USDA Natural Resources
Conservation Service

Ecological site VX161B01X502
Kona Weather Udic Forest

Accessed: 05/01/2024

General information

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

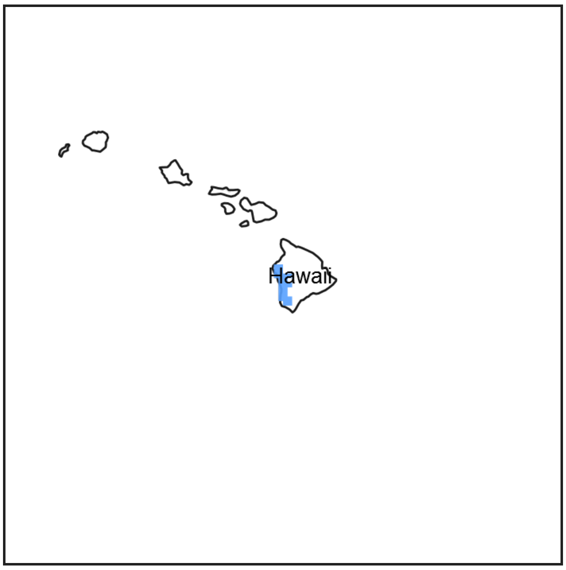

Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 161B–Semiarid and Subhumid Organic Soils on Lava Flows

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

Classification relationships

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

Ecological site concept

This ecological site is the wet forest that begins in the north on the slopes of Hualalai mauka of Kona International Airport. It follows the main highways (Rtes. 190 and 11) southward to Hawaiian Ocean View Estates in South Kona, with the makai boundary of the ecological site following the highways the entire distance. Much of the area is private land, with large areas held by Kamehameha Schools, the State of Hawaii, The Nature Conservancy, and the Federal government. Most areas near public roads are dominated by introduced plant species. The coffee-growing areas mauka of Highway 11 are in this ecological site.

The central concept of the Kona Weather Udic Forest is of somewhat poorly to well drained, very shallow to very deep soils formed in deposits of highly decomposed plant material or volcanic ash, either of which may be found over pahoehoe (flat lava flows) or within the spaces of aa (cobbly lava flows). Lava flows range from 750 to 10,000 years old. Annual air temperatures and rainfall create warm (isothermic), moist (udic) soil conditions. This ecological site has a Kona weather pattern in which most of the rainfall occurs during April through October, with Kona storms providing some additional rainfall during the winter months. The temperature and moisture conditions override the diverse soil characteristics to the extent that a clearly definable ecological site exists across all the soil types within it. The result is a tropical rain forest consisting of four canopy levels: an overstory up to 100 feet (30 meters) tall of ohia lehua (Metrosideros polymorpha) or ohia lehua and koa (Acacia koa); a secondary canopy from 30 to 60 feet (9 to 18 meters) tall of multiple tree species; a dense tree fern (hapuu = Cibotium spp.) canopy 10 to 30 feet (3 to 9 meters) tall; and a diverse understory of ferns, shrubs, and vines. Where this ecological site grades into dry forest at lower elevations there can be found in places a distinctive plant community characterized by olopua (*Nestegis sandwicensis*), papala kepau (*Pisonia brunoniana*), hame (Antidesma pulvinatum), and aiea (Nothocestrum breviflorum).

Associated sites

VX161B01X501	**Kona Weather Ustic Forest** F161BY501 Kona Weather Ustic Forest borders F161BY502 at lower elevations. The two ecological sites have similar soil parent materials and underlying lava flow types, but F161BY501 is warmer and drier than F161BY502. They share a transitional zone between them dominated by olopua trees.
VX161B01X503	**Ustic Isomesic Forest** F161BY503 Ustic Isomesic Forest borders F161BY502 at higher elevations. F161BY503 is cooler and drier than F161BY502.

Similar sites

VX159B01X500	**Udic Forest** F159BY500 Udic Forest is in the Kau District of the island of Hawaii. It contains similar rain forest plant species to F161BY502.
VX159A01X500	**Well Drained Udic and Perudic Forest** F159AY500 Deep and Very Deep Volcanic Ash Forest is on the windward side of the island of Hawaii. It contains similar rain forest species to F161BY502.

Table 1. Dominant plant species

Tree	(1) *Metrosideros polymorpha* (2) *Acacia koa*
Shrub	(1) *Cibotium glaucum*
Herbaceous	Not specified

Legacy ID

F161BY502HI

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 fields range from very shallow to 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	Very brief (4 to 48 hours)
Ponding frequency	None to occasional
Elevation	457–1,372 m
Slope	2–40%
Ponding depth	0–5 cm
Water table depth	8–152 cm
Aspect	SW, W

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 45 to 80 inches (1125 to 2000 millimeters). Most of the precipitation falls from April through October, with Kona storms providing some additional rainfall during the winter months. Average annual temperature ranges from 60 to 67 degrees F (15 to 20 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 leeward side of the island, particularly in the Kona area, a “Kona weather pattern” exists. Heating of the land during the day pulls moist ocean air up the mountain slopes that produces clouds and rain in the afternoon. A cool breeze moves down the slopes at night. This weather pattern is strongest during the summer, creating a summer seasonal rainfall maximum.

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

Shallow gulches may briefly carry floodwaters after heavy rainfall events.

Soil features

Typical soils in this ecological site are of three types: highly decomposed plant materials in aa or over pahoehoe; shallow to deep, rapidly weathered volcanic ash deposited on aa or pahoehoe; and very shallow, rapidly weathered volcanic ash deposited over pahoehoe. Most landscape surfaces in this ecological site are young (generally 750 to 5,000 years old). The youngest surfaces (lava flows from 750-3,000 years old) are covered with soils that are derived primarily from highly decomposed plant materials. Older surfaces (lava flows >3,000 years old) are usually covered with soils with much higher volcanic ash content than younger soils. These differences in age and/or ash content can affect the nature of the plant community as well as the trafficability by humans and livestock (and therefore disturbance history) of a given site.

Soils in the Manahaa and Hokukano series (soil map units 390, 394, 397, and possibly 395) have high water retention properties and are often in kipukas that receive runoff from surrounding, slightly higher lava flows. Some of these kipukas have been used for water catchment areas by ranches. Many of these kipukas are at higher elevations than the main part of this ecological site and receive lower precipitation than is typical for the ecological site, and as such may represent high elevation outliers of this wet forest.

Runoff potential ranges from negligible in aa to very high over pahoehoe. Soil temperature regimes are isothermic. Soil moisture regimes are udic (in most years, not dry for as long as 90 cumulative days).

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.

Figure 5. Honuaulu soil under grass.

Table 4. Representative soil features

Parent material	(1) Basaltic volcanic ash–basalt (2) Organic material–aa lava

Surface texture	(1) Medial silt loam (2) Hydrous silty clay loam
Family particle size	(1) Loamy
Drainage class	Somewhat poorly drained to well drained
Permeability class	Very slow to moderately rapid
Soil depth	5–152 cm
Surface fragment cover <=3"	0–15%
Surface fragment cover >3"	0–40%
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)	4.5–7.3
Subsurface fragment volume <=3" (Depth not specified)	0–55%
Subsurface fragment volume >3" (Depth not specified)	0–60%

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 consistent 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. The lava flows in this ecological site create a complex matrix of age, width, lava type, degree of ash accumulation, climate, and nearby seed sources that create some of the variability observed here. Flows on this ecological site range from 750 to 10,000 years old, with most of the flows being in the younger part of this age spectrum. This is a sufficient length of time for development of soils that support the typical vegetation, although the youngest flows of the ecological site will have less developed soils and vegetation than other areas. Still younger and as yet unvegetated flows have cut across this ecological site and will do so again.

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 seed sources. Flows located in warm, moist climates such as this are rapidly colonized by the nitrogen-fixing lichen Stereocaulon vulcani, followed soon by vascular plants including ohia lehua trees. In these environments, considerable vegetation can be established in periods measured in decades. Cooler locations at higher elevations revegetate more slowly. Cobbly aa lava provides safe sites for seed germination as well as sites that promote plant rooting and soil accumulation in the gaps between cobbles. This is a more favorable situation for revegetation and soil development than flat, bare pahoehoe lava. Where lava flows are narrow or where kipukas (areas of land surrounded by younger lava) occur, revegetation is hastened by the proximity of seed sources from intact vegetation stands nearby.

In general, younger flows have received smaller inputs of volcanic ash than older flows. Soil parent materials on these younger soils typically consist of decomposed organic material with small amounts of volcanic ash. Soils on older flows are more likely to be mineral soils composed largely of volcanic ash. Mature vegetation on organic versus mineral soils may have differed to some extent. These differences are difficult to discern today because of human-related disturbances. Also, some areas with mineral soils are in kipukas that receive runoff from surrounding younger flows; this extra moisture does not generally create aquic soil conditions but probably alters plant growing conditions to some extent.

Vegetation can be killed by erupted layers of ash 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 of soil particles, 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). Future ash falls may occur here; past ash flows are old enough for soils and vegetation to have developed to the typical range for this ecological site.

To some extent, lava flows may start wildfires, but this is not a frequent occurrence. Wildfires started by lightning may occur occasionally but are unlikely to carry far due to the moist environment.

Wind throw of vegetation can occur during hurricanes or other high wind events. This disturbance can open the canopy to create observable variations in the natural vegetation.

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. 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). Prehistoric native lowland forest disturbance can be attributed to clearing for agriculture by hand or by fire, introduction of new plants, diseases, and animals, and wood harvesting (Athens 1997). Much of this ecological site occurs at higher elevations above areas that supported high human populations and intensive agriculture.

Where this ecological site grades into drier forests at lower elevations (ecological site F161BY501) was (and still is in limited areas) a transitional forest dominated by olopua (*Nestegis sandwicensis*) and papala kepau (*Pisonia brunoniana*) and having diminishing abundance of hapuu (Cibotium spp.). Much of this zone was utilized for intensive agriculture by native Hawaiians as part of the Kona Field System. Today, much of this land is utilized for coffee and macadamia orchards and residential development.

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.

This ecological site evolved without the presence of large mammals. 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. By 1851, records reported severe overstocking of pastures, lack of fences, and large numbers of feral livestock (Henke 1929). Today, much of this ecological site is utilized for cattle ranching.

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.

The original forest plant community is now disturbed and fragmented due to agriculture, establishment of introduced timber tree species, domestic and feral ungulate foraging, and invasion by introduced plant, animal, and microbe species. Foraging by cattle and pigs or clearing and abandonment accelerate invasion by weeds. However, weeds appear able to successfully invade native stands regardless of human or ungulate disturbances.

The naturalized kikuyugrass grasslands in this ecological site (all of which were formerly forested) become infested with unpalatable grasses and shrubs under conditions of improper grazing management.

There is little native vegetation present in the lower elevations of this ecological site. Previously cleared or otherwise heavily-disturbed sites at lower elevations are invaded rapidly by introduced plant species, resulting ultimately in a forest dominated by introduced trees, shrubs, vines, and ferns.

