USDA Natural Resources Conservation Service

Ecological site VX162X01X505
Isothermic Aquic Forest

Accessed: 05/19/2024

General information

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

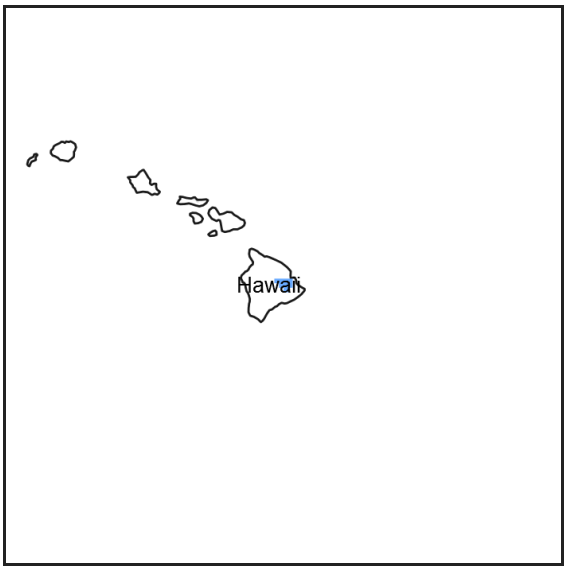

Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 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 a wet forest with areas of standing water or water very near the soil surface that exists mauka of Hilo along both sides of Saddle Road (Route 200) and in isolated examples near Stainback Highway. It exists as a complex (tightly intermixed) within the better-drained forest that surrounds it. Much of the area is private land or owned by the State of Hawaii.

The central concept of the Isothermic Aquic Forest is of poorly to moderately well drained, very shallow to moderately deep soils formed in deposits of volcanic ash over pahoehoe (flat lava flows). Lava flows range from 1,500 to 11,000 years old. Annual air temperatures and rainfall create warm (isothermic), water-saturated and anaerobic (aquic) soil conditions. These soils support forest with an open overstory of ohia lehua (Metrosideros polymorpha) or ohia lehua with scattered koa (Acacia koa) from 60 to 75 feet (18 to 23 meters) tall, a diverse secondary tree canopy 16 to 25 feet (5 to 8 meters) tall, a tree fern or hapuu (Cibotium spp.) canopy 10 to 16 feet (3 to 5 meters) tall, and an understory of shrubs, ferns, and forbs. Uluhe fern (*Dicranopteris linearis*) forms scattered thickets. Small, shallow pools of standing water are abundant.

Associated sites

VX162X01X503	**Udic Isothermic Forest** F162XY503 Isothermic Forest is a forest ecological site that surrounds F162XY505. F162XY503 is has better drained soils that are not aquic and supports a more diverse forest plant community.

Table 1. Dominant plant species

Tree	(1) *Metrosideros polymorpha* (2) *Acacia koa*
Shrub	Not specified
Herbaceous	(1) *Dicranopteris linearis*

Legacy ID

F162XY505HI

Physiographic features

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

Table 2. Representative physiographic features

Landforms	(1) Shield volcano (2) Lava flow
Flooding duration	Extremely brief (0.1 to 4 hours)
Flooding frequency	Very rare to occasional
Ponding duration	Brief (2 to 7 days) to very long (more than 30 days)
Ponding frequency	Occasional to frequent
Elevation	305–1,676 m
Slope	2–10%
Ponding depth	5–15 cm
Water table depth	0–38 cm
Aspect	E

Climatic features

Average annual precipitation ranges from 80 to 240 inches (2000 to 6000 millimeters). Most of the precipitation falls

from October through April. The mean annual air temperature ranges from 60 to 71 degrees F (16 to 22 degrees C).

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)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	6,096 mm

Climate stations used

- (1) GLENWOOD NO. 2 55.4 [USC00510746], Volcano, HI

Influencing water features

This ecological site exists in shallow depressions in the underlying lava flows that receive runoff from surrounding areas. Standing water frequently occurs. This standing water often is in small pools (5-20’ across) tightly complexed with similarly-sized areas of soil above the water level. Some deeper, larger depressions also occur. These larger areas can be in kipukas. The surrounding younger flows are slightly higher in elevation than the kipukas, allowing runoff to collect in the kipukas.

Soil features

The soils of this ecological site are composed of very shallow to moderately deep volcanic ash deposited over poorly permeable pahoehoe. Two soils occur within this ecological site. The first is Ihope hydrous silt loam, a very shallow to shallow, somewhat poorly drained to poorly drained soil that is frequently ponded and seasonally undergoes persistent anaerobic conditions through most of the profile as evidenced by common, distinct to prominent redoximorphic features. The second is Endoaquands, 0-3% slopes, consisting of moderately deep, somewhat poorly drained soils that seasonally or permanently undergo persistent anaerobic conditions throughout the profile as evidenced by high chroma masses of iron or, in the deepest horizon, gleying. Most landscape surfaces in this ecological site are from 3,000 to 5,000 years old, although some areas are less than 1,500 years old and others are up to 11,000 years old.

Table 4. Representative soil features

Parent material	(1) Basaltic volcanic ash–basalt
Surface texture	(1) Hydrous silt loam (2) Silty clay loam
Family particle size	(1) Loamy

Drainage class	Somewhat poorly drained to very poorly drained
Permeability class	Very slow to moderately slow
Soil depth	10–102 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
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)	4.5–5.5
Subsurface fragment volume <=3" (Depth not specified)	0–30%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

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

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

This ecological site exists in small to large kipukas or other depressions scattered within a broad area of relatively young lava flows. The surrounding lava flows support other ecological sites. Being below the level of the surrounding younger flows, the occurrences of this site receive runoff water from them, or, in some cases may be near the water table of surrounding terrain.

Aside from the chance of being covered by a new lava flow or receiving aerial volcanic ash, these sites probably are not frequently subject to natural disturbances such as wildfire and windthrow. Trees sometimes will topple over due to shallow rooting in wet soils, and water levels may rise during wet weather periods.

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

Humans arrived in the Hawaiian Islands 1200 to 1500 years ago. Their population gradually increased so that by 1600 AD at least 80% of all the lands in Hawaii below about 1500 feet (roughly 500 meters) in elevation had been extensively altered by humans (Kirch 1982); 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). However, much of this ecological site occurs in remote areas surrounded by dense forest, where the chance of human disturbance was low.

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

The Polynesians introduced dogs, Pacific rats, and small pigs to the islands. Cattle, sheep, horses, goats, and larger European pigs were introduced in the final decades of the 18th century. These animals ranged free on the islands, becoming very numerous and destructive by the early decades of the 19th century. Wild pigs and cattle damage soils and vegetation in this ecological site. Rooting by pigs can be severe due to the low rock content of the soils.

Paddocks of pangolagrass or Californiagrass become infested with unpalatable grasses and shrubs under conditions of improper grazing management. Due to the shallow soils and high rainfall of this ecological site, land clearing operations that pile slash in such a way as to block subtle, natural drainage pathways can cause seasonal flooding and ponding.

Through the 20th and into the 21st centuries, increases in human populations with attendant urban 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. Introduced, invasive plant species are probably the greatest threat to native plant communities in this ecological site.

State and transition model

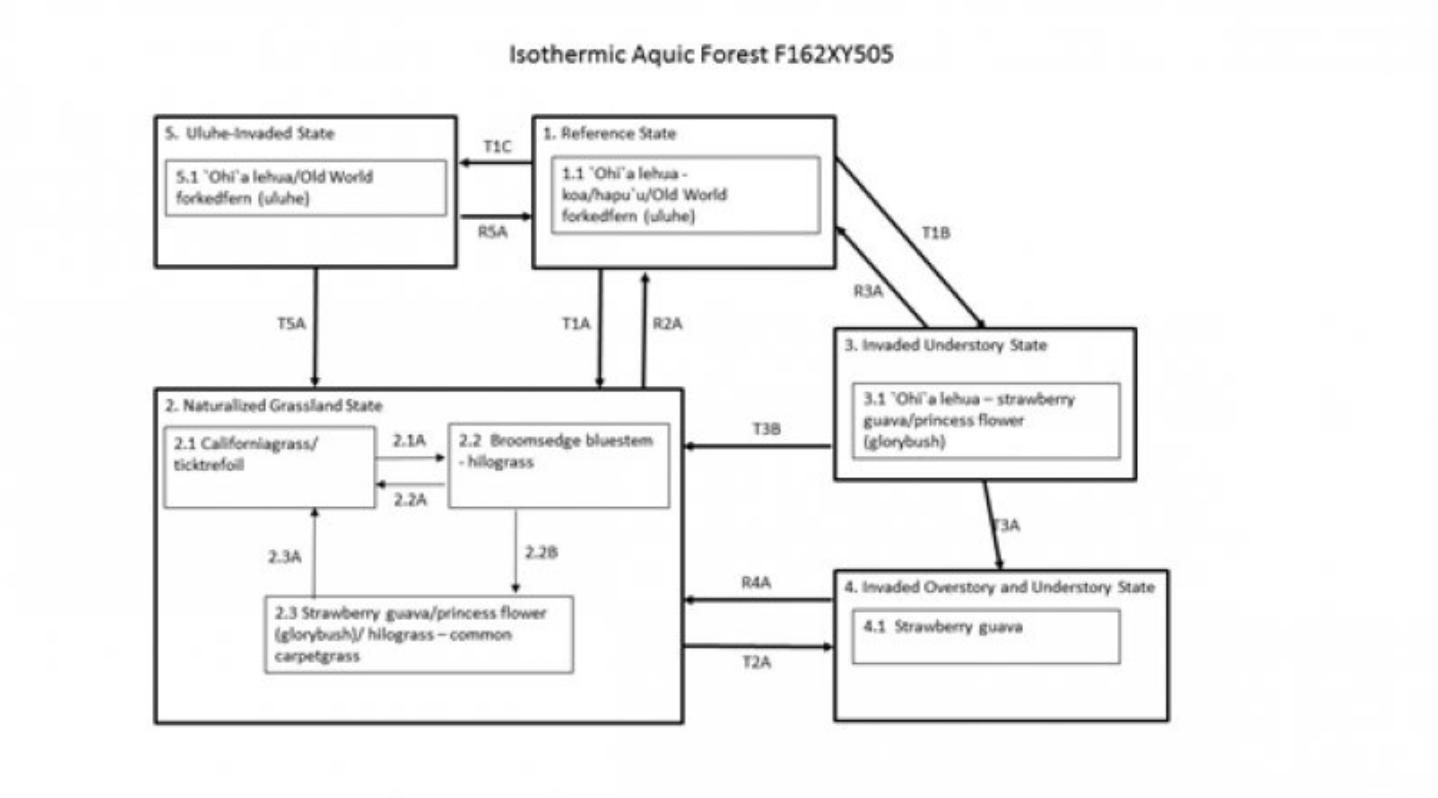

Figure 6. State and Transition Diagram for F162XY505.

State 1
Reference State

The Reference State consists of one community phase. Rainfall and temperature vary based on elevation, while the soils in this ecological site vary mostly by depth and age. The interaction of the range of substrate ages with rainfall amounts and temperatures within this ecological site produces variations in the makeup of the native plant community. Areas on the youngest (<3,000 years) lava flows within this ecological site have lower stature forests with more abundant cover of the three uluhe fern species. Abundance of early successional species (i.e. *Myrsine sandwicensis*, Hedyotis centranthioides, and Sadleria species) as well as shrubs (e.g., *Vaccinium calycinum*) is high. However, populations of most of the characteristic forest species are present on these young flows. Given the high rainfall and temperatures on these sites, it seems likely that these young sites will develop soils and vegetation more typical of the central concept of the ecological site within a few hundred years. Some areas have been cleared for livestock grazing, either mechanically or simply by allowing livestock to graze and browse the native understory; this represents a transition to State 2 Naturalized Grassland. Gradual invasion by introduced species

into existing forest, accelerated by damage from feral ungulates, results in State 3 Invaded Understory. Mechanical clearing or wildfire in areas few introduced weeds brings a transition to State 5 Uluhe-invaded.

