

Ecological site VX161A01X009

Isothermic Ustic Naturalized Grassland

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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): 161A–Lava Flows and Rock Outcrops

This MLRA occurs in the State of Hawaii on the Big Island of Hawaii and to a small extent on Maui. Elevation ranges from sea level to 13,796 feet (0 to 4,206 meters), which includes the tops of Mauna Kea, Mauna Loa, Haleakala, Kilauea, and Hualalai volcanoes. Slopes follow the undulating to very steep topography of the lava flows. The terrain includes barren lava flows, rocky cliffs, rock outcrops, and steep cinder cones. Lava flows are basaltic aa or pahoehoe lava. Average annual precipitation ranges from 10 to 100 inches (255 to 2,540 millimeters). Most of the rainfall occurs from October through March in most areas and from May through September in the Kona area of the Big Island. In Kona and isolated areas elsewhere, afternoon fog accumulation at higher elevations adds significant moisture by fog drip and ameliorates evapotranspiration. This effect is cut off sharply at the atmospheric inversion layer at about 6,000 feet (about 2,000 meters) elevation. Average annual air temperatures range from 38 to 76 degrees F (3 to 25 degrees C), with little seasonal variation. Freezing temperatures occur at the highest elevations. Dominant soils are Andisols and Histosols with isohyperthermic to isofrigid soil temperature regimes and ustic to udic soil moisture regimes. Large parts of the MLRA consist of miscellaneous (nonsoil) areas, including lava flows, rock outcrop, and cinder land. Native vegetation varies considerably as temperature, moisture, and soil development vary with elevation and flow age. In the driest areas near sea level, sparse, low-stature shrubs, grasses, and forbs predominate. Vegetation stature and density gradually increase with elevation to typical dry forest species such as lama, wiliwili, and alahee, koa-mamane-sandalwood or mamane-sandalwood forest, open ohia-lovegrass savanna, and finally sparse subalpine vegetation with silversword, shrubs, and grasses. Vegetation is extremely sparse at the highest elevations.

Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 161A – Lava Flows and Rock Outcrops.

Ecological site concept

This ecological site occurs on the southeastern side of the island of Hawaii. Most of the ecological site is within Volcanoes National Park. Some is on private ranches. The central concept of the Isothermic Ustic Naturalized Grassland is of well drained, very shallow to moderately deep soils formed in volcanic ash; most are in the Andisols soil order. Soil temperature regimes are isothermic; soil moisture regimes are ustic and, in some areas, ustic/udic intergrade or udic. Available water holding capacity is low due to ashy or sandy textures, high rock contents, shallow depths, and/or vitric (high volcanic glass content) mineralogy. Mean annual rainfall ranges from 40 to 80 inches (1000 to 2000 mm). Elevations range from 1000 to 4000 feet (310 to 1230 m). Common introduced grass species are kikuyugrass (*Cenchrus clandestinus*), common velvetgrass (*Holcus lanatus*), rose Natal grass (*Melinis repens*), broomsedge bluestem (*Andropogon virginicus*), and thatching grass (*Hyparrhenia rufa*). Common native trees include koa (*Acacia koa*) and ohia lehua (*Metrosideros polymorpha*); common native shrubs include pukiawe (*Styphelia tameiameia* syn. *Leptocophylla tameiameia*), ulei (*Osteomeles anthyllidifolia*), and aalii (*Dodonaea viscosa*).