State and transition model

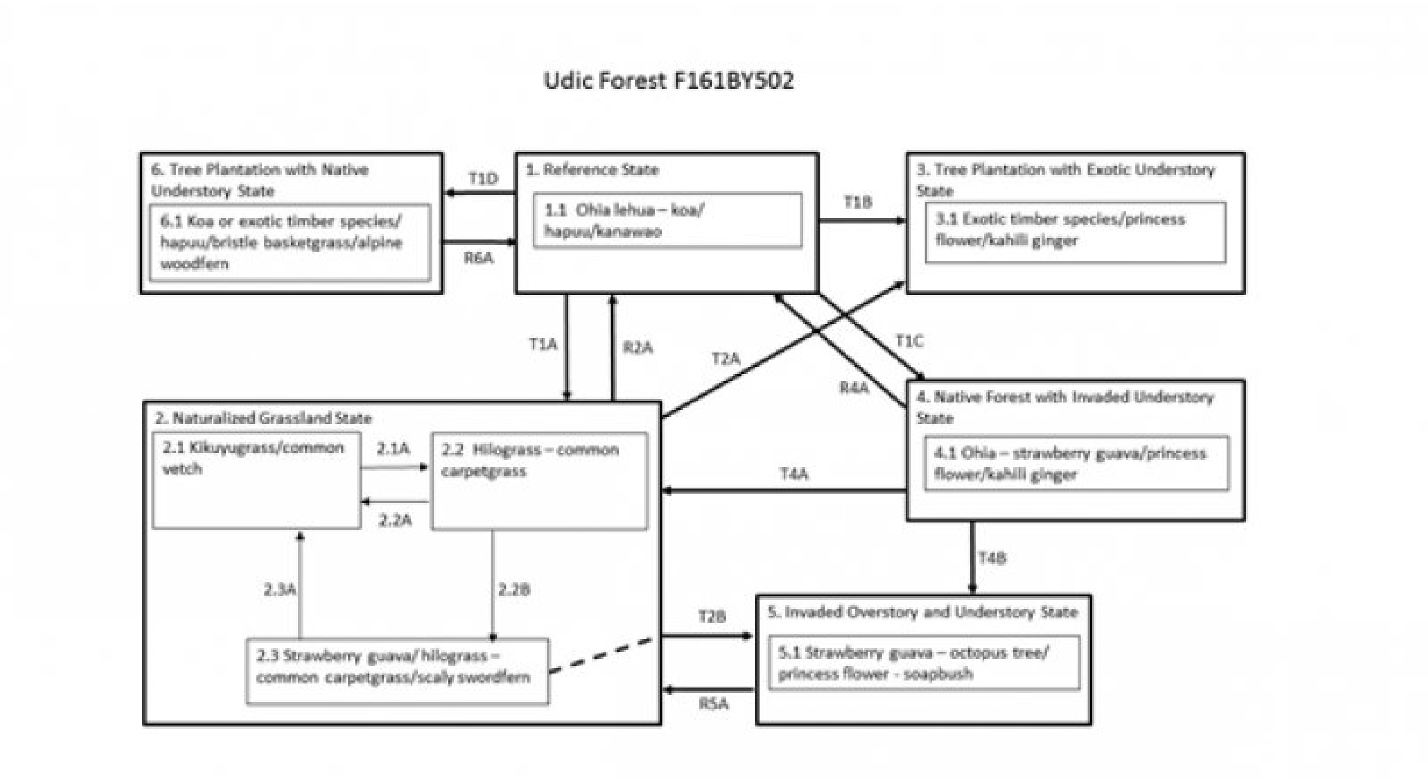

Figure 6. State and Transition Model Diagram F161BY502

State 1
Reference State

The Reference State consists of one community phase. Under a regime of natural disturbances, this community has probably been stable through post-glacial time frames and from a broad-scale spatial perspective. Rainfall and temperature vary based on elevation, while substrate varies by lava flow type (aa versus pahoehoe) and age. This produces a matrix of natural variability that changes over a scale of decades and centuries as soils and vegetation communities develop. Overlaid on this matrix are more localized variations caused by wind throw, tree death, and propagule availability. New lava flows bring about a return to primary succession that proceeds at different rates due to lava type and climate. Much of this ecological site has 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. Clearing the forest and then planting introduced timber tree species results in a transition to either State 3 Tree Plantation with Exotic Understory or State 6 Tree Plantation with Native Understory, depending on local availability of seeds for native or invasive introduced species. Gradual invasion by introduced species into existing forest results in State 4 Native Forest with Invaded Understory.

Community 1.1
`Ohi`a lehua - koa/hapu`u/kanawao

Figure 7. Reference community phase. 4/28/06 D Clausnitzer MU113

Figure 8. Nestegis-dominated variant. 11/1/05 D Clausnitzer MU112

Figure 9. Forest on younger lava flow. 1/17/06 D Clausnitzer

Figure 10. Reference community. 5/5/06 D Clausnitzer MU201

This community phase is a forest consisting of four canopy strata: an open or closed upper canopy of ohia lehua or ohia lehua and koa up to about 100 feet (30 meters) tall, a secondary canopy of diverse tree species 30 to 60 feet (9 to 18 meters) tall, a dense tree fern canopy 10 to 30 feet (3 to 9 meters) tall, and a diverse understory of shrubs, forbs, sedges, and ferns. Vines, particularly ieie, are common both on the ground and on trees. These forests have standing live timber of 900 to 8000 cubic feet per acre, with a representative value of about 5500 cubic feet per acre. Variability in both the overstory and understory occurs throughout this ecological site. This variability represents occurrences of a spectrum of differences in vegetation and soils that are primarily due to different lava flow ages. The different vegetation and soils apparently are succeeding to a common state. The rate of this succession is determined by local temperature and rainfall, and it can be set back to primary succession by unpredictable fresh lava flows.

Forest overstory. The uppermost forest canopy consists of ohia lehua or a combination of ohia lehua and koa. Total overstory tree canopy cover ranges from about 10% to 80%. Neither overstory species grows well in shade. Primary succession in Hawaii typically results in an initial forest overstory of ohia lehua consisting of roughly even-aged cohorts. Over time, a number of factors (discussed below) influence the overstory composition.

Ohia lehua dominates the forest canopy on younger lava flows, which also tend to be organic (highly decomposed plant material) soils rather than mineral (volcanic ash) soils. Older lava flows tend to be mineral, volcanic ash soils; these soils have a greater likelihood of koa occurrence. Koa is able to grow on both organic and mineral soils. Landscape surface age, and hence stage of succession, is more important to koa occurrence than is soil type (organic versus mineral/volcanic ash).

Koa is an opportunistic species that often occurs along roadsides or near old sawmills in areas where it does not occur in the forest but where logging operations have distributed koa seeds. Koa also can occur on soils on which it is typically not found, such as young organic soils, when those soils occur on narrow lava flows that have run through areas of older volcanic ash soils that support stands of koa.

In general, koa is more abundant at higher elevations (above 2800 feet) of this ecological site. The lowest natural koa occurrences are at about 2000 feet elevation. It is possible that populations of koa were more widespread at lower elevations in Kona in the past (personal communication, Rick Warshauer, 2006).

Forest understory. Understory composition appears to be controlled by the cover of the secondary canopy of medium-stature tree species and, in particular, by the cover of tree ferns, which is usually in the range of 60% to 90%. Koa and ohia do not reproduce successfully in the typically shady understory of intact forest. Tree ferns, medium-stature trees such as olapa, kopiko, kolea lau nui, kawau, and olomea, and shrubs such as kanawao and clermontia reproduce well in the understory. The ground layer of small ferns is typically very dense.

The most common secondary canopy tree species are olapa or olapalapa (Cheirodendron trigynum), kolea lau nui (Myrsine lessertiana), and kopiko (Psychotria spp.). The palm native to this ecological site, loulu (Pritchardia lanigera), is rare but may have been more abundant in the past.

The mid-canopy is dominated by olapa trees in the southern part of the ecological site; however, olapa is somewhat less abundant in the northern part.

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. Hapuu or Chamisso's manfern (Cibotium chamissoi) is present but uncommon.

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 (some prostrate, some climbing, some both), sedges, and ferns and fern allies. Ieie vine (Freycenetia arborea) can be very abundant, both on the ground and climbing on trees.

Some of the youngest lava flows, especially on Mawae soil series, can have large ohia trees but an understory with much less tree fern cover, more abundant amau (Sadleria spp.) fern cover, and more abundant kolea lau lii (Myrsine sandwicensis) than is typical for this ecological site. This understory species composition reflects an earlier successional stage with less soil development.

Table 5. Soil surface cover

Tree basal cover	3-5%
Shrub/vine/liana basal cover	0.0-0.1%
Grass/grasslike basal cover	0%
Forb basal cover	1-2%
Non-vascular plants	10-50%
Biological crusts	0%
Litter	20-50%
Surface fragments >0.25" and <=3"	0-40%
Surface fragments >3"	0-40%
Bedrock	0%
Water	0%
Bare ground	0%

Table 6. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	1-2%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	1-3%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	2-5 per hectare
Tree snag count** (hard***)	2-5 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 7. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0-1%	0%	1-1%
>0.15 <= 0.3	0%	1-1%	0-1%	5-10%
>0.3 <= 0.6	0%	5-10%	0-1%	5-15%
>0.6 <= 1.4	1-5%	5-10%	–	0-1%
>1.4 <= 4	5-10%	1-5%	–	–
>4 <= 12	10-30%	1-5%	–	–
>12 <= 24	20-50%	–	–	–
>24 <= 37	0-20%	–	–	–
>37	–	–	–	–

State 2
Naturalized Grassland State

This state is comprised of three community phases that may or may not have an open canopy of remnant native trees (usually ohia lehua but sometimes koa). Koa may occur in or on the edges of grasslands on soils that do not usually contain koa as part of the original forest. These trees may be opportunistic individuals that have taken advantage of increased light and survived browsing long enough to reach maturity. Trees in these grasslands provide shade and protection from the elements to livestock. However, very little regeneration of trees occurs, so the trees will eventually die out. Community phase 2.1 usually consists of kikuyugrass (*Pennisetum clandestinum*) and/or pangolagrass (*Digitaria eriantha*) with an admixture of common vetch (*Vicia sativa*) or desmodium (Desmodium spp.). Continuous grazing that does not allow favored forage species time to recover from defoliation results in community phase 2.2, which is dominated by lower value forage species but contains enough remnant kikuyugrass to allow for a transition back to community phase 2.1 with prescribed grazing. Longer-term continuous grazing leads to community phase 2.3, which consists of low value grass species and increasing cover of weedy shrubs and vines. Improvement of this community phase requires weed control and restoration of desirable grasses in addition to prescribed grazing.