Community 1.1
`Ohi`a lehua - koa/hapu`u/Old World forked fern (uluhe)

Figure 7. Reference community phase. 9/19/06 D Clausnitzer MU604

Figure 8. Understory. 9/19/06 D Clausnitzer MU604

Figure 9. Ground level. 9/19/06 D Clausnitzer MU604

This community phase is a four-tiered forest with an open overstory of large trees, a diverse, open secondary tree, a tree fern canopy, and an understory of shrubs, herbs, and ferns. These forests have standing live timber of 200 to 1000 cubic feet per acre, with a representative value of about 600 cubic feet per acre. Koa trees appear to occur mostly in limited areas in the northern parts of this ecological site with seed sources from older koa-ohia forests on Mauna Kea or in kipukas. The shallowest and/or youngest soils in this ecological site tend to support extensive, dense stands of uluhe or Old World forkedfern (*Dicranopteris linearis*) with relatively open canopies of emergent trees and shrubs. As tree canopies become more closed over time, uluhe density may decrease and the sites will

become more like the central concept.

Forest overstory. The open overstory consists of ohia lehua (Metrosideros polymorpha) or ohia lehua and koa (Acacia koa) 60 to 75 feet (18 to 23 meters) tall and up to 36 inches (90 centimeters) diameter at breast height, an open secondary canopy of diverse trees species 15 to 25 feet (4.6 to 8 meters) tall, a tree fern canopy 10 to 15 feet (3 to 4.6 meters) tall with 30 to 60 percent cover, and an understory of shrubs, forbs, and ferns.

The native loulu palm (Pritchardia beccariana) appears to occur only on older geologic areas of this ecological site, at least in the present day. While koa occurs on all soil map units and geologic ages of the ecological site, occurrence of koa appears to be related to proximity to seed sources on much older surfaces on Mauna Kea or in kipukas. Koa have not been observed growing on ponded soils, but do occur on saturated soils or on small hummocks of Kopua soils that are surrounded by ponded soils.

Forest understory. The secondary canopy is a diverse array of common Hawaiian rainforest trees.

The tertiary canopy contains small trees but is dominated by two species of hapuu or tree ferns, hapuu (Cibotium glaucum) and hapuu ii or hapuu li (Cibotium menziesii). Cibotium glaucum is the more abundant of the two species.

The lowest canopy stratum, which ranges in height from the ground to about 4.5 feet (1.5 meters), consists of seedlings and immature individuals of species in the taller strata, small shrub species, forbs, vines, sedges, and ferns and fern allies. Uluhe (Dicranopteris linearis), pukiawe (Styphelia tameiameiae), and ohelo kau lau (Vaccinium calycinum) are more abundant here than in other Hawaiian moist forest ecological sites due to the increased amount of light penetrating the relatively open upper canopies. Small ferns are diverse and abundant on the ground, on downed logs, and on live tree trunks.

Table 5. Soil surface cover

Tree basal cover	2-3%
Shrub/vine/liana basal cover	0-1%
Grass/grasslike basal cover	0%
Forb basal cover	1-2%
Non-vascular plants	3-5%
Biological crusts	0-1%
Litter	50-60%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0-15%
Bare ground	0-2%

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)	0-1%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-2 per hectare
Tree snag count** (hard***)	0-7 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%	0%
>0.15 <= 0.3	0%	0%	0-1%	3-5%
>0.3 <= 0.6	0-1%	0-1%	0-1%	10-15%
>0.6 <= 1.4	1-5%	5-10%	0-1%	1-2%
>1.4 <= 4	30-50%	0-1%	–	1-2%
>4 <= 12	25-35%	–	–	–
>12 <= 24	1-2%	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

State 2
Naturalized Grassland State

This state is comprised of three community phases. Continuous grazing that does not allow the favored forage species time to recover from defoliation results brings a phase change to phase 2.2, which is dominated by lower value forage species but contains enough remnant desirable grass species to allow for a change back to phase 2.1 with prescribed grazing. Longer-term continuous grazing leads to phase 2.3, which consists of low value grass species and increasing cover of weedy shrubs, tree saplings, and vines.

Community 2.1
Californiagrass/ticktrefoil

Figure 10. Californiagrass. D Clausnitzer generic photo

This phase is maintained by application of prescribed grazing. Invasion by broomsedge bluestem and beardgrass or bushybeard bluestem (*Schizachyrium condensatum*) may be kept in check by increasing soil pH through lime applications and by mowing these tall weedy grasses before they set seed.

Forest overstory. This phase typically has few or no trees.

Forest understory. The dominant grass species is typically Californiagrass or para grass (Urochloa mutica), often with an admixture of leguminous desmodium (Desmodium spp.).

Community 2.2
Broomsedge bluestem - hilograss

Figure 12. Broomsedge bluestem and hilograss. D Clausnitzer generic photo

This phase is maintained by application of prescribed grazing and, when needed, weed control methods. It is dominated by grasses of lower forage value than phase 2, and cover of weedy shrubs and forbs has increased.

Forest overstory. This phase typically has few or no trees.

Forest understory. The most abundant grasses typically are broomsedge bluestem (Andropogon virginicus), bushybeard bluestem (Schizachyrium condensatum), hilograss (Paspalum conjugatum), and common carpetgrass (Axonopus fissifolius). Californiagrass or para grass (Urochloa mutica) is still common. Sourbush (Pluchea carolinensis) is common. Seedlings of common guava (Psidium guajava) and strawberry guava (Psidium cattleianum) are common.

Table 8. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0.0-0.5%
Grass/grasslike basal cover	25-30%
Forb basal cover	0%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	55-65%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	5-10%

Table 9. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0%	1-2%	0-1%
>0.15 <= 0.3	0%	0-1%	25-35%	1-2%
>0.3 <= 0.6	0-1%	1-1%	25-40%	2-3%
>0.6 <= 1.4	0-1%	5-15%	35-45%	0-1%
>1.4 <= 4	0-1%	–	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Community 2.3
Strawberry guava/princess flower (glorybush)/hilograss - common carpetgrass

Figure 13. Weedy grassland. D Clausnitzer generic photo

This phase is dominated by low value forage species and weedy shrubs, vines, and forbs.

Forest overstory. An open overstory of strawberry guava (Psidium cattleianum) may have grown.

Forest understory. The most abundant grasses typically are broomsedge bluestem (Andropogon virginicus), bushybeard bluestem (Schizachyrium condensatum), hilograss (Paspalum conjugatum), and common carpetgrass (Axonopus fissifolius). Strawberry guava is abundant, along with glorybush or princess-flower (Tibouchina urvilleana), Koster's curse (Clidemia hirta), sourbush (Pluchea carolinensis), and introduced blackberries (Rubus ellipticus and R. rosifolius). Native uluhe (Dicranopteris linearis) is often abundant as thickets. Many species of introduced forbs may be present.

Table 10. Soil surface cover

Tree basal cover	0-1%
Shrub/vine/liana basal cover	0-1%
Grass/grasslike basal cover	10-20%
Forb basal cover	0.5%
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 11. 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 12. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0-1%	1-2%	1-2%
>0.15 <= 0.3	0%	1-2%	10-20%	5-10%
>0.3 <= 0.6	1-1%	1-2%	20-30%	5-10%
>0.6 <= 1.4	1-2%	15-20%	5-15%	1-2%
>1.4 <= 4	1-10%	25-35%	–	–
>4 <= 12	0-2%	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Pathway 2.1A
Community 2.1 to 2.2

Californiagrass/ticktrefoil

Broomsedge bluestem - hilograss

This phase degrades to phase 2.2 by continuous grazing that weakens preferred grass species in relation to less desirable forage species.

Pathway 2.2A
Community 2.2 to 2.1

Broomsedge bluestem - hilograss

Californiagrass/ticktrefoil

This phase can be converted to phase 2.1 by prescribed grazing. A prescribed grazing plan provides for intensive but temporary grazing of pastures that ensures that cattle consume some low-value forage species along with preferred forages and allows preferred forages time to recover from defoliation. The grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing. Some weed control methods may need to be applied.

Pathway 2.2B
Community 2.2 to 2.3

Broomsedge bluestem - hilograss

Strawberry guava/princess flower (glorybush)/hilograss - common carpetgrass

This phase degrades to phase 2.3 by long-term continuous grazing and continued weed invasion and growth. Remnant desirable forage species have been much reduced and replaced by low value forage grasses.

Pathway 2.3A
Community 2.3 to 2.1

Strawberry guava/princess flower (glorybush)/hilograss - common carpetgrass

Californiagrass/ticktrefoil

This phase can be converted to phase 2.1 by a combination of weed control, prescribed grazing, and replanting of desirable forage species. Weeds such as blackberries, sourbush, and strawberry guava are not controllable by domestic livestock and must be killed with herbicide. The grazing prescription will require removal of livestock until seeded forage species have reestablished adequately to support grazing. Thereafter, the grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

State 3
Invaded Understory State

This state consists of one community phase. It has an intact or diminished overstory of native trees and a dense understory of introduced shrubs, grasses, ferns, and small trees. Native species are unable to regenerate eventually die out, leading to a transition to State 5 Invaded Overstory and Understory. Mechanical clearing could restore this state to State 2 Naturalized Grassland. Intensive efforts may enable restoration to State 1 Reference.

Community 3.1
`Ohi`a lehua - strawberry guava/princess flower (glorybush)

Figure 14. Ohia lehua and hapuu with weedy understory. D Clausnitzer generic photo

Most native species are unable to regenerate, but small populations of kopiko (Psychotria sp.) and hapuu (*Cibotium glaucum*) appear able to persist in the understory for a time.

Forest overstory. The overstory consists of ohia lehua (Metrosideros polymorpha) or a combination of ohia lehua and koa (Acacia koa).

Forest understory. The most abundant species are strawberry guava (Psidium cattleianum), Koster's curse (Clidemia hirta), and glorybush (Tibouchina urvilleana). Yellow Himalayan raspberry (Rubus ellipticus) often forms thickets. Palmgrass (Setaria palmifolia) is common. Some uluhe (Dicranopteris linearis) may persist.

Table 13. Soil surface cover

Tree basal cover	1-2%
Shrub/vine/liana basal cover	0.5-1.0%
Grass/grasslike basal cover	1-2%
Forb basal cover	0.5-1.0%
Non-vascular plants	20-25%
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 14. 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***)	2-5 per hectare

Tree snag count** (hard***)	5-7 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 15. Canopy structure (% cover)

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

State 4
Invaded Overstory and Understory State

This state is comprised of one community phase dominated by introduced species in both the overstory and understory. It should be possible to restore this state to State 2 Naturalized Grassland by intensive mechanical clearing, weed control, and planting forage species.

Community 4.1
Strawberry guava

Figure 15. Strawberry guava; Ihope soil series. D Clausnitzer generic photo

Strawberry guava is typically the dominant tree species because it invades sites by seeds spread by pigs and reproduces vegetatively by root suckers. Strawberry guava appears able to dominate a site indefinitely because of the dense shade it produces and the competitive advantage of its very dense root system. Strawberry guava can reproduce and grow under these shady canopies.

Forest overstory. The overstory consists of a dense stand of strawberry guava (Psidium cattleianum).

Forest understory. There is little or no understory under dense stands of strawberry guava.

Table 16. Soil surface cover

Tree basal cover	1-3%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	15-20%
Biological crusts	0%
Litter	60-70%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	10-20%

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***)	0-2 per hectare
Tree snag count** (hard***)	7-10 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 18. 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%	0%	0%
>0.3 <= 0.6	0-1%	0%	0%	0%
>0.6 <= 1.4	3-5%	0%	–	0%
>1.4 <= 4	50-80%	0%	–	–
>4 <= 12	20-50%	–	–	–
>12 <= 24	0-1%	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

State 5
Uluhe-Invaded State

This state is comprised of one plant community dominated by dense thickets of uluhe fern. It forms where

disturbance has cleared the original forest and introduced weeds are not abundant, allowing uluhe to cover the ground. This state should restore itself to State 1 Reference over time.

Community 5.1
`Ohi`a lehua/Old World forkedfern (uluhe)

Figure 16. Dense uluhe fern thicket. D Clausnitzer generic photo

This community phase consists of dense thickets of uluhe fern that grow up to about 10 feet (3 meters) high with emergent native trees and tree ferns.

Forest overstory. The overstory consists of ohia lehua (Metrosideros polymorpha), sometimes in combination with a few koa (Acacia koa). Occasionally, small numbers of other native tree species occur.