Associated sites

VX161A01X008	Isohyperthermic Ustic Naturalized Grassland ISOHYPERTHERMIC USTIC NATURALIZED GRASSLAND. Both ecological sites occur only on the island of Hawaii. The Isohyperthermic Ustic Naturalized Grassland occurs at lower, warmer elevations than this ecological site. Both ecological sites have shallow soils developed in young volcanic ash fields deposited over young lava flows. Soil water holding capacities are similarly low in both ecological sites. The Isohyperthermic Ustic Naturalized Grassland supports less productive, sparser vegetation than this ecological site and guineagrass rather than the kikuyugrass and cool-season (C3) grasses of this ecological site.
VX159B01X500	Udic Forest UDIC FOREST. Both ecological sites occur only on the island of Hawaii. The Udic Forest occurs partly at higher elevations that are somewhat cooler and moister than this ecological site. Where the two ecological sites overlap in elevation, temperature, and rainfall, the deeper soils, older substrates, greater soil water holding capacity, and older, more developed vegetation communities have created tall, diverse, multi-canopy rainforest rather than the open forests of this ecological site.
VX159A01X500	Well Drained Udic and Perudic Forest WELL DRAINED UDIC AND PERUDIC FOREST. Both ecological sites occur only on the island of Hawaii. The Deep and Very Deep Volcanic Ash Forest occurs partly at higher elevations that are somewhat cooler and much moister than this ecological site. Where the two ecological sites overlap in elevation, temperature, and rainfall, the deeper soils, older substrates, greater soil water holding capacity, and older, more developed vegetation communities have created tall, diverse, multi-canopy rainforest rather than the open forests of this ecological site.
VX162X01X503	Udic Isothermic Forest SHALLOW WET OHIA-OLAPA FOREST. Both ecological sites occur only on the island of Hawaii. The Shallow Wet Ohia-Olapa Forest occurs at similar elevations with similar temperatures but higher rainfall than this ecological site. Landforms and soils are similarly young on both ecological sites, but the much higher weathering rates and vegetation production occurring in the wetter climate creates a dense, mostly low stature rainforest rather than the open forests of this ecological site.

Table 1. Dominant plant species

Tree	(1) <i>Metrosideros polymorpha</i> (2) <i>Acacia koa</i>
Shrub	(1) <i>Dodonaea viscosa</i> (2) <i>Styphelia tameiameiae</i>
Herbaceous	(1) <i>Andropogon virginicus</i>

Legacy ID

R161AY009HI

Physiographic features

This ecological site occurs on ash fields deposited over lava flows on sloping mountainsides of shield volcanoes. Lava flows are aa (loose, cobbly) or pahoehoe (smooth, relatively unbroken).

Table 2. Representative physiographic features

Landforms	(1) Shield volcano > Lava flow (2) Shield volcano > Ash field (3) Shield volcano > Mountainside
Runoff class	Very low to very high
Flooding frequency	None
Ponding frequency	None
Elevation	310 – 1,220 m
Slope	0 – 20 %
Water table depth	150 cm
Aspect	SE, S, SW

Table 3. Representative physiographic features (actual ranges)

Runoff class	Not specified
Flooding frequency	Not specified
Ponding frequency	Not specified
Elevation	Not specified
Slope	0 – 40 %
Water table depth	Not specified

Climatic features

Summary for this ecological site

Average annual precipitation in this ecological site ranges from 40 to 80 inches (1000 to 2000 mm). Extremes of average annual precipitation range as low as 30 inches (750 mm) where this ecological site grades into a neighboring drier, lower elevation ecological site. Most of the precipitation occurs from October through April. Average annual temperatures range from 60 to 69 degrees F (16 to 20 degrees C). Rainfall occurs as trade wind showers that drift over or around Mauna Loa from the windward side of the island and as heavier rainfall during major winter storms. Major storms are important for soil moisture recharge, and the number of major storms is highly variable; drought can result from a winter with few or no storms. Due to the latitude, daylength varies little during the year, resulting in only about a 50 percent variation in solar energy input between June maximum to December minimum; this variation is somewhat less

than that found in the continental United States.

Table 4 Representative climatic features

Frost-free period (characteristic range)	370 days
Freeze-free period (characteristic range)	370 days
Precipitation total (characteristic range)	1,020-2,030 mm
Frost-free period (actual range)	370 days
Freeze-free period (actual range)	370 days
Precipitation total (actual range)	760-2,030 mm
Frost-free period (average)	370 days
Freeze-free period (average)	370 days
Precipitation total (average)	1,520 mm

Influencing water features

This ecological site has no perennial water features. Intermittent streams occur at lower elevations within this ecological site.

