USDA Natural Resources Conservation Service

Ecological site VX164X01X001
Gleyed Soil Forest

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General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

MLRA notes

Major Land Resource Area (MLRA): 164X–Humid and Very Humid Steep and Very Steep Mountain Slopes

This MLRA occurs in the State of Hawaii on the islands of Hawaii, Maui, Molokai, Oahu, and Kauai. It consists primarily of deeply dissected mountainous areas. Elevation ranges from sea level to 7000 feet (0 to 2100 meters). Topography is mostly steep, with ridges, gulches, and canyons, as well as areas of plateau. Underlying geology is fractured, basic, igneous rock (mostly basalt) that is slightly to highly weathered. Over this are found deposits of local volcanic ash, tropospheric dust from Asia, and/or organic deposits. Climate is mostly wet tropical. Average annual precipitation typically ranges from 75 to 250 inches (1875 to 6250 millimeters), with extremes of 30 to 450 inches (750 to 11,250 millimeters). Rainfall is well distributed throughout the year with and enhanced rainy season from November through April. Fog drip can add significant amounts of water to the soil. Average annual temperatures range from 53 to 75 degrees F (12 to 24 degrees C), with very little seasonal variation. Soils are mostly Inceptisols, Andisols, and Histosols with isothermic or isomesic soil temperature regimes. Native vegetation consists of moderate stature rainforests, dwarf forests, and stands of uluhe with emergent shrubs and trees.

Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 164 - Humid and Very Humid Steep and Very Steep Mountain Slopes.

Ecological site concept

This ecological site consists of very wet, boggy areas with stunted vegetation on the

islands of Maui and Molokai. On Maui, it occurs in the Koolau Forest Reserve and Haleakala National Park on the northeast-facing slope of Haleakala at elevations between 2000 and 5500 feet (615 and 1690 meters) in an area mauka of Hana Highway (Rte. 360), southeast of Makawao, and west of Hana and Kipahulu. On Molokai, it occurs in the east Molokai mountains at elevations between 2000 and 4500 feet (275 and 1385 meters). The area is owned by the State of Hawaii, Kamehameha Schools, The Nature Conservancy, and private ranches. On both islands, no public roads provide access to this ecological site, and foot access is difficult.

Soils in this area have not been mapped in detail due to very difficult accessibility. For this reason, this Provisional Ecological Site is described broadly.

Parts of this ecological site are mapped as Amalu soils, which are the soil series found in Ecological Site F164XY501 Sphagnum Peat Dwarf Forest on Kohala on the island of Hawaii. This ecological site on Maui differs from F164XY501 by having a peaty or mucky soil surface horizon that is not formed in sphagnum moss. Sphagnum occurs only on Kohala and on Mt. Eke in West Maui (Wagner et al. 1999, page 102).

The central concept of the Gleyed Soil Forest is of poorly drained soils formed in deposits of volcanic ash and organic materials that are shallow to an ironstone layer and covered with a layer of peat. Annual air temperatures and rainfall interacting with the dense ironstone horizon create warm (isothermic), water saturated and anaerobic (aquic) soil conditions. These soils support vegetation consisting of low-stature, open-canopy vegetation with a stunted tree overstory and an understory of shrubs, forbs, grasses, sedges, and ferns. In places, there are bogs dominated by sedges or cushion-forming mosses, with or without stunted trees and shrubs. Uluhe fern thickets cover parts of the area; sparse ohia lehua trees are emergent through the thickets. There typically is a thick growth of mosses, liverworts, and small ferns on tree trunks. The ground is covered with a layer of moss, peat, or muck underlain by gleyed (gray and anaerobic) silty clay; plant roots may be found in these two upper horizons, but roots are excluded from deeper soil horizons by a cemented ironstone sheet that occurs from 12 to 23 inches (30 to 58 centimeters) deep.