Forest understory. The understory is primarily uluhe (Dicranopteris linearis). However, a diverse assemblage of typical Hawaiian moist forest trees typically occurs. Canopy cover of hapuu (Cibotium glaucum) often is around 20%.

Table 19. Soil surface cover

Tree basal cover	0-1%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	1-2%
Non-vascular plants	15-20%
Biological crusts	0%
Litter	75-80%
Surface fragments >0.25" and <=3"	0-1%
Surface fragments >3"	0-1%
Bedrock	0%
Water	0%
Bare ground	0-1%

Table 20. 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%

Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	0%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-2 per hectare
Tree snag count** (hard***)	0-5 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 21. 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%	0-1%	0%
>0.3 <= 0.6	0%	1-1%	0-1%	1-2%
>0.6 <= 1.4	1-1%	3-5%	–	30-40%
>1.4 <= 4	1-20%	0-1%	–	40-50%
>4 <= 12	0-30%	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Transition T1A
State 1 to 2

This state transitions to State 2 Naturalized Grassland by clearing the forest with heavy machinery and planting desirable forage species. Native forest may be cleared gradually by allowing cattle uncontrolled access to the forest. Cattle eventually eat or destroy understory ferns, forbs, shrubs, and saplings, opening up the forest so that forage grasses will thrive.

Transition T1B
State 1 to 3

This state can transition to State 4 Native Forest with Invaded Understory by gradual replacement of the understory by introduced shrubs, vines, ferns, and small trees that outcompete the native understory species. This process is accelerated by ungulate foraging that disturbs the soil surface and directly destroys native plants and prevents their regeneration.

Transition T1C
State 1 to 5

This state transitions to State 5 Uluhe Invaded Understory by mechanical land clearing or wildfire clear areas of forest that are not near seed sources of invasive, introduced plants.

Restoration pathway R2A
State 2 to 1

It may be possible to restore this state to a facsimile of State 1 Reference. Weed control must be applied to forage species and the many opportunistic weeds that invade the site. Weed control would be a perpetual process to capture and maintain the site. Domestic and feral ungulates would be excluded from the restoration site, but domestic ungulates would be useful to manage vegetation outside the restoration site perimeter. Extensive planting

of native species would follow.

Transition T2A
State 2 to 4

This state transitions to State 4 Invaded Over and Understory by abandonment of grazing areas, which leads to rapid invasion of weedy tree species that take over from the initial growth of weedy vines and shrubs. The most common tree species is strawberry guava.

Restoration pathway R3A
State 3 to 1

From this state, it may be possible to restore a facsimile of State 1 Reference. Before restoration of native plants, introduced understory plants must be eliminated by weed control and brush management practices, and ungulates must be excluded from the restoration site.

Transition T3B
State 3 to 2

This state may be restored to State 2 Naturalized Grassland by mechanical clearing of weedy and remnant native understory plants; native overstory trees may be harvested for timber, destroyed, or left for shade. If leaving native trees for shade, care must be taken to not damage roots within about 20 feet (6 meters) of the trees. Introduced forage grasses may then be seeded. Herbicide applications will be necessary before and during forage establishment to control reemerging weed species.

Transition T3A
State 3 to 4

This state transitions to State 4 Invaded Overstory and Understory because the native trees that form the overstory of are unable to regenerate in the dense weed understory. Eventually the mature native trees die without replacement and introduced tree species grow to form a new overstory.

Restoration pathway R4A
State 4 to 2

This state may be restored to State 2 Naturalized Grassland by mechanical clearing of overstory and understory vegetation. Introduced forage grasses may then be seeded into the site. Herbicide applications will be necessary before and during forage establishment to control reemerging weed species.

Restoration pathway R5A
State 5 to 1

With few or no weeds present, this state would be expected to restore itself to State 1 Reference as emergent native tree and tree fern canopies increase. If some alien weeds are present, timely weed control can prevent them from achieving dominance.

Transition T5A
State 5 to 2

This state may transition to State 2 Naturalized Grassland by wildfire or by mechanical clearing, followed by intentional establishment or invasion of grasses.

Additional community tables

Table 22. 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	4–12.2	15–30	–	–
koa	ACKO	*Acacia koa*	Native	4–12.2	1–5	–	–
wild coffee	PSYCH	*Psychotria*	Native	4–7.6	0–1	–	–
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	4–12.2	0–1	–	–
mirrorplant	COPRO	*Coprosma*	Native	4–6.1	0–1	–	–
ha'a	ANPL2	*Antidesma platyphyllum*	Native	4–4.9	0–1	–	–
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	4–9.1	0–1	–	–
Hawai'i holly	ILAN	*Ilex anomala*	Native	4–7.6	0–1	–	–
koa	ACKO	*Acacia koa*	Native	12.2–19.8	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	12.2–18.3	0–1	–	–
Kilauea pritchardia	PRBE	*Pritchardia beccariana*	Native	12.2–15.2	0–0.5	–	–
Kilauea pritchardia	PRBE	*Pritchardia beccariana*	Native	4–12.2	0–0.5	–	–
Tree Fern							
hapu'u	CIGL	*Cibotium glaucum*	Native	4–5.5	0–1	–	–
hapu'u li	CIME8	*Cibotium menziesii*	Native	4–4.9	0–1	–	–

Table 23. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
twigrush	MACHA2	*Machaerina*	Native	0.6–0.9	0–0.5
Hawai'i sedge	CAAL12	*Carex alligata*	Native	0.3–0.6	–
Forb/Herb					
pua'akuhinia	ASME4	*Astelia menziesiana*	Native	0.2–0.3	0–1
peperomia	PEPER	*Peperomia*	Native	0.2–0.3	0–1
Fern/fern ally					
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	0.6–1.5	5–15
Hawai'i umbrella fern	STOW	*Sticherus owhyensis*	Native	0.6–1.5	0–1
akolea	ATMI	*Athyrium microphyllum*	Native	0.3–0.6	0–1
Pacific woodfern	DRSA	*Dryopteris sandwicensis*	Native	0.3–0.9	0–1
alpine woodfern	DRWA	*Dryopteris wallichiana*	Native	0.3–0.6	0–1
scrambling fern	DIPI3	*Diplopterygium pinnatum*	Native	0.6–1.5	0–1
sadleria	SADLE	*Sadleria*	Native	0.6–0.9	0–1
vandenboschia	VANDE	*Vandenboschia*	Native	0.2–0.3	0–0.5
Old World adderstongue	OPPEP	*Ophioglossum pendulum ssp. pendulum*	Native	0.2–0.3	0–0.5
staghorn clubmoss	LYCE2	*Lycopodiella cernua*	Native	0.2–0.3	0–0.5
whisk fern	PSNU	*Psilotum nudum*	Native	0.2–0.3	0–0.5
flatfork fern	PSCO3	*Psilotum complanatum*	Native	0.2–0.3	0–0.5

