USDA Natural Resources Conservation Service

Ecological site VX162X01X500
Isohyperthermic Forest

Accessed: 05/11/2025

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.

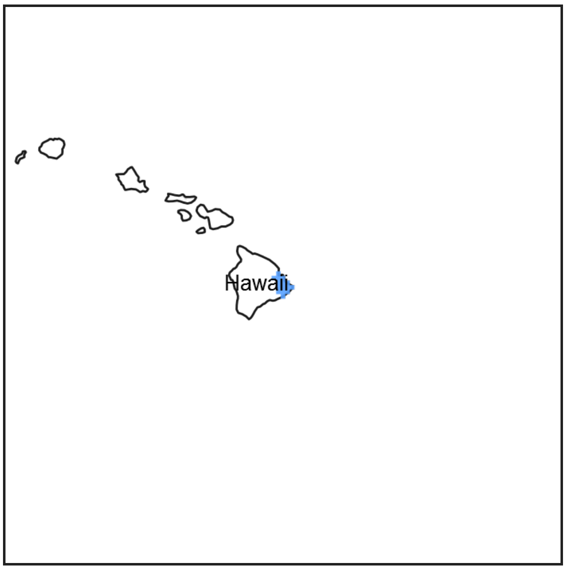

Figure 1. Mapped extent

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): 162X–Humid and Very Humid Organic Soils on Lava Flows

This MLRA occurs in the State of Hawaii on the Big Island of Hawaii on the southeastern slopes of Mauna Loa and Mauna Kea volcanoes. Elevation ranges from sea level to 4000 feet (0 to 1200 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 or in limited areas by recent volcanic ash. Climate is mostly wet tropical. Average annual precipitation typically ranges from 60 to 235 inches (1500 to 5875 millimeters), increasing with elevation and to the north. Rainfall occurs mostly from November through April in udic areas and is evenly distributed throughout the year in perudic areas. Average annual temperatures range from 54 to 73 degrees F (12 to 23 degrees C), with little seasonal variation. Soils are mostly Udifolists with isothermic or isohyperthermic soil temperature regimes. Very young lava flows may have no soil covering. Native vegetation consists of moderate to tall stature rain forests, low stature dry forests, and “savannas” dominated by dense thickets of uluhe ferns.

Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 162 - Humid and Very Humid Organic Soils on Lava Flows.

Ecological site concept

This ecological site is the moist, moderate stature forest that follows both sides of Route 11 from Hilo south to Keaau and then Route 130 from Keaau through Pahoa to mauka of Kalapana. It starts just inland from the coast, existing where very young lava flows have not covered the slightly more developed soils of this ecological site. Much of the area is private land, with large areas held by Kamehameha Schools and the State of Hawaii. Most of this forest is heavily impacted by introduced plant species.

The central concept of the Isohyperthermic Forest is of well to somewhat excessively drained, very shallow to shallow soils formed in deposits of highly decomposed plant material over pahoehoe (flat lava flows) or within the spaces of aa (cobbly lava flows). Lava flows are young, ranging from 400 to 1500 years old. Annual air temperatures and rainfall create hot (isohyperthermic), moist (udic) soil conditions. These soils support a forest an overstory up to 80 feet (25 meters) tall of ohia lehua (*Metrosideros polymorpha*), a secondary canopy from 25 to 40 feet (8 to 12 meters) tall of multiple tree species, an open tree fern or hapuu (Cibotium spp.) canopy 10 to 16 feet (3 to 5 meters) tall, and a diverse understory of ferns, shrubs, and vines. Tahitian screw pine (Pandanus tectorius) trees are common near the coast but decline in abundance inland.

Associated sites

VX162X01X503	**Udic Isothermic Forest** F162XY503 Udic Isothermic Forest borders F162XY500 at higher elevations that receive more rainfall.
VX162X01X504	**Pahoehoe Organic Fern Savanna** F162XY504 Pahoehoe Organic Fern Savanna adjoins F162XY500 on very shallow, young, organic soils.

Table 1. Dominant plant species

Tree	(1) *Metrosideros polymorpha* (2) *Diospyros sandwicensis*
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

F162XY500HI

Physiographic features

This ecological site occurs on lava flows on sloping mountainsides of shield volcanoes. Lava flows are aa (loose, cobbly) or pahoehoe (smooth, relatively unbroken). Volcanic ash flows range from very shallow to deep on the underlying lava.

Table 2. Representative physiographic features

Landforms	(1) Shield volcano (2) Lava flow
Flooding duration	Brief (2 to 7 days)
Flooding frequency	None to occasional
Ponding duration	Brief (2 to 7 days)
Ponding frequency	None to occasional
Elevation	20–1,200 ft
Slope	3–25%
Water table depth	60 in
Aspect	NE, E

Climatic features

Average annual precipitation ranges from 100 to 160 inches (2500 to 4000 millimeters). Most of the precipitation falls from November through April. Average annual temperature is about 66 to 72 degrees F (19 to 22 degrees C).

Air temperature in Hawai`i 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).

Hawaii lies 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 6000 feet (very roughly 2000 meters). As the trade winds from the northeast are forced up the mountains of the island their moisture condenses, creating rain on the windward slopes; the leeward side of the island receives little of this moisture.

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

In winter, low pressure systems often approach the island from the west, producing extensive rainstorms that primarily affect the leeward sides of the island.

Reference: Giambelluca and Schroeder 1998.

Table 3. Representative climatic features

Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	127 in

Climate stations used

- (1) HILO INTL AP [USW00021504], Hilo, HI

Influencing water features

There are no water features influencing this ecological site.

Soil features

Soils in this ecological site are of two types: (1) highly decomposed plant materials in aa or on pahoehoe or (2) hydrous (high water holding capacity) loam formed from volcanic ash. Landscape surfaces in this ecological site are young (generally 400 to 1,500 years old). Soil temperature regime is isohyperthermic. Soil moisture regime is udic (in most years, not dry for as long as 90 cumulative days).

The soil phase "Hakuma highly organic hydrous loam, occasionally flooded," is a very shallow soil that occurs in kipukas surrounded by slightly higher parts of the landscape. Runoff from the adjoining landscape enters the kipukas to cause occasional flooding.

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. However, these soils may present some tillage difficulties when formed in aa and containing significant amounts of coarse rock fragments near the surface. Very shallow and shallow ash soils over pahoehoe are sometimes ripped to break up the underlying lava and create a deeper rooting zone.

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. However, live roots are often present in this horizon. These soils often support dense forests with large trees despite their unusual conformation. 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.

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

Table 4. Representative soil features

Parent material	(1) Organic material–pahoehoe lava (2) Basaltic volcanic ash–aa lava
Surface texture	(1) Hydrous silty clay loam
Drainage class	Moderately well drained to well drained
Permeability class	Very slow to rapid
Soil depth	10–60 in
Surface fragment cover <=3"	0–50%
Surface fragment cover >3"	0–60%
Available water capacity (0-40in)	1–5 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	5.1–5.7
Subsurface fragment volume <=3" (Depth not specified)	0–65%
Subsurface fragment volume >3" (Depth not specified)	0–95%

Ecological dynamics

The information in this ecological site description (ESD), including the state-and-transition model (STM), was developed using archaeological and historical data, professional experience, and scientific studies. The information is representative of a complex set of plant communities. Not all scenarios or plants are included. Key indicator plants, animals, and ecological processes are described to inform land management decisions.