Soil features

Most of the soils correlated with this ecological site are in the Andisols soil order that formed in recent deposits of volcanic ash, eolian sand, and pumice. Soil temperature regimes are isothermic (warm). Soil moisture regimes are mostly ustic (in normal years, dry for more than 90 cumulative days but less than 180 days), although some soils are ustic/udic intergrades or udic ((in most years, not dry for as long as 90 cumulative days).

Table 5. Representative soil features

Parent material	(1) Basic volcanic ash – basalt (2) Eolian sands
Surface texture	(1) Ashy sand (2) Medial loam (3) Ashy sandy loam (4) Ashy silt loam

Family particle size	(1) Ashy (2) Fragmental (3) Medial (4) Sandy
Drainage class	Well drained to somewhat excessively drained
Permeability class	Very slow to moderately rapid
Depth to restrictive layer	10 – 100 cm
Soil depth	10 – 180 cm
Surface fragment cover <=3"	10 – 70 %
Surface fragment cover >3"	10 – 50 %
Available water capacity (0-101.6cm)	1.52 – 10.16 cm
Calcium carbonate equivalent (0-101.6cm)	Not specified
Electrical conductivity (0-101.6cm)	Not specified
Sodium adsorption ratio (0-101.6cm)	Not specified
Soil reaction (1:1 water) (0-101.6cm)	3.5 – 7.8
Subsurface fragment volume <=3" (0-101.6cm)	10 – 80 %

Subsurface fragment volume >3" (0-101.6cm)	0 – 50 %
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Table 6. Representative soil features (actual values)

Drainage class	Well drained to excessively drained
Permeability class	Not specified
Depth to restrictive layer	Not specified
Soil depth	Not specified
Surface fragment cover <=3"	10 – 80 %
Surface fragment cover >3"	Not specified
Available water capacity (0-101.6cm)	0 – 20.32 cm
Calcium carbonate equivalent (0-101.6cm)	Not specified
Electrical conductivity (0-101.6cm)	Not specified
Sodium adsorption ratio (0-101.6cm)	Not specified
Soil reaction (1:1 water) (0-101.6cm)	2.9 – 7.8
Subsurface fragment volume <=3" (0-101.6cm)	10 – 90 %

Subsurface fragment volume >3" (0-101.6cm)	Not specified
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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.

States and community phases within this ecological site were differentiated by inspection of data; ordination programs were not available. They were verified by professional consensus and observation of examples in the field.

Natural Disturbances

The important natural disturbances in this ecological site are lava flows and volcanic ash falls. Lava flows cover existing soils and destroy all vegetation, causing soil and biological succession to restart. Lava flows also ignite nearby vegetation. The original native vegetation was able to carry fire to some extent. Deep ash falls may destroy some or all vegetation but provide a substrate that allows for relatively rapid revegetation. Shallow ash falls may leave existing vegetation fairly intact.

Human Disturbances

The most important human-related disturbances in the ecological site are clearing forests to create grazing land, foraging and trampling by feral ungulates, invasion by introduced plant and animal species, and fire. Introduced vegetation, especially grasses and some fern species, are very susceptible to catching fire and have a high capacity to carry fire.

State and transition model

Figure 1. State and Transition Model for R161AY00 (Isothermic Ustic Naturlized Grassland)

Additional community tables

Table 7. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 8. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 9. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 10. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 11. Community 4.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 12. Community 5.1 plant community composition

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

Andisols: Andisols are soils formed in volcanic ash and defined as soils containing high proportions of glass and amorphous colloidal materials, including allophane, imogolite and ferrihydrite.

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.

CaCO₃ 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, 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.

Isofrigid soil temperature regime: A regime which has mean annual soil temperatures of greater than 32 degrees F (0 °C), but less than 46.4 (8 °C), with a difference between mean summer and mean winter soil temperatures of less than 41 degrees F (5 °C) at a specified depth.

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.

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.

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.

Pahoehoe lava: A type of basaltic lava with a smooth, billowy, or rope-like surface and vesicular interior.

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 of 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	10/09/2026
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):

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:
