USDA Natural Resources Conservation Service

Ecological site VX159A01X009
Isothermic Aquic Bog

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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.

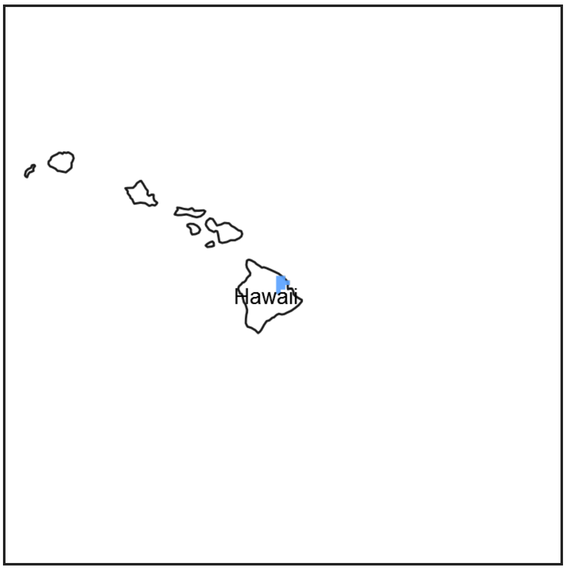

Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

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 6,000 feet (about 2000 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 (3000 to 5000 millimeters); extremes range from 70 inches to 300 inches (1750 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 medium to tall statured rain forest and open bogs.

Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 159A - Humid and Very Humid Volcanic Ash Soils on Low and Intermediate Rolling Mountain Slopes.

Ecological site concept

This ecological site is a system of open bogs scattered within the very wet, higher portions of windward Mauna Kea. It is mostly found within State Forest Reserves, with minor examples existing on private land. No public roads provide direct access to it.

The central concept of the Isothermic Aquic Bog is of very poorly drained, deep to very deep soils consisting of a layer of organic muck overlying deposits of mucky volcanic ash ranging from 100,000 to 300,000 years old. Annual temperatures are warm and rainfall is very high year-round, creating warm (isothermic), water-saturated and anaerobic (aquic) soils. Vegetation is an open bog with native and introduced grasses, sedges, and rushes of small stature growing in very shallow, standing or slowly moving water.

Associated sites

VX159A01X504	**Moderately Well Drained Perudic Forest** R159AY009 is associated with F159AY504 Isothermic Perudic Forest, which is on slightly higher microtopographic sites and has better drained soils than R159AY009. These better drained soils allow F159AY504 to support medium stature ohia forest, whereas R159AY009 is a bog with only grasses and sedges. The forests of R159AY009 surround the bogs.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Eleocharis obtusa* (2) *Deschampsia nubigena*

Legacy ID

R159AY009HI

Physiographic features

This ecological site occurs on ash fields on the side of Mauna Kea volcano. Volcanic ash fields range from deep to very deep on the underlying lava. Within the broader landscape, this ecological site occurs in microdepressions and at foot slopes where water collects.

Table 2. Representative physiographic features

Landforms	(1) Bog (2) Shield volcano
Flooding frequency	None
Ponding duration	Very long (more than 30 days)
Ponding frequency	Frequent
Elevation	1,100–5,300 ft
Slope	0–6%
Ponding depth	1–3 in
Water table depth	0–12 in
Aspect	NE

Climatic features

IMPORTANT NOTE: The climate data on the tables below come from the nearest available station with complete data. This station approximates the temperature and precipitation PATTERNS but not the actual temperature DEGREES and rainfall AMOUNTS. The temperatures shown are probably fairly close to those of this ecological site, but the actual rainfall amounts would be 2 to 3 times the amounts shown on the tables below.

The mean annual precipitation of this ecological site is about 230 inches (5840 millimeters)and ranges from 200 to 240 inches (5000 to over 6100 millimeters). The mean annual temperature is about 60 degrees F (16 degrees C) and ranges from 59 to 69 degrees F (15 to 21 degrees C). These estimates are based on modeled climate maps and incomplete and/or historic data sets from multiple stations compiled by NRCS Hawaii Soil Survey.