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

Natural Disturbances

The natural (not human-caused) disturbances most important for discussion in this ecological site are lava flows, natural fires, volcanic ash falls, and wind throw.

A lava flow obviously destroys all the vegetation it covers. Regrowth of vegetation through primary succession and formation of new soil proceed at widely varying rates depending on flow age, local climate, lava type (aa or pahoehoe), and proximity of vegetation seed sources. Flows located in warm, moist climates are rapidly colonized the nitrogen-fixing lichen Stereocaulon vulcani, followed soon by vascular plants including ohia lehua (*Metrosideros polymorpha*) trees. In these environments, considerable vegetation can be established in periods measured in decades. Cooler locations at higher elevations revegetate more slowly. Cobbly aa lava provides safe sites for seed germination as well as sites that promote plant rooting and soil accumulation in the gaps between cobbles. This is a more favorable situation for revegetation and soil development than flat, bare pahoehoe lava. Where lava flows are narrow or where kipukas (“islands” of surfaces not covered by lava) occur, revegetation is hastened by the proximity of seed sources from intact vegetation stands nearby.

Heat from nearby lava flows sears and kills vegetation and can ignite wildfires that may carry to some extent. These effects can be seen in vegetation growing near the edges of recent flows. Natural wildfire caused by lava or possibly by lightning is probably a widespread disturbance in this ecological site given the frequency of lava flows. Most of the surfaces within this ecological site consist of lava flows that are from 400 to 1500 years old.

Vegetation can be killed by erupted layers of ash from volcanic vents, depending on the temperature of the ash and the depth of accumulation. However, vegetation sometimes survives ash flows (Vitousek 2004). Vegetation rapidly recovers because ash flow deposits possess physical and chemical properties favorable to plant growth including high water holding capacity, high surface area, rapid weathering, and favorable mineral nutrient content. New soils develop very rapidly in ash deposits, and further soil development is facilitated in turn by the rapidly-developing vegetation (Shoji et al. 1993).

Wind throw of vegetation can occur during hurricanes or other high wind events. As some of the soils of this ecological site are shallow, wind throw may occasionally occur.

Human Disturbances

Human-related disturbances have been much more important than natural disturbances in this ecological site since the arrival of Polynesians and, later, Europeans. These reflected in the State and Transition Model Diagram.

Humans arrived in the Hawaiian Islands 1200 to 1500 years ago. Their population gradually increased so that by 1600 AD at least 80% of all the lands in Hawaii below about 1500 feet (roughly 500 meters) in elevation had been extensively altered by humans (Kirch 1982); some pollen core data suggest that up to 100% of lowlands may have been altered (Athens 1997). By the time of European contact late in the 18th century, the Polynesians had developed high population densities and placed extensive areas under intensive agriculture (Cuddihy and Stone 1990).

Prehistoric native lowland forest disturbance can be attributed to clearing for agriculture by hand or by fire, introduction of new plants and animals, and wood harvesting Higher elevation forests would have been much less affected, but may have been affected by factors such as inadvertently introduced plant diseases and seed predation the introduced Pacific rat (Athens 1997).

It seems likely that early agriculture in this area would have been concentrated in areas, mostly kipukas, that have deeper volcanic ash soils that have not recently been covered by fresh lava. Individual Polynesian crop plants can still be encountered in many locations.

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

The Polynesians introduced dogs, Pacific rats, and small pigs to the islands. Cattle, sheep, horses, goats, and larger European pigs were introduced in the final decade the 18th century. These animals ranged free on the islands, becoming very numerous and destructive by the early decades of the 19th century.

Native forests were damaged by the extensive harvesting of tree ferns (hapuu) for pulu in the mid-1800s. Pulu is a soft fiber that covers the base of fronds of the hapuu was exported to the west coast of America to be used in pillows and mattresses.

By the early 20th century, concerns over watershed conditions due to destruction of forests led to establishment of forest reserves and efforts to replant forests. Introduced tree species were often planted because they were considered to be hardier or more valuable than native species. The introduced tree species christmasberry or Brazil peppertree (*Schinus terebinthifolius*) was selected for planting in Hawaii because it is apparently worthless; the reasoning was that no one would be tempted to cut down worthless trees. Seeds of introduced species were often sown in the mountains by airplanes (Little and Skolmen 1989). Some of these species have proven to be highly invasive. In addition to direct competitive effects, introduced tree species (e.g., tropical ash or shamel ash (*Fraxinus uhdei*) and nitrogen-fixing species albizia or peacocks plume (*Falcataria moluccana*) produce litter that is very different in chemical composition or physical form from native plant litter, bringing about changes in nutrient cycling and physical conditions in soils and on the forest floor (Vitousek 2004).

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. This ecological site evolved without the presence of large mammals or human-caused fires. The native plant community in many areas been highly disturbed and in some places destroyed due to agriculture, urban development, domestic and feral ungulate foraging, and invasion by introduced plant and animal species.

Foraging by feral cattle and pigs or forest clearing and abandonment facilitate invasion by weeds. However, introduced weeds appear able to successfully invade native stands regardless of human or ungulate disturbances. Among the major weeds are strawberry guava or waiawi (*Psidium cattleianum*), Koster's curse or soapbush (*Clidemia hirta*), Asian melastome (Melastoma candida), and introduced grasses.