wahini noho mauna	ADTA	*Adenophorus tamariscinus*	Native	0.2–0.3	0–0.5
royal tonguefern	ELCR2	*Elaphoglossum crassifolium*	Native	0.2–0.3	0–0.5
kolokolo	GRTE	*Grammitis tenella*	Native	0.1–0.2	0–0.5
Chinese creepingfern	ODCH	*Odontosoria chinensis*	Native	0.3–0.6	–
Shrub/Subshrub					
ohelo kau la'au	VACA8	*Vaccinium calycinum*	Native	0.6–1.5	1–5
pukiawe	STTA	*Styphelia tameiameiae*	Native	0.6–1.5	1–5
kanawao	BRAR6	*Broussaisia arguta*	Native	0.6–1.5	0–1
Waimea pipturus	PIAL2	*Pipturus albidus*	Native	0.6–1.8	0–1
clermontia	CLERM	*Clermontia*	Native	0.6–1.2	0–1
small treefern	CYPA7	*Cyathea parvula*	Native	0.3–0.6	0–1
forest cyrtandra	CYGI3	*Cyrtandra giffardii*	Native	0.6–0.9	–
forest cyrtandra	CYGI3	*Cyrtandra giffardii*	Native	0.6–0.9	–
pele clermontia	CLPE2	*Clermontia peleana*	Native	0.6–1.5	–
Tree					
kokea lau li'i	MYSA2	*Myrsine sandwicensis*	Native	0.6–3	1–5
mirrorplant	COPRO	*Coprosma*	Native	0.6–4	1–2
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	0.6–4	1–2
ha'a	ANPL2	*Antidesma platyphyllum*	Native	0.6–4	0–1
variable starviolet	HETE21	*Hedyotis terminalis*	Native	0.6–3	0–1
Hawai'i holly	ILAN	*Ilex anomala*	Native	0.6–4	0–1
olomea	PESA3	*Perrottetia sandwicensis*	Native	0.6–3	0–1
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	0.6–4	0–1
wild coffee	PSYCH	*Psychotria*	Native	0.6–4	0–1
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	0.6–4	0–1
Kilauea pritchardia	PRBE	*Pritchardia beccariana*	Native	0.6–4	0–0.5
koa	ACKO	*Acacia koa*	Native	0.6–4	–
'aku 'aku	CYTR6	*Cyanea tritomantha*	Native	0.6–3	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	0.6–4	15–25
hapu'u li	CIME8	*Cibotium menziesii*	Native	0.6–4	5–10
Vine/Liana					
'ie'ie	FRAR	*Freycinetia arborea*	Native	0.3–6.1	0–1
Maile	ALST11	*Alyxia stellata*	Native	0.6–2.4	0–1
forest starviolet	HECE	*Hedyotis centranthoides*	Native	0.3–0.9	–
Hawai'i blackberry	RUHA	*Rubus hawaiensis*	Native	0.6–1.2	–

Table 24. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Naturalized Warm Season Midgrasses**			4573–4842	
	para grass	URMU	*Urochloa mutica*	3228–4842	–
	dallisgrass	PADI3	*Paspalum dilatatum*	54–215	–
	torpedo grass	PARE3	*Panicum repens*	0–108	–
	common carpetgrass	AXFI	*Axonopus fissifolius*	54–108	–
	Oahu flatsedge	CYHY2	*Cyperus hypochlorus*	0–54	–
	violet crabgrass	DIVI2	*Digitaria violascens*	0–54	–
	shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	0–54	–
	hilograss	PACO14	*Paspalum conjugatum*	0–54	–
	Vasey's grass	PAUR2	*Paspalum urvillei*	0–54	–
	glenwoodgrass	SAIN	*Sacciolepis indica*	0–54	–
	Colombian bluestem	SCCO10	*Schizachyrium condensatum*	0–54	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	0–54	–
	smut grass	SPIN4	*Sporobolus indicus*	0–54	–
	broomsedge bluestem	ANVI2	*Andropogon virginicus*	0–54	–
Forb					
2	**Naturalized Forbs**			269–538	
	climbing dayflower	CODI5	*Commelina diffusa*	54–161	–
	greenleaf ticktrefoil	DEIN2	*Desmodium intortum*	0–108	–
	zarzabacoa comun	DEIN3	*Desmodium incanum*	0–108	–
	Hawai'i ticktrefoil	DESA81	*Desmodium sandwicense*	0–108	–
	threeflower ticktrefoil	DETR4	*Desmodium triflorum*	0–54	–
	shameplant	MIPU8	*Mimosa pudica*	0–54	–
	scaly swordfern	NEHI	*Nephrolepis hirsutula*	0–54	–
	light-blue snakeweed	STJA	*Stachytarpheta jamaicensis*	0–54	–
	Colombian waxweed	CUCA4	*Cuphea carthagenensis*	0–54	–
	tropical whiteweed	AGCO	*Ageratum conyzoides*	0–54	–
	bamboo orchid	ARGR6	*Arundina graminifolia*	0–54	–
	sensitive partridge pea	CHNI2	*Chamaecrista nictitans*	0–54	–
Shrub/Vine					
3	**Naturalized Shrubs**			54–161	
	soapbush	CLHI3	*Clidemia hirta*	0–54	–
	strawberry guava	PSCA	*Psidium cattleianum*	0–54	–
	guava	PSGU	*Psidium guajava*	0–54	–