Associated sites

VX164X01X002	**Organic Surface Forest** The Gleyed Soil Forest occurs on Maui and Molokai; the Organic Surface Forest occurs only on Maui. Both ecological sites share similar rainfall and temperatures, and are closely associated within a large soil
VX164X01X004	**Epiaquic Forest** The Gleyed Soil Forest occurs on Maui and Molokai; the Epiaquic Forest occurs on Kauai, Molokai, and Lanai. Both ecological sites share similar rainfall and temperatures, and are closely associated within a soil

VX160X01X007	**Isothermic Ustic Naturalized Grassland (Kikuyugrass)** The Isothermic Ustic Naturalized Grassland borders the Gleyed Soil Forest's low elevation southwestern boundary on Maui; it also occurs on Hawaii. The Isothermic Ustic Naturalized Grassland lies on the leeward side of Haleakala, giving it a much drier, sunnier climate that has well drained, more fertile soils that support diverse dry to mesic forest rather than wetness-adapted species and stunted rainforest species.
VX160X01X502	**Isomesic-Cool Isothermic Forest** The Isomesic Cool Isothermic Forest borders the Gleyed Soil Forest's high elevation southwestern boundary on Maui where it lies on the leeward side of Haleakala, giving it a drier, sunnier, but cool climate that has well drained, more fertile soils that support moderately dry forest dominated by koa and mamane trees rather than wetness-adapted species and stunted rainforest species.
VX167X01X001	**Oxidic Dissected Lowland** The Gleyed Soil Forest occurs on Maui and Molokai. The Oxidic Dissected Lowland occurs on Maui, Oahu, and Kauai. It abuts the low elevation, southern and southwestern boundary of the Gleyed Soil Forest. The Oxidic Dissected Lowland is well or moderately well drained rather than poorly drained, receives less rainfall, lies at lower elevations, and is somewhat warmer than the Gleyed Soil Forest. The Oxidic Dissected Lowland would have had a medium stature, closed canopy rain forest dominated by ohia lehua trees rather than wetness-adapted species and stunted rainforest species.

Similar sites

VX164X01X501	**Sphagnum Peat Dwarf Forest** The Sphagnum Peat Dwarf Forest occurs on Kohala on the island of Hawaii, while the Gleyed Soil Forest occurs on Maui and Molokai. Both ecological sites have the same overall environmental conditions; they exist on different phases of the same soil series. The Sphagnum Peat Dwarf Forest has a surface layer composed of sphagnum, while the Gleyed Soil Forest does not have sphagnum moss.
VX164X01X003	**Very Poorly Drained Terric Forest** The Very Poorly Drained Terric Forest occurs on Kauai and Oahu, while the Gleyed Soil Forest occurs on Maui and Molokai. Both ecological sites have the similar environmental conditions, although the Very Poorly Drained Terric Forest mostly occurs at higher, cooler elevations and is wetter. It has a much thicker and mucky peat layer (not sphagnum). The two ecological sites apparently have vegetation of similar character (open canopy, wetness-adapted species, and stunted rainforest species) but have differences among plant genera and species due to evolutionary and biogeographical reasons.

Table 1. Dominant plant species

Tree	(1) *Metrosideros polymorpha*

Shrub	(1) *Vaccinium calycinum*
Herbaceous	(1) *Dicranopteris linearis*

Legacy ID

F164XY001HI

Physiographic features

This ecological site occurs on volcanic ash fields deposited over lava flows on interfluves and ridges of sloping mountainsides of shield volcanoes.