State and transition model

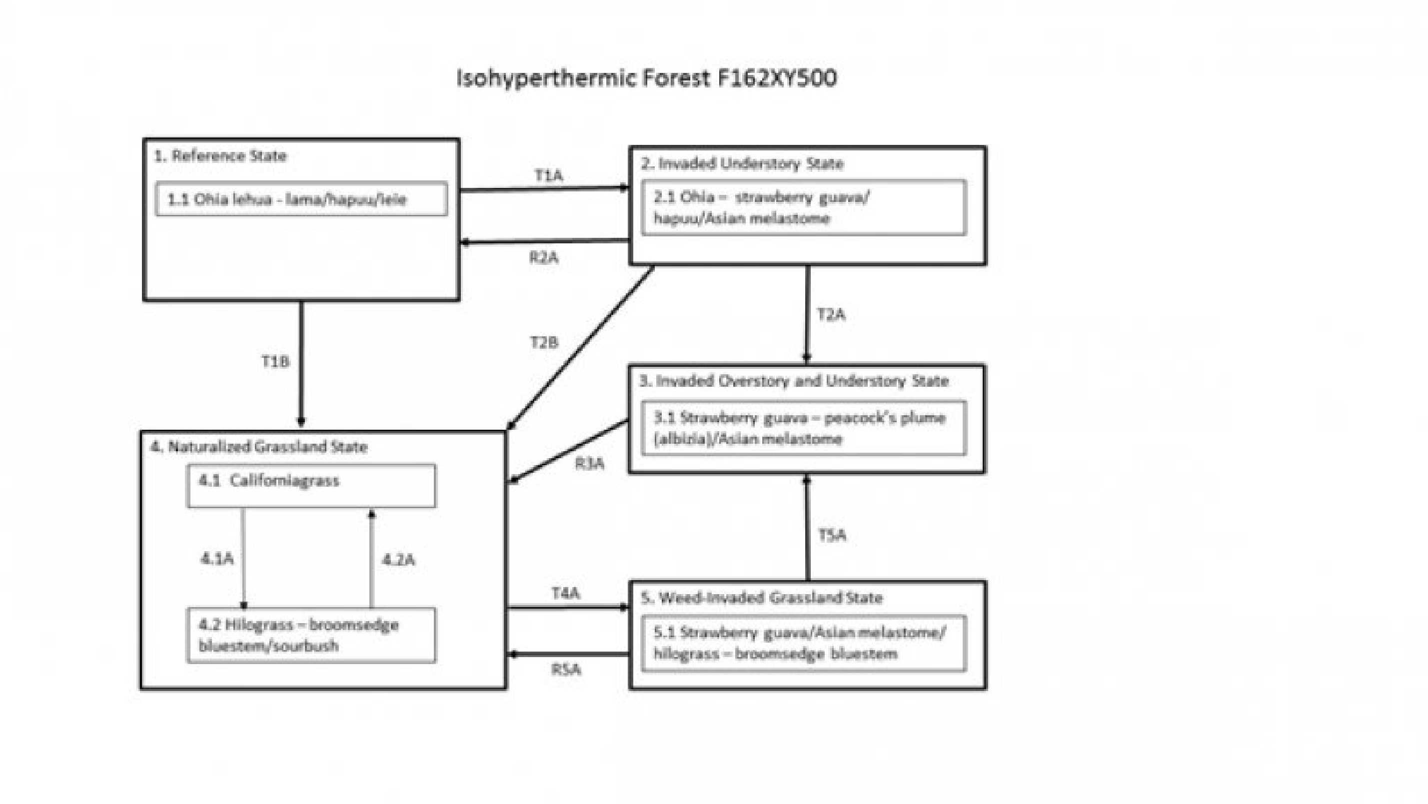

Figure 6. STM F162XY500

State 1
Reference State

This state consists of one community phase. The general aspect is a forest with a tall (to about 80 feet or 25 meters), closed to open overstory, a secondary canopy of diverse trees species 25 to 40 feet (8 to 12 meters) tall, an open tree fern canopy 10 to 15 feet (3 to 4.5 meters) tall, and a diverse understory of shrubs, vines, and ferns. When cleared by machinery or long-term, heavy ungulate browsing, this state transitions to State 4 Naturalized Grassland. Gradual invasion by weedy, introduced plant species brings a transition to State 2 Invaded Understory.

Community 1.1
`Ohi`a lehua lama/hapu`u/`ie`ie

Figure 7. Reference community phase. 6/2/06 D Clausnitzer MU659

Figure 8. Reference community phase. 6/2/06 D Clausnitzer MU659

The tall overstory consists of ohia lehua (*Metrosideros polymorpha*). The secondary tree canopy consists of a mix of wet environment species and dry environment species. Joseph Rock (1913) described this in the early 20th Century: "Diospyros (lama tree) in lowland forest is especially common back of Hilo along the road to Olaa" (=Keaau), and "Immediately back of Hilo is a somewhat mixed forest composed of species of trees peculiar to the dry and wet regions." Tree ferns are common. Vines are moderately abundant, particularly ieie (Freycenetia arborea), both on the ground and on trees. Large bird's nest ferns (*Asplenium nidus*) are common on trees and on the ground, but mostly at lower elevations. The mid-canopy is dominated by pandanus or Tahitian screwpine (Pandanus tectoria) trees near the coast; this species becomes less common with distance from the coast. Pandanus seems to be moderately invasive, and may be more common on previously disturbed sites or where it was encouraged by the Polynesians in the past. The forests of this ecological site have standing live timber of 500 to 8000 cubic feet per acre, with a representative value of about 1500 cubic feet per acre.

Forest overstory. The tall overstory consists of ohia lehua that typically range from 75 to 100 feet (23 to 30 meters) tall. The secondary tree canopy today consists mostly of lama (Diospyros sandwicensis) to 50 feet (15 meters) tall and olapa (Cheirodendron trigynum) to 40 feet (12 meters) tall. Pandanus grows to 30 feet (9 meters) tall.

Forest understory. Tree ferns, or hapuu (Cibotium glaucum) and hapuu li (Cibotium menziesii) are common, forming an open canopy up to about 13 feet (4 meters) tall; C. glaucum is by far the more common species of the two. Ieie (Freycenetia arborea) is abundant, growing both on the ground and on trees to heights of about 40 feet (12 meters). Cyrtandra species are common in places, along with kanawao (Broussaisia arguta). At least 14 small fern and fern-ally species are commonly found growing on the ground and on tree trunks.

Table 5. Soil surface cover

Tree basal cover	2-5%
Shrub/vine/liana basal cover	1-2%
Grass/grasslike basal cover	0%

Forb basal cover	0%
Non-vascular plants	20-50%
Biological crusts	0%
Litter	30-40%
Surface fragments >0.25" and <=3"	0-40%
Surface fragments >3"	0-40%
Bedrock	0%
Water	0%
Bare ground	0-1%

Table 6. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	1-2%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	1-3%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	1-2 per acre
Tree snag count** (hard***)	1-5 per acre

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

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

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

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	1-2%	–	0%
>0.5 <= 1	0%	3-5%	–	1-3%
>1 <= 2	1-1%	3-5%	–	5-10%
>2 <= 4.5	1-2%	0-1%	–	1-1%
>4.5 <= 13	15-25%	0-2%	–	–
>13 <= 40	15-25%	0-1%	–	–
>40 <= 80	35-40%	–	–	–
>80 <= 120	0-10%	–	–	–
>120	–	–	–	–

State 2
Invaded Understory State

This state consists of one community phase. Native ohia lehua trees still dominate the overstory. However, introduced trees, shrubs, vines, and ferns produce a dense layer of low, competitive vegetation that severely inhibits reproduction of native species. Many native species are still present in this plant community but their abundance is much reduced. Activity of feral pigs and cattle further reduces native plant abundance and produces bare, disturbed soil patches that promote weed invasion. Eventually, this state transitions to State 3 Invaded Overstory and Understory through growth of introduced tree species.

Community 2.1
`Ohi`a lehua - strawberry guava/hapu`u/Asian melastome

Figure 9. Invaded understory behind cleared plot. 12/8/05 D Clausnitzer MU628

Figure 10. Introduced fern understory. D Clausnitzer generic photo

Figure 11. Melastome understory. 1/18/07 D Clausnitzer generic photo

While native trees still dominate the overstory, introduced tree species are beginning to grow into the secondary overstory. Litter from nitrogen-fixing albizia (*Falcataria moluccana*) produces a favorable environment for fast-growing introduced species. Smaller, shade-tolerant introduced trees and shrubs gradually produce extremely dense canopies and root systems that exclude other species. Dense stands of introduced ferns form a layer that inhibits reproduction of native species.

Forest overstory. Tall ohia lehua still dominate the overstory, and the more common native trees are still present in the secondary canopy. However, trees with the potential grow at least as tall as ohia lehua, such as albizia or peacocks plume (Falcataria moluccana), octopus tree (Schefflera actinophylla), Oriental trema (Trema orientalis), and trumpet tree (Cecropia obtusifolia) are present in the secondary canopy and increasing in abundance.

Forest understory. Strawberry guava (Psidium cattleianum) is increasingly abundant, gradually forming extremely dense stands with dense, intertwined root systems. The introduced ferns scaly swordfern (Nephrolepis hirsutula), Deparia petersonii, and parasitic maiden fern (Thelypteris parasitica) form dense stands under 3 feet (1 meter) tall. Native tree ferns may still be common. The melastomes Koster’s curse or soapbush (Clidemia hirta), Asian melastome (Melastoma candidum), and velvet tree (Miconia calvescens) are present and increasing in abundance.

