Natural Resources
Conservation Service

Ecological site VX162X01X501
Dry Isohyperthermic Forest

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General information

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

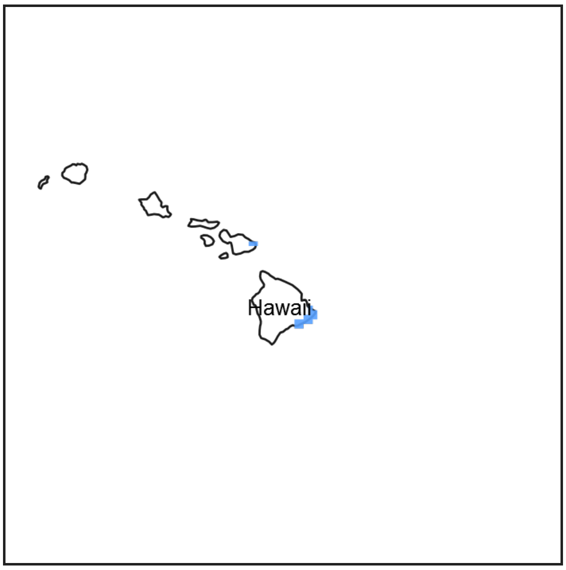

Figure 1. Mapped extent

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 “dry forest” that follows the Puna coastline from Kalapana to Nanawale Forest Park along Rte. 137. A segment also exists in Hawaii Volcanoes National Park on Hilina Pali. Much of the area is private land, with large areas held by Kamehameha Schools, and the State of Hawaii. Most areas are dominated by introduced plant species.

The central concept of the Ustic/Dry Udic Isohyperthermic Forest is of well to somewhat excessively drained, very shallow to shallow soils formed in deposits of highly decomposed plant material or volcanic ash 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 20 to 30 feet (6 to 9 meters) tall of lama (Diospyros sandwicensis) and Tahitian screwpine (Pandanus tectorius), a secondary canopy from 8 to 16 feet (2.5 to 5 meters) tall of alahee (Psydrax odorata), and a sparse understory of shrubs, forbs, and vines. Tahitian screwpine (Pandanus tectorius) trees are most common near the coast and decline in abundance inland.

Associated sites

VX162X01X500	**Isohyperthermic Forest** F162XY Isohyperthermic Forest is a moist forest bordering F162XY501 to the north and west.

Similar sites

VX161B01X501	**Kona Weather Ustic Forest** F161BY501 Kona Weather Ustic Forest is located in Kona and Kau. It has similar dominant plant species to F162XY501.

Table 1. Dominant plant species

Tree	(1) *Diospyros sandwicensis* (2) *Pandanus tectorius*
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

F162XY501HI

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 shallow on the underlying lava.

Table 2. Representative physiographic features

Landforms	(1) Shield volcano (2) Ash flow (3) Lava flow
Flooding duration	Extremely brief (0.1 to 4 hours)
Flooding frequency	Very rare to occasional
Ponding frequency	None
Elevation	6–107 m
Slope	2–55%
Water table depth	152–8 cm
Aspect	E, SE

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.

Average annual precipitation ranges from 70 to 120 inches (1750 to 3000 millimeters). Most of the precipitation falls from November through April. Average annual temperature ranges from 63 to 77 degrees F (17 to 25 degrees C). Evapotranspiration is high, usually exceeding and at least equaling annual precipitation. The frost free and freeze free periods are 365 days per year.

Air temperature in Hawaii 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)	0 days
Freeze-free period (average)	0 days
Precipitation total (average)	0 mm

Influencing water features

There are no water features influencing this site.

Soil features

Soils are very shallow to shallow highly decomposed plant materials in aa or over pahoehoe, very shallow to shallow volcanic ash over pahoehoe, or moderately deep volcanic ash in aa. Landscape surfaces in this ecological site are young (generally 400 to 1,500 years old). Soil temperature regimes are isohyperthermic. Soil moisture regimes are ustic or the dry range of udic; some soils are dry phases of udic series.

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–basalt (2) Basaltic volcanic ash–aa lava
Surface texture	(1) Hydrous loam (2) Ashy sand
Drainage class	Well drained to excessively drained
Permeability class	Very slow to rapid
Soil depth	5–102 cm
Surface fragment cover <=3"	0–60%
Surface fragment cover >3"	0–50%
Available water capacity (0-101.6cm)	2.54–10.16 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)	4.3–6.6
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 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. 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. Also, kipukas are older surfaces than surrounding flows and may contain volcanic ash soils, which are conducive to plant growth.

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. Native plant communities may not carry lava-ignited fires widely due to the nature of the vegetation. However, introduced understory vegetation is dense and susceptible to fire. Fountaingrass (*Pennisetum setaceum*), which can carry catastrophic wildfires, is beginning to invade this ecological site and has formed limited but dense stands in places.

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).

Most of the surfaces within this ecological site consist of lava flows that are from 400 to 1500 years old. This has created a mosaic of bare lava, older lava flows with native and introduced vegetation in various stages of regeneration, and small kipukas with older soils that, in most cases, have been cultivated by humans. Scattered 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.

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 Brazilian 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, the introduced, nitrogen-fixing tree albizia or peacocks plume (*Falcataria moluccana*) produces 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 that favors growth of invasive plants (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.

