USDA Natural Resources Conservation Service

# Ecological site VX161B01X001
# Dry Ustic Isomesic Shrubland

Accessed: 05/21/2024

## 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.

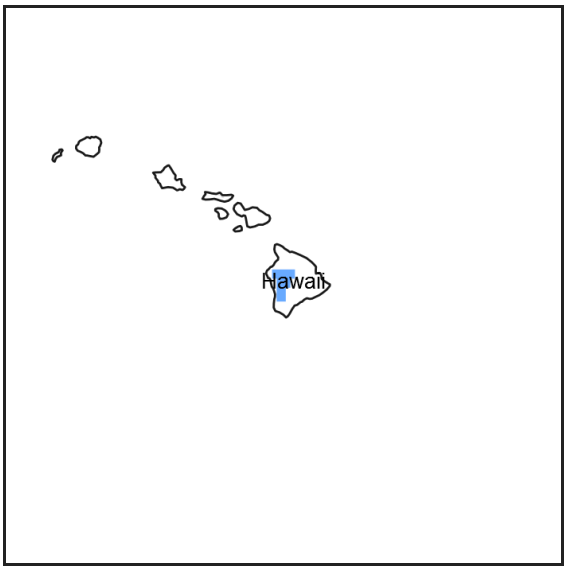


**Figure 1. Mapped extent**

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): 161B–Semiarid and Subhumid Organic Soils on Lava Flows

This MLRA occurs in the State of Hawaii in the Districts North and South Kona on the Big Island of Hawaii. This area is the leeward (western) side of the island on the slopes of Mauna Loa and Hualalai volcanoes. Elevation ranges from sea level to 6000 feet (about 2000 meters). Slopes follow the undulating to very steep topography of the lava flows. The flows are basaltic aa or pahoehoe lava, which are covered by a very shallow layer of organic material mixed with varying amounts of volcanic ash, although some places are covered only by volcanic ash. Climate ranges from dry to moist tropical. Average annual precipitation typically ranges from 30 to 80 inches (750 to 2000 millimeters), increasing with elevation. Rainfall occurs mostly in spring and summer. At higher elevations, frequent afternoon fog accumulation ameliorates evaporation and may add fog drip to the soil. Average annual air temperatures range from 55 to 75 degrees F (12 to 24 degrees C), with little seasonal variation. Dominant soils are Histosols and Andisols with isomesic to isohyperthermic soil temperature regimes. Very young lava flows may have no soil covering. Native vegetation changes as rainfall and fog increase with elevation. 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, transitional forest with olopua and papala kepau, rain forest with ohia lehua, koa, and hapuu, cool dry forest with koa, mamani, and mountain sandalwood, and finally cool dry shrublands that extend up to the highest unvegetated lava flows.

## Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 161B - Semiarid and Subhumid Organic Soils on Lava Flows.

## Ecological site concept

This ecological site is the sparse shrubland situated on the high elevation, north and west facing slopes of Mauna Loa and south and southeast facing slopes of Hualalai. Much of the area is private land, with large areas held by Kamehameha Schools, the State of Hawaii, The Nature Conservancy, and the Federal government. The US Army Pohakuloa Training Area contains extensive parts of this ecological site.

The central concept of the Dry Ustic Isomesic Shrubland is of moderately well to somewhat excessively drained, very shallow to moderately deep soils formed in young deposits of volcanic ash, ash and cinders, or highly decomposed organic matter deposited primarily over pahoehoe lava. Soils generally range from 1500 to <5000 years old. Annual air temperatures and rainfall create cool (isomesic), seasonally dry (ustic) soil conditions. The temperature and moisture conditions override the diverse soil characteristics to the extent that a clearly definable ecological site exists across all the soil types within it. The vegetation is a dense to open shrubland with scattered trees and grasses and sedges beneath the shrub canopy or in interspaces between shrubs. There is a sparse canopy of ohia lehua (Metrosideros polymorpha) trees 25 to 50 feet (8 to 16 meters) tall and a sparse secondary canopy of mountain pilo (Coprosma montana), kolea (*Myrsine lanaiensis*), mamani (Sophora chrysophylla), naio (Myoporum sandwicense), and an occasional koa (Acacia koa). The shrub understory is dominated by pukiawe (Styphelia tameiameiae), ulei (Osteomeles anthyllidifolia), and aalii (Dodonaea viscosa). The most abundant grass species is alpine hairgrass (Deschampsia nubigena).

## Associated sites

| | |
|---|---|
| VX161B01X503 | **Ustic Isomesic Forest**<br>F161BY503 Ustic Isomesic Forest exists at similar and lower elevations to R161BY001 on both Hualalai and Mauna Loa volcanoes. |

## Similar sites

| | |
|---|---|
| VX160X01X006 | **Isomesic Savanna**<br>R160XY006 Isomesic Savanna occurs at similar elevations to R161BY001 on Mauna Loa volcano and to some extent on Hualalai volcano. It shares many species in common with R161BY001 but has greater tree cover and stature and more native grass cover due to higher rainfall and a higher ratio of rainfall to pan evaporation. |

**Table 1. Dominant plant species**

| | |
|---|---|
| Tree | Not specified |
| Shrub | (1) *Styphelia tameiameiae*<br>(2) *Coprosma ernodeoides* |
| Herbaceous | Not specified |

## Legacy ID

R161BY001HI

## Physiographic features

This ecological site occurs on lava flows on mountain slopes of shield volcanoes. Lava flows are mostly pahoehoe (smooth, relatively unbroken) or, to a small extent, aa (loose, cobbly) or covered with a layer of volcanic ash and cinders.

**Table 2. Representative physiographic features**

| | |
|---|---|
| Landforms | (1) Shield volcano |

| | |
|---|---|
| Flooding frequency | None |
| Ponding frequency | None |
| Elevation | 1,067–2,743 m |
| Slope | 2–50% |
| Water table depth | 152 cm |
| Aspect | Aspect is not a significant factor |

## Climatic features

There are no climate stations near this ecological site with complete data sets suitable for automatically filling the data boxes and charts below.

The estimates in the following text are based on modeled climate maps and incomplete and/or historic data sets from multiple stations compiled by NRCS Hawaii Soil Survey.

The historic data shown below is from a suitably located weather station. Temperature data were not available. Average monthly precipitation is shown in the "High" row of data; monthly maximum and minimum were not available.

Average annual rainfall ranges from 20 to 30 inches (500 to 750 millimeters). Most rainfall occurs from January through May. Annual temperatures range from 47 to 57 degrees F (8 to 14 degrees C). Average annual pan evaporation ranges from 30 to 60 inches. The ratio of rainfall to pan evaporation generally range from 0.4 to 0.8, but may be as high as 1.0.