Table 8. Soil surface cover

Tree basal cover	1-2%
Shrub/vine/liana basal cover	0-1%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	15-25%
Biological crusts	0%
Litter	65-75%
Surface fragments >0.25" and <=3"	0-30%

Surface fragments >3"	0-30%
Bedrock	0%
Water	0%
Bare ground	1-5%

Table 9. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	1-2%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	2-3%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	1-2 per acre
Tree snag count** (hard***)	2-3 per acre

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

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

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

Table 10. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	0-1%	0-1%	1-2%
>0.5 <= 1	0%	1-5%	0-1%	10-20%
>1 <= 2	0-1%	1-5%	–	20-25%
>2 <= 4.5	0-1%	20-25%	–	0-1%
>4.5 <= 13	10-35%	20-25%	–	–
>13 <= 40	15-25%	1-5%	–	–
>40 <= 80	35-45%	–	–	–
>80 <= 120	0-10%	–	–	–
>120	–	–	–	–

State 3
Invaded Overstory and Understory State

This state consists of one community phase dominated by introduced species in both the overstory and understory. Some tall native trees may persist for a long time, and a few native species appear able to reproduce and maintain low populations. The diversity of weedy trees, shrubs, vines, ferns, and herbs is high. Conversion to State 4 Naturalized Grassland is possible by using heavy machinery and applying aggressive weed control measures.

Community 3.1
Strawberry guava/peacocksplume (albizia)/Asian melastome

Figure 12. Invaded over- and understory. D Clausnitzer generic photo

Tall ohia lehua (*Metrosideros polymorpha*) persist until they die but do not successfully reproduce. A few native species including kopiko, tree ferns, pandanus, and bird’s nest ferns are able to reproduce and maintain low populations. The introduced species present on different sites varies, but strawberry guava, melastomes, and albizia are typically present.

Forest overstory. Species composition varies from site to site, but the overstory is often dominated by albizia or peacocksplume (Falcataria moluccana), which grows rapidly and is able to overtop all other tree species. Besides remnant ohia lehua, introduced trees such as Oriental trema (Trema orientalis), trumpet tree (Cecropia obtusifolia), melaleuca or punktree (Melaleuca quinquenervia), and octopus tree (Schefflera actinophylla) may be present. Ironwood or beach sheoak trees (Casuarina equisetifolia) are common near the coast. Strawberry guava (Psidium cattleianum) typically dominates the secondary canopy.

Forest understory. Koster’s curse or soapbush (Clidemia hirta) and Asian melastome (Melastoma candidum) may be abundant along with introduced fern species.

Table 11. Soil surface cover

Tree basal cover	1-3%
Shrub/vine/liana basal cover	0.5-1.0%
Grass/grasslike basal cover	0.0-0.5%
Forb basal cover	0%
Non-vascular plants	10-20%
Biological crusts	0%
Litter	65-75%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-25%
Bedrock	0%
Water	0%
Bare ground	0-1%

Table 12. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	1-2%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	1-3%

Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	1-2 per acre
Tree snag count** (hard***)	2-3 per acre

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

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

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

Table 13. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	0%	0-2%	1-3%
>0.5 <= 1	0-1%	0-1%	1-3%	10-20%
>1 <= 2	1-1%	1-1%	–	10-30%
>2 <= 4.5	5-10%	15-25%	–	–
>4.5 <= 13	15-25%	15-25%	–	–
>13 <= 40	25-35%	0-1%	–	–
>40 <= 80	1-5%	–	–	–
>80 <= 120	1-2%	–	–	–
>120	–	–	–	–

State 4
Naturalized Grassland State

This state consists of two community phases dominated by introduced grass species. Continuous grazing results in increased abundance of less desirable forage species and presence of weedy shrubs, as represented by the phase change from 4.1 Californiagrass to 4.2 Hilograss – broomsedge bluestem/sourbush. Longer-term overgrazing and lack of weed control measures results in a transition to State 5 Weed-Invaded Grassland.

Community 4.1
Californiagrass

Figure 13. Californiagrass is dominant in foreground. D Clausnitzer generic photo

Landowners choose to establish a dominant forage grass species from the options of suitable species for this community phase. Dominance of desired forage species is maintained by prescribed grazing techniques that allow desired species time to recover from grazing and trampling, but includes periods of grazing of sufficient intensity to suppress invasion of weedy shrubs and trees. Invasion by weedy beardgrass, also called Colombian bluestem (*Schizachyrium condensatum*) and broomsedge bluesedge (*Andropogon virginicus*) is minimized by mowing these species before they set seed and by liming. Failure to properly maintain the selected forage species results in this community phase shifting to community phase 4.2.

Forest overstory. There typically is no overstory in this community.

Forest understory. Commonly planted forage species are Californiagrass, also called para grass (Urochloa mutica), digitgrass, also called pangolagrass (Digitaria eriantha), or limpograss (Hemarthria altissima) in mixture with desmodium legume species (Desmodium intortum, D. incanum, D. sandwicense, and D. triflorum).

Community 4.2
Hilograss - broomsedge bluestem/sourbush

Figure 15. Hilograss and shrub-invaded grassland. 4/19/05 D Clausnitzer generic photo

This community phase is dominated by grasses of lower forage value. Desirable forage legumes largely have been grazed out, and weedy forbs and shrubs have increased. It can be shifted back to phase 4.1 by using a prescribed grazing plan.

Forest overstory. Scattered albizia trees are sometimes present.

Forest understory. Narrowleaf carpetgrass (Axonopus fissifolius), hilograss (Paspalum conjugatum), and broomsedge bluestem (Andropogon virginicus) are typically the most abundant grasses. Sourbush or cure for all (Pluchea carolinensis), and tarweed or Colombian waxweed (Cuphea carthagenensis) also are common.

Table 14. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0.0-0.5%
Grass/grasslike basal cover	30-35%
Forb basal cover	0.0-0.5%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	60-70%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	5-10%

Table 15. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0%	15-20%	0-1%
>0.5 <= 1	–	0-1%	20-25%	1-5%
>1 <= 2	–	1-1%	10-20%	1-2%
>2 <= 4.5	0-1%	5-10%	20-40%	1-2%
>4.5 <= 13	0-1%	–	–	–
>13 <= 40	0-1%	–	–	–
>40 <= 80	0-1%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Pathway 4.1A
Community 4.1 to 4.2

Californiagrass

Hilograss - broomsedge bluestem/sourbush

Phase 4.1 changes to phase 4.2 by long-term continuous grazing. Remnant high-quality forages have been greatly reduced in abundance and largely replaced by lower-value species. Weedy forbs and shrubs are increasing.

Pathway 4.2A
Community 4.2 to 4.1

Hilograss - broomsedge bluestem/sourbush

Californiagrass

A grazing plan is needed that provides for intensive but temporary grazing of pastures to ensure that cattle consume some low-value forage species along with preferred forages and to allow preferred forages time to recover from defoliation. Desirable grass species are competitive and able to recover with proper management. The grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing. Weed control may be necessary to eliminate some species such as inedible shrubs. Broomsedge and/or beardgrass are controlled by increasing soil pH through lime applications and by mowing before seed set.

State 5
Weed-Invaded Grassland State

This state consists of one community phase consisting primarily of weedy shrubs. Weedy grasses and forbs dominate between shrub patches. Introduced tree species are present and will attain dominance if fire does not set them back. Average annual rainfall is relatively high, producing large amounts of fine fuels that present a fire danger in dry periods.