This ecological site is often shrouded in dense fog, which can be captured by trees and shrubs in closely adjoining (often complexed) ecological sites and channeled into the soil; additionally, fog reduces evapotranspiration. The actual amounts of fog drip in this ecological site have yet to be estimated.

Table 3. Representative climatic features

Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	105 in

Climate stations used

- (1) KULANI CAMP 79 [USC00515011], Hilo, HI

Influencing water features

These sites are saturated to the soil surface or ponded to a few inches deep during much of the year. In places the shallow ponded water may have a slow general flow in a slight downhill direction.

Soil features

This ecological site exists on Onomea series soils. This series consists of deep and very deep soils that formed at foot slopes and in microdepressions in organic matter and volcanic ash over basaltic lava. The surface horizon of the soil consists of organic muck. Horizons deeper than about 6 inches (15 centimeters)contain iron depletions and/or concentrations indicative of anaerobic conditions. Onomea soils are very poorly drained and are typically saturated to the surface; they may remain wet between the surface and 12 inches (30 centimeters) depth during the drier season of June through August.

Permeability is moderately slow in the Oa and Bg horizons and slow to very slow in the Bhs horizon and underlying bedrock. The soil moisture regime is aquic (defined as a mostly reducing soil moisture regime nearly free of dissolved oxygen due to saturation by groundwater or its capillary fringe and occurring at periods when the soil temperature at 50 cm below the surface is >5°C.).

Onomea soils often are complexed with Akaka soils, which are at slightly higher landscape positions and moderately well drained. The ecological site on Akaka soils is F159AY504 Isothermic Perudic Forest, which consists of small to medium height trees, tree ferns, small, and thickets of uluhe fern.

Figure 6. Onomea soil.

Table 4. Representative soil features

Surface texture	(1) Mucky (2) Muck
Drainage class	Very poorly drained
Permeability class	Moderately slow to very slow
Soil depth	41–60 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	14–15 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	5.9–6.2
Subsurface fragment volume <=3" (Depth not specified)	0–30%
Subsurface fragment volume >3" (Depth not specified)	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.

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 consistent examples in the field.

This ecological site consists of bogs occurring on deep and very deep soils derived from volcanic ash in warm, very wet regions of South Hilo and North Hilo districts of the Island of Hawaii. It occurs mostly from 2700 to 3850 feet (830 to 1185 meters), but small, isolated examples occur from about 1900 to about 5000 feet (585 to 1540 meters). It evolved without the presence of large mammals or the regular occurrence of fires. Most of this ecological site is nearly inaccessible on foot. Small examples can be easily reached on foot from lower elevations. Despite this inaccessibility, even remotely located examples that we observed were dominated by introduced plant species. Pigs and feral cattle may disturb these bogs and encourage the success of introduced plant species, and seeds of introduced plant species may be brought in by birds and other animals.

This ecological site occurs only on Onomea soils, which are found only as major components complexed with other soils or as minor components within map units. It is intimately complexed on the landscape with two other ecological sites and their associated soils. Onomea soils support bog vegetation consisting primarily of grasses, rushes, and sedges. The transition from bog vegetation on aquic Onomea soils to Isothermic Perudic Forest (F159AY504) is typically abrupt, occurring with slight changes in micro-elevation and drainage. Kaiwiki soils support tall, diverse forest (F159AY500HI Isothermic Udic Forest) on still higher micro-elevations and steeper slopes. In many areas, the underlying landscape consists of a series of ridges and lowlands that support all three of these ecological sites in close proximity.

An interesting observation is the common occurrence of very large (>36 inch dbh) downed logs and snags within the surrounding Isothermic Perudic Forest, indicating the presence of a very different forest type on these sites at some time in the past. Additionally, the aquic Onomea soils of the Isothermic Aquic Bog contain coarse pieces of wood at depth. The gradual formation of drainage-impeding soil horizons containing accumulated humus and precipitated iron compounds provides a reasonable hypothesis for the transformation of tall-stature forest to medium-stature forest to treeless bog (Hodges et al. 1986).