Table 25. Community 2.2 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	25–35
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.2–0.3	15–25
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.2–0.3	5–15
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	0.6–0.9	5–15
para grass	URMU	*Urochloa mutica*	Introduced	0.3–0.6	5–15
torpedo grass	PARE3	*Panicum repens*	Introduced	0.3–0.6	1–5
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.3–0.6	1–5
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.2–0.3	0–1
glenwoodgrass	SAIN	*Sacciolepis indica*	Introduced	0.2–0.3	0–1
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	0.3–0.6	0–1
dallisgrass	PADI3	*Paspalum dilatatum*	Introduced	0.3–0.6	0–1
Job's tears	COLA	*Coix lacryma-jobi*	Introduced	0.3–0.6	0–1
violet crabgrass	DIVI2	*Digitaria violascens*	Introduced	0.3–0.6	0–1
Vasey's grass	PAUR2	*Paspalum urvillei*	Introduced	0.3–0.6	0–1
Forb/Herb					
Colombian waxweed	CUCA4	*Cuphea carthagenensis*	Introduced	0.2–0.3	1–5
light-blue snakeweed	STJA	*Stachytarpheta jamaicensis*	Introduced	0.6–0.9	0–1
sensitive partridge pea	CHNI2	*Chamaecrista nictitans*	Introduced	0.1–0.2	0–1
shameplant	MIPU8	*Mimosa pudica*	Introduced	0.1–0.2	0–1
tropical whiteweed	AGCO	*Ageratum conyzoides*	Introduced	0.3–0.6	0–1
climbing dayflower	CODI5	*Commelina diffusa*	Introduced	0.2–0.3	0–1
bamboo orchid	ARGR6	*Arundina graminifolia*	Introduced	0.6–0.9	0–1
zarzabacoa comun	DEIN3	*Desmodium incanum*	Introduced	0.2–0.3	–
Hawai'i ticktrefoil	DESA81	*Desmodium sandwicense*	Introduced	0.2–0.3	–
threeflower ticktrefoil	DETR4	*Desmodium triflorum*	Introduced	0.2–0.3	–
Shrub/Subshrub					
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	0.6–1.2	1–10
soapbush	CLHI3	*Clidemia hirta*	Introduced	0.6–1.2	0–1
Tree					
guava	PSGU	*Psidium guajava*	Introduced	0.6–2.4	0–1
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–1.5	0–1
Vine/Liana					
greenleaf ticktrefoil	DEIN2	*Desmodium intortum*	Introduced	0.2–0.3	–

Table 26. Community 2.3 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–4.9	0–2	–	–

Table 27. Community 2.3 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.2–0.3	5–15
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.2–0.3	10–15
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	0.6–0.9	3–5
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	0.6–0.9	3–5
para grass	URMU	*Urochloa mutica*	Introduced	0.3–0.6	3–5
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.2–0.3	3–5
torpedo grass	PARE3	*Panicum repens*	Introduced	0.3–0.6	0–1
dallisgrass	PADI3	*Paspalum dilatatum*	Introduced	0.3–0.6	0–1
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.2–0.3	0–1
glenwoodgrass	SAIN	*Sacciolepis indica*	Introduced	0.2–0.3	0–1
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	0.2–0.3	0–1
Vasey's grass	PAUR2	*Paspalum urvillei*	Introduced	0.3–0.6	0–1
Job's tears	COLA	*Coix lacryma-jobi*	Introduced	0.3–0.6	0–1
violet crabgrass	DIVI2	*Digitaria violascens*	Introduced	0.3–0.6	0–1
Forb/Herb					
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	0.3–0.6	0–1
sensitive partridge pea	CHNI2	*Chamaecrista nictitans*	Introduced	0.1–0.2	0–1
shameplant	MIPU8	*Mimosa pudica*	Introduced	0.1–0.2	0–1
tropical whiteweed	AGCO	*Ageratum conyzoides*	Introduced	0.3–0.6	0–1
Colombian waxweed	CUCA4	*Cuphea carthagenensis*	Introduced	0.2–0.3	0–1
light-blue snakeweed	STJA	*Stachytarpheta jamaicensis*	Introduced	0.6–0.9	0–1
climbing dayflower	CODI5	*Commelina diffusa*	Introduced	0.2–0.3	0–1
bamboo orchid	ARGR6	*Arundina graminifolia*	Introduced	0.3–0.6	0–1
Fern/fern ally					
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	0.3–1.2	5–10
staghorn clubmoss	LYCE2	*Lycopodiella cernua*	Native	0.2–0.3	0–0.5
Shrub/Subshrub					
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	0.6–2.4	5–15
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	0.6–1.5	5–10
soapbush	CLHI3	*Clidemia hirta*	Introduced	0.6–1.2	3–5
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	5–15
guava	PSGU	*Psidium guajava*	Introduced	0.6–2.4	1–2
Vine/Liana					
yellow Himalayan raspberry	RUEL3	*Rubus ellipticus*	Introduced	0.6–1.2	3–5
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	0.6–1.2	1–2

Table 28. Community 3.1 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	25–50	–	–
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–7.6	10–25	–	–
koa	ACKO	*Acacia koa*	Native	12.2–18.3	5–10	–	–
wild coffee	PSYCH	*Psychotria*	Native	4–7.6	1–2	–	–
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	4–9.1	1–2	–	–
Hawai'i holly	ILAN	*Ilex anomala*	Native	4–7.6	0–1	–	–

Table 29. Community 3.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
palmgrass	SEPA6	*Setaria palmifolia*	Introduced	0.3–0.6	1–5
para grass	URMU	*Urochloa mutica*	Introduced	0.3–0.6	0–1
glenwoodgrass	SAIN	*Sacciolepis indica*	Introduced	0.2–0.3	0–1
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.2–0.3	0–1
Forb/Herb					
Kahila garland-lily	HEGA	*Hedychium gardnerianum*	Introduced	0.6–1.5	5–10
narrowleaf plantain	PLLA	*Plantago lanceolata*	Introduced	0.1–0.2	0–1
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	0.6–0.9	0–1
Fern/fern ally					
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	0.6–1.5	1–5
Krauss' spikemoss	SEKR	*Selaginella kraussiana*	Introduced	0–0.1	0–1
Shrub/Subshrub					
soapbush	CLHI3	*Clidemia hirta*	Introduced	0.6–1.8	10–20
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	0.6–4	10–15
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	15–25
wild coffee	PSYCH	*Psychotria*	Native	1.5–4	0–1
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	1.5–4	0–1
Hawai'i holly	ILAN	*Ilex anomala*	Native	2.4–4	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	1.5–4	1–5
hapu'u li	CIME8	*Cibotium menziesii*	Native	1.5–4	1–2
Vine/Liana					
yellow Himalayan raspberry	RUEL3	*Rubus ellipticus*	Introduced	0.6–1.5	1–5
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	0.6–1.2	0–1
'ie'ie	FRAR	*Freycinetia arborea*	Native	0.3–3	0–1