Table 2. Representative physiographic features

Landforms	(1) Shield volcano > Mountainside > Lava flow unit (2) Shield volcano > Ash field > Lava flow unit (3) Shield volcano > Interfluve > Lava flow unit
Runoff class	Very low to medium
Flooding frequency	None
Ponding frequency	None
Elevation	610–1,676 m
Slope	3–20%
Water table depth	10 cm
Aspect	W, N, E, SE, S

Table 3. Representative physiographic features (actual ranges)

Runoff class	Not specified
Flooding frequency	Not specified
Ponding frequency	Not specified
Elevation	Not specified
Slope	Not specified
Water table depth	10–152 cm

Climatic features

Summary for this ecological site
Average annual precipitation ranges from 75 to 400 inches (1875 to 10,000 millimeters). Rainfall occurs throughout the year, with the heaviest precipitation occurring from October through April. Landscapes are shrouded in fog or overcast during much of the day

throughout the year, which reduces evapotranspiration and adds additional moisture from condensation of fog on vegetation. Mean annual temperature ranges from 59 to 60 degrees F (15 to 16 degrees C). Frost free and freeze free periods are 365 days per year.

General principles
Air temperature in the Hawaiian Islands is buffered by the surrounding ocean so that the range in temperature through the year is narrow. This creates “iso-“ soil temperature regimes in which mean summer and winter temperatures differ by less than 6 degrees C (11 degrees F).

The islands lie within the trade wind zone. Significant amounts of moisture are picked up from the ocean by trade winds up to an altitude of more than about 6000 feet (1850 meters). As the trade winds from the northeast are forced up the mountains of the islands their moisture condenses, creating rain on the windward slopes; the leeward sides of the island receive little of this moisture.

Two seasons can be defined during the year: a seven-month winter season from October through April and a five-month summer season from May through September. Summer has warmer temperatures, steadier and stronger trade winds, few widespread rainstorms, and generally lower average monthly rainfall than winter. Differences in rainfall amounts between winter and summer are most marked in low elevation dry areas; wetter areas exhibit less seasonal variation in rainfall.

On the windward sides of the island, cool, moist air at higher elevations descends toward the ocean where it meets the trade winds; this process brings rainfall, often at night, to lower elevation areas.

Extensive low-pressure systems often approach the islands from the west, producing heavy rainstorms that primarily affect the leeward sides, but can envelope the entire island. These major storms occur most frequently between October and March.

Sea-to-land naulu winds regularly flow up the western and southern slopes of Haleakala on Maui, forming clouds on these faces of the mountain between about 3000 to 6000 feet (925 to 1850 meters). These clouds form a shadow at lower elevations and produce fog drip at higher elevations where the clouds contact the mountain (Leopold 1949; Schroeder 1981).

Table 4. Representative climatic features

Frost-free period (characteristic range)	365 days
Freeze-free period (characteristic range)	365 days
Precipitation total (characteristic range)	1,905-10,160 mm
Frost-free period (average)	365 days

Freeze-free period (average)	365 days
Precipitation total (average)	6,045 mm

Influencing water features

Streams exist in shallow to deep gulches. Vegetation in small gulches is similar to that of the rest of the ecological site. Ponding is common in depressions.

Soil features

One soil series, Amalu peat, is correlated with this ecological site. Amalu soils are classified within the Inceptisols soil order (soils with weak soil horizon development). They are in the Histic subgroup, meaning they have a histic (organic, in this case peat) surface horizon, and are saturated with water, and are reduced ("anaerobic" is a partial definition of this term) for some time in normal years.

These soils formed in organic matter over basic volcanic ash over residuum weathered from basalt. Soil temperature regimes are isothermic. Soil moisture regimes are aquic, which is a reducing regime in a soil that is virtually free of dissolved oxygen because it is saturated by water. They are poorly drained and are shallow (typically 10 to 20 inches or 25 to 50 centimeters) to the root-restricting placic (thin, solid ironstone horizon). The organic surface horizon is typically about 8 inches (20 centimeters) thick. Directly beneath it is the gleyed (gray, anaerobic, reduced) mineral horizon. Plant roots appear to be exclusively in the surface peat horizon and underlying gleyed horizon.