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 well above that elevation. However, this ecological site may have been affected by factors such as inadvertently introduced plant diseases and seed predation by the introduced Pacific Rat (Athens 1997).

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

The Polynesians introduced dogs, Pacific rats, and small pigs to the islands. Cattle, sheep, horses, goats, and larger European pigs were introduced in the final decades of the 18th century. These animals ranged free on the islands, becoming very numerous and destructive by the early decades of the 19th century (Henke 1929). The most destructive introduced animals in this remote ecological site have been feral pigs and cattle.
Through the 20th and into the 21st centuries, increases in human populations with attendant land development, as well as accelerated introduction of non-native mammals, birds, reptiles, amphibians, invertebrates, plants, and microorganisms, have brought about dramatic changes to wild ecosystems in Hawaii. The soils of most of the original area of this ecological site remains fairly intact. However, the native plant community in many and possibly all areas has been disturbed domestic and feral ungulate foraging and invasion by introduced plant species.

State and transition model

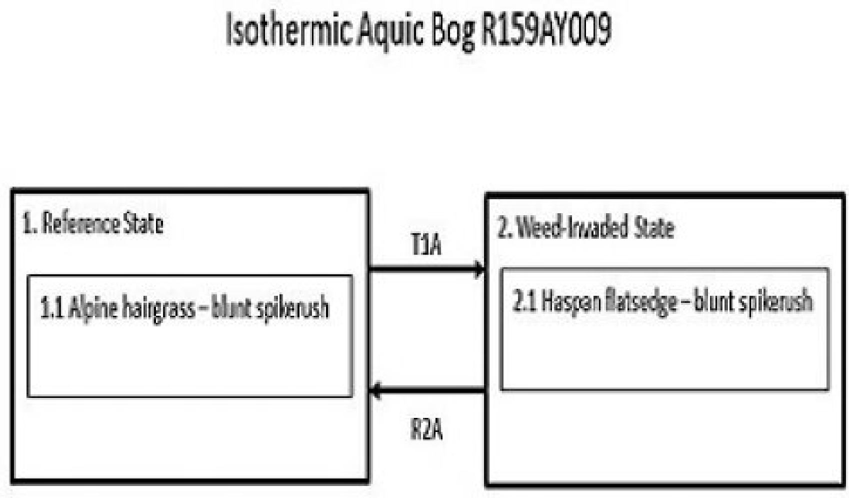

Figure 7. State and Transition Model Diagram R159AY009

State 1
Reference State

This state is comprised of one community phase. We observed no examples of this community phase that were not dominated by introduced species. It consists of flat areas of soils that are saturated to the surface or shallowly flooded or ponded. These areas are surrounded by medium-stature forest vegetation described for ecological site F159AY504. Vegetation is sedges, rushes, and grasses. Small ohia lehua trees, ohelo shrubs, and uluhe fern grow on fallen logs and old stumps within the bogs.

Community 1.1
Alpine hairgrass - blunt spikerush

Figure 8. Aerial view of bog 9/15/08 D Clausnitzer

The vegetation of this community phase consists of low-stature sedges, rushes, and grasses. The soils of this ecological site are usually saturated to or near the surface, and may be permanently ponded to a depth a 1 to 3 inches (2.5 to 7.5 centimeters). In many of these bogs, surface water has a slow, consistent flow toward lower areas.

Forest understory. The most common native species are alpine hairgrass (Deschampsia nubigena), ohe or ridgetop bloodgrass (Isachne distichophylla), and blunt spikerush (Eleocharis obtusa). Small `ohi`a lehua trees, ohelo shrubs, and uluhe (Dicranopteris linearis) ferns grow on fallen logs and old stumps within the bogs.

As no intact examples of this community phase were observed, no cover estimates for individual species are included on the tables below.