Table 30. Community 4.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–7.6	20–50	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	12.2–18.3	–	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	9.1–12.2	–	–	–

Table 31. Community 4.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Fern/fern ally					
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	0.6–0.9	–
staghorn clubmoss	LYCE2	*Lycopodiella cernua*	Native	0.1–0.2	–
Shrub/Subshrub					
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	0.6–3	–
soapbush	CLHI3	*Clidemia hirta*	Introduced	0.6–1.2	–
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	20–50
Malabar plum	SYJA	*Syzygium jambos*	Introduced	0.3–0.6	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	1.5–3	–

Table 32. 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	4–12.2	0–30	–	–
koa	ACKO	*Acacia koa*	Native	4–12.2	0–1	–	–
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	4–7.6	0–1	–	–
wild coffee	PSYCH	*Psychotria*	Native	4–7.6	0–1	–	–
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	4–7.6	0–1	–	–

Table 33. Community 5.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
twigrush	MACHA2	*Machaerina*	Native	0.6–0.9	0–0.5
Oahu sedge	CAWA	*Carex wahuensis*	Native	0.3–0.6	0–0.5
Hawai'i sedge	CAAL12	*Carex alligata*	Native	0.3–0.6	0–0.5
Forb/Herb					
peperomia	PEPER	*Peperomia*	Native	0.2–0.3	0–0.5
Fern/fern ally					
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	0.6–4	70–85
Hawai'i umbrella fern	STOW	*Sticherus owhyensis*	Native	0.6–4	5–10
scrambling fern	DIPI3	*Diplopterygium pinnatum*	Native	0.6–4	1–2
sadleria	SADLE	*Sadleria*	Native	0.6–1.2	0–1
staghorn clubmoss	LYCE2	*Lycopodiella cernua*	Native	0.2–0.3	0–0.5
whisk fern	PSNU	*Psilotum nudum*	Native	0.1–0.2	0–0.5
Shrub/Subshrub					
ohelo kau la'au	VACA8	*Vaccinium calycinum*	Native	0.6–1.5	1–5
Waimea pipturus	PIAL2	*Pipturus albidus*	Native	0.6–3	0–1
clermontia	CLERM	*Clermontia*	Native	0.6–1.8	0–1
pukiawe	STTA	*Styphelia tameiameiae*	Native	0.6–1.5	0–1
kanawao	BRAR6	*Broussaisia arguta*	Native	0.6–1.8	–
Tree					
wild coffee	PSYCH	*Psychotria*	Native	0.6–4	0–1
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	0.6–4	0–1
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	0.6–4	0–1
koa	ACKO	*Acacia koa*	Native	0.6–4	0–1
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	0.6–4	0–1
mirrorplant	COPRO	*Coprosma*	Native	0.6–4	0–1
olomea	PESA3	*Perrottetia sandwicensis*	Native	0.6–4	0–1
kokea lau li'i	MYSA2	*Myrsine sandwicensis*	Native	0.6–4	0–1
Hawai'i holly	ILAN	*Ilex anomala*	Native	0.6–4	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	0.6–4	1–20
Vine/Liana					
forest starviolet	HECE	*Hedyotis centranthoides*	Native	0.6–1.2	0–0.5
'ie'ie	FRAR	*Freycinetia arborea*	Native	0.3–3	–
Hawai'i blackberry	RUHA	*Rubus hawaiensis*	Native	0.6–1.2	–

Animal community

This ecological site provides habitat to the following native birds: elepaio (Chasiempis sandwichensis), amakihi (Hemignathus virens), apapane (Himatione sanguinea), iiwi (Vestiaria coccinea), omao (Myadestes obscurus), akepa (Loxops coccineus), and akiapolaau (Hemignathus wilsoni). Species and populations may be limited by avian malaria carried by introduced mosquitoes. This ecological site also is home to the Hawaiian hoary bat or opeapea (Lasiurus cenarius semotus). These species may be encountered within all community phases but are most prevalent in open canopy native forest and forest adjacent to clearings. Community phases that provide open grassland or savannah-like settings provide habitat for the native Hawaiian hawk, or io (Buteo solitarius) and

Hawaiian owl or pueo (Asio flammeus spp. sandwichensis).

This ecological site provides habitat to a variety of introduced birds. Species such as wild turkey (Meleagris gallopavo), ring-necked pheasant (Phasianus colchicus), Erckel's francolin (Pternistis erckelii), black francolin (Francolinus francolinus), and kalij pheasant (Lophura leucomelanos) are considered to be game birds.

Feral pigs are abundant. They provide hunting opportunities but are very destructive to native vegetation. Public sport hunting typically does not have a major impact on their populations, especially in remote areas.

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

Grazing Interpretations
The following table lists suggested initial stocking rates for cattle under the Forage Value Rating system for only community phase 2.1. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Sometimes 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 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 may result in an increased stocking rate.

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 2.1. It is a utilitarian rating of the existing forage value for that specific plant community.

(note 2) Conservationists must use considerable judgment, because some pastures in the 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 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 plant community is suitable for grazing by all kinds and classes of livestock, at any season, particularly cattle. 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 this plant community is to be maintained.

Hydrological functions

This ecological site typically is found in low spots on the landscape, particularly kipukas surrounds by the better-drained soils of F162XY503. Soils are often saturated to the surface or ponded.

Recreational uses

Feral pigs may be hunted on this ecological site. Hiking and other access is limited by wetness and remote locations.

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° 34′ 34″
Longitude	155° 13′ 5″
General legal description	From Hwy. 11, drive 12.25 miles W on Stainback Hwy. Stop at blocked jeep trail and walk northwest 0.5 mile to end. Climb down into kipuka and continue along foot trail another 0.1 mile.

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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:**

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17. **Perennial plant reproductive capability:**