This ecological site correlated with Amalu soils, which are the same soil series correlated with Ecological Site F164XY501 Sphagnum Peat Dwarf Forest on Kohala on the island of Hawaii. This ecological site, on Maui and Molokai, differs from F164XY501 by having a peaty or mucky soil surface horizon that is not formed in sphagnum moss. Sphagnum occurs only on Kohala and on Mt. Eke in West Maui (Wagner et al. 1999, page 102). On Kohala, Amalu soils have an Oi horizon that is pale yellow (2.5Y 7/4) peat; on Maui and Molokai, Amalu soils have an Oi horizon that is black (5YR 2/1) peat.

Large areas of Miscellaneous Land Types adjoin this ecological site. These are areas that were mapped in very little detail. Parts of these areas contain soils described as Tropaquods, which are considered to be "similar to Amalu" in the 1972 Five Islands Soil Survey. Tropaquods occur in a large area mapped as Hydrandepts-Tropaquods association (map unit rHT) on Maui and as Tropaquods (map unit rTO) on Molokai.

Tropaquods are in the Spodosols soil order (soils with a spodic horizon having coarse texture, high pH-dependent charge, and few base cations). They are poorly drained soils that formed in basic igneous materials and organic material. Their surface horizon is peat or sometimes muck; see Definitions in Other Information section); this overlays a gleyed

horizon (water-saturated and reduced). Beneath this is a placic horizon (solid, thin ironstone) that restricts root penetration and water percolation.

Table 5. Representative soil features

Parent material	(1) Organic material (2) Volcanic ash (3) Residuum–basalt
Surface texture	(1) Highly organic
Drainage class	Poorly drained
Permeability class	Very slow
Depth to restrictive layer	25–51 cm
Soil depth	170–404 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	7.62–10.16 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	3.5–5.5
Subsurface fragment volume <=3" (0-101.6cm)	23%
Subsurface fragment volume >3" (0-101.6cm)	20%

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.

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.

Natural Disturbances

Most of this ecological site has not been affected by local volcanic activity for hundreds of thousands of years. Limited areas may be subject to future lava flows that would bury those areas. Rainfall is very high, so fires would only occur during extreme drought, if at all. Vegetation is low in stature, so windfall is not an important factor.

Human Disturbances

Humans arrived in the Hawaiian Islands 1200 to 1500 years ago. Their population gradually increased so that by 1600 AD at least 80 percent 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 has been affected by factors connected with the arrival of humans (Athens 1997).

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 relatively remote ecological site have been feral pigs and cattle.

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.

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.

Access to this ecological site by humans has always been difficult, and much of the original vegetation remains fairly intact. However, the native plant community in some areas has been disturbed by feral ungulate foraging and invasion by introduced plant species. Introduced plant species are capable of largely replacing native vegetation.

State and transition model

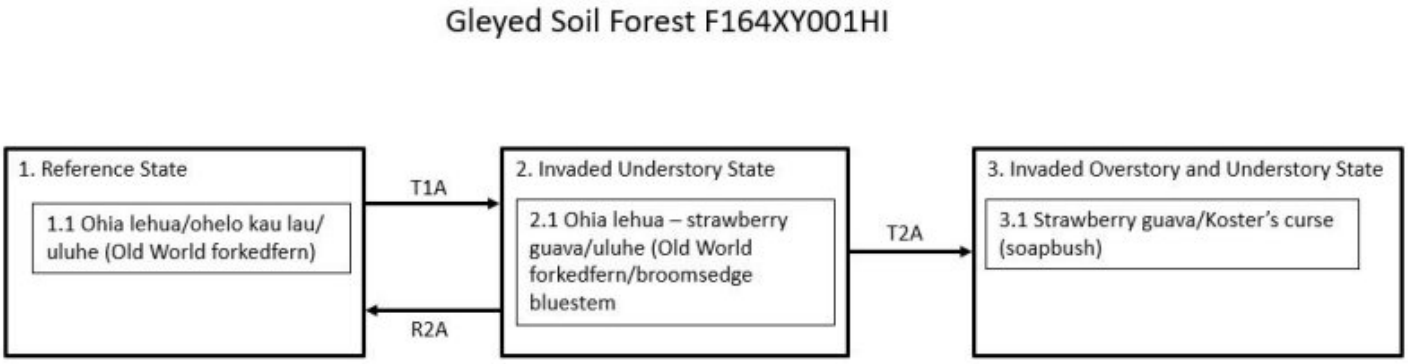

Figure 1. State and Transition Model for the Gleyed Soil Forest (F164XY001HI)