Community 2.1
Kikuyugrass/common vetch

Figure 11. Kikuygrass with native trees. 8/26/05 D Clausnitzer MU396

This community phase is maintained by grazing, which keeps preferred species from becoming too tall or dense, and adequate recovery periods, which ensure vigor and cover of preferred species. High production of preferred grass species and extensive cover allow for increased soil moisture retention, vegetative production, and overall soil quality. These factors are degraded by grazing practices that result in loss of preferred grass species leading to increase in less desirable grasses, weed invasion, and an increase in the extent of bare soil. The normal total annual production (all types and species of plants) of the grasslands in this community phase is about 4,000 lb/acre of forage. Above normal production is about 8,000 lb/acre; below normal production is about 2,000 lb/acre).

Forest overstory. Up to about 25% canopy cover of large, native ohia lehua trees may be present.

Forest understory. The dominant grass species is kikuyugrass, although pangolagrass also has been planted on some sites. Naturalized leguminous herbs, particularly common vetch and desmodium species, as well as a small admixture of cool-season grass species such as common velvetgrass (Holcus lanatus), orchardgrass (Dactylis glomerata), ryegrasses (Lolium spp.), and Kentucky bluegrass (Poa pratensis).

Community 2.2
Hilograss - common carpetgrass

Figure 13. Degraded kikuyugrass site. D Clausnitzer generic photo

This community phase is created and maintained by excessive, continuous grazing that favors growth of less desirable forage species. Cattle can be maintained on these forages, but animal growth and vigor will be reduced. Also, the number of weedy species is high, and their stature, seed production potential, and wide distribution can lead to rapid increase and a shift to community phase 2.3 unless management is improved.

Forest overstory. Up to about 25% canopy cover of large, native ohia lehua trees may be present.

Forest understory. Community phase 2.2 is dominated by grasses of lower forage value such as Hilograss (Paspalum conjugatum), common carpetgrass (Axonopus fissifolius), and sedges, plus forbs such as narrowleaf plantain (Plantago lanceolata). Desirable forage legumes have been reduced in abundance.

Table 8. Soil surface cover

Tree basal cover	0-1%
Shrub/vine/liana basal cover	0.0-0.5%
Grass/grasslike basal cover	25-30%
Forb basal cover	0.0-0.5%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	30-40%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-20%
Bedrock	0-1%
Water	0%
Bare ground	3-5%

Table 9. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0-1%	3-5%	0-1%
>0.15 <= 0.3	0%	0-1%	40-50%	0-1%
>0.3 <= 0.6	0%	1-2%	40-50%	0-1%
>0.6 <= 1.4	0-1%	0-5%	–	–
>1.4 <= 4	0-5%	–	–	–
>4 <= 12	0-20%	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Community 2.3
Strawberry guava/hilograss - common carpetgrass/scaly swordfern

Figure 14. Weedy grassland. D Clausnitzer generic photo

This community phase is dominated by grass species that have little forage value. Spiny forbs and vines are common, as are a large number of forb and fern species with little or no forage value. Introduced shrubs and small trees are common, and seedlings and saplings of introduced tree species are present. The abundance of immature trees with potential mature heights of 20 to over 100 feet (6 to over 30 meters) presents a risk of losing the grassland to weedy forest.

Forest overstory. Up to about 25% canopy cover of large, native ohia lehua trees may be present; these provide shade to livestock.

Large specimens of invasive introduced tree species such as autograph tree or Scotch attorney (Clusia rosea), strawberry guava (Psidium cattleianum), octopus tree (Schefflera actinophylla), christmasberry or Brazilian peppertree (Schinus terebinthifolius), and African tuliptree (Spathodea campanulata) may be present.

Forest understory. Hilograss (Paspalum conjugatum), common carpetgrass (Axonopus fissifolius), broomsedge bluestem (Andropogon virginicum), and beardgrass or Colombian bluestem (Schizachyrium condensatum) are the most abundant grasses. West Indian raspberry(Rubus rosifolius)and cat's claw or shoofly (Caesalpinia decapetala) form small thickets. Shrubs such as cure for all or sourbush (Pluchea carolinensis), along with small trees such as strawberry guava (Psidium cattleianum) and Christmasberry or Brazilian peppertree (Schinus terebinthifolius) have combined canopy cover of about 20% and heights of 2 to 4.5 feet (0.5 to 1.5 meters). Seedlings and saplings of large tree species such as octopus tree (Schefflera actinophylla) and African tuliptree (Spathodea campanulata) are often present.

Table 10. Soil surface cover

Tree basal cover	10-35%
Shrub/vine/liana basal cover	5-10%
Grass/grasslike basal cover	70-80%
Forb basal cover	10-20%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	55-65%
Surface fragments >0.25" and <=3"	0-40%
Surface fragments >3"	0-40%
Bedrock	0%
Water	0%
Bare ground	3-5%

Table 11. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	1-2%	1-2%	1-5%
>0.15 <= 0.3	0%	1-2%	10-20%	3-5%
>0.3 <= 0.6	1-2%	3-5%	40-50%	5-10%
>0.6 <= 1.4	3-5%	1-5%	10-20%	–
>1.4 <= 4	10-20%	–	–	–
>4 <= 12	3-5%	–	–	–
>12 <= 24	0-25%	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Pathway 2.1A
Community 2.1 to 2.2

Kikuyugrass/common vetch

Hilograss - common carpetgrass

Community phase 2.1 degrades to community phase 2.2 by continuous grazing that weakens preferred kikuyugrass, pangolagrass, and legumes in relation to less desirable forage species such as Hilograss (*Paspalum conjugatum*), common carpetgrass (*Axonopus fissifolius*), and sedges. Undesirable forbs such as narrowleaf plantain (*Plantago lanceolata*) also increase under these conditions.

Pathway 2.2A
Community 2.2 to 2.1

Hilograss - common carpetgrass

Kikuyugrass/common vetch

Community phase 2.2 can be reconverted 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. Kikuyugrass is very competitive and adapted to grazing and is able to recover with proper management. The grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

Pathway 2.2B
Community 2.2 to 2.3

Hilograss - common carpetgrass

Strawberry guava/hilograss - common carpetgrass/scaly swordfern

Community phase 2.2 degrades to community phase by long-term continuous grazing. Remnant kikuyugrass, pangolagrass, and forage legumes are further reduced in abundance and replaced by low-value forage grasses. Weedy forbs, blackberries, and shrubs begin to increase.