Dense fog forms over this ecological site on many afternoons; this would reduce evapotranspiration and possibly supply fog drip to the soil.

**Table 3. Representative climatic features**

| | |
|---|---|
| Frost-free period (average) | 357 days |
| Freeze-free period (average) | 362 days |
| Precipitation total (average) | 330 mm |

## Influencing water features

There are no water features that influence this ecological site.

## Soil features

Parent materials of the majority of soils by area within this ecological site consist of either (1) very shallow organic matter over pahoehoe lava, (2) moderately deep to very deep volcanic ash over aa or pahoehoe that forms soils of low water holding capacity due to gravel and/or sand content and "ashy" (relatively low water holding capacity compared to "medial" and "hydrous") volcanic ash soil materials.

Soil moisture regimes are ustic, meaning that soil moisture is limited but is present at a time during the year when conditions are suitable for plant growth.

Contents of subsurface rock fragments <=3" diameter may be as high as 100% in some soil horizons that consist of volcanic cinders.

The volcanic ash soils of the Island of Hawaii are derived mostly from basaltic ash that varies relatively little in chemical composition (Hazlett and Hyndman 1996; Vitousek 2004)). Most of these volcanic ash soils are classified as Andisols, which have these general management characteristics: ion exchange capacity that varies with pH, but mostly retaining anions such as nitrate; high phosphorus adsorption, which restricts phosphorus availability to

plants; excellent physical properties (low bulk density, good friability, weak stickiness, stable soil aggregates) for cultivation, seedling emergence, and plant root growth; resistance to compaction and an ability to recover from compaction following repeated cycles of wetting and drying; and high capacity to hold water that is available to plants. These characteristics are due to the properties of the parent material, the clay-size noncrystalline materials formed by weathering, and the soil organic matter accumulated during soil formation (Shoji et al. 1993).

Andisols formed on pahoehoe lava can be very shallow to very deep. 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). 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 stands of large trees growing on very shallow and shallow ash soils over pahoehoe.

The lava rock fragments that constitute aa range in size from gravel (2 mm to 76 mm, or up to 3 inches) to stones (250 mm to 600 mm, or 10 to 25 inches), but are primarily gravel and cobbles (76 mm to 250 mm, or 3 to 10 inches). Below the layer of rock fragments is massive lava called “bluerock.” The interstices between rock fragments of Andisols formed in aa are filled with soil from the surface to the blue rock at the bottom of the soil. Some Andisols in aa have few or no rock fragments in the upper horizons, while others may have large amounts of rock fragments in all horizons and on the soil surface.

Soils that are moderately deep (20 to 40 inches, or 50 to 100 cm) or deeper over underlying lava appear to present few or no limits on native, pasture, or weedy vegetation, and it seems to make no difference whether the lava rock is pahoehoe or aa.

The organic soils of the Island of Hawaii are classified as Histosols. They were formed mainly in organic material consisting of highly decomposed leaves, twigs, and wood with small amounts of basic volcanic ash, cinders, and weathered lava; this is called highly decomposed parent material. 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 form in long-term water-saturated conditions, these organic soils form 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.

All of the Histosols on the Big Island are classified as “euic,” which means they have relatively high base saturation as indicated by a pH of 4.5 or higher; most Big Island Histosols have pH well above this minimum.

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). 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. When depth of soil to pahoehoe is less than 18 cm (7.2 inches), the soil is referred to as “micro.”

The lava rock fragments that constitute aa range in size from gravel (2 mm to 76 mm, or up to 3 inches) to stones (250 mm to 600 mm, or 10 to 25 inches), but are primarily gravel and cobbles (76 mm to 250 mm, or 3 to 10 inches). Below the layer of rock fragments is massive lava called “bluerock.” The interstices between rock fragments of Histosols formed in aa are filled with soil material from the surface to a particular depth, often moderately deep (20 to 40 inches, or 50 to 100 centimeters), but sometimes shallower or deeper depending on the soil series. Between this soil material-filled horizon and the bluerock the interstices contain little or no soil material. In order to observe the natural state of the soil, one must carefully disassemble the lava rock fragments so as not to allow the soil materials to fall into the gaps below.

**Table 4. Representative soil features**

| | |
|---|---|
| Parent material | (1) Basaltic volcanic ash–basalt |
| Surface texture | (1) Medial silt loam<br>(2) Ashy loamy sand |

| | |
|---|---|
| Drainage class | Moderately well drained to somewhat excessively drained |
| Permeability class | Moderately rapid to very rapid |
| Soil depth | 5–102 cm |
| Surface fragment cover <=3" | 0–60% |
| Surface fragment cover >3" | 0–50% |
| Available water capacity (0-101.6cm) | 1.52–3.81 cm |
| Calcium carbonate equivalent (0-101.6cm) | 0% |
| Electrical conductivity (0-101.6cm) | 0–2 mmhos/cm |
| Sodium adsorption ratio (0-101.6cm) | 0 |
| Soil reaction (1:1 water) (0-101.6cm) | 4.5–7.8 |
| Subsurface fragment volume <=3" (Depth not specified) | 0–100% |
| Subsurface fragment volume >3" (Depth not specified) | 0–50% |

## Ecological dynamics

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 occurs on young lava flows in seasonally dry, cool regions of the west slope of Mauna Loa volcano, Hualalai volcano, and the saddle between those two volcanoes on the Island of Hawaii. Plant communities evolved without the presence of large mammals or frequent occurrence of fires.

The general appearance is a dense to open shrubland with scattered trees and an understory of grasses and sedges. Ohia trees are common and typically are 25 to 50 feet tall. Sandalwood, mamane, naio, dryland kolea (*Myrsine lanaiensis*), and mountain pilo are common smaller trees. Koa trees occur occassionally.

Invasion by exotic grasses and forbs can change the species content of State 1, Native Shrubland, without altering the general structure of the plant community. The result is State 2, Invaded Shrubland. However, invasion by silk oak or German ivy has the potential radically alter the plant community. Invasion by exotic grasses together with foraging by feral and/or domestic ungulates results in State 3, Grassland, due to destruction of many native species and prevention of their successful reproduction.

State 2 can shift to State 3 by frequent wildfires carried by exotic grasses. This is particularly true if fountaingrass has invaded the plant community in State 2. This shift from State 2 to State 3 due to fountaingrass invasion and wildfire has already occurred on areas of this ecological site near Puuwaawaa cinder cone at elevations between 3500 and 4000 feet. Dense fountaingrass stands of limited extent exist at elevations as high as 5200 feet, and the species occurs up to 8000 feet.