Community 5.1
Strawberry guava/Asian melastome/hilograss - broomsedge bluestem

Figure 16. Open weedy site. D Clausnitzer generic photo

This community phase has a wide diversity of mostly introduced species. Some locations are nearly covered by dense stands of large shrubs. Native uluhe fern (*Dicranopteris linearis*) often forms dense thickets.

Forest overstory. Large albizia or peacocksplume (Falcataria moluccana) is the most common species.

Forest understory. Numerous small ohia lehua (Metrosideros polymorpha) trees are present on some sites. Strawberry guava (Psidium cattleianum) is becoming common and is poised to expand rapidly. Asian melastome (Melastoma candidum), Koster's curse or soapbush (Clidemia hirta), and sourbush or cure for all (Pluchea carolinensis) are abundant. Thickets of uluhe or Old World forkedfern (Dicranopteris linearis) are often present. Scaly swordfern (Nephrolepis hirsutula) is abundant. An assortment of introduced forbs and grasses is present.

Table 16. Soil surface cover

Tree basal cover	0.0-0.5%
Shrub/vine/liana basal cover	0.5-1.0%
Grass/grasslike basal cover	10-15%
Forb basal cover	1-2%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	60-70%
Surface fragments >0.25" and <=3"	0-1%
Surface fragments >3"	0-1%
Bedrock	0%
Water	0%
Bare ground	3-5%

Table 17. Woody ground cover

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

Tree snag count** (hard***)	

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

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

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

Table 18. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	0-1%	0-1%	1-5%
>0.5 <= 1	0%	1-2%	10-20%	5-10%
>1 <= 2	0-1%	1-2%	10-20%	10-20%
>2 <= 4.5	3-5%	5-10%	5-10%	1-2%
>4.5 <= 13	5-10%	25-35%	–	–
>13 <= 40	1-5%	–	–	–
>40 <= 80	0-2%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Transition T1A
State 1 to 2

This state transitions to State 2 Invaded Understory by the very aggressive, introduced weed species present in this ecological site invading intact native forest and gradually replacing native species in the understory. This invasion is greatly facilitated by feral pigs and cattle that damage and consume native plants, disturb the soil, and spread weed seeds.

Transition T1B
State 1 to 4

Restoration pathway R2A
State 2 to 1

This state may be restored to a facsimile of State 1 Reference. Pig-proof fence and removal of all ungulates are necessary. Intensive weed control must then be initiated and maintained in the long term. In some cases, large amounts of dead weed biomass must be dealt with by removal or decomposition. Reintroduction of missing native species is likely to be necessary.

Transition T2A
State 2 to 3

This state transitions to State 3 Invaded Over and Understory through the process of fast-growing weeds inhibiting reproduction of native plants and gradually replacing them. This process is accelerated by feral pigs and cattle directly damaging native plants and promoting the spread of weeds by disturbing the soil and spreading weed seeds.

Transition T2B
State 2 to 4

This state can transition to State 4 Naturalized Grassland by clearing the forest with heavy machinery and planting desirable forage species. Native forest may be cleared gradually by allowing cattle access to the forest. Cattle eventually eat or destroy understory ferns, forbs, shrubs, and saplings, opening up the forest so that introduced forage species will thrive. On shallow soils over lava substrates, underlying lava rock may be ripped and crushed by heavy machinery. Ripping and crushing produces fine mineral particles and small, abundant gaps between the rock fragments. When this is done on organic soils, about 50% of the soil organic matter may be lost in the process due to exposure to air and higher temperatures.

Transition R3A
State 3 to 4

This state can be converted to State 4 Naturalized Grassland by clearing vegetation using heavy machinery, applying aggressive weed control measures, and planting desirable forage species. On shallow soils over lava substrates, underlying lava rock may be ripped and crushed by heavy machinery. Ripping and crushing produces some fine mineral particles and small, abundant gaps between the rock fragments. When this is done on organic soils, about 50% of the soil organic matter may be lost in the process due to exposure to air and higher temperatures.

Transition T4A
State 4 to 5

This state transitions to State 5 Weed Invaded Grassland by long-term continuous grazing and lack of weed control measures. Remnant desirable forages have been grazed out and replaced entirely by weedy grasses, forbs, shrubs, and small trees.

Transition T5A
State 5 to 3

This state transitions to State 3 Invaded Over and Understory due to the presence of fast-growing, introduced tree species; wildfire may prevent this from occurring.

Restoration pathway R5A
State 5 to 4

This state can be restored to State 4 Naturalized Grassland by brush management, re-establishment of desirable forage species, persistent weed control, and prescribed grazing.

Additional community tables

Table 19. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	40–75	35–55	–	–
wild coffee	PSYCH	*Psychotria*	Native	13–30	10–20	–	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	13–30	0–20	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	75–100	0–10	10–40	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	13–40	0–5	–	–
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	13–40	0–2	–	–
lama	DISA10	*Diospyros sandwicensis*	Native	13–40	0–2	–	–
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	13–35	0–1	–	–
hapu'u	CIGL	*Cibotium glaucum*	Native	13–18	0–1	–	–
ha'a	ANPL2	*Antidesma platyphyllum*	Native	13–20	0–0.5	–	–
'ahakea	BOTI	*Bobea timonioides*	Native	13–20	–	–	–
Remy's gardenia	GARE	*Gardenia remyi*	Native	13–18	–	–	–
Hawai'i pritchardia	PRAF	*Pritchardia affinis*	Native	13–30	–	–	–
lama	DISA10	*Diospyros sandwicensis*	Native	40–50	–	–	–
tetraplasandra	TETRA11	*Tetraplasandra*	Native	13–40	–	–	–
grand devil's-claws	PIGR6	*Pisonia grandis*	Native	30–40	–	–	–
Tree Fern							
hapu'u li	CIME8	*Cibotium menziesii*	Native	13–18	0–1	–	–

Table 20. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Forb/Herb					
twinsorus fern	DIPLA2	*Diplazium*	Native	1–2	0–1
peperomia	PEPER	*Peperomia*	Native	0.5–1	0–0.5
Fern/fern ally					
Hawai'I birdnest fern	ASNI	*Asplenium nidus*	Native	2–6	0–5
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	1–3	0–1
narrow swordfern	NECO3	*Nephrolepis cordifolia*	Native	0.5–1	0–1
Hudson's air fern	PNHU	*Pneumatopteris hudsoniana*	Native	1–3	0–1
whisk fern	PSNU	*Psilotum nudum*	Native	0.5–1	0–0.5
Cretan brake	PTCR2	*Pteris cretica*	Native	0.5–1	0–0.5
wahini noho mauna	ADTA	*Adenophorus tamariscinus*	Native	0.5–1	0–0.5
Old World adderstongue	OPPEP	*Ophioglossum pendulum ssp. pendulum*	Native	0.5–1	0–0.5
staghorn clubmoss	LYCE2	*Lycopodiella cernua*	Native	0.5–1	0–0.5
waimakanui	PTEX	*Pteris excelsa*	Native	1–2	0–0.5
Chinese creepingfern	ODCH	*Odontosoria chinensis*	Native	1–2	0–0.5
vandenboschia	VANDE	*Vandenboschia*	Native	0.5–1	0–0.5
royal tonguefern	ELCR2	*Elaphoglossum crassifolium*	Native	0.5–1	0–0.5
stiff shoestring fern	VIEL3	*Vittaria elongata*	Native	0.5–1	0–0.5
clubmoss	HUPER	*Huperzia*	Native	0.5–1	0–0.5
Shrub/Subshrub					
cyrtandra	CYRTA	*Cyrtandra*	Native	2–4	0–10
kanawao	BRAR6	*Broussaisia arguta*	Native	2–6	1–5
po'ola	CLSA	*Claoxylon sandwicense*	Native	2–8	–
Waimea pipturus	PIAL2	*Pipturus albidus*	Native	2–8	–
puna cyanea	CYPL7	*Cyanea platyphylla*	Native	2–4	–
Tree					
ha'a	ANPL2	*Antidesma platyphyllum*	Native	2–13	1–5
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	–	0–5
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	–	1–2
wild coffee	PSYCH	*Psychotria*	Native	2–13	0–2
lama	DISA10	*Diospyros sandwicensis*	Native	2–13	0–1
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	2–13	0–1
Remy's gardenia	GARE	*Gardenia remyi*	Native	2–13	0–0.5
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	2–13	15–25
hapu'u li	CIME8	*Cibotium menziesii*	Native	2–13	0–2
Vine/Liana					
'ie'ie	FRAR	*Freycinetia arborea*	Native	1–40	1–10
queen coralbead	COOR11	*Cocculus orbiculatus*	Native	1–4	0–1
Maile	ALST11	*Alyxia stellata*	Native	1–2	0–1