Pathway 2.3A
Community 2.3 to 2.1

Strawberry guava/hilograss - common carpetgrass/scaly swordfern

Kikuyugrass/common vetch

Community phase 2.3 can be converted to phase 2.1 by a combination of weed control and prescribed grazing. Weeds such as introduced raspberries and sourbush are not controllable by domestic livestock and must be killed with herbicide. The grazing prescription will require removal of livestock from the pasture until kikuyugrass has been reestablished adequately to support grazing. Kikuyugrass may need to be resprigged into the grassland. Thereafter, the grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

State 3
Tree Plantation with Exotic Understory State

This state has its origin in sites that were cleared of native forest in the mid- to late-20th century and planted to exotic timber species that were considered to be more valuable and useful than native forest species. More recently, previously cleared areas have been planted to timber species. In either case, invasion of the understory by weedy introduced species is a likelihood in most locations. Once established, this state has little or no tendency to transition to another state.

Community 3.1
Exotic timber species/princess flower/kahila garland lily (kahili ginger)

Figure 15. Tree plantation with mostly exotic understory. 3/13/09 D Clausnitzer generic photo

This community is typically managed for long term economic returns. Many introduced timber species will potentially grow well in the environment of this ecological site, where they may be free of pests that are present in their native habitats. Many older examples of this phase have not received ongoing management since their establishment.

Forest overstory. Timber species that were established in the past are red gum (Eucalyptus robusta), toon or Australian redcedar (Toona ciliata), tropical ash (Fraxinus uhdei), sugi pine (Cryptomeria japonica), and redwood (Sequoia sempervirens). Some areas have been planted to native koa (Acacia koa).

Other valuable species can be planted, for example African mahogany (Khaya senegalensis), Honduran mahogany (Swietenia macrophylla), and Spanish cedar (Cedrela odorata). Still other species may be grown in this ecological site.

Koa is a valuable, fast-growing native tree that can be planted here. It is much more likely to thrive at elevations higher than about 1500 feet (460 meters); lower elevation plantings are often subject to diseases. Feral and domestic animals must be fenced out of koa plantations for enough years to allow the trees to attain a stature at which animals are unable to push down and eat them. Trampling of koa's shallow roots and eating the trees' bark can remain a problem for a longer time. There are examples of adequately mature koa stands being maintained along with careful cattle grazing in silvopastures.

Forest understory. Common understory species are strawberry guava (Psidium cattleianum), kahili ginger (Hedychium gardnerianum), Koster's curse (Clidemia hirta), and glorybush (Tibouchina urvilleana). These species grow very densely and are difficult to control.

Kikuyugrass can grow beneath timber trees if shade is not excessive.

Table 12. Soil surface cover

Tree basal cover	85-95%
Shrub/vine/liana basal cover	20-25%
Grass/grasslike basal cover	5-10%
Forb basal cover	5-15%
Non-vascular plants	3-5%
Biological crusts	0%
Litter	75-85%
Surface fragments >0.25" and <=3"	0-5%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%

Bare ground	0-2%

Table 13. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	1-1%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	1-1%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-5 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 14. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0-1%	0%	0%
>0.15 <= 0.3	0%	1-1%	3-5%	3-5%
>0.3 <= 0.6	1-2%	1-2%	5-10%	10-15%
>0.6 <= 1.4	5-10%	5-15%	–	1-2%
>1.4 <= 4	15-25%	5-15%	–	–
>4 <= 12	35-40%	0-1%	–	–
>12 <= 24	85-95%	–	–	–
>24 <= 37	0-1%	–	–	–
>37	–	–	–	–

State 4
Native Forest with Invaded Understory State

This state consists of one community phase. It arises by invasion by introduced species of intact native forest (the Reference State) or, in some cases, of native overstory stands from which the original understory has been cleared. Native species are unable to regenerate in the highly competitive understory of introduced plants and eventually die out. With time, large introduced tree species will emerge to replace the native overstory trees and form a new overstory. When this last step has occurred, the site will have transitioned to State 5, Invaded Overstory and Understory State. Disturbance of the soil and direct damage to native understory plants by introduced ungulates, particularly pigs and cattle, will speed the transition to this state by killing native plants and by creating better germination sites for introduced species. Restoration to the Reference State or a facsimile of it is possible by fencing the site, removing all ungulates, applying herbicides, and replanting native species when needed. Restoration efforts will be affected by the degree of invasion by introduced species and by the particular species that have invaded the site. Long term weed management and fence maintenance will be necessary.

Community 4.1
\`Ohi\`a lehua - strawberry guava/princess flower/kahila garland lily (kahili ginger)

Figure 16. Native forest with exotic understory. 1/11/06 D Clausnitzer MU111

Figure 17. Native trees with glyphosate-killed strawberry guava. 3-13-09 D Clausnitzer generic photo

Figure 18. Desmodium intortum invaded understory. 6/28/06 D Clausnitzer MU110

The community has an intact or diminished overstory of large ohia lehua and/or koa trees with a dense understory of introduced shrubs, ferns, vines, grasses, and small trees. Most native species are unable to regenerate in this plant community and eventually die out.

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

Forest understory. Secondary canopy native species are usually somewhat diminished or nonexistent. Kopiko or wild coffee (Psychotria spp.) sometimes remains in the secondary canopy.

The only native species remaining in the lower canopy levels are a few hapuu (Cibotium glaucum) or hapuu li (Cibotium menziesii), traces of small kopiko (Psychotria spp.) trees, some peperomia (Peperomia spp.) at ground level, an occasional ieie vine (Freycenetia arborea), and a few patches of uluhe or Old World forkedfern. Some small native fern species may be found growing on trees.

The understory is usually dominated by a nearly impenetrable stand of strawberry guava or waiawi (Psidium cattleianum), which can be 10 to about 30 feet (3 to 9 meters) tall. Other species indicated on the table grow sparsely beneath the strawberry guava or fill in gaps between it.

Table 15. Soil surface cover

Tree basal cover	75-90%
Shrub/vine/liana basal cover	30-35%
Grass/grasslike basal cover	5-10%
Forb basal cover	15-25%
Non-vascular plants	3-5%
Biological crusts	0%
Litter	80-85%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-20%
Bedrock	0%
Water	0%
Bare ground	0-1%

Table 16. 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***)	2-5 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 17. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0-1%	0-1%	0%	0%
>0.15 <= 0.3	0-1%	0-1%	3-5%	1-2%
>0.3 <= 0.6	1-2%	1-1%	5-10%	15-25%
>0.6 <= 1.4	5-10%	5-10%	–	1-10%
>1.4 <= 4	15-25%	15-25%	–	–
>4 <= 12	45-55%	0-5%	–	–
>12 <= 24	5-10%	0-1%	–	–
>24 <= 37	0-10%	–	–	–
>37	–	–	–	–

State 5
Invaded Overstory and Understory State

This state is comprised of one community phase dominated by introduced species in both the overstory and understory. Remnant individuals of a few native species may persist. This state might be considered a dead end as far as further succession or transition to another state. Restoration to a facsimile of the Reference State could probably be done with expensive and intensive practices followed by long-term weed management. The site would need to be cleared of all vegetation except any remnant native species, which essentially would represent a transition to State 2 Grassland. From State 2, further restoration could be pursued to State 1 Reference. Clearing of the site followed by establishment of an overstory of noninvasive, introduced timber trees with a native understory as an intermediate step to native forest restoration may be done.