## State and transition model

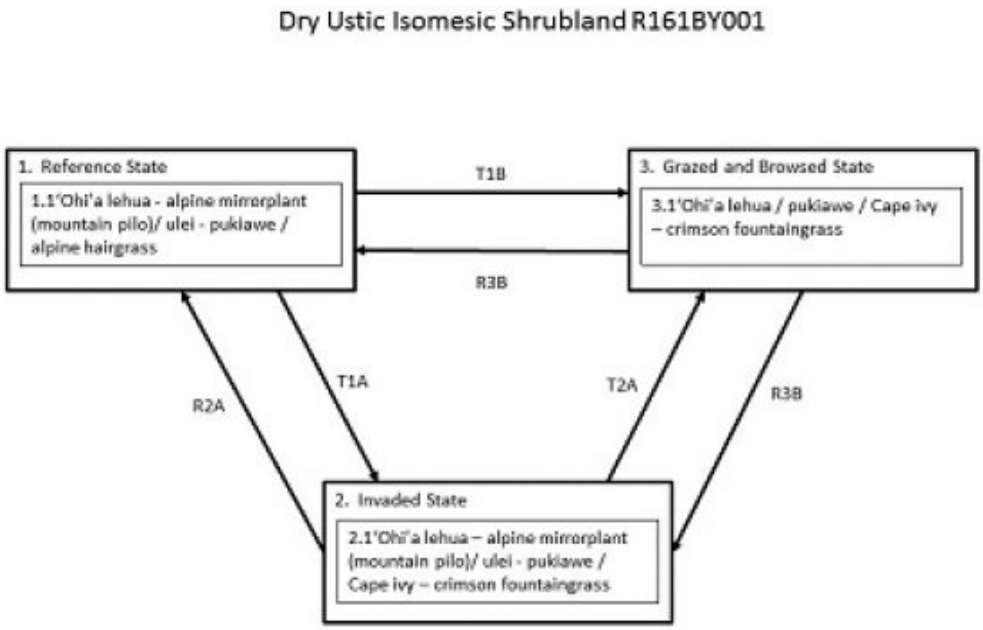


**Figure 5. State and Transition Diagram Model R161BY001**

## State 1
## Reference State

This state consists of one community phase. Much of this ecological site is of marginal value as grazing land. Invasion by exotic grasses and forbs can change the species content of State 1 Reference without altering the general structure of the plant community, resulting in a transition to State 2 Invaded. Invasion by silkoak (*Grevillea robusta*) and/or Cape ivy (*Delairea odorata*) has the eventual potential to radically alter the plant community. Invasion by introduced plant species such as those, together with loss of native species due to foraging by feral and/or domestic ungulates, results in State 3 Grazed and Browsed.

## Community 1.1
## `Ohi`a lehua - alpine mirrorplant (mountain pilo)/`ulei -pukiawe/alpine hairgrass

**Figure 6. Reference community phase. 5/18/07 D Clausnitzer MU166**

**Figure 7. More open site on Ohianui soil. 5/18/05 D Clausnitzer MU470**

**Figure 8. Example of sparse extreme. D Clausnitzer generic**

This community phase is savanna with a sparse to open canopy of trees 25 to 50 feet (8 to 16 meters) tall and a sparse secondary canopy of trees 8 to 20 feet (2.5 to 6 meters) tall. There is a diverse understory of shrubs. Grass/grasslike canopy cover typically ranges from 5 to 10 percent.

**Forest overstory.** The overstory consists of primarily of ohia lehua (Metrosideros polymorpha) and, rarely, koa (Acacia koa). The secondary stratum consists of mountain pilo or alpine mirrorplant (Coprosma montana). Other small tree species, including dryland kolea (Myrsine lanaiensis), naio (Myoporum sandwicense), mamani (Sophora chrysophylla), ae or Hawaii pricklyash (Zanthoxylum hawaiiense), and mountain sandalwood (Santalum paniculatum), occur locally but are not ubiquitous across the ecological site.

**Forest understory.** The most abundant shrubs are pukiawe (Styphelia tameiameiae), aalii or Florida hopbush (Dodonaea viscosa), aiakanene (Coprosma ernodeoides), and ulei or Hawaii hawthorn (Osteomeles anthyllidifolia). A number of forbs, vines, and ferns are common. The most abundant grass species is alpine hairgrass (Deschampsia nubigena). Sedges are common.

**Table 5. Ground cover**

| | |
|---|---|
| Tree foliar cover | 1% |
| Shrub/vine/liana foliar cover | 1% |
| Grass/grasslike foliar cover | 5-10% |
| Forb foliar cover | 1-10% |
| Non-vascular plants | 1% |
| Biological crusts | 1% |
| Litter | 5-70% |
| Surface fragments >0.25" and <=3" | 1-10% |

| | |
|---|---|
| Surface fragments >3" | 1-50% |
| Bedrock | 1-70% |
| Water | 0% |
| Bare ground | 1-10% |

**Table 6. Canopy structure (% cover)**

| Height Above Ground (M) | Tree | Shrub/Vine | Grass/ Grasslike | Forb |
|---|---|---|---|---|
| <0.15 | 1-1% | 1-1% | 1-1% | 1-1% |
| >0.15 <= 0.3 | 1-1% | 1-5% | 1-5% | 1-5% |
| >0.3 <= 0.6 | 1-1% | 1-5% | 1-5% | 1-5% |
| >0.6 <= 1.4 | 1-1% | 10-50% | – | – |
| >1.4 <= 4 | 1-10% | 1-5% | – | – |
| >4 <= 12 | 1-15% | – | – | – |
| >12 <= 24 | – | – | – | – |
| >24 <= 37 | – | – | – | – |
| >37 | – | – | – | – |

**Figure 10. Plant community growth curve (percent production by month). HI1612, 161A-Isomesic ustic community growth curve. For the isomesic soil temperature regime with ustic soil moisture regime within MLRA 161A, this is a generalized growth curve for all plants..**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 10 | 20 | 25 | 15 | 10 | 2 | 2 | 2 | 3 | 3 | 3 |

## State 2
## Invaded State

This state resembles the Reference state in general structure, but some native plant species have been lost or reduced in abundance. Introduced grasses have replaced native grasses to a great extent, native ferns are much reduced in abundance, and the forb category is greater in diversity, stature, and abundance. If fountaingrass is abundant, the risk of wildfire is greatly increased. Silk oak may be invading and becoming abundant in some areas, particularly at lower elevations of the ecological site. Introduced vines can be very invasive, covering and killing other vegetation. Vines can be kept in check by sheep; however, sheep also graze and browse native vegetation.

