

Ecological site VX159A01X501

Pahoehoe Histosol Woodland

Ohia lehua - pandanus/uluhe (Old World forkedfern)

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

This ecological site occurs within Major Land Resource Area (MLRA) 159A - Humid and Very Humid Organic Soils on Lava Flows.

Ecological site concept

This ecological site located in a small area on the coast of East Maui near Hana Airport and the National Tropical Botanical Garden, north of Highway 36. Much of the area is owned by the State of Hawaii and the Botanical Garden; some is on small private parcels. The central concept of the Pahoehoe Histosol Woodland is of well drained, very shallow soils formed in deposits of highly decomposed plant material over pahoehoe (flat lava flows). Lava flows are young, ranging from 750 to 1500 years old. Annual air temperatures and rainfall create hot (isohyperthermic), moist (udic) soil conditions. These soils support a woodland consisting of a thicket of dense, deep (to 13 feet or 4 meters), uluhe fern (*Dicranopteris linearis*) with sparse to open emergent canopy of ohia lehua (*Metrosideros polymorpha*) that is 30 to 50 feet (9 to 15 meters) tall.

Associated sites

VX159A01X003	Isohyperthermic Perudic Naturalized Grassland (Guineagrass - Californiagrass) The Isohyperthermic Udic and Perudic Naturalized Grassland surrounds this ecological site. It has the same climate but has much deeper soils, resulting in higher annual production of grasses and a taller statured and much more diverse forest.
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Similar sites

VX162X01X504	Pahoehoe Organic Fern Savanna The Pahoehoe Organic Fern Savanna occurs on the island of Hawaii. It is much larger in extent than this ecological site but has very similar climate and soils, resulting in very similar vegetation.
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Table 1. Dominant plant species

Tree	(1) <i>Metrosideros polymorpha</i> (2) <i>Pandanus tectorius</i>
Shrub	Not specified
Herbaceous	(1) <i>Dicranopteris linearis</i>

Legacy ID

F159AY501HI

Physiographic features

This ecological site occurs on a small area of young lava flows on the toe slope of Haleakala volcano. Lava flows are pahoehoe (smooth, relatively unbroken).

Table 2. Representative physiographic features

Landforms	(1) Shield volcano > Pahoehoe lava flow
Runoff class	Low to medium
Flooding duration	Extremely brief (0.1 to 4 hours)
Flooding frequency	Very rare to occasional
Ponding duration	Long (7 to 30 days)
Ponding frequency	None to frequent
Elevation	0 – 370 m
Slope	0 – 30 %
Ponding depth	0 – 10 cm
Water table depth	150 cm
Aspect	N

Climatic features

Summary for this ecological site

Average annual precipitation is 79 inches (2006 millimeters). Extremes of average annual precipitation may range as low as 50 inches (1270 mm) and as high as 125 inches (3175 mm). Most of the precipitation falls from October through April. Average annual temperature is 72 to 74 degrees F (22 to 23 degrees C).

Table 3 Representative climatic features

Frost-free period (characteristic range)	370 days
Freeze-free period (characteristic range)	370 days
Precipitation total (characteristic range)	1,650-2,310 mm
Frost-free period (actual range)	370 days
Freeze-free period (actual range)	370 days
Precipitation total (actual range)	1,270-3,180 mm
Frost-free period (average)	370 days
Freeze-free period (average)	370 days
Precipitation total (average)	2,010 mm

- (1) HANA AP 355 [USC00511125], Hana, HI

Influencing water features

There are no water features associated with this ecological site.

Soil features

This small ecological site is correlated with Opihikao extremely rocky muck, 3 to 25 percent slopes, as named in the 1972 Soil Survey. This soil formed in highly decomposed organic matter and small amounts of volcanic ash deposited over pahoehoe lava. Its depth is two to five inches (5 to 13 centimeters). The soil temperature regime is isohyperthermic (very warm); the soil moisture regime is udic (the soil is typically moist throughout the profile but may experience periodic drying of the control section less than 90 cumulative days). Soil pH is 4.9 throughout the very shallow profile.

The organic soils of the Island of Maui are classified in the Histosols soil order. They were formed in high decomposed parent material consisting of decomposed leaves, twigs, and wood with small amounts of basic volcanic ash, cinders, and weathered lava. Some of these soils contain slightly or moderately decomposed parent material, especially at or near the soil surface. Unlike many organic soils such as peat or muck that formed in long-term water-saturated conditions, these organic soils formed by accumulation and transformation of litter on dry surfaces of lava rock or in gaps between lava rocks. These organic soils are referred to as litter or an O horizon.