Community 5.1
Strawberry guava - octopus tree/princess flower - soapbush

Figure 19. Exotic species-dominated forest. 5/10/06 D Clausnitzer MU111

It is possible that shifts will eventually occur in the introduced species that dominate the site, particularly if competitive, tall-statured tree species are present. This would change the mix of species present and may affect soil characteristics such as nitrate availability or organic matter decomposition, but would not represent a transition to another state. Sites that are completely dominated by dense stands of strawberry guava typically show no indications, such as death or partial death of stands or emergence of potentially taller tree species, of yielding to change in the foreseeable future.

Forest overstory. Depending on local seed sources, invasive trees of moderate stature including strawberry guava (Psidium cattleianum), christmasberry (Schinus terebinthifolius), or common guava (Psidium guajava) can dominate a given site initially, but strawberry guava generally becomes dominant over time. 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 can dominate a site for years because of the dense shade it produces and the competitive advantage conferred by its very dense root system.

Taller statured introduced trees including silkoak (Grevillea robusta), albizia or peacocksplume (Falcataria moluccana), and octopus tree (Schefflera actinophylla) could potentially emerge through the canopy of moderate stature species.

A few remnant ohia lehua trees often remain as emergents above the canopy of introduced species, but seedlings or saplings are unlikely to be present.

Forest understory. The tree overstory species are highly competitive and produce dense shade. A variety of introduced understory species is often present but in small numbers. Typical species include Koster's curse or soapbush (Clidemia hirta), kahili ginger or Kahila garland-lily (Hedychium gardnerianum), and some shade tolerant grass species.

Strawberry guava can grow under shady overstories. Common guava eventually dies out when overtopped by a dense overstory.
Scattered individuals of remnant native species such as kopiko (Psychotria spp.), hapuu (Cibotium glaucum), and uluhe (Dicranopteris linearis) may remain in the understory.

Table 18. Soil surface cover

Tree basal cover	70-80%
Shrub/vine/liana basal cover	20-25%
Grass/grasslike basal cover	5-10%
Forb basal cover	10-15%
Non-vascular plants	3-5%
Biological crusts	0%
Litter	75-85%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-20%
Bedrock	0%
Water	0%
Bare ground	0-1%

Table 19. 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***)	0-2 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 20. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0-1%	0-1%	0%
>0.15 <= 0.3	0%	1-1%	3-5%	1-2%
>0.3 <= 0.6	0-1%	1-1%	3-5%	10-15%
>0.6 <= 1.4	3-5%	5-10%	–	1-2%
>1.4 <= 4	15-20%	10-15%	–	–
>4 <= 12	45-55%	3-5%	–	–
>12 <= 24	0-1%	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

State 6
Tree Plantation with Native Understory State

This state is comprised of one community phase dominated by introduced timber or native koa trees. It results from clearing the original native forest, often without fundamentally altering the soil, and planting introduced trees or koa. When the surrounding area remains as native forest with few weeds, native species gradually repopulate the plantation site. This state has its origin in sites that were cleared of native forest in the mid- to late-20th century and planted to exotic timber species that were considered to be more valuable and useful than native forest species. Some of these plantations were deep in the native forest and so not near major sources of introduced weeds.

Community 6.1
Koa or exotic timber species/hapu`u/bristle basketgrass/alpine woodfern

Figure 20. Old eucalyptus plantation with native understory. 5/10/06 D Clausnitzer MU112

This community is typically managed for long term economic returns. Many introduced timber species will potentially grow well in the environment of this ecological site, where they may be free of pests that are present in their native habitats. Many older examples of this phase have not received ongoing management since their establishment. The eventual condition of this community phase depends on the tree species that was planted and now dominates the overstory and, if some weeds are present, ongoing management to control them. Details of every possible scenario are not known.

Forest overstory. Timber species that were established in the past are red gum (Eucalyptus robusta), toon or Australian redcedar (Toona ciliata), tropical ash (Fraxinus uhdei), sugi pine (Cryptomeria japonica), and redwood (Sequoia sempervirens). Some areas have been planted to native koa (Acacia koa).

Other valuable species can be planted, for example African mahogany (Khaya senegalensis), Honduran mahogany (Swietenia macrophylla), and Spanish cedar (Cedrela odorata). Still other species may be grown in this ecological site.

Koa is a valuable, fast-growing native tree that can be planted here. It is much more likely to thrive at elevations higher than about 1500 feet (460 meters); lower elevation plantings are often subject to diseases. Feral and domestic animals must be fenced out of koa plantations for enough years to allow the trees to attain a stature at which animals are unable to push down and eat them. Trampling of koa’s shallow roots and eating the trees’ bark can remain a problem for a longer time. There are examples of adequately mature koa stands being maintained along with careful cattle grazing in silvopastures.

Forest understory. The tree ferns hapuu (Cibotium glaucum) and hapuu ii (C. menziesii) are common. Common secondary and tertiary canopy trees are kopiko (Psychotria spp.), kolea lau nui (Myrsine lessertiana), pilo (Coprosma spp.), olomea (Perrottetia sandwicensis), olapa (Cheirodendron trigynum), and mamaki (Pipturus albidus). Ieie vines are present on the ground and climbing on introduced and native trees. Fern species such as io nui (Dryopteris wallichiana) and hoio kula (Pneumatopteris sandwicensis) are found under introduced and native timber species. Under koa plantations, ohia lehua are able to grow because koa canopies allow sufficient light to penetrate to the ground. However, redwood plantations contain very few native species other than very hardy species such as io nui (Dryopteris wallichiana).

Table 21. Soil surface cover

Tree basal cover	4-6%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	35-45%
Biological crusts	0%
Litter	45-55%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-20%
Bedrock	0%
Water	0%
Bare ground	0-1%

Table 22. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	1-4%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	1-4%
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 23. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	0%	–	0%
>0.15 <= 0.3	0%	1-1%	–	0-1%
>0.3 <= 0.6	1-1%	1-1%	0%	3-5%
>0.6 <= 1.4	1-2%	1-1%	–	3-5%
>1.4 <= 4	45-55%	0-1%	–	–
>4 <= 12	1-2%	0-1%	–	–
>12 <= 24	5-10%	0-1%	–	–
>24 <= 37	80-90%	–	–	–
>37	–	–	–	–

Transition T1A
State 1 to 2

State 1, Reference State, can transition to State 2, Naturalized Grassland, by clearing the forest with heavy machinery or by gradual clearing by allowing cattle 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. On lava substrates, underlying lava rock often is ripped and crushed by heavy machinery to produce Udarents (sandy, organic) soils. Ripping and crushing produces some fine mineral particles and small, abundant gaps between the rock fragments. However, about 50% of the soil organic matter may be lost in the process due to exposure to air and higher temperatures.