### Community 2.1
### `Ohi`a lehua - alpine mirrorplant (mountain pilo)/`ulei - pukiawe/Cape ivy - crimson fountaingrass

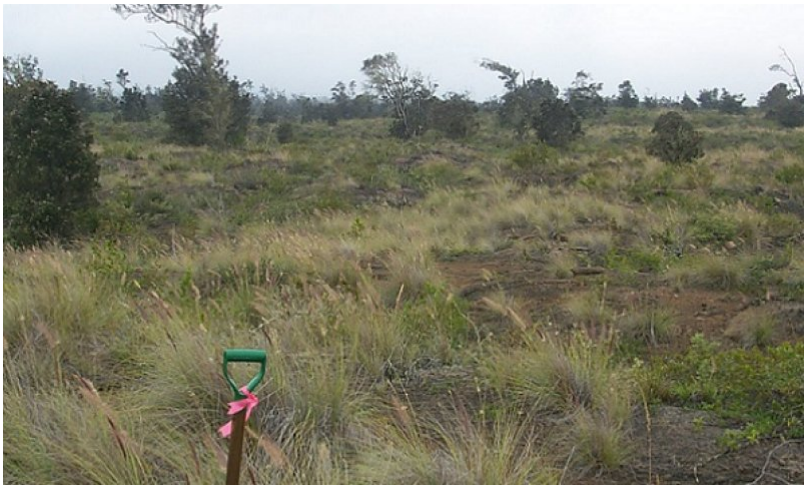

**Figure 11. Fountaingrass invaded site. 8/17/05 D Clausnitzer MU466**

This community phase is savanna with a sparse to open canopy of trees 25 to 50 feet (8 to 16 meters) tall and a sparse secondary canopy of trees 8 to 20 feet (2.5 to 6 meters) tall. Abundance of native tree species in the secondary canopy may be less than that found in community phase 1.1. The shrub understory has also been diminished in abundance and diversity. Cover and diversity of grass/grasslike species and forbs is higher than in phase 2.1 due to the abundance of introduced species.

**Forest overstory.** The overstory consists of primarily of ohia lehua (Metrosideros polymorpha) and, rarely, koa (Acacia koa). The secondary stratum consists of mountain pilo or alpine mirrorplant (Coprosma montana). Other small tree species, including dryland kolea (Myrsine lanaiensis), naio (Myoporum sandwicense), mamani (Sophora chrysophylla), ae or Hawaii pricklyash (Zanthoxylum hawaiiense), and mountain sandalwood (Santalum paniculatum), occur locally but are not ubiquitous across the ecological site. Introduced silkoak (Grevillea robusta) may be present.

**Forest understory.** Native alpine hairgrass may be common, along with native Oahu sedge (Carex wahuensis) and manyspike flatsedge (Cyperus polystachyos). Introduced fountaingrass, kikuyugrass (Pennisetum clandestinum), sweet vernalgrass (Anthoxanthum odoratum), orchardgrass (Dactylis glomerata), common velvetgrass (Holcus lanatus), and other introduced grass species have more than replaced in abundance the native species that have diminished. Introduced forbs are very abundant, especially Australasian geranium (Geranium homeanum), stinking strawflower (Helichrysum foetidum), and common mullein (Verbascum thapsus). Native shrubs still are common, but some introduced species are also present. Introduced vines, especially Cape ivy (Delairea odorata), are common and very competitive with other plants.

**Table 7. Ground cover**

| | |
|---|---|
| Tree foliar cover | 1% |
| Shrub/vine/liana foliar cover | 1-60% |
| Grass/grasslike foliar cover | 5-20% |
| Forb foliar cover | 1-20% |
| Non-vascular plants | 1% |
| Biological crusts | 1% |
| Litter | 5-70% |
| Surface fragments >0.25" and <=3" | 1-10% |
| Surface fragments >3" | 1-50% |
| Bedrock | 1-70% |
| Water | 0% |
| Bare ground | 1-10% |

**Table 8. Canopy structure (% cover)**

| Height Above Ground (M) | Tree | Shrub/Vine | Grass/ Grasslike | Forb |
|---|---|---|---|---|
| <0.15 | 1-1% | 1-60% | 1-20% | 1-5% |
| >0.15 <= 0.3 | 1-1% | 1-5% | 1-20% | 1-5% |
| >0.3 <= 0.6 | 1-1% | 1-5% | 1-30% | 1-5% |
| >0.6 <= 1.4 | 1-1% | 10-50% | – | 1-5% |
| >1.4 <= 4 | 1-10% | 1-5% | – | – |
| >4 <= 12 | 1-15% | – | – | – |
| >12 <= 24 | – | – | – | – |
| >24 <= 37 | – | – | – | – |
| >37 | – | – | – | – |

**Figure 13. Plant community growth curve (percent production by month). HI1612, 161A-Isomesic ustic community growth curve. For the isomesic soil temperature regime with ustic soil moisture regime within MLRA 161A, this is a generalized growth curve for all plants..**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 10 | 20 | 25 | 15 | 10 | 2 | 2 | 2 | 3 | 3 | 3 |

## State 3
## Grazed and Browsed State

This state consists of one community phase. It occurs when introduced plant invasion, increased wildfire, and/or ungulate foraging diminish the abundance of trees and shrubs. Native trees and shrubs are particularly vulnerable to these disturbances.

### Community 3.1
### `Ohi`a lehua/pukiawe/Cape ivy - crimson fountaingrass

**Figure 14. Degraded site. 8/17/05 D Clausnitzer MU466**

This community phase is essentially an open grassland with small numbers of trees and shrubs. If fountaingrass is the dominant grass species, it is possible to lose most other species, both native and introduced, due to greatly increased wildfire.

**Forest overstory.** The original ohia lehua overstory may be largely intact, but over time it will diminish due to wildfire and/or reduced reproduction caused by weed competition and browsing by ungulates. Mountain pilo, mamani, and mountain sandalwood typically have been greatly reduced in abundance by browsing.

**Forest understory.** Introduced grass species, particularly fountaingrass and kikuyugrass, have increased greatly, while native grass abundance has been reduced. Overall grass abundance has increased greatly in comparison to

the Reference or Invaded states. Introduced forbs are abundant. Abundance of most native shrub species is reduced, except possibly for aalii and pukiawe.