State and transition model

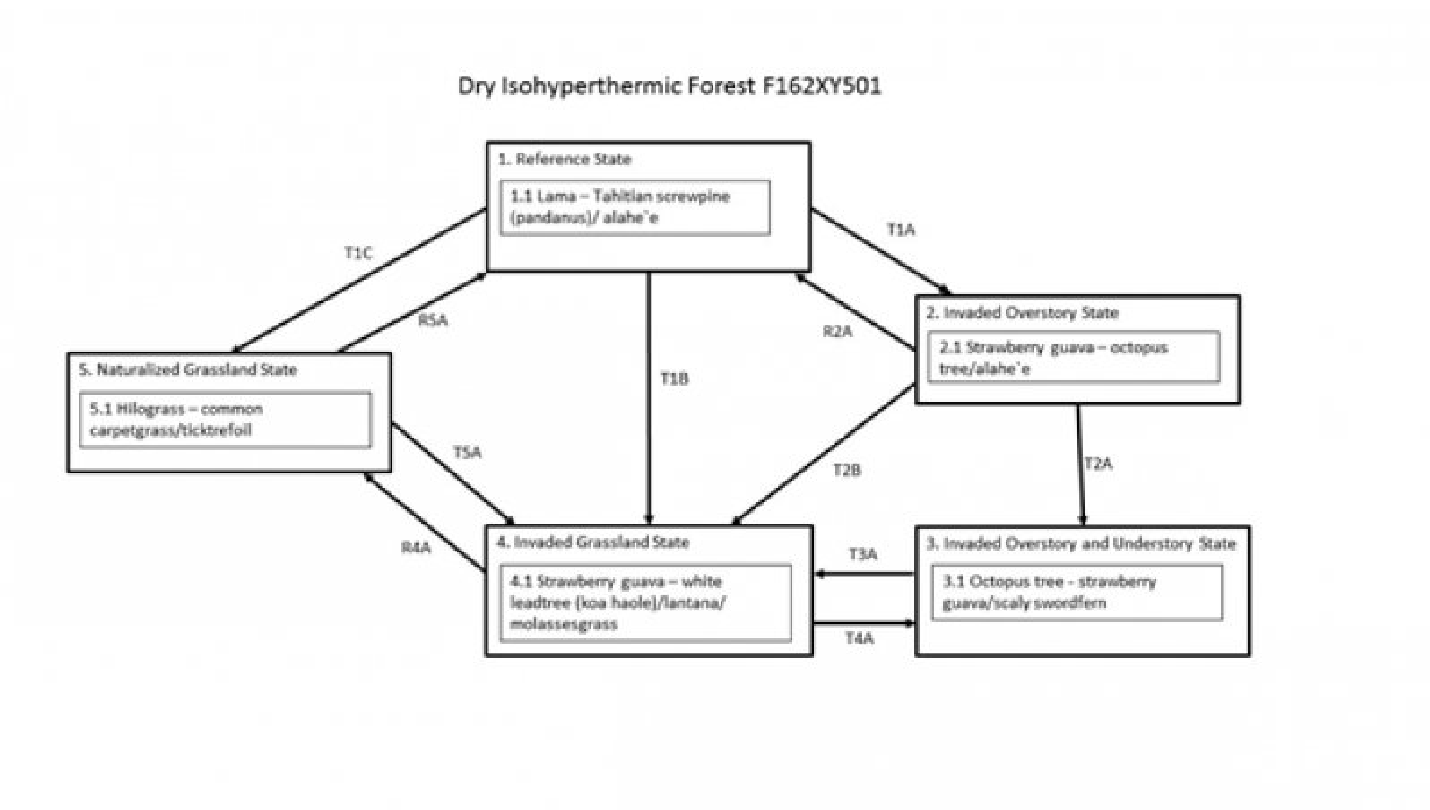

Figure 5. State and Transition Diagram F162XY501

State 1
Reference State

This state consists of on community phase that contains species typical of Hawaiian lowland dry forests. Gradual invasion by weedy, introduced plant species brings a transition to State 2 Invaded Overstory. When cleared and abandoned, this state transitions to State 4 Invaded Grassland. When cleared and managed for cattle grazing, it transitions to State 5 Naturalized Grassland.

Community 1.1
Lama - Tahitian screwpine (pandanus)/alahe`e

Figure 6. Reference community phase. 4/25/05 D Clausnitzer MU670

Figure 7. Lama leaf litter on soil surface. 4/25/05 D Clausnitzer MU670

Figure 8. Coastal strip of naupaka and pandanus. D Clausnitzer generic photo

Figure 9. Abrupt naupaka-alahee boundary at coast. D Clausnitzer generic photo

Figure 10. Pandanus-dominated site. 1/12/06 D Clausnitzer MU667

The general aspect is a forest with an open or closed upper canopy 20 to 30 feet (6 to 9 meters) tall, a secondary canopy 8 to 15 feet (2.5 to 4.5 meters) tall, and a sparse understory of shrubs, forbs, and vines. These forests have standing live timber of 150 to 800 cubic feet per acre, with a representative value of about 250 cubic feet per acre.

Forest overstory. Ohia lehua (Metrosideros polymorpha) and lama (Diospyros sandwicensis) are the two ubiquitous overstory species. Pandanus or Tahitian screwpine (Pandanus tectorius) trees are normally a major part of the overstory near the coast, but it 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.

Forest understory. Alahee (Psydrax odorata) is the main understory species. Other dryland forest species that are now rare or nonexistent may have been more abundant in the past. Shrubs make up the remainder of the understory, along with a few vines and forbs, and ferns.

Table 5. Soil surface cover

Tree basal cover	0.5-1.0%
Shrub/vine/liana basal cover	0.0-0.5%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0-1%
Biological crusts	0-1%
Litter	60-70%
Surface fragments >0.25" and <=3"	0-25%
Surface fragments >3"	0-25%
Bedrock	0-10%
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)	0-1%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	–
Tree snags** (hard***)	–

Tree snags** (soft***)	–
Tree snag count** (hard***)	0-2 per hectare
Tree snag count** (hard***)	0-2 per hectare

*** 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 (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0%	–	0-1%
>0.15 <= 0.3	0%	0-1%	–	0-1%
>0.3 <= 0.6	1-1%	1-1%	–	1-1%
>0.6 <= 1.4	1-2%	1-1%	–	–
>1.4 <= 4	15-25%	3-5%	–	–
>4 <= 12	20-70%	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