Table 21. Community 2.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	40–80	35–45	–	–
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	13–20	10–25	–	–
wild coffee	PSYCH	*Psychotria*	Native	13–30	5–20	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	80–105	0–10	–	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	13–25	0–5	–	–
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	13–30	0–1	–	–
lama	DISA10	*Diospyros sandwicensis*	Native	13–50	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	13–40	0–1	–	–
guava	PSGU	*Psidium guajava*	Introduced	13–18	0–1	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	13–25	0–0.5	–	–
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	13–20	–	–	–
hierba del soldado	MEUM3	*Melochia umbellata*	Introduced	13–20	–	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	13–25	–	–	–
Oriental trema	TROR	*Trema orientalis*	Introduced	13–25	–	–	–
beach sheoak	CAEQ	*Casuarina equisetifolia*	Introduced	13–25	–	–	–
Tree Fern							
hapu'u	CIGL	*Cibotium glaucum*	Native	13–16	0–1	–	–

Table 22. Community 2.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	0.5–1	0–1
Forb/Herb					
pinklady	DIRO2	*Dissotis rotundifolia*	Introduced	0.5–1	0–1
peperomia	PEPER	*Peperomia*	Native	0.5–1	–
Fern/fern ally					
hammock fern	BLOC	*Blechnum occidentale*	Introduced	1–2	1–10
parasitic maiden fern	THPA4	*Thelypteris parasitica*	Introduced	1–2	5–10
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	5–10
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	1–2	1–5
Hawai'I birdnest fern	ASNI	*Asplenium nidus*	Native	2–6	0–5
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	2–3	0–1
vandenboschia	VANDE	*Vandenboschia*	Native	0.5–1	0–0.5
staghorn clubmoss	LYCE2	*Lycopodiella cernua*	Native	0.5–1	0–0.5
whisk fern	PSNU	*Psilotum nudum*	Native	0.2–0.5	–

Cretan brake	PTCR2	*Pteris cretica*	Native	0.5–1	–
Chinese creepingfern	ODCH	*Odontosoria chinensis*	Native	1–2	–
royal tonguefern	ELCR2	*Elaphoglossum crassifolium*	Native	0.5–1	–
wahini noho mauna	ADTA	*Adenophorus tamariscinus*	Native	0.5–1	–
Shrub/Subshrub					
Asian melastome	MECA9	*Melastoma candidum*	Introduced	2–13	5–30
soapbush	CLHI3	*Clidemia hirta*	Introduced	2–4	5–15
lantana	LACA2	*Lantana camara*	Introduced	2–6	0–1
Tree					
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	2–13	0–10
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	2–13	1–5
hierba del soldado	MEUM3	*Melochia umbellata*	Introduced	2–13	0–1
guava	PSGU	*Psidium guajava*	Introduced	6–13	0–1
lama	DISA10	*Diospyros sandwicensis*	Native	4–13	0–1
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	6–13	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	2–13	–
wild coffee	PSYCH	*Psychotria*	Native	2–13	–
velvet tree	MICA20	*Miconia calvescens*	Introduced	2–13	–
beach sheoak	CAEQ	*Casuarina equisetifolia*	Introduced	2–13	–
Waimea pipturus	PIAL2	*Pipturus albidus*	Native	2–10	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	2–13	–
Oriental trema	TROR	*Trema orientalis*	Introduced	2–13	–
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	2–13	–
pengua	MAMA28	*Macaranga mappa*	Introduced	2–13	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	2–13	5–30
hapu'u li	CIME8	*Cibotium menziesii*	Native	5–13	0–1
Vine/Liana					
'ie'ie	FRAR	*Freycinetia arborea*	Native	1–30	1–20
stinkvine	PAFO3	*Paederia foetida*	Introduced	1–6	0–1
queen coralbead	COOR11	*Cocculus orbiculatus*	Native	1–3	0–1
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	1–2	0–1
fiveleaf yam	DIPE2	*Dioscorea pentaphylla*	Introduced	2–10	0–0.5

Table 23. Community 3.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	13–25	25–35	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	13–40	5–20	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	40–110	1–10	8–48	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	30–80	0–10	–	–
wild coffee	PSYCH	*Psychotria*	Native	13–25	0–5	–	–
Oriental trema	TROR	*Trema orientalis*	Introduced	13–50	1–3	–	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	13–25	0–2	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	13–35	0–2	–	–
beach sheoak	CAEQ	*Casuarina equisetifolia*	Introduced	13–50	0–2	–	–
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	13–40	0–2	–	–
pengua	MAMA28	*Macaranga mappa*	Introduced	13–25	0–2	–	–
Alexandra palm	ARAL	*Archontophoenix alexandrae*	Introduced	13–30	0–2	–	–
punktree	MEQU	*Melaleuca quinquenervia*	Introduced	13–35	0–1	–	–
lama	DISA10	*Diospyros sandwicensis*	Native	20–50	0–1	–	–
Java plum	SYCU	*Syzygium cumini*	Introduced	13–30	0–1	–	–
Malabar plum	SYJA	*Syzygium jambos*	Introduced	13–30	0–1	–	–
velvet tree	MICA20	*Miconia calvescens*	Introduced	13–20	–	–	–

Table 24. Community 3.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	1–2	1–5
palmgrass	SEPA6	*Setaria palmifolia*	Introduced	1–2	0–1
Forb/Herb					
Kahila garland-lily	HEGA	*Hedychium gardnerianum*	Introduced	2–4	0–2
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	1–2	0–2
pinklady	DIRO2	*Dissotis rotundifolia*	Introduced	0.5–1	0–1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	5–15
parasitic maiden fern	THPA4	*Thelypteris parasitica*	Introduced	1–2	5–10
hammock fern	BLOC	*Blechnum occidentale*	Introduced	1–2	3–5
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	1–2	3–5
Hawai'I birdnest fern	ASNI	*Asplenium nidus*	Native	2–5	0–1
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	1–3	–
royal tonguefern	ELCR2	*Elaphoglossum crassifolium*	Native	0.5–1	–
staghorn clubmoss	LYCE2	*Lycopodiella cernua*	Native	0.5–1	–
whisk fern	PSNU	*Psilotum nudum*	Native	0.2–0.5	–
Cretan brake	PTCR2	*Pteris cretica*	Native	0.2–0.5	–