**Table 9. Ground cover**

| | |
|---|---|
| Tree foliar cover | 1% |
| Shrub/vine/liana foliar cover | 1-5% |
| Grass/grasslike foliar cover | 20-40% |
| Forb foliar cover | 1-10% |
| Non-vascular plants | 1% |
| Biological crusts | 1% |
| Litter | 40-70% |
| Surface fragments >0.25" and <=3" | 1-10% |
| Surface fragments >3" | 1-50% |
| Bedrock | 1-70% |
| Water | 0% |
| Bare ground | 1-10% |

**Table 10. Canopy structure (% cover)**

| Height Above Ground (M) | Tree | Shrub/Vine | Grass/ Grasslike | Forb |
|---|---|---|---|---|
| <0.15 | 1-1% | 1-1% | 1-5% | 1-1% |
| >0.15 <= 0.3 | 1-1% | 1-1% | 5-30% | 1-5% |
| >0.3 <= 0.6 | 1-1% | 1-1% | 50-90% | 1-5% |
| >0.6 <= 1.4 | 1-1% | 1-1% | – | – |
| >1.4 <= 4 | 1-1% | – | – | – |
| >4 <= 12 | 1-10% | – | – | – |
| >12 <= 24 | – | – | – | – |
| >24 <= 37 | – | – | – | – |
| >37 | – | – | – | – |

**Figure 16. Plant community growth curve (percent production by month). HI1612, 161A-Isomesic ustic community growth curve. For the isomesic soil temperature regime with ustic soil moisture regime within MLRA 161A, this is a generalized growth curve for all plants..**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 10 | 20 | 25 | 15 | 10 | 2 | 2 | 2 | 3 | 3 | 3 |

## Transition T1A
## State 1 to 2

This state transitions to State 2 Invaded by gradual invasion by introduced grasses and forbs.

## Transition T1B
## State 1 to 3

This state transitions to State 3 Grazed and Browsed by reduction or loss of native species due to grazing and browsing by ungulates along with invasion by introduced plant species.

### Restoration pathway R2A
### State 2 to 1

This state may be restored to State 1 Reference State by excluding all ungulates with a suitably designed fence. Spot weed removal must be done initially and maintained in the long term. Missing native plant species must be reintroduced.

### Transition T2A
### State 2 to 3

State 2 Invaded can shift to State 3 Grazed and Browsed by frequent wildfires carried by introduced grasses. This is particularly true if fountaingrass (*Pennisetum setaceum*) has invaded the plant community in State 2. This transition due to fountaingrass invasion and subsequently increased wildfire has already occurred on areas of this ecological site near Puuwaawaa cinder cone at elevations between 3500 and 4000 feet (1080 to 1230 meters). Dense fountaingrass stands of limited extent exist at elevations as high as 5200 feet (1600 meters), and the species occurs currently up to 8000 feet (2460 meters).

### Restoration pathway R3A
### State 3 to 1

It may be possible to return this state to a semblance of State 1 Reference. However, the dry climate, typically very shallow soils, and low abundance of native shrubs and trees would make this very difficult in most areas. Fencing, removal of all ungulates, intensive and long-term weed control, and replanting of native species would be required.

### Restoration pathway R3B
### State 3 to 2

It may be possible to return this state to a semblance of State 2 Invaded. However, the dry climate, typically very shallow soils, and low abundance of native shrubs and trees would make this very difficult in most areas. Fencing, removal of all ungulates, intensive and long-term weed control, and replanting of native species would be required.

## Additional community tables

**Table 11. Community 1.1 plant community composition**

| Group | Common Name | Symbol | Scientific Name | Annual Production (Kg/Hectare) | Foliar Cover (%) |
|---|---|---|---|---|---|
| **Grass/Grasslike** | | | | | |
| 1 | **Native bunchgrass** | | | 168–448 | |
| | alpine hairgrass | DENU6 | *Deschampsia nubigena* | 140–336 | – |
| | hardstem lovegrass | ERAT | *Eragrostis atropioides* | 11–28 | – |
| | mountain lovegrass | ERLE3 | *Eragrostis leptophylla* | 11–28 | – |
| | pili uka | TRGL3 | *Trisetum glomeratum* | 11–28 | – |
| | Pacific bentgrass | AGAV | *Agrostis avenacea* | 11–28 | – |
| 2 | **Native grasslike** | | | 56–112 | |
| | Gaudichaud's sawsedge | MOGA | *Morelotia gahniiformis* | 17–28 | – |
| | Oahu sedge | CAWA | *Carex wahuensis* | 17–28 | – |
| | Hillebrand's flatsedge | CYHID | *Cyperus hillebrandii var. decipiens* | 6–11 | – |
| | manyspike flatsedge | CYPO | *Cyperus polystachyos* | 6–11 | – |
| | Hawai'i woodrush | LUHA2 | *Luzula hawaiiensis* | 6–11 | – |
| | Polynesian twigrush | MAAN | *Machaerina angustifolia* | 6–11 | – |
| **Forb** | | | | | |
| 6 | **Native herb** | | | 22–56 | |