State 2
Invaded Overstory State

This state is comprised of one community phase. Native plant species are still common, but introduced species dominate the overstory and are invading the understory. Unlike State 1 Reference, this state usually has a fairly dense understory of shrubs, grasses, and ferns that is very susceptible to fire. Wildfire brings about a transition to State 4 Invaded Grassland. Some smaller native tree species are able to reproduce to an extent, but reproduction of native species is somewhat inhibited by competition from introduced species. Activity of feral pigs and cattle further reduces native plant abundance and produces bare, disturbed soil patches that promote weed invasion. Litter from nitrogen-fixing albizia (*Falcataria moluccana*) produces a favorable environment for fast-growing introduced species. These conditions eventually bring about a transition to State 3 Invaded Overstory and Understory.

Community 2.1
Strawberry guava - octopus tree/alahe`e

Figure 11. Weed tree overstory. 6/20/06 D Clausnitzer MU670

This community phase is a forest with an open to closed upper canopy of mostly introduced trees 50 to 80+ feet (15 to 25+ meters) tall, a secondary canopy of native trees 8 to 30 feet (2.5 to 9 meters) tall, and a mixed understory of mostly introduced shrubs, vines, ferns, and grasses.

Forest overstory. Tall ohia lehua (Metrosideros polymorpha) are often still present the upper canopy, 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 and increasing in the secondary canopy and sometimes the upper canopy.

Forest understory. Native alahee (Psydrax odorata) and pandanus (Pandanus tectorius) are able to reproduce to some extent and maintain their presence. Strawberry guava (Psidium cattleianum) is increasingly abundant, gradually forming extremely dense stands with dense, intertwined root systems. Christmasberry (Schinus terebinthifolius) is also common. The introduced ferns scaly swordfern (Nephrolepis hirsutula) is common; it is capable of producing large amounts of fine fuel for wildfire.

Table 8. Soil surface cover

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

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)	0-1%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	–
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 10. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0-1%	0%	0-1%
>0.15 <= 0.3	0%	0-1%	0-1%	3-5%
>0.3 <= 0.6	0-1%	0-1%	0-1%	3-5%
>0.6 <= 1.4	1-1%	1-2%	–	–
>1.4 <= 4	10-45%	1-2%	–	–
>4 <= 12	10-45%	–	–	–
>12 <= 24	0-30%	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

State 3
Invaded Overstory and Understory State

This state consists of one community phase dominated by introduced species in both the overstory and understory. This state may transition to State 4 Invaded Grassland due to wildfire.

Community 3.1
Octopus tree - strawberry guava/scaly swordfern

Figure 12. Weedy forest. D Clausnitzer generic photo

This community phase is a forest with a closed to open upper canopy of introduced trees 60 to 120 feet (18 to 37 meters) tall, a secondary canopy of introduced trees of various heights, and a mixed understory of mostly introduced shrubs, vines, ferns, and grasses.

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), and octopus tree (Schefflera actinophylla) may be present. Ironwood or beach sheoak trees (Casuarina equisetifolia) are common near the coast. Native pandanus trees are able to reproduce and survive to some extent.

Forest understory. Strawberry guava (Psidium cattleianum) typically dominates the understory, but christmasberry (Schinus terebinthifolius) is common. Scaly swordfern (Nephrolepis hirsutula) and maile-scented fern or hammock fern (Blechnum appendiculatum) are common.

Table 11. Soil surface cover

Tree basal cover	2-4%
Shrub/vine/liana basal cover	0%

Grass/grasslike basal cover	0%
Forb basal cover	0-1%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	70-80%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-25%
Bedrock	0-5%
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)	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 13. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0%	0%	0%
>0.15 <= 0.3	0-1%	0-1%	0-1%	1-2%
>0.3 <= 0.6	1-1%	0-1%	0-1%	5-10%
>0.6 <= 1.4	5-10%	0-1%	–	–
>1.4 <= 4	35-45%	1-3%	–	–
>4 <= 12	25-35%	1-2%	–	–
>12 <= 24	15-25%	–	–	–
>24 <= 37	0-5%	–	–	–
>37	–	–	–	–

State 4
Invaded Grassland State

This state consists of one community phase consisting primarily of introduced grasses and shrubs. Grasses and forbs fill the interspaces between shrub patches. Introduced tree species are present, so this state may transition to State 3 Invaded Over and Understory with lack of wildfire. Heavy growth of fine fuels presents a fire danger in dry periods.