State 1
Reference State

The Reference State consists of one community phase that contains a range of vegetation that varies with very small changes in elevation and drainage. State 1 will transition into State 2 Invaded Understory by gradual weed invasion, which is exacerbated greatly by activities of feral ungulates, particularly pigs.

Community 1.1
Ohia lehua/ohelo kau lau/uluhe (Old World forkedfern)

This state is wetland with scattered, low-stature trees with gnarled growth form, scattered tree ferns, and diverse shrubs, forbs, vines, grasses, and sedges. Soil surfaces are covered by a layer of moss or peat (fibric material or recognizable plant remains). Areas of Tropaquods can have a surface of muck (sapric material or unrecognizable plant remains). The tallest trees typically range from 6 to 20 feet (2 to 6 meters) tall. At higher elevations within this community that are frequently enveloped in fog, trunks and branches of trees and shrub are covered by a growth of mosses, liverworts, and small ferns. Many of the vascular plant species occurring in the Reference State are typical of other Hawaiian moist forest types. Tree species that can occur are ohia lehua (*Metrosideros polymorpha*), olapa (*Cheirodendron trigynum*), kawau (*Ilex anomala*), various alani (Melicope spp.), and pilo (Coprosma spp.). Common shrubs are ohelo (Vaccinium spp.), greensword or Hana Forest silversword (*Argyroxiphium grayanum*), and pukiawe (Leptecophylla tameiameiae. Uluhe fern (*Dicranopteris linearis*) can form thicket that dominate the ground cover in places. Two species of tree ferns may occur: hapuu (*Cibotium glaucum*) and hapuu li (*C. menziesii*). Small ferns and fern allies are diverse. Common sedges and grasses are uki or tropical twigrush (*Machaerina mariscoides*), rosette grass (Dichanthelium spp.), Hawaii Island sedge (*Oreobolus furcatus*), Hawaii sedge (*Carex alligata*), star sedge (*Carex echinata*), and alpine hairgrass (*Deschampsia nubigena*).

Dominant plant species

- 'ohi'a lehua (*Metrosideros polymorpha*), tree

- ohelo kau la'au (*Vaccinium calycinum*), shrub
- Old World forkedfern (*Dicranopteris linearis*), other herbaceous

State 2
Invaded Understory State

This state consists of one community phase. Native plant abundance and diversity are lower than in the Reference state. Most native species are unable to regenerate well in this plant community and eventually die out. Some small native ferns persist on tree trunks and limbs. Ground cover of moss is lower than in the Reference state. Where moss cover is naturally shallow, digging and rooting by pigs removes the moss cover completely, exposing the mineral soil beneath. These bare soil patches are easily invaded by introduced weed species.

Community 2.1
Ohia lehua – strawberry guava/uluhe (Old World forkedfern)/broomsedge bluestem

This community phase has an intact or diminished overstory of native trees with a dense understory of native and introduced forbs, shrubs, ferns, grasses, and small trees. The overstory is dominated by ohia lehua (*Metrosideros polymorpha*) and olapa (*Cheirodendron trigynum*). The introduced paperbark or punktree (*Melaleuca quinquenervia*) may be present in the overstory. Native uluhe fern (*Dicranopteris linearis*) is still common. Strawberry guava (*Psidium cattleianum*) is more abundant than native trees in the secondary canopy. Koster’s curse (*Clidemia hirta*) and cane tibouchina (*Tibouchina herbacea*) are common. Cover of introduced grasses, sedges, rushes, and forbs has increased. Some of these species are broomsedge bluestem (*Andropogon virginicus*), Glenwood grass (*Sacciolepis indica*), haspan flatsedge (*Cyperus haspan*), and broadleaf rush (*Juncus planifolius*). An introduced forb, Asiatic pennywort or spadeleaf (*Centella asiatica*), often occurs. Few to no seedlings and saplings of native tree and shrub species occur in this phase.