Chinese creepingfern	ODCH	*Odontosoria chinensis*	Native	1–2	–
vandenboschia	VANDE	*Vandenboschia*	Native	0.2–0.5	–
Shrub/Subshrub					
Asian melastome	MECA9	*Melastoma candidum*	Introduced	2–13	25–35
soapbush	CLHI3	*Clidemia hirta*	Introduced	2–13	5–15
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	2–13	25–35
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	2–13	0–5
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	2–13	0–1
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	2–13	0–1
wild coffee	PSYCH	*Psychotria*	Native	2–13	0–1
guava	PSGU	*Psidium guajava*	Introduced	5–13	0–1
velvet tree	MICA20	*Miconia calvescens*	Introduced	2–13	0–1
pengua	MAMA28	*Macaranga mappa*	Introduced	2–13	0–1
Alexandra palm	ARAL	*Archontophoenix alexandrae*	Introduced	5–13	0–1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	2–13	0–1
Java plum	SYCU	*Syzygium cumini*	Introduced	2–13	0–1
Malabar plum	SYJA	*Syzygium jambos*	Introduced	2–13	0–1
Oriental trema	TROR	*Trema orientalis*	Introduced	2–13	–
hierba del soldado	MEUM3	*Melochia umbellata*	Introduced	5–13	–
beach sheoak	CAEQ	*Casuarina equisetifolia*	Introduced	2–13	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	2–13	0–2
Oriental vessel fern	ANEV	*Angiopteris evecta*	Introduced	2–8	–
Vine/Liana					
'ie'ie	FRAR	*Freycinetia arborea*	Native	2–10	0–1
centipede tongavine	EPPI	*Epipremnum pinnatum*	Introduced	1–10	0–1
stinkvine	PAFO3	*Paederia foetida*	Introduced	1–20	0–1
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	1–3	0–1
queen coralbead	COOR11	*Cocculus orbiculatus*	Native	1–2	–
fiveleaf yam	DIPE2	*Dioscorea pentaphylla*	Introduced	2–8	–

Table 25. Community 4.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1				2550–3000	
	digitgrass	DIER	*Digitaria eriantha*	2550–3000	–
	limpograss	HEAL5	*Hemarthria altissima*	2550–3000	–
	para grass	URMU	*Urochloa mutica*	2550–3000	–
	torpedo grass	PARE3	*Panicum repens*	0–60	–
	Vasey's grass	PAUR2	*Paspalum urvillei*	0–30	–
	glenwoodgrass	SAIN	*Sacciolepis indica*	0–30	–
	Colombian bluestem	SCCO10	*Schizachyrium condensatum*	0–30	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	0–30	–
	smut grass	SPIN4	*Sporobolus indicus*	0–30	–
	shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	0–30	–
	hilograss	PACO14	*Paspalum conjugatum*	0–30	–
	dallisgrass	PADI3	*Paspalum dilatatum*	0–30	–
	violet crabgrass	DIVI2	*Digitaria violascens*	0–30	–
	broomsedge bluestem	ANVI2	*Andropogon virginicus*	0–30	–
	common carpetgrass	AXFI	*Axonopus fissifolius*	0–30	–
	Oahu flatsedge	CYHY2	*Cyperus hypochlorus*	0–30	–
Forb					
2	**Naturalized Forbs**			150–300	
	climbing dayflower	CODI5	*Commelina diffusa*	30–90	–
	greenleaf ticktrefoil	DEIN2	*Desmodium intortum*	0–60	–
	zarzabacoa comun	DEIN3	*Desmodium incanum*	0–60	–
	Hawai'i ticktrefoil	DESA81	*Desmodium sandwicense*	0–60	–
	threeflower ticktrefoil	DETR4	*Desmodium triflorum*	0–30	–
	shameplant	MIPU8	*Mimosa pudica*	0–30	–
	scaly swordfern	NEHI	*Nephrolepis hirsutula*	0–30	–
	light-blue snakeweed	STJA	*Stachytarpheta jamaicensis*	0–30	–
	Colombian waxweed	CUCA4	*Cuphea carthagenensis*	0–30	–
	tropical whiteweed	AGCO	*Ageratum conyzoides*	0–30	–
	bamboo orchid	ARGR6	*Arundina graminifolia*	0–30	–
	sensitive partridge pea	CHNI2	*Chamaecrista nictitans*	0–30	–
Shrub/Vine					
3	**Naturalized Shrubs**			30–150	
	soapbush	CLHI3	*Clidemia hirta*	0–30	–
	strawberry guava	PSCA	*Psidium cattleianum*	0–30	–
	guava	PSGU	*Psidium guajava*	0–30	–

Table 26. Community 4.2 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	30–60	0–1	–	–

Table 27. Community 4.2 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	2–3	25–35
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.5–1	25–35
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.5–1	15–25
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	2–3	5–10
digitgrass	DIER	*Digitaria eriantha*	Introduced	1–2	3–5
torpedo grass	PARE3	*Panicum repens*	Introduced	1–2	3–5
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.5–1	3–5
para grass	URMU	*Urochloa mutica*	Introduced	1–2	3–5
Job's tears	COLA	*Coix lacryma-jobi*	Introduced	0.5–1	0–1
violet crabgrass	DIVI2	*Digitaria violascens*	Introduced	2–3	0–1
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.5–1	0–1
glenwoodgrass	SAIN	*Sacciolepis indica*	Introduced	0.5–1	0–1
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	0.5–1	0–1
dallisgrass	PADI3	*Paspalum dilatatum*	Introduced	2–3	0–1
Vasey's grass	PAUR2	*Paspalum urvillei*	Introduced	1–2	0–1
Forb/Herb					
Colombian waxweed	CUCA4	*Cuphea carthagenensis*	Introduced	0.5–1	3–5
light-blue snakeweed	STJA	*Stachytarpheta jamaicensis*	Introduced	2–3	0–1
tropical whiteweed	AGCO	*Ageratum conyzoides*	Introduced	0.5–1	0–1
sensitive partridge pea	CHNI2	*Chamaecrista nictitans*	Introduced	0.5–1	0–1
shameplant	MIPU8	*Mimosa pudica*	Introduced	0.2–0.5	0–1
climbing dayflower	CODI5	*Commelina diffusa*	Introduced	0.5–1	0–1
bamboo orchid	ARGR6	*Arundina graminifolia*	Introduced	1–2	0–1
threeflower ticktrefoil	DETR4	*Desmodium triflorum*	Introduced	0.2–0.5	–
zarzabacoa comun	DEIN3	*Desmodium incanum*	Introduced	0.5–1	–
Hawai'i ticktrefoil	DESA81	*Desmodium sandwicense*	Introduced	0.5–1	–
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	0–1
Shrub/Subshrub					
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	2–6	1–10
soapbush	CLHI3	*Clidemia hirta*	Introduced	1–3	0–2
Tree					
guava	PSGU	*Psidium guajava*	Introduced	2–8	0–2
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	2–6	0–2
Vine/Liana					
greenleaf ticktrefoil	DEIN2	*Desmodium intortum*	Introduced	0.5–1	–

Table 28. Community 5.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	13–40	1–10	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	40–80	0–5	–	–
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	13–20	0–2	–	–
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	13–25	0–1	–	–
punktree	MEQU	*Melaleuca quinquenervia*	Introduced	13–20	0–1	–	–
fig	FITH2	*Ficus thonningii*	Introduced	13–25	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	13–40	0–1	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	13–25	0–1	–	–
Oriental trema	TROR	*Trema orientalis*	Introduced	13–35	0–1	–	–
Alexandra palm	ARAL	*Archontophoenix alexandrae*	Introduced	13–20	0–1	–	–
pengua	MAMA28	*Macaranga mappa*	Introduced	13–20	0–1	–	–