Community 4.1
Strawberry guava - white leadtree (koa haole)/lantana/molassesgrass

Figure 13. Invaded grassland. 6/20/06 D Clausnitzer MU670

Figure 14. Burned site; aalii and invasive ferns. 1/14/05 MU754

This community phase has a wide diversity of mostly introduced species.

Forest overstory. A scattering of large albizia or peacocksplume (Falcataria moluccana) is typical. A few individuals of other tall, introduced tree species may be present. Remnant large ohia lehua trees may be present.

Forest understory. Strawberry guava (Psidium cattleianum) is common and is poised to expand rapidly. Seedlings and saplings of potentially tall introduced trees are abundant. Christmasberry (Schinus terebinthifolius) is common. Native aalii (Dodonaea viscosa) is common, along with introduced sourbush or cure for all (Pluchea carolinensis). Scaly swordfern (Nephrolepis hirsutula) is common, but is often outcompeted by grasses. Introduced grasses, including mollassesgrass (Melinis minutiflora), broomsedge bluestem (Andropogon virginicus), and Colombian bluestem (Schizachyrium condensatum) are abundant.

Table 14. Soil surface cover

Tree basal cover	0-1%
Shrub/vine/liana basal cover	0.0-0.5%
Grass/grasslike basal cover	25-35%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	60-70%
Surface fragments >0.25" and <=3"	0-20%

Surface fragments >3"	0-25%
Bedrock	0-5%
Water	0%
Bare ground	0-1%

Table 15. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0%	0%	0%
>0.15 <= 0.3	0%	0-1%	5-10%	1-2%
>0.3 <= 0.6	1-1%	1-3%	50-60%	2-4%
>0.6 <= 1.4	1-2%	10-15%	5-10%	1-1%
>1.4 <= 4	15-25%	5-10%	–	–
>4 <= 12	0-2%	0-1%	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

State 5
Naturalized Grassland State

This state consists of one community phase dominated by introduced grass species. Long-term, continuous overgrazing and lack of weed control measures results in a transition to State 4 Invaded Grassland.

Community 5.1
Hilograss - common carpetgrass/tick trefoil

Figure 15. Grassland; invaded by shrubs in background. D Clausnitzer generic photo

This community phase is used for cattle grazing. 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.

Forest overstory. The overstory may contain a few remnant ohia lehua (Metrosideros polymorpha) or pandanus (Pandanus tectoria) trees.

Forest understory. Hilograss (Paspalum conjugatum) and common carpetgrass (Axonopus fissifolius) are typically the most common grasses. in mixture with leguminous desmodium or ticktrefoil species. Seedlings and saplings of introduced trees are common.

Table 16. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	20-30%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	40-50%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-25%
Bedrock	0-5%
Water	0%
Bare ground	0-1%

Table 17. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	–	5-10%	–
>0.15 <= 0.3	0%	–	55-65%	0-1%
>0.3 <= 0.6	0%	–	5-10%	–
>0.6 <= 1.4	0-1%	–	0-1%	–
>1.4 <= 4	0-1%	–	–	–
>4 <= 12	0-1%	–	–	–
>12 <= 24	0-1%	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Transition T1A
State 1 to 2

This state transitions to State 2 Invaded Overstory by growth of introduced tree species that grow faster than native species and eventually overtop them. This process is facilitated by feral ungulates that damage and consume native plants, disturb the soil, and spread weed seeds.

