World forkedfern (*Dicranopteris linearis*), shrub

State 4
Grazed Woodland State

The Grazed Woodland State (4) consists of a variable mix of introduced tree species, sometimes with a few native species, that form a dense forest. Small Philippine acacia (*Acacia confusa*) may dominate, or other tree species may gradually invade a site. Cattle may forage in these forests, but carrying capacity is low (CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

Community 4.1
Small Philippine Acacia – Woman’s Tongue/Guineagrass – Mission grass

Small Philippine acacia (*Acacia confusa*) is often dominant, along with woman’s tongue (*Albizia lebbeck*). Other common introduced tree species are royal poinciana (*Delonix regia*) and African tulip tree (*Spathodea campanulata*). Possible native species are *Guamia mariannae*, *Melanolepis multiglandulosa*, and wild coffee (Psychotria spp). Invasive vines such as Jack in the bush (*Chromolaena odorata*) are likely to be present. Guineagrass (*Urochloa maxima*) and mission grass (*Pennisetum polystachion*) persist in sunny openings (CNMI SWARS Council, 2010; Donnegan et al., 2011; Liske-Clark, 2015; Willsey et al., 2019).

Dominant plant species

- small Philippine acacia (*Acacia confusa*), tree
- woman's tongue (*Albizia lebbeck*), tree
- guineagrass (*Urochloa maxima*), grass
- mission grass (*Pennisetum polystachion*), grass

Transition T1A
State 1 to 2

The Reference State (1) may transition to the Naturalized Grassland State (2) by mechanical clearing of the land followed by invasion by or planting of introduced forage species.

Transition T1B
State 1 to 3

The Reference State (1) may transition to the Cleared and Abandoned State (3) by clearing the forest, temporary cultivation of crops, abandonment, and invasion by mostly introduced species.

Restoration pathway R2A
State 2 to 1

The Naturalized Grassland State (2) can be restored to a facsimile of the Reference State (1) by suppressing the forage species and replanting native trees.

Transition T2A
State 2 to 3

The Naturalized Grassland State (2) will transition to the Cleared and Abandoned State (3) from community phase 2.1 if the forage species are reduced in cover and vitality by heavy grazing before abandonment, allowing invasion of the site by weedy shrub, forb, and vine species.

Restoration pathway R3B
State 3 to 1

The Cleared and Abandoned State (3) can be restored to a facsimile of the Reference State (1) by brush and weed control followed by replanting of native trees.

Restoration pathway R3A
State 3 to 2

The Cleared and Abandoned State (3) may be restored to the Naturalized Grassland State (2) by brush control, weed control, reseeding of desired forage species, and cutting back white leadtree to a shorter stature.

Transition T3A
State 3 to 4

The Cleared and Abandoned State (3) will transition to the Grazed Woodland State (4) by continued growth and spread of small Philippine acacia, possible invasion by other tree species, and closure of the overstory to shade out most shrubs, forbs, and grasses.

Restoration pathway R4A
State 4 to 1

The Grazed Woodland State (4) may be restored to a facsimile of the Reference State (1) by brush and weed control followed by replanting of native trees.

Restoration pathway R4B
State 4 to 3

The Grazed Woodland State (4) may be restored to the Cleared and Abandoned State (3) by clearing and abandoning the site, allowing lower-growing species that require sunlight to invade.

Additional community tables

Other references

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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	06/04/2025
Approved by	Curtis Talbot
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

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

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

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

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

    Dominant:

Sub-dominant:

Other:

Additional:

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

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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:**