| | | | | | |
|---|---|---|---|---|---|
| 6 | **Native herb** | | | 22–56 | |
| | 'uki'uki | DISA6 | *Dianella sandwicensis* | 11–28 | – |
| | 'ena'ena | PSSA8 | *Pseudognaphalium sandwicensium* | 6–11 | – |
| | pawale | RUGI | *Rumex giganteus* | 6–11 | – |
| | narrowleaf stenogyne | STAN3 | *Stenogyne angustifolia* | – | – |
| | 'ihi makole | POSC9 | *Portulaca sclerocarpa* | – | – |
| 7 | **Native fern** | | | 11–56 | |
| | alpine woodfern | DRWA | *Dryopteris wallichiana* | 6–22 | – |
| | black spleenwort | ASAD | *Asplenium adiantum-nigrum* | 1–11 | – |
| | dotted polypody | POPE5 | *Polypodium pellucidum* | 6–11 | – |
| | western brackenfern | PTAQ | *Pteridium aquilinum* | 1–11 | – |
| | Cretan brake | PTCR2 | *Pteris cretica* | 1 | – |
| | maidenhair spleenwort | ASTR2 | *Asplenium trichomanes* | 1 | – |
| | Trans-Pecos cliffbrake | PETE2 | *Pellaea ternifolia* | 1 | – |
| **Shrub/Vine** | | | | | |
| 9 | **Native shrub** | | | 2242–3811 | |
| | Florida hopbush | DOVI | *Dodonaea viscosa* | 673–1121 | – |
| | pukiawe | STTA | *Styphelia tameiameiae* | 673–1121 | – |
| | Hawai'i hawthorn | OSAN | *Osteomeles anthyllidifolia* | 673–897 | – |
| | 'aiakanene | COER3 | *Coprosma ernodeoides* | 56–336 | – |
| | ohelo 'ai | VARE | *Vaccinium reticulatum* | 28–112 | – |
| | Hawai'i false ohelo | WIPH2 | *Wikstroemia phillyreifolia* | 28–56 | – |
| | yellow ‘ilima | SIFA | *Sida fallax* | 22–56 | – |
| | hinahina | GECU | *Geranium cuneatum* | 11–28 | – |
| | Mauna Loa beggarticks | BIME | *Bidens menziesii* | 11–28 | – |
| | lava dubautia | DUCI | *Dubautia ciliolata* | 1–11 | – |
| | alpine tetramolopium | TEHU | *Tetramolopium humile* | 6–11 | – |
| | pukamole | LYMA3 | *Lythrum maritimum* | 1–6 | – |
| | Menzies' ballart | EXME | *Exocarpos menziesii* | 1–6 | – |
| | Big Island ma'oloa | NEOV | *Neraudia ovata* | – | – |
| | Kauai catchfly | SILA7 | *Silene lanceolata* | – | – |
| | thorny popolo | SOIN | *Solanum incompletum* | – | – |
| 11 | **Native vine** | | | 1–28 | |
| | littleleaf stenogyne | STMI3 | *Stenogyne microphylla* | 1–22 | – |
| | ma'ohi'ohi | STRU2 | *Stenogyne rugosa* | 1–6 | – |
| | queen coralbead | COOR11 | *Cocculus orbiculatus* | 1–6 | – |
| **Tree** | | | | | |
| 13 | **Native tree** | | | 56–140 | |
| | 'ohi'a lehua | MEPO5 | *Metrosideros polymorpha* | 56–112 | – |
| | mamani | SOCH | *Sophora chrysophylla* | 1–56 | – |
| | alpine mirrorplant | COMO3 | *Coprosma montana* | 1–28 | – |
| | Lanai colicwood | MYLA3 | *Myrsine lanaiensis* | 1–28 | – |
| | naio | MYSA | *Myoporum sandwicense* | 1–28 | – |
| | mountain sandalwood | SAPA7 | *Santalum paniculatum* | 1–28 | – |

| | | | | | |
|---|---|---|---|---|---|
| | mountain sandalwood | SAPA7 | *Santalum paniculatum* | 1–28 | – |
| | koa | ACKO | *Acacia koa* | 1–28 | – |
| | alpine sandmat | CHOL3 | *Chamaesyce olowaluana* | 0–1 | – |
| | Hawai'i pricklyash | ZAHA | *Zanthoxylum hawaiiense* | 0–1 | – |

**Table 12. Community 2.1 plant community composition**

| Group | Common Name | Symbol | Scientific Name | Annual Production (Kg/Hectare) | Foliar Cover (%) |
|---|---|---|---|---|---|
| **Grass/Grasslike** | | | | | |
| 1 | **Native bunchgrass** | | | 6–112 | |
| | alpine hairgrass | DENU6 | *Deschampsia nubigena* | 6–112 | – |
| | hardstem lovegrass | ERAT | *Eragrostis atropioides* | 1 | – |
| | mountain lovegrass | ERLE3 | *Eragrostis leptophylla* | 1 | – |
| | pili uka | TRGL3 | *Trisetum glomeratum* | 1 | – |
| | Pacific bentgrass | AGAV | *Agrostis avenacea* | 1 | – |
| 2 | **Native grasslike** | | | 1–28 | |
| | manyspike flatsedge | CYPO | *Cyperus polystachyos* | 1–17 | – |
| | Oahu sedge | CAWA | *Carex wahuensis* | 1–6 | – |
| | Gaudichaud's sawsedge | MOGA | *Morelotia gahniiformis* | 1–6 | – |
| | Hillebrand's flatsedge | CYHID | *Cyperus hillebrandii var. decipiens* | 1 | – |
| | Hawai'i woodrush | LUHA2 | *Luzula hawaiiensis* | 1 | – |
| | Polynesian twigrush | MAAN | *Machaerina angustifolia* | 1 | – |
| 3 | **Exotic bunchgrass** | | | 168–560 | |
| | crimson fountaingrass | PESE3 | *Pennisetum setaceum* | 1–560 | – |
| | sweet vernalgrass | ANOD | *Anthoxanthum odoratum* | 56–168 | – |
| | orchardgrass | DAGL | *Dactylis glomerata* | 56–168 | – |
| | common velvetgrass | HOLA | *Holcus lanatus* | 56–168 | – |
| | annual bluegrass | POAN | *Poa annua* | 6–56 | – |
| | molassesgrass | MEMI2 | *Melinis minutiflora* | 6–28 | – |
| | rose Natal grass | MERE9 | *Melinis repens* | 6–28 | – |
| | weeping grass | MIST | *Microlaena stipoides* | 1–28 | – |
| | smut grass | SPIN4 | *Sporobolus indicus* | 6–28 | – |
| | brome fescue | VUBR | *Vulpia bromoides* | 1–11 | – |
| | marsh bristlegrass | SEPA10 | *Setaria parviflora* | 1–11 | – |
| | little quakinggrass | BRMI2 | *Briza minor* | 1 | – |
| 4 | **Exotic stoloniferous grass** | | | 1–224 | |
| | kikuyugrass | PECL2 | *Pennisetum clandestinum* | 1–224 | – |
| 5 | **Exotic grasslike** | | | 1 | |
| | densetuft hairsedge | BUCA2 | *Bulbostylis capillaris* | 1 | – |
| **Forb** | | | | | |
| 6 | **Native herb** | | | 1 | |
| | 'uki'uki | DISA6 | *Dianella sandwicensis* | 1 | – |
| | 'ena'ena | PSSA8 | *Pseudognaphalium sandwicensium* | 1 | – |
| | pawale | RUGI | *Rumex giganteus* | 1 | – |