Table 5. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	10-15%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	5-10%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	5-100%
Bare ground	5-10%

Table 6. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	–
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	0-0%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	
Tree snag count** (hard***)	

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	60-70%	–
>0.5 <= 1	–	–	1-5%	–
>1 <= 2	–	–	–	–
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

State 2
Weed-Invaded State

This state is comprised of one community phase. It comes into being by gradual invasion of introduced species. Disturbance of the soil and direct damage to native plants by introduced ungulates, particularly pigs and cattle, will likely facilitate the transition to this state.

Community 2.1
Haspan flatsedge - blunt spikerush

Figure 9. View of bog 8/13/04 D Clausnitzer MU904

Figure 10. Closeup of bog surface 8/13/08 D Clausnitzer MU904

The vegetation consists of low-stature sedges, rushes, grasses, and forbs. Native species are present, but introduced species are dominant.

Forest understory. The most abundant introduced species are haspan flatsedge (Cyperus halpan) and tapertip rush (Juncus acuminatus). Small ohia trees, ohelo shrubs, introduced herbaceous glorytree or cane tibouchina (Tibouchina herbacea) shrubs, introduced Japanese false spleenwort (Deparia petersenii) ferns, and native uluhe ferns grow on fallen logs and old stumps within the bogs.

Table 8. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	10-15%
Forb basal cover	0.0-0.1%
Non-vascular plants	0.1-1.0%
Biological crusts	0%
Litter	10-15%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	5-100%
Bare ground	5-40%

Table 9. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	60-70%	0%
>0.5 <= 1	–	–	1-5%	–
>1 <= 2	–	–	–	–
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Transition T1A
State 1 to 2

State 1, the Reference State, transitions to State 2, Weed-Invaded State, by invasion of introduced grass, sedge, rush, and forb species. Disturbance by feral cattle and pigs may hasten this process.

Restoration pathway R2A
State 2 to 1

Restoration of State 2 Weed-Invaded State to State 1 Reference State or a facsimile of it may be possible by installing pig-proof fence, removing all ungulates, removal of introduced species by hand weeding, and replanting native species when needed. Long term weed management and fence maintenance would be necessary. We are aware of no attempts at this restoration. Because we observed no undisturbed, weed-free examples of this ecological site, attempts at restoration would be speculative as to species composition.

Additional community tables

Table 10. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
flatsedge	CYPER	*Cyperus*	Native	0.5–2	20–30
blunt spikerush	ELOB2	*Eleocharis obtusa*	Native	0.5–1	10–20
alpine hairgrass	DENU6	*Deschampsia nubigena*	Native	0.5–1.5	5–10
ridgetop bloodgrass	ISDI	*Isachne distichophylla*	Native	0.5–1.5	1–5

Table 11. Community 2.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
haspan flatsedge	CYHA	*Cyperus haspan*	Introduced	0.5–1	30–40
tapertip rush	JUAC	*Juncus acuminatus*	Introduced	0.5–1	25–40
blunt spikerush	ELOB2	*Eleocharis obtusa*	Native	1–2	10–25
glenwoodgrass	SAIN	*Sacciolepis indica*	Introduced	0.5–1	0.1–10
common rush	JUEF	*Juncus effusus*	Introduced	0.5–1	1–5
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.5–1	1–5
alpine hairgrass	DENU6	*Deschampsia nubigena*	Native	1–2	1–2
dallisgrass	PADI3	*Paspalum dilatatum*	Introduced	1–2	0.1–1
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.5–1	0.1–1
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	2–3	0.1–1
ridgetop bloodgrass	ISDI	*Isachne distichophylla*	Native	0.5–1.5	0–0.1
Forb/Herb					
Colombian waxweed	CUCA4	*Cuphea carthagenensis*	Introduced	–	0–0.1
dwarf St. Johnswort	HYMU	*Hypericum mutilum*	Introduced	0.5–1	0–0.1

Animal community

There are no native mammals, reptiles, amphibians, or fish that utilize this ecological site. No native wetland birds were observed on any field visits. The sites may possibly be utilized by native insects. The bogs probably are visited by feral cattle and pigs.