Transition T1B
State 1 to 4

This state transitions to State 4 Invaded Grassland by clearing the forest with heavy machinery and then abandoning the land or by wildfire that removes the native forest. After clearing, areas with shallow soils over lava substrates 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 T1C
State 1 to 5

This state can transition to State 5 Naturalized Grassland by clearing the forest with heavy machinery and planting desirable forage species. After clearing areas with 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.

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. 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 lack of regeneration of most native plant species, eventual death of larger native trees, vigorous growth of introduced species, and feral ungulate foraging that impacts mostly native plants.

Transition T2B
State 2 to 4

This state transitions to State 4 Invaded Grassland by wildfire caused by lava flows or humans. It also may come about by clearing the forest with heavy machinery and subsequent abandonment. 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. Ripped and crushed substrates appear to be favorable to growth of introduced plant species.

Transition T3A
State 3 to 4

This state may transition to State 4 Invaded Grassland by wildfire. However, as the overstory and secondary story close, fine fuels decrease in abundance, reducing the possibility of wildfire.

Transition T4A
State 4 to 3

In the absence of wildfire, this state transitions to State 3 Invaded Over and Understory due to the presence of fast-growing, introduced tree species.

Restoration pathway R4A
State 4 to 5

This state can be restored to State 5 Naturalized Grassland by brush management, re-establishment of desirable forage species, persistent weed control, and prescribed grazing.

Restoration pathway R5A
State 5 to 1

This state may be restored to a facsimile of State 1 Reference by installing pig-proof fence, removing all ungulates, intensive weed control, and reintroduction of native species. Depending on the community phase adjoining the restoration area, a firebreak may need to be created and maintained.

Transition T5A
State 5 to 4

This state transitions to State 4 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.

Additional community tables

Table 18. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	4–9.1	0–70	7.6–15.2	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	4–7.6	0–20	–	–
lama	DISA10	*Diospyros sandwicensis*	Native	4–12.2	3–10	10.2–27.9	–
wili wili	ERSA11	*Erythrina sandwicensis*	Native	4–6.1	–	–	–
Hawai'i hala pepe	PLHA4	*Pleomele hawaiiensis*	Native	4–6.1	–	–	–
'ahakea	BOTI	*Bobea timonioides*	Native	4–4.6	–	–	–
Hawai'i pritchardia	PRAF	*Pritchardia affinis*	Native	4–6.1	–	–	–

Table 19. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Forb/Herb					
peperomia	PEPER	*Peperomia*	Native	0.2–0.3	0–0.5
Fern/fern ally					
whisk fern	PSNU	*Psilotum nudum*	Native	0.2–0.3	0–0.5
Shrub/Subshrub					
false ohelo	WIKST	*Wikstroemia*	Native	0.6–1.8	1–5
pukiawe	STTA	*Styphelia tameiameiae*	Native	0.6–1.2	1–2
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	0.6–1.5	1–2
beach naupaka	SCSE6	*Scaevola sericea*	Native	0.6–1.5	0–1
Hawai'i hawthorn	OSAN	*Osteomeles anthyllidifolia*	Native	0.2–0.3	0.5–1
uhaloa	WAIN	*Waltheria indica*	Native	0.3–0.6	0–0.5
Tree					
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	0.6–4	0–5
lama	DISA10	*Diospyros sandwicensis*	Native	0.6–4	1–5
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	0.6–4	0–1
wili wili	ERSA11	*Erythrina sandwicensis*	Native	0.6–4	–
Vine/Liana					
devil's gut	CAFI4	*Cassytha filiformis*	Native	0.2–0.9	0–2
queen coralbead	COOR11	*Cocculus orbiculatus*	Native	0.2–0.6	0–1
seabean	MUGI	*Mucuna gigantea*	Native	0.3–3	0–0.5