Dominant plant species

- 'ohi'a lehua (*Metrosideros polymorpha*), tree
- strawberry guava (*Psidium cattleianum*), tree
- broomsedge bluestem (*Andropogon virginicus*), grass
- Old World forkedfern (*Dicranopteris linearis*), other herbaceous

State 3
Invaded Over and Understory State

This state contains one community phase. The vegetation consists almost entirely of introduced species. Restoration to State 1 Reference would be very difficult.

Community 3.1
Strawberry guava/Koster's curse (soapbush)

This community phase may have a few remnant native trees. Introduced species dominate all strata. Scattered strawberry guava (*Psidium cattleianum*) have grown into the overstory. Other introduced tree species such as paperbark (Melaleuca quinquinervia) sometimes occur in the overstory. Where a dense strawberry guava overstory is present, few other species remain common. A few ohia lehua (*Metrosideros polymorpha*) remain in the overstory. Scattered uluhe ferns are present. Introduced grasses, forbs, and shrubs can reproduce and grow in open areas.

Dominant plant species

- strawberry guava (*Psidium cattleianum*), tree
- soapbush (*Clidemia hirta*), shrub

Transition T1A
State 1 to 2

State 1 Reference transitions to State 2 Invaded Understory by gradual replacement of the understory by introduced plant species that outcompete native understory species. This process is accelerated by ungulate foraging that disturbs the soil surface and directly destroys native plants and prevents their regeneration.

Restoration pathway R2A
State 2 to 1

It may be possible to restore State 2 Invaded Understory to State 1 Reference. Before restoration of native plants, introduced understory plants must be eliminated, and ungulates must be excluded from the restoration site.

Transition T2A
State 2 to 3

State 2 Invaded Understory will transition to State 3 Invaded Overstory and Understory. Native species are unable to successfully regenerate due to the dense, shady weed understory. Mature native plants eventually die out and are replaced by more competitive, introduced species.

Additional community tables

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DEFINITIONS

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

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.

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.

Gleyed: A condition of soil from which iron has been reduced (in the redox chemistry

sense) and removed during soil formation or that saturation with stagnant water has preserved a reduced state. If iron has been removed, the soil is the color of uncoated sand and silt particles. If iron is present in a reduced state, the soil is the color of reduced iron (typically bluish-gray). Redox concentrations (spots of oxidized iron, formerly called mottles are often present.

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.

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

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

Muck: Organic material of which virtually all the material has undergone sufficient decomposition to limit recognition of the plant parts.

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.

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

Peat: Organic material of which virtually all of the organic remains are sufficiently fresh and intact to permit identification of plant forms.

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.

Contributors

David Clausnitzer
John Proctor
Mike Kolman
Carolyn Auweloa

Jennifer Higashino
Amy Koch
Kendra Moseley
Mathew Cocking

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Alex Franco, Kaupo Ranch
Ranae Ganske-Cerizo, NRCS
Carl Hashimoto, NRCS
Bob Hobdy, consultant, Maui
Wallace Jennings, NRCS
Mel Johansen, The Nature Conservancy
Jordan Jokiel, Haleakala Ranch
David Leonard, volunteer
Penny Levin
Reese Libby, GIS - NRCS
Hannah Lutgen, Maui SWCD
Joseph May, NRCS
Scott Meidel, Haleakala Ranch
Anna Palomino, Hoolawa Farms Inc.
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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	03/15/2026
Approved by	Kendra Moseley
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

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:

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17. **Perennial plant reproductive capability:**