Table 29. Community 5.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.5–1	10–20
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.5–1	10–20
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	2–3	5–10
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.5–1	3–5
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	2–3	3–5
molassesgrass	MEMI2	*Melinis minutiflora*	Introduced	1–2	3–5
para grass	URMU	*Urochloa mutica*	Introduced	–	3–5
torpedo grass	PARE3	*Panicum repens*	Introduced	1–2	0.5–1
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.5–1	0.5–1
glenwoodgrass	SAIN	*Sacciolepis indica*	Introduced	0.5–1	0–1
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	1–2	0–1
violet crabgrass	DIVI2	*Digitaria violascens*	Introduced	1–2	0–1
Vasey's grass	PAUR2	*Paspalum urvillei*	Introduced	1–2	0–1
Job's tears	COLA	*Coix lacryma-jobi*	Introduced	1–2	0–0.5
Hawai'i nutrush	SCTE6	*Scleria testacea*	Native	0.2–0.5	0–0.5
dallisgrass	PADI3	*Paspalum dilatatum*	Introduced	2–3	0–0.5
Forb/Herb					
sensitive partridge pea	CHNI2	*Chamaecrista nictitans*	Introduced	0.2–0.5	0.5–2
shameplant	MIPU8	*Mimosa pudica*	Introduced	0.2–0.5	0.5–2
tropical whiteweed	AGCO	*Ageratum conyzoides*	Introduced	1–2	1–2
bamboo orchid	ARGR6	*Arundina graminifolia*	Introduced	1–2	1–2
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	1–2	1–2
Colombian waxweed	CUCA4	*Cuphea carthagenensis*	Introduced	0.5–1	0.5–1
light-blue snakeweed	STJA	*Stachytarpheta jamaicensis*	Introduced	2–3	0.5–1

climbing dayflower	CODI5	*Commelina diffusa*	Introduced	0.5–1	0–1
Hawai'i ticktrefoil	DESA81	*Desmodium sandwicense*	Introduced	0.5–1	–
Fern/fern ally					
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	1–5	5–15
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	5–15
staghorn clubmoss	LYCE2	*Lycopodiella cernua*	Native	0.5–1	0–0.5
Cretan brake	PTCR2	*Pteris cretica*	Native	1–2	–
Chinese creepingfern	ODCH	*Odontosoria chinensis*	Native	1–2	–
Shrub/Subshrub					
Asian melastome	MECA9	*Melastoma candidum*	Introduced	2–13	5–30
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	2–6	1–10
soapbush	CLHI3	*Clidemia hirta*	Introduced	2–5	1–10
lantana	LACA2	*Lantana camara*	Introduced	2–4	0–1
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	2–13	1–10
shoebutton	AREL4	*Ardisia elliptica*	Introduced	2–10	1–5
guava	PSGU	*Psidium guajava*	Introduced	2–13	1–2
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	2–13	0–1
fig	FITH2	*Ficus thonningii*	Introduced	2–13	0–1
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	2–13	0–1
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	2–13	0–1
wild coffee	PSYCH	*Psychotria*	Native	2–13	0–1
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	2–13	0–1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	2–13	0–1
Oriental trema	TROR	*Trema orientalis*	Introduced	2–13	0–1
Alexandra palm	ARAL	*Archontophoenix alexandrae*	Introduced	2–13	0–1
pengua	MAMA28	*Macaranga mappa*	Introduced	2–13	0–1
punktree	MEQU	*Melaleuca quinquenervia*	Introduced	2–13	–
Vine/Liana					
yellow Himalayan raspberry	RUEL3	*Rubus ellipticus*	Introduced	1–4	0–2
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	1–4	0–2
stinkvine	PAFO3	*Paederia foetida*	Introduced	1–20	0–1

Animal community

Few native wildlife species are present in this low elevation ecological site. High populations of mosquitoes carrying avian malaria limit the numbers and species of native birds that can survive in this ecological site. However, the Io or Hawaiian hawk (Buteo solitarius) has been sighted here. There are many introduced animals including pigs, mongoose, turkeys, and khalij pheasants.

Grazing Interpretations
The following table lists suggested initial stocking rates for cattle under the Forage Value Rating system for community phase 4.1 only. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (described in this ecological site description). Because of this, a field visit is recommended, in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using the following stocking rate information along with animal preference

data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity.

Forage Value Rating (note 1)

Very High (note 2) 0.40-0.59 acre/AUM (note 3) 2.56-1.70 AUM/acre

High 0.59-0.78 acre/AUM 1.70-1.28 AUM/acre

Moderate 0.78-1.56 acre/AUM 1.28-0.64 AUM/acre

Low 1.56-+ acre/AUM 0.64-+ AUM/acre

(note 1) The Forage Value Rating System is not an ecological evaluation of community phase 4.1. It is a utilitarian rating of the existing forage value of a specific tract of naturalized pastureland.

(note 2) Conservationists must use considerable judgment, because in places Very High forage class could be producing less than normal volumes of forage, and adjustments would need to be made in the initial stocking rate.

(note 3) Stocking rates vary in accordance with such factors as kind and class of livestock or wildlife, season of use, and fluctuations in climate. Actual use records and on-site inventories for individual naturalized pasture ecological sites, together with a determination of the degree to which the sites have been grazed, offer the most reliable basis for developing initial stocking rates.

This community phase is suitable for grazing by all kinds and classes of livestock, at any season, particularly cattle. However, this site is best utilized for late spring and summer grazing as this is the major plant growth period. This site is suited for grazing by both cow-calf operations and stocker operations. However, sheep can be grazed on this site as well. This site is poorly suited to continuous year-long use if the interpretive naturalized plant community is to be maintained.

Hydrological functions

High amounts of runoff occur where soils are very shallow to shallow over pahoehoe lava. This runoff can cause localized flooding in low-lying kipukas and ponding in low spots on the pahoehoe.

The water permeability of pahoehoe is highly variable due to variable cracking and uplift of the lava. However, most areas of pahoehoe in this ecological site have relatively little cracking.

Recreational uses

Hunting is the most common recreational use.

Wood products

None.

Other products

None.

Other information

Definitions
These definitions have been greatly simplified for brevity and do not cover every aspect of each topic.

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

Alluvial: Materials or processes associated with transportation and/or deposition by running water.

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

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

Ash field: a land area covered by a thick or distinctive deposit of volcanic ash that can be traced to a specific source and has well defined boundaries. The term “ash flow” is erroneously used in the Physiographic section of this ESD due to a flaw in the national database.

Ashy: A “soil texture modifier” for volcanic ash soils having a water content at the crop wilting point of less than 30 percent; a soil that holds relatively less water than “medial” and “hydrous” soils.

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

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

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

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

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° 25′ 12″
Longitude	154° 57′ 7″
General legal description	Hawaii County, Island of Hawaii, USGS Quad: Pahoa South. From Pahoa drive south 5.5 miles on Hwy. 130. Park at intersection of highway with Upper Puna Road. Walk 0.13 mile east into Keauohana Forest Reserve.

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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	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

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

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

14. **Average percent litter cover (%) and depth (in):**

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

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

17. **Perennial plant reproductive capability:**