Transition T1B
State 1 to 3

State 1 Reference State can transition to State 3 Tree Plantation with Exotic Understory by mechanical removal of the original forest overstory and understory followed by planting of introduced timber species or koa. This practice was common in Kona in the mid-20th century. When the surrounding area is infested with introduced weeds such as Koster’s curse (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*), or kahili ginger (*Hedychium gardnerianum*), those species will invade the site and dominate the understory unless controlled by herbicides. Restoration of native forest would be difficult but possible in koa plantations.

Transition T1C
State 1 to 4

State 1 Reference State can transition to State 4 Native Forest with Invaded Understory by gradual replacement of the understory by introduced shrubs, vines, and small trees that outcompete the native understory species. This process is accelerated by foraging by ungulates and rodents that disturbs the soil surface and directly destroys native plants and prevents their regeneration.

Transition T1D
State 1 to 6

State 1 Reference State can transition to State 6 Tree Plantation with Native Understory by mechanical removal of the original forest overstory and understory followed by planting of introduced timber species or koa. This practice was common in Kona in the mid-20th century. When the surrounding area contains native understory species and is fairly weed-free, native plants such as tree ferns, ieie vines, native ferns, and small native trees reestablish themselves beneath the canopies of many exotic timber species. An exception is redwood plantations, which appear to exclude establishment of most native plants. The ultimate plant community that will develop over time is unknown.

Restoration pathway R2A

State 2 to 1

It is possible to restore a facsimile of the Reference State from Naturalized Grassland. Weed control must be applied to grass species and the many opportunistic plant species that will invade the site. Increased shade from trees growing on the site causes a shift from C4 (warm-season) grass dominance (typically kikuyugrass or pangolagrass) to C3 (cool-season) shade-tolerant grasses (typically meadow ricegrass). This meadow ricegrass layer can be almost as dense and detrimental to establishment of native plants as kikuyugrass. Attempts have been made to suppress meadow ricegrass by planting native shrubs and tree ferns that produce dense shade near the ground and litter that covers the grass. Weed control will be a perpetual process to capture and maintain the site, with the intensity of control depending on the proximity of weed seed sources. Foraging ungulates, both domestic and feral, must be excluded from the restoration site, but domestic ungulates are useful to initially reduce grass cover and afterward to manage vegetation outside the restoration site perimeter. Extensive planting of native species would follow. On sites where soils have been converted to Udarents by ripping and crushing by heavy machinery, forest restoration may be more problematic due to the dramatically changed soil conditions. Udarents appear to be a very favorable seedbed for alien weeds.

Transition T2A
State 2 to 3

This state may transition to State 3 Tree Plantation with Exotic Understory by herbiciding kikuyugrass, removing ungulates, and then planting introduced timber species. Gradual weed invasion creates an understory dominated by introduced trees, shrubs, grasses, and ferns. It may be possible to develop silvopasture systems that would combine timber production with cattle grazing; this system would control weeds and maintain an understory of introduced forage grasses.

Transition T2B
State 2 to 5

Abandonment of State 2 Naturalized Grassland community 2.3 leads to continued invasion by, and rapid growth of, introduced tree species leading to transition to State 5 Invaded Overstory and Understory.

Restoration pathway R4A
State 4 to 1

It is possible to restore a facsimile of State 1 Reference from State 4 Invaded Understory. Before restoration of native plants, introduced understory plants must be eliminated by herbicidal weed control practices, and ungulates must be excluded from the restoration site by a suitable fence. Native species that have been eliminated or greatly reduced in numbers must be restored by replanting. Biodegradable mulch such as cardboard covered with plant litter is very useful for weed control around replanted native species. Long-term control of weeds will be necessary.

Transition T4A
State 4 to 2

State 4 Invaded Understory State may be restored to State 2 Naturalized Grassland State by mechanical clearing of introduced and remnant native understory plants; native overstory trees may be harvested for timber, destroyed, or left for shade. If leaving large native trees for shade, care must be taken to not damage near-surface roots within about 20 feet (6 meters) of the trees. Introduced pasture grasses may then be seeded or sprigged into the site. Herbicide applications will be necessary before and during pasture establishment to control reemerging weed species.

Transition T4B
State 4 to 5

The large native ohia lehua and koa trees that form the overstory of State 4 Invaded Understory State are unable to successfully regenerate due to the very dense, shady understory of introduced species. Eventually the large native trees die and are replaced by introduced tree species, which is a transition to State 5 Invaded Overstory and Understory.

Restoration pathway R5A
State 5 to 2

State 5 Invaded Overstory and Understory may be restored to State 2 Naturalized Grassland by mechanical clearing of overstory and understory vegetation. Introduced forage grasses may then be seeded or sprigged into the site. Herbicide applications will be necessary before and during establishment of grasses to control reemerging weed species.

Restoration pathway R6A
State 6 to 1

Where the overstory is koa, it is probable that this state would eventually return to State 1 Reference if not harvested. Where the overstory consists of introduced tree species, some of which successfully reproduce in the understory, the eventual trajectory of this plant community is unknown.

Additional community tables

Table 24. 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	18.3–32	20–40	22.9–121.9	–
koa	ACKO	*Acacia koa*	Native	15.2–24.4	0–20	–	–
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	4–12.2	0–15	–	–
wild coffee	PSYCH	*Psychotria*	Native	4–12.2	1–5	–	–
wild coffee	PSYCH	*Psychotria*	Native	13.7–19.8	0–2	17.8–40.6	–
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	4–12.2	0–1	–	–
Australasian catchbirdtree	PIBR3	*Pisonia brunoniana*	Native	4–9.1	0–0.5	–	–
tetraplasandra	TETRA11	*Tetraplasandra*	Native	4–15.2	0–0.5	–	–
ha'a	ANPL2	*Antidesma platyphyllum*	Native	4–6.1	0–0.5	–	–
Hawai'i holly	ILAN	*Ilex anomala*	Native	4–10.7	0–0.5	–	–
lo'ulu	PRLA4	*Pritchardia lanigera*	Native	4–12.2	–	–	–
Tree Fern							
hapu'u	CIGL	*Cibotium glaucum*	Native	4–9.1	5–10	–	–
hapu'u li	CIME8	*Cibotium menziesii*	Native	4–7.6	0–1	–	–
Chamisso's manfern	CICH	*Cibotium chamissoi*	Native	4–7.6	–	–	–