| | | | | | |
|---|---|---|---|---|---|
| | pukiawe | | *Rumex giganteus* | 1 | |
| 7 | **Native fern** | | | 1–6 | |
| | western brackenfern | PTAQ | *Pteridium aquilinum* | 1–6 | – |
| | Cretan brake | PTCR2 | *Pteris cretica* | 1 | – |
| | maidenhair spleenwort | ASTR2 | *Asplenium trichomanes* | 1 | – |
| | alpine woodfern | DRWA | *Dryopteris wallichiana* | 1 | – |
| | Trans-Pecos cliffbrake | PETE2 | *Pellaea ternifolia* | 1 | – |
| | dotted polypody | POPE5 | *Polypodium pellucidum* | 1 | – |
| 8 | **Exotic herb** | | | 28–112 | |
| | stinking strawflower | HEFO4 | *Helichrysum foetidum* | 1–28 | – |
| | common mullein | VETH | *Verbascum thapsus* | 1–28 | – |
| | Australasian geranium | GEHO5 | *Geranium homeanum* | 1–11 | – |
| | oxeye daisy | LEVU | *Leucanthemum vulgare* | 1–6 | – |
| | pinkhead smartweed | POCA21 | *Polygonum capitatum* | 1–6 | – |
| | common sheep sorrel | RUAC3 | *Rumex acetosella* | 1–6 | – |
| | Madagascar ragwort | SEMA15 | *Senecio madagascariensis* | 1–6 | – |
| | common St. Paul's wort | SIOR2 | *Sigesbeckia orientalis* | 1–6 | – |
| | muster John Henry | TAMI3 | *Tagetes minuta* | 1–6 | – |
| | bull thistle | CIVU | *Cirsium vulgare* | 1–6 | – |
| | lilac tasselflower | EMSO | *Emilia sonchifolia* | 1–6 | – |
| | southern rockbell | WAMA | *Wahlenbergia marginata* | 1 | – |
| | pepperweed | LEPID | *Lepidium* | 1 | – |
| **Shrub/Vine** | | | | | |
| 9 | **Native shrub** | | | 2018–3363 | |
| | Florida hopbush | DOVI | *Dodonaea viscosa* | 673–1121 | – |
| | pukiawe | STTA | *Styphelia tameiameiae* | 785–1121 | – |
| | Hawai'i hawthorn | OSAN | *Osteomeles anthyllidifolia* | 673–897 | – |
| | yellow ʻilima | SIFA | *Sida fallax* | 22–56 | – |
| | Hawai'i false ohelo | WIPH2 | *Wikstroemia phillyreifolia* | 28–56 | – |
| | 'aiakanene | COER3 | *Coprosma ernodeoides* | 22–56 | – |
| | ohelo 'ai | VARE | *Vaccinium reticulatum* | 11–28 | – |
| | hinahina | GECU | *Geranium cuneatum* | 6–11 | – |
| | Mauna Loa beggarticks | BIME | *Bidens menziesii* | 6–11 | – |
| | pukamole | LYMA3 | *Lythrum maritimum* | 1–6 | – |
| | lava dubautia | DUCI | *Dubautia ciliolata* | 1–6 | – |
| | Menzies' ballart | EXME | *Exocarpos menziesii* | 1–6 | – |
| | alpine tetramolopium | TEHU | *Tetramolopium humile* | 1–6 | – |
| 10 | **Exotic shrub** | | | 56–112 | |
| | spreading snakeroot | AGRI2 | *Ageratina riparia* | 28–56 | – |
| | Peruvian groundcherry | PHPE4 | *Physalis peruviana* | 11–28 | – |
| | cure for all | PLCA10 | *Pluchea carolinensis* | 11–28 | – |
| 11 | **Native vine** | | | 1–6 | |
| | littleleaf stenogyne | STMI3 | *Stenogyne microphylla* | 1–6 | – |
| | ma'ohi'ohi | STRU2 | *Stenogyne rugosa* | 1 | – |

| | | | | | |
|---|---|---|---|---|---|
| | queen coralbead | COOR11 | *Cocculus orbiculatus* | 1 | – |
| 12 | **Exotic vine** | | | 1–112 | |
| | Cape-ivy | DEOD | *Delairea odorata* | 1–112 | – |
| | banana passionflower | PATRM | *Passiflora tripartita var. mollissima* | 1–28 | – |
| | Mexican twist | LOER3 | *Lophospermum erubescens* | 1–6 | – |
| **Tree** | | | | | |
| 13 | **Native tree** | | | 56–140 | |
| | 'ohi'a lehua | MEPO5 | *Metrosideros polymorpha* | 56–112 | – |
| | mamani | SOCH | *Sophora chrysophylla* | 1–56 | – |
| | Lanai colicwood | MYLA3 | *Myrsine lanaiensis* | 1–28 | – |
| | kokea lau li'i | MYSA2 | *Myrsine sandwicensis* | 1–28 | – |
| | mountain sandalwood | SAPA7 | *Santalum paniculatum* | 1–28 | – |
| | koa | ACKO | *Acacia koa* | 1–28 | – |
| | alpine mirrorplant | COMO3 | *Coprosma montana* | 1–28 | – |
| 14 | **Exotic tree** | | | 1–11 | |
| | silkoak | GRRO | *Grevillea robusta* | 1–11 | – |