Table 20. Community 2.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
peacocksplume	FAMO	*Falcataria moluccana*	Native	12.2–24.4	0–50	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–15.2	10–20	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–6.1	5–15	–	–
Oriental trema	TROR	*Trema orientalis*	Introduced	4–15.2	5–10	–	–
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–6.1	5–10	–	–
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	4–15.2	1–10	–	–
beach sheoak	CAEQ	*Casuarina equisetifolia*	Introduced	4–18.3	0–2	–	–
Scotch attorney	CLRO	*Clusia rosea*	Introduced	4–7.6	0–1	–	–
Java plum	SYCU	*Syzygium cumini*	Introduced	4–13.7	0–1	–	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	4–6.1	0–1	–	–
lama	DISA10	*Diospyros sandwicensis*	Native	4–6.1	0–1	–	–
mango	MAIN3	*Mangifera indica*	Introduced	9.1–15.2	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	12.2–15.2	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	4–12.2	0–1	–	–

Table 21. Community 2.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
molassesgrass	MEMI2	*Melinis minutiflora*	Introduced	0.3–0.6	0–1
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	0.6–0.9	0–1
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	0.6–0.9	0–1
Forb/Herb					
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	0.3–0.6	–
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	5–15
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	0.3–0.6	0–1
hammock fern	BLOC	*Blechnum occidentale*	Introduced	0.3–0.6	0–1
whisk fern	PSNU	*Psilotum nudum*	Native	0.2–0.3	–
Shrub/Subshrub					
lantana	LACA2	*Lantana camara*	Introduced	0.6–1.2	0–1
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	0.6–1.5	0–1
false ohelo	WIKST	*Wikstroemia*	Native	1.2–2.4	0–0.5
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	20–45
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	0.6–4	1–5
Java plum	SYCU	*Syzygium cumini*	Introduced	0.6–3	0–5
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	0.6–4	0–2
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	0.6–4	0–1
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	0.6–4	0–1
Oriental trema	TROR	*Trema orientalis*	Introduced	1.2–4	0–1
guava	PSGU	*Psidium guajava*	Introduced	1.2–4	0–1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	0.6–4	0–1
white leadtree	LELE10	*Leucaena leucocephala*	Introduced	1.5–3.7	0–1
lama	DISA10	*Diospyros sandwicensis*	Native	1.2–4	–
beach sheoak	CAEQ	*Casuarina equisetifolia*	Introduced	0.6–4	–
Tree Fern					
queen coralbead	COOR11	*Cocculus orbiculatus*	Native	0.3–0.9	0–1
Vine/Liana					
stinkvine	PAFO3	*Paederia foetida*	Introduced	0.3–6.1	1–5

Table 22. Community 3.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–15.2	10–20	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	12.2–24.4	0–20	–	–
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–6.1	5–10	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–5.5	0–5	–	–
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	4–10.7	0–5	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	24.4–30.5	0–5	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	7.6–15.2	0–2	–	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	4–4.9	0–1	–	–
beach sheoak	CAEQ	*Casuarina equisetifolia*	Introduced	4–15.2	0–1	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	4–12.2	0–1	–	–
Oriental trema	TROR	*Trema orientalis*	Introduced	12.2–24.4	0–1	–	–
Oriental trema	TROR	*Trema orientalis*	Introduced	4–12.2	0–1	–	–

Table 23. Community 3.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	0.6–0.9	0–1
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	0.6–0.9	0–1
Forb/Herb					
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	0.3–0.6	–
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	5–15
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	0.3–0.6	0–1
hammock fern	BLOC	*Blechnum occidentale*	Introduced	0.3–0.6	0–1
Shrub/Subshrub					
lantana	LACA2	*Lantana camara*	Introduced	0.6–1.2	0–1
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	0.6–1.2	0–1
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	45–65
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	0.6–4	1–5
Oriental trema	TROR	*Trema orientalis*	Introduced	0.6–4	0–1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	0.6–4	0–1
beach sheoak	CAEQ	*Casuarina equisetifolia*	Introduced	0.6–4	0–1
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	0.6–4	0–1
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	0.6–4	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	0.6–4	–
Vine/Liana					
stinkvine	PAFO3	*Paederia foetida*	Introduced	0.3–9.1	3–5

Table 24. Community 4.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
Oriental trema	TROR	*Trema orientalis*	Introduced	4–12.2	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	4–15.2	0–1	–	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	4–5.5	0–1	–	–
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	4–6.1	0–1	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–6.1	0–1	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	4–15.2	–	–	–

Table 25. Community 4.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
molassesgrass	MEMI2	*Melinis minutiflora*	Introduced	0.3–0.6	70–80
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	0.6–0.9	3–5
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	0.6–0.9	3–5
Forb/Herb					
ticktrefoil	DESMO	*Desmodium*	Introduced	0.3–0.6	3–5
bamboo orchid	ARGR6	*Arundina graminifolia*	Introduced	0.3–0.6	0–1
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	0.3–0.6	0.5–1
porterweed	STACH2	*Stachytarpheta*	Introduced	0.6–0.9	0–1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	3–5
Shrub/Subshrub					
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	0.6–1.5	5–10
lantana	LACA2	*Lantana camara*	Introduced	0.6–1.5	5–10
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	0.6–1.8	1–5
false ohelo	WIKST	*Wikstroemia*	Introduced	0.9–1.5	–
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–3	1–10
guava	PSGU	*Psidium guajava*	Introduced	0.6–1.8	0–5
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	0.6–2.4	1–5
Oriental trema	TROR	*Trema orientalis*	Introduced	0.6–4	0–1
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	1.5–4	0–1
trumpet tree	CEOB	*Cecropia obtusifolia*	Introduced	0.6–4	0–1
Indian mulberry	MOCI3	*Morinda citrifolia*	Introduced	1.5–2.4	0–1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	0.6–4	0–1
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	0.6–4	–
Vine/Liana					
stinkvine	PAFO3	*Paederia foetida*	Introduced	0.3–9.1	1–5
devil's gut	CAFI4	*Cassytha filiformis*	Native	0.3–9.1	0–1

Table 26. Community 5.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	12.2–18.3	0–1	–	–
Oriental trema	TROR	*Trema orientalis*	Introduced	4–12.2	0–1	–	–
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	4–4.9	–	–	–

Table 27. Community 5.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.2–0.3	45–55
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.2–0.3	35–45
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	0.6–0.9	0–1
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	0.6–0.9	0–1
molassesgrass	MEMI2	*Melinis minutiflora*	Introduced	0.3–0.6	0–1
Forb/Herb					
ticktrefoil	DESMO	*Desmodium*	Introduced	0.3–0.6	3–5
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	0–1
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	0–1
Indian mulberry	MOCI3	*Morinda citrifolia*	Introduced	1.5–2.4	0–1
guava	PSGU	*Psidium guajava*	Introduced	0.6–1.5	0–1
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	0.6–1.8	0–1
Tahitian screwpine	PATE2	*Pandanus tectorius*	Native	1.8–4	–

Animal community

Few native wildlife species are present in this low elevation ecological site. Introduced mosquitoes carrying avian malaria limit the numbers and species of native birds that can survive in this ecological site.

There are many introduced mammals and birds, for example pigs, mongoose, and game birds. Introduced wildlife species are able to utilize all community phases within the ecological site.

Hydrological functions

Runoff can occur where soils are very shallow to shallow over pahoehoe lava. This runoff can cause localized ponding in low spots on the pahoehoe.

The water permeability of pahoehoe is highly variable due to variable cracking and uplift of the lava.

Recreational uses

Hunting of introduced game species is possible where human habitations are sparse.

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° 20′ 30″
Longitude	155° 0′ 7″
General legal description	Hawaii County, USGS Quad: Kalapana. Drive S on Hwy 130 from Pahoa to where pahoehoe flow ran over road. Go W on trail about 1 mi. Stop where road goes through last forested kipuka before end of road at large pahoehoe flow. Walk N into forest 50 ft.

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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:**