Hydrological functions

The bogs receive runoff from surrounding areas. Connection of subsurface waters in the bogs with aquifers is unknown due to the complex nature of underlying lava.

The shallow surface waters of the bogs may be static or have a slow, downhill flow toward neighboring streams.

Recreational uses

Most examples of this ecological site are remote and very difficult to access by vehicle or by hiking. They have no recreational uses.

Wood products

None.

Other products

None.

Other information

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.

Aquic soil moisture regime: A regime in which the soil is free of dissolved oxygen because it is saturated by water. This regime typically exists in bogs or swamps.

Aridic soil moisture regime: A regime in which defined parts of the soil are, in normal years, dry for more than half of the growing season and moist for less than 90 consecutive days during the growing season. In Hawaii it is associated with hot, dry areas with plants such as kiawe, wiliwili, and buffelgrass. The terms aridic and torric are basically the same.

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.

Basal area or basal cover: The cross sectional area of the stem or stems of a plant or of all plants in a stand.

Blue rock: The dense, hard, massive lava that forms the inner core of an aa lava flow.

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

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

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

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

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

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

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

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

Friability: A soil consistency term pertaining to the ease of crumbling of soils.

Hydrous: A “soil texture modifier” for volcanic ash soils having a water content at the crop wilting point of 100 percent or more; a soil that holds more water than “medial” or “ashy” soils.

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.

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.

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.

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

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

Medial: A “soil texture modifier” for volcanic ash soils having a water content at the crop wilting point of 30 to 100 percent; a soil that holds an amount of water intermediate to “hydrous” or “ashy” soils.

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.

Phosphorus adsorption: The ability of soil materials to tightly retain phosphorous ions, which are a plant nutrient. Some volcanic ash soils retain phosphorus so strongly that it is partly unavailable to plants.

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.

Torric soil moisture regime: See Aridic soil moisture regime.

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.

Type locality

Location 1: Hawaii County, HI	
Latitude	19° 48′ 15″
Longitude	155° 9′ 17″
General legal description	Near mile marker 8 on Hwy 9 turn W on Indian Tree Rd; go 0.7 mi thru locked gate and 3.7 mi on pasture road to 19d47m30.1s N, 155d8m54.2s W. Walk 0.1 mi W on forest trail. Go N, take trail downhill to Kaieie Stream. Cross stream to bog.

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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)	David Clausnitzer
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Date	04/12/2016
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Foliar Cover

Indicators

1. **Number and extent of rills:** Not applicable.

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2. **Presence of water flow patterns:** Not applicable.

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3. **Number and height of erosional pedestals or terracettes:** Not applicable.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Not applicable; site is submerged under shallow surface water.

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5. **Number of gullies and erosion associated with gullies:** Not applicable.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Not applicable.

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7. **Amount of litter movement (describe size and distance expected to travel):** Not applicable.

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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):** Not applicable.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** The surface soil horizon (Oa) is runs from 0 to 6 inches (0 to 15 centimeters depth. It is very dark brown (10YR 2/2) rubbed, consists of muck, and is massive.

   The Ag horizon runs from 6 to 14 inches (15 to 35 centimeters) depth. It is very dark brown (10YR 2/2) crushed, consists of mucky hydrous silt loam, and has weak fine subangular blocky structure.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The differences in relative proportions of functional groups and plant spatial distribution among different community phases is unknown but is likely to be similar. There is probably no effect 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):** None.

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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: By foliar cover, Grass/grasslikes >> Forb/herbs.

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Not applicable.

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14. **Average percent litter cover (%) and depth (in):** This small amount of litter sinks below the surface water and lodges on the soil surface.

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

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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:** Haspan flatsedge (Cyperus haspan)
tapertip rush (Juncus acuminatus)

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17. **Perennial plant reproductive capability:** There are no known inhibiting factors.