Opihikao soils are classified as "euic," which means they have relatively high base saturation as indicated by a pH of 4.5 or higher.

Histosols on pahoehoe lava tend to be shallow (less than 20 inches or 50 centimeters) or very shallow (less than 10 inches or 25 centimeters). Pahoehoe is referred to as a "lithic contact," which is a boundary between soil and underlying material that is coherent,

continuous, difficult to dig with a spade, and contains few cracks that can be penetrated by roots (Soil Survey Staff 1999). When depth of soil to pahoehoe is less than 18 cm (7.2 inches), the soil is referred to as “micro.” Pahoehoe is typically very limiting to root penetration due to the spacing and size of cracks. However, this characteristic of pahoehoe is variable, and there are many instances of large trees growing on very shallow and shallow soils over pahoehoe. In some locations, the pahoehoe has cracked completely through and has been partly upended. Then the lava behaves more like aa, supporting denser tree stands, typically of hala (*Pandanus tectorius*) in this ecological site.

Ripping and crushing lava by heavy machinery transforms these organic soils into Arents, which basically means sandy (the “Ar” or arenic; think of a sandy arena) soils with little or no natural horizon development (the “ents” or Entisols). Ripping pahoehoe lava eliminates the root-limiting layer of the lava. Crushing of ripped pahoehoe fragments reduces the size of the fragments and the gaps between them and creates some finer, sand-sized particles. As much as 50 percent of the original organic matter can be lost in this process due to oxidation, but the resulting Arents are more suitable for agricultural operations. Arents are very susceptible to weed invasion, but there have been apparently successful attempts at restoration of native plant species on them.

Table 4. Representative soil features

Parent material	(1) Organic material – pahoehoe lava (2) Volcanic ash – pahoehoe lava
Surface texture	(1) Extremely stony
Drainage class	Well drained
Permeability class	Very slow
Depth to restrictive layer	10 cm
Soil depth	10 cm
Surface fragment cover ≤3"	Not specified
Surface fragment cover >3"	Not specified
Available water capacity (0-12.7cm)	2.54 cm
Soil reaction (1:1 water) (0-12.7cm)	4.9
Subsurface fragment volume ≤3" (0-12.7cm)	Not specified

Subsurface fragment volume >3" (0-12.7cm)	Not specified
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Table 5. Representative soil features (actual values)

Drainage class	Well drained
Permeability class	Very slow
Depth to restrictive layer	10 cm
Soil depth	10 cm
Surface fragment cover <=3"	0 %
Surface fragment cover >3"	0 %
Available water capacity (0-12.7cm)	2.54 cm
Soil reaction (1:1 water) (0-12.7cm)	4.5 – 5.5
Subsurface fragment volume <=3" (0-12.7cm)	0 %
Subsurface fragment volume >3" (0-12.7cm)	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

Lava flows in this ecological site are all recent, having occurred within the past 750 to 1500 years. These very young surfaces have not received many inputs of volcanic ash, so soils are very shallow and consist of highly decomposed organic matter. These very young soils support natural stands of largely pioneer plant species that arrive from surrounding areas and small kipukas.

Human Disturbances

Human-related disturbances have been much 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)). This ecological site occurs within that elevation range, but human habitation has been inhibited by two factors. First, the deep, dense thickets of uluhe fern are nearly impenetrable in many areas. Second, the soils on this ecological site are not suitable for agriculture. Soils over large areas are only 2 to 5 inches (5 to 13 centimeters) deep, underlain by pahoehoe lava with low water holding capacity, and consisting of highly decomposed organic matter. Areas with cracked, uplifted pahoehoe support dense stands of pandanus or Tahitian screwpine (*Pandanus tectorius*) that may have been harvested for fiber.

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). 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.

Little of the original vegetation of this ecological site appears to be intact. The native plant community has been highly disturbed and, in some places, destroyed due to wildfires, clearing followed by abandonment, crushing and ripping of surface lava flows by heavy equipment to produce flat lawns, domestic and feral ungulate foraging, and invasion by introduced species. Introduced weeds are abundant in disturbed areas.

State and transition model

Figure 7. STM for F159AY501HI Pahoehoe Hisosol Woodland

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 7. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 8. Community 3.1 plant community composition

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

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

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.

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.

Kipuka: An area of land surrounded by younger (more recent) lava. Soils and plant communities within a kipuka are older than, and often quite different from, those on the surrounding surfaces.

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.

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 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.

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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	10/04/2026
Approved by	
Approval date	

Composition (Indicators 10 and 12) based on	Annual Production
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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:
