Ecological site VX159A01X002
Rocky Alluvium Naturalized Grassland
(Koa haole/guineagrass/glycine)

Last updated: 4/17/2025
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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): 159A–Humid and Very Humid Volcanic Ash Soils on Low and Intermediate Rolling Mountain Slopes

This MLRA occurs in the State of Hawaii on the windward, wetter sides of the islands of Hawaii and Maui. Elevation ranges from near sea level to 6000 feet (0 to 1830 meters). Topography is rolling mountain slopes that have been eroded by steep-sided gulches. In most of the area, volcanic ash is underlain by basic igneous rocks, although in some areas volcanic ash was deposited over cinders. Average annual precipitation in most of the area ranges from 120 to 200 inches (3050 to 5080 millimeters); extremes range from 70 inches to 300 inches (1780 to 7500 millimeters). Rainfall is well-distributed throughout the year with an enhanced rainy season from November through April. Average annual air temperatures range from 54 to 73 degrees F (12 to 23 degrees C) with little seasonal variation. The dominant soil order is Andisols with an isothermic or isohyperthermic soil temperature regime and udic or perudic soil moisture regime. Native vegetation consists of moderate to tall stature rain forests, low to medium stature dry forests, and “savannas” dominated by dense thickets of uluhe ferns.

Classification relationships

MLRA 159AY – Humid and Very Humid Volcanic Ash Soils on Low and Intermediate Rolling Mountain Slopes.

Ecological site concept

This ecological site is largely naturalized grassland at low elevations on the southern slope of Haleakala, near Kaupo Gap, on the Island of Maui. Much of the area is used for livestock grazing. Principal landowners are a large private ranch and numerous smaller, private holdings. The central concept of the Ustic Naturalized Grassland is well drained, moderately deep soils with mollic (high organic matter and high base saturation) properties that formed in volcanic ash or alluvium from basic igneous rock deposited over aa lava. Rock content (cobbles, stones, and gravel) is high throughout the soil profile. Annual air temperatures and rainfall create very warm (isohyperthermic), seasonally dry (ustic) soil conditions. Elevations range from sea level (0 meters) to about 1,800 feet (555 meters). Because very little of the original native vegetation remains, the reference state of this ecological site consists of the dominant, naturalized grassland vegetation. The dominant grass species is guineagrass (Urochloa maxima). Common naturalized trees are koa haole (Leucaena leucocephala) and christmasberry (Schinus terebinthifolius). The original native vegetation was dry forest. Common species, based on the environment and remnant occurrences, were lama (Diospyros sandwicense), alahee (Psydrax odorata), ohe makai (Polyscias sandwicensis), wiliwili (Erythrina sandwicensis), naio (Myoporum sandwicense), koaia (Acacia koaia), aalii (Dodonaea viscosa), ulei (Osteomeles anthyllidifolia), huehue (Cocculus orbiculatus), and native grasses.

Associated sites

VX158X01X004	**Rocky Isohyperthermic Torric Naturalized Grassland Kiawe/uhaloa/buffelgrass (Prosopis pallida/Waltheria indica/Pennisetum ciliare)** The Rocky Isohyperthermic Torric Naturalized Grassland borders this ecological site to the west. It receives less rainfall than this ecological site, resulting in different dominant introduced grass species and lower annual production than this ecological site. Both support typical native dry forest species

VX159A01X403	**Isohyperthermic Udic Naturalized Grassland (Guineagrass / Desmodium)** The Isohyperthermic Udic Naturalized Grassland borders this ecological site to the east. It receives more rainfall than this ecological site, resulting in the same dominant introduced grass species but with higher annual production than this ecological site. It supports a mix of native species typical to both dry and moist habitats.

Table 1. Dominant plant species

Tree	(1) *Leucaena leucocephala*
Shrub	Not specified
Herbaceous	(1) *Urochloa maxima* (2) *Neonotonia wightii*

Legacy ID

R159AY002HI

Physiographic features

This ecological site occurs on alluvial fans on sloping mountainsides of shield volcanoes. Lava flows are aa (loose, cobbly).

Table 2. Representative physiographic features

Landforms	(1) Shield volcano > Alluvial fan
Runoff class	Low to medium
Flooding frequency	None
Ponding frequency	None
Elevation	0 – 550 m
Slope	0 – 30 %
Water table depth	150 cm
Aspect	S

Table 3. Representative physiographic features (actual ranges)

Runoff class	Low to medium

Flooding frequency	None
Ponding frequency	None
Elevation	0 – 550 m
Slope	0 – 30 %
Water table depth	150 cm

Climatic features

(Unless otherwise cited, the information in this section is derived from Western Regional Climate Center, cited 2020).

Summary for this ecological site
Average annual precipitation is 50 inches (1270 millimeters). Extremes of average annual precipitation range from 35 inches to 65 inches (889 to 1651 millimeters). Most precipitation occurs from October through April. Average annual temperature is 75 degrees F (24 degrees C).

Table 4 Representative climatic features

Frost-free period (characteristic range)	370 days
Freeze-free period (characteristic range)	370 days
Precipitation total (characteristic range)	890-1,650 mm
Frost-free period (average)	
Freeze-free period (average)	
Precipitation total (average)	1,270 mm

Influencing water features

Ephemeral streams run in gulches after heavy rainfall.

Soil features

One soil series, Kaupo, is correlated with this small ecological site. It consists of well drained soils on alluvial fans. These soils developed in a mixture of volcanic ash and alluvium derived from basic igneous rock. The soil temperature regime is isohyperthermic (very warm). The soil moisture regime is ustic (in normal years, dry for more than 90 cumulative days but less than 180 days). Kaupo soils are moderately deep (20 to 40 inches or 50 to 100 centimeters). Soil pH is 6.4 in the surface horizon; subsurface soils within 30 inches (75 centimeters) of the surface have an extreme pH of 6.9.

The amounts of stones, cobbles, and gravel in these soils take up 35 to 50 percent of the whole soil volume in the upper 19 inches (47 centimeters) of the profile and 60 to 70 percent of the volume between depths of 19 to 27 inches (47 to 67 centimeters). Roots are described as “many” in the fine soil portion of the volume throughout these depths. The deepest horizon, starting at about 27 inches (67 centimeters) depth, consists of aa lava rock with very little soil material between the aa lava stones.

Kaupo soils are classified as Pachic Haplustolls (Mollisols soil order). Some of the important properties of Mollisols are a combination of a relatively thick, dark surface horizon (mollic epipedon) that does not become hard when dry, a dominance of calcium among the extractable cations, high organic matter content, and a dominance of crystalline clay minerals of moderate to high cation-exchange capacity. Kaupo soils have thicker (“pachic”) mollic epipedons than other Haplustolls. These properties mean that plant nutrients are abundant, conditions for root penetration are favorable, and water holding capacity is good. Although Mollisols usually form under grass in seasonally-dry climates, Kaupo soils probably formed under a dry forest ecosystem.

Table 5. Representative soil features

Parent material	(1) Volcanic ash – igneous rock (2) Alluvium – igneous rock
Surface texture	(1) Extremely stony silty clay (2) Very stony silty clay loam
Drainage class	Well drained
Permeability class	Moderately rapid
Depth to restrictive layer	70 cm
Soil depth	50 – 100 cm
Surface fragment cover <=3"	Not specified
Surface fragment cover >3"	0 – 10 %
Available water capacity (0-101.6cm)	6.86 cm
Soil reaction (1:1 water) (0-25.4cm)	6.4
Subsurface fragment volume <=3" (0-101.6cm)	20 %
Subsurface fragment volume >3" (0-101.6cm)	100 %

Table 6. Representative soil features (actual values)

Drainage class	Not specified
Permeability class	Not specified
Depth to restrictive layer	Not specified
Soil depth	Not specified
Surface fragment cover <=3"	0 %
Surface fragment cover >3"	0 – 10 %
Available water capacity (0-101.6cm)	6.86 cm
Soil reaction (1:1 water) (0-25.4cm)	Not specified
Subsurface fragment volume <=3" (0-101.6cm)	20 %
Subsurface fragment volume >3" (0-101.6cm)	100 %