**Table 13. Community 3.1 plant community composition**

| Group | Common Name | Symbol | Scientific Name | Annual Production (Kg/Hectare) | Foliar Cover (%) |
|---|---|---|---|---|---|
| **Grass/Grasslike** | | | | | |
| 1 | **Native bunchgrass** | | | 1–56 | |
| | alpine hairgrass | DENU6 | *Deschampsia nubigena* | 1–56 | – |
| | Pacific bentgrass | AGAV | *Agrostis avenacea* | 1 | – |
| 2 | **Native grasslike** | | | 1–6 | |
| | manyspike flatsedge | CYPO | *Cyperus polystachyos* | 1–6 | – |
| | Oahu sedge | CAWA | *Carex wahuensis* | 1 | – |
| 3 | **Exotic bunchgrass** | | | 2018–3811 | |
| | crimson fountaingrass | PESE3 | *Pennisetum setaceum* | 2018–3811 | – |
| | orchardgrass | DAGL | *Dactylis glomerata* | 673–1121 | – |
| | common velvetgrass | HOLA | *Holcus lanatus* | 673–1121 | – |
| | sweet vernalgrass | ANOD | *Anthoxanthum odoratum* | 560–897 | – |
| | annual bluegrass | POAN | *Poa annua* | 6–56 | – |
| | molassesgrass | MEMI2 | *Melinis minutiflora* | 11–56 | – |
| | rose Natal grass | MERE9 | *Melinis repens* | 11–56 | – |
| | smut grass | SPIN4 | *Sporobolus indicus* | 6–56 | – |
| | brome fescue | VUBR | *Vulpia bromoides* | 1–28 | – |
| | weeping grass | MIST | *Microlaena stipoides* | 11–28 | – |
| | marsh bristlegrass | SEPA10 | *Setaria parviflora* | 6–11 | – |
| | little quakinggrass | BRMI2 | *Briza minor* | 1–6 | – |
| 4 | **Exotic herb** | | | 112–336 | |
| | kikuyugrass | PECL2 | *Pennisetum clandestinum* | 224–336 | – |
| 5 | **Exotic bunchgrass** | | | 1 | |
| | densetuft hairsedge | BUCA2 | *Bulbostylis capillaris* | 1 | – |
| **Forb** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 7 | **Native fern** | | | 1–6 | |
| | western brackenfern | PTAQ | *Pteridium aquilinum* | 1–6 | – |
| | Cretan brake | PTCR2 | *Pteris cretica* | 1 | – |
| | maidenhair spleenwort | ASTR2 | *Asplenium trichomanes* | 1 | – |
| | Trans-Pecos cliffbrake | PETE2 | *Pellaea ternifolia* | 1 | – |
| 8 | **Exotic herb** | | | 11–224 | |
| | stinking strawflower | HEFO4 | *Helichrysum foetidum* | 1–56 | – |
| | common mullein | VETH | *Verbascum thapsus* | 1–56 | – |
| | Madagascar ragwort | SEMA15 | *Senecio madagascariensis* | 6–56 | – |
| | pinkhead smartweed | POCA21 | *Polygonum capitatum* | 1–11 | – |
| | 'akala | RUMA6 | *Rubus macraei* | 1–11 | – |
| | Australasian geranium | GEHO5 | *Geranium homeanum* | 1–11 | – |
| | lilac tasselflower | EMSO | *Emilia sonchifolia* | 1–11 | – |
| | pepperweed | LEPID | *Lepidium* | 1–6 | – |
| | oxeye daisy | LEVU | *Leucanthemum vulgare* | 1–6 | – |
| | bull thistle | CIVU | *Cirsium vulgare* | 1–6 | – |
| | common St. Paul's wort | SIOR2 | *Sigesbeckia orientalis* | 1–6 | – |
| **Shrub/Vine** | | | | | |
| 9 | **Native shrub** | | | 6–280 | |
| | Florida hopbush | DOVI | *Dodonaea viscosa* | 1–224 | – |
| | pukiawe | STTA | *Styphelia tameiameiae* | 1–224 | – |
| | ohelo 'ai | VARE | *Vaccinium reticulatum* | 1–28 | – |
| | Hawai'i false ohelo | WIPH2 | *Wikstroemia phillyreifolia* | 1–28 | – |
| | Hawai'i hawthorn | OSAN | *Osteomeles anthyllidifolia* | 1–28 | – |
| | yellow ‘ilima | SIFA | *Sida fallax* | 1–28 | – |
| | pukamole | LYMA3 | *Lythrum maritimum* | 1–6 | – |
| | 'aiakanene | COER3 | *Coprosma ernodeoides* | 1–6 | – |
| 10 | **Exotic shrub** | | | 6–168 | |
| | spreading snakeroot | AGRI2 | *Ageratina riparia* | 1–112 | – |
| | Peruvian groundcherry | PHPE4 | *Physalis peruviana* | 1–56 | – |
| | cure for all | PLCA10 | *Pluchea carolinensis* | 1–56 | – |
| 11 | **Native vine** | | | 1 | |
| | queen coralbead | COOR11 | *Cocculus orbiculatus* | 1 | – |
| 12 | **Exotic vine** | | | 1–112 | |
| | Cape-ivy | DEOD | *Delairea odorata* | 1–112 | – |
| **Tree** | | | | | |
| 13 | **Native tree** | | | 1–112 | |
| | 'ohi'a lehua | MEPO5 | *Metrosideros polymorpha* | 1–112 | – |
| | mamani | SOCH | *Sophora chrysophylla* | 1–28 | – |
| | Lanai colicwood | MYLA3 | *Myrsine lanaiensis* | 1–11 | – |
| | alpine mirrorplant | COMO3 | *Coprosma montana* | 1–11 | – |
| 14 | **Exotic tree** | | | 1–28 | |
| | silkoak | GRRO | *Grevillea robusta* | 1–28 | – |

## Animal community

Wildlife
This ecological site provides habitat for the native Hawaiian hawk or io (Buteo solitarius), nene (Branta sandvicensis), and Hawaiian owl or pueo (Asio flammeus spp. sandwichensis).

A large number of native bird species have gone extinct both before and after European contact.

Introduced Wildlife
This ecological site provides habitat to a variety of introduced birds. Species such as wild turkey (Meleagris gallopavo), ring-necked pheasant (Phasianus colchicus), Erckel's francolin (Pternistis erckelii), chuckar partridge (Alectoris chukar), and California quail (Callipepla californica) are considered to be game birds.

Feral pigs and mouflon sheep (Ovis orientalis orientalis) are common. They provide hunting opportunities but are very destructive to native vegetation. Public sport hunting typically does not have a major impact on their populations; exclusion by fences followed by intensive control measures are necessary to eliminate feral ungulates.

Introduced wildlife species are able to utilize both community phases within the ecological site.

## Hydrological functions

Due to the relatively dry climate and generally intact vegetation structure, runoff is not a problem.

## Recreational uses

Hiking, bird watching, and hunting are recreational uses.

## Wood products

There are no wood products obtained from this ecological site.

## 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.

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 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° 44′ 29″ |
| Longitude | 155° 49′ 25″ |
| General legal description | This location is along the jeep trail leading south from Puuwaawaa cone. |

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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) | Loretta J. Metz; David Clausnitzer |
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| Date | 12/20/2017 |
| Approved by | |
| Approval date | |
| Composition (Indicators 10 and 12) based on | Annual Production |

## Indicators

1. **Number and extent of rills:** None

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2. **Presence of water flow patterns:** None

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3. **Number and height of erosional pedestals or terracettes:** None

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** 1 to 10% bare ground is expected.

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5. **Number of gullies and erosion associated with gullies:** None

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6. **Extent of wind scoured, blowouts and/or depositional areas:** None

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7. **Amount of litter movement (describe size and distance expected to travel):** Litter does not commonly move on this site, unless there is an rainfall event. If a heavy rainfall occurs, the smaller litter particles (eg, pukiawe and mamane leaves) may travel until they encounter a lava obstruction or rock outcrop.

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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):** For the volcanic ash soils on this site, the stability values will range from 1 to 3.

   For the organic soils on this site (highly decomposed plant materials), the stability values will range from 2 to 4.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Variable.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** There is not an appreciable difference.

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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: Dominant: Native shrubs = native cool-season bunchgrasses >> Sub-dominant: Native trees > native grass-likes.
    Other:
    Additional:

    Sub-dominant:

    Other:

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Plant mortality is not frequent in these long-lived plant communities. Decadence is surprisingly low in this harsh environment.

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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):** Typical annual above-ground production is about 3200 lb/ac.

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:** Invasion of alien grasses and vines are the biggest threat. Refer to Plant Community 3 Plant Species Composition table in the ESD for a list of those species.

17. **Perennial plant reproductive capability:** Capacity to reproduce should not be reduced or impaired in the reference state.