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

There have been no lava flows or heavy volcanic ash flows on this ecological site that are recent enough to have affected the current vegetation and soils. Young lava flows 750 to 1500 years old adjoin this site, and 3000 to 5000 year old flows are within the site. Future flows within the site are possible that may start wildfires that could be carried by some of the introduced grass, fern, and shrub species present. Strong storms may sometimes cause minor windthrow of trees. Wildfires started by lightning rarely may affect this ecological site.

Human Disturbances

Human-related disturbances have been more important than natural disturbances in this ecological site since the arrival of Polynesians and, later, Europeans. This is reflected in the State and Transition Model Diagram.

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); some pollen core data suggest that up to 100 percent of lowlands may have been altered (Athens 1997). By the time of European contact late in the 18th century, the Polynesians had developed high population densities and placed large areas under intensive agriculture (Cuddihy and Stone 1990).

Prehistoric native lowland forest disturbance can be attributed to clearing for agriculture by hand or by fire, introduction of new plants, animals, possibly plant diseases, and wood harvesting. The introduced Pacific rat would have eaten bird eggs, invertebrates, and the seeds of native plants (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. After European discovery, 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. Additionally, packs of feral dogs had become established, as confirmed by reports of their depredations on sheep. By 1851, records reported severe overstocking of pastures, lack of fences, and large numbers of feral livestock (Henke 1929).

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 (including deer), birds, reptiles, amphibians, invertebrates, plants, and microorganisms, have brought about dramatic changes to wild ecosystems in Hawaii. Much of the original forest of this ecological site was cleared and converted to grazing land, and the remaining native plant communities have been highly disturbed.

The most important disturbances currently affecting this ecological site are domestic livestock, introduced mammals, and introduced, weedy plant species.

State and transition model

Figure 1. STM for R159AY002HI Rocky Alluvium Naturalized Grassland

Additional community tables

Table 7. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 8. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 9. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 10. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 11. Community 4.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 12. Community 5.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Other references

Definitions
These definitions have been greatly simplified for brevity and do not cover every aspect of each topic.

Aa lava: A type of basaltic lava having a rough, jagged, clinkery surface and a vesicular interior.

Alluvial: Materials or processes associated with transportation and/or deposition by running water.

Ash field: a land area covered by a thick or distinctive deposit of volcanic ash that can be traced to a specific source and has well defined boundaries. The term “ash flow” is erroneously used in the Physiographic section of this ESD due to a flaw in the national database.

Ashy: A “soil texture modifier” for volcanic ash soils having a water content at the crop wilting point of less than 30 percent; a soil that holds relatively less water than “medial” and “hydrous” soils.

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

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, duration, and depth 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.

Ion exchange capacity: The ability of soil materials such as clay or organic matter to retain ions (which may be plant nutrients) and to release those ions for uptake by roots.

Isohyperthermic soil temperature regime: A regime in which mean annual soil temperature is 72 degrees F (22 degrees C) or higher 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.

Mollisols: Soils with relatively thick, dark surface horizons, high cation-exchange capacity, high calcium content, that do not become hard or very hard when dry. Mollisols are conducive to plant growth. They characteristically form under grass in climates that are seasonally dry, but can form under forests.

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.

Pachic Haplustolls: These soils have a thick mollic epipedon. Some of the soils receive runoff but little sediment from the higher adjacent soils.

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

Perudic soil moisture regime: A very wet regime found where precipitation exceeds evapotranspiration in all months of normal years. On the island of Hawaii, this regime is found on top of Kohala and on parts of the windward side of Mauna Kea.

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.

Ustic soil moisture regime: A regime in which moisture is limited but present at a time when conditions are suitable for plant growth. In Hawaii it usually is associated with dry forests and subalpine shrublands.

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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	09/28/2026
Approved by	
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):**

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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:**