Table 25. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
Hawai'i birdcatching sedge	UNUN	*Uncinia uncinata*	Native	0.2–0.3	0–1
Forb/Herb					
peperomia	PEPER	*Peperomia*	Native	0.2–0.3	0–1
pukamole	LYMA3	*Lythrum maritimum*	Native	0.3–0.6	–
Fern/fern ally					

palapalai	MIST4	*Microlepia strigosa*	Native	0.3–0.9	1–5
vandenboschia	VANDE	*Vandenboschia*	Native	0.2–0.3	0–5
Boston swordfern	NEEX	*Nephrolepis exaltata*	Native	0.3–0.6	0–1
Hawai'i air fern	PNSA	*Pneumatopteris sandwicensis*	Native	0.3–0.9	0–1
Hawai'i twinsorus fern	DISA3	*Diplazium sandwichianum*	Native	0.6–0.9	0–1
alpine woodfern	DRWA	*Dryopteris wallichiana*	Native	0.3–0.6	0–1
spleenwort	ASPLE	*Asplenium*	Native	0.3–0.6	0–1
akolea	ATMI	*Athyrium microphyllum*	Native	0.3–0.6	0–1
wahini noho mauna	ADTA	*Adenophorus tamariscinus*	Native	0.2–0.3	0–0.5
kolokolo	GRTE	*Grammitis tenella*	Native	0.2–0.3	0–0.1
Hawai'I birdnest fern	ASNI	*Asplenium nidus*	Native	0.3–0.9	–
flatfork fern	PSCO3	*Psilotum complanatum*	Native	0.2–0.3	–
whisk fern	PSNU	*Psilotum nudum*	Native	0.2–0.3	–
Cretan brake	PTCR2	*Pteris cretica*	Native	0.2–0.3	–
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	0.3–0.9	–
Hudson's air fern	PNHU	*Pneumatopteris hudsoniana*	Native	0.3–0.6	–
waimakanui	PTEX	*Pteris excelsa*	Native	0.2–0.3	–
sadleria	SADLE	*Sadleria*	Native	0.6–0.9	–
dwarf spikemoss	SEAR5	*Selaginella arbuscula*	Native	0–0.1	–
palaihinahina	HYLA2	*Hymenophyllum lanceolatum*	Native	0.2–0.3	–
Gaudichaud's halberd fern	TEGA	*Tectaria gaudichaudii*	Native	0.2–0.3	–
Shrub/Subshrub					
cyrtandra	CYRTA	*Cyrtandra*	Native	0.6–1.2	0–5
kanawao	BRAR6	*Broussaisia arguta*	Native	0.9–2.4	0–2
clermontia	CLERM	*Clermontia*	Native	0.9–1.8	0–0.5
Marks' cyanea	CYMA14	*Cyanea marksii*	Native	0.6–1.2	–
puna cyanea	CYPL7	*Cyanea platyphylla*	Native	0.6–1.2	–
labordia	LABOR	*Labordia*	Native	0.9–1.5	–
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	1.2–1.8	–
Tree					
wild coffee	PSYCH	*Psychotria*	Native	0.6–4	1–5
Waimea pipturus	PIAL2	*Pipturus albidus*	Native	0.6–4	0–2
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	0.6–4	0–1
olomea	PESA3	*Perrottetia sandwicensis*	Native	0.6–3	0–1
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	0.6–4	0–1
mirrorplant	COPRO	*Coprosma*	Native	0.6–4	0–1
ha'a	ANPL2	*Antidesma platyphyllum*	Native	0.6–4	0–1
variable starviolet	HETE21	*Hedyotis terminalis*	Native	0.6–4	0–1
Hawai'i holly	ILAN	*Ilex anomala*	Native	0.3–0.9	0–0.5
lo'ulu	PRLA4	*Pritchardia lanigera*	Native	1.2–4	0–0.5
cheesewood	PITTO	*Pittosporum*	Native	1.5–4	0–0.5
kokea lau li'i	MYSA2	*Myrsine sandwicensis*	Native	1.2–2.4	0–0.5
olona	TOLA	*Touchardia latifolia*	Native	1.2–2.4	0–0.5
hopue	URGL	*Urera glabra*	Native	1.5–3	0–0.1

hopue	URGL	*Urera glabra*	Native	1.5–3	0–0.1
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	0.6–1.2	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	0.6–4	10–50
hapu'u li	CIME8	*Cibotium menziesii*	Native	0.6–4	0–10
Chamisso's manfern	CICH	*Cibotium chamissoi*	Native	0.6–4	–
Vine/Liana					
'ie'ie	FRAR	*Freycinetia arborea*	Native	0.3–15.2	1–40
Hawai'i blackberry	RUHA	*Rubus hawaiensis*	Native	0.6–1.2	0–1
Hawai'i greenbrier	SMME	*Smilax melastomifolia*	Native	0.6–3	0–1
Maile	ALST11	*Alyxia stellata*	Native	0.3–0.9	0–1
Hawai'i jadevine	STRU4	*Strongylodon ruber*	Native	0.6–9.1	–

Table 26. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Naturalized Warm Season Grasses**			3138–3811	
	kikuyugrass	PECL2	*Pennisetum clandestinum*	2085–2780	–
	digitgrass	DIER	*Digitaria eriantha*	521–695	–
	dallisgrass	PADI3	*Paspalum dilatatum*	174–347	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	174	–
	smut grass	SPIN4	*Sporobolus indicus*	0–104	–
	Colombian bluestem	SCCO10	*Schizachyrium condensatum*	–	–
	broomsedge bluestem	ANVI2	*Andropogon virginicus*	–	–
2	**Naturalized (mostly) Grasses and Grasslikes**			56–140	
	orchardgrass	DAGL	*Dactylis glomerata*	35–174	–
	common velvetgrass	HOLA	*Holcus lanatus*	35–174	–
	sweet vernalgrass	ANOD	*Anthoxanthum odoratum*	35–174	–
	shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	35–104	–
	perennial ryegrass	LOPE	*Lolium perenne*	0–104	–
	Kentucky bluegrass	POPR	*Poa pratensis*	0–104	–
	Oahu flatsedge	CYHY2	*Cyperus hypochlorus*	0–35	–
Forb					
3	**Naturalized Forbs**			224–673	
	field clover	TRCA5	*Trifolium campestre*	4–22	–
	white clover	TRRE3	*Trifolium repens*	4–22	–
	garden vetch	VISA	*Vicia sativa*	13–22	–
	greenleaf ticktrefoil	DEIN2	*Desmodium intortum*	4–18	–
	bird's-foot trefoil	LOCO6	*Lotus corniculatus*	1–9	–
	common mullein	VETH	*Verbascum thapsus*	1–4	–
	scaly swordfern	NEHI	*Nephrolepis hirsutula*	1–4	–
	narrowleaf plantain	PLLA	*Plantago lanceolata*	1–4	–
	cayenne porterweed	STCA8	*Stachytarpheta cayennensis*	–	–
	light-blue snakeweed	STJA	*Stachytarpheta jamaicensis*	–	–
	Carolina geranium	GECA5	*Geranium carolinianum*		

	Carolina geranium	GECA5	*Geranium carolinianum*	–	–
	tropical whiteweed	AGCO	*Ageratum conyzoides*	–	–
	bull thistle	CIVU	*Cirsium vulgare*	–	–
	asthmaweed	COBO	*Conyza bonariensis*	–	–
	Canadian horseweed	COCA5	*Conyza canadensis*	–	–
Tree					
4	**Native Trees, Shrubs, and Tree Ferns**			22–168	
	'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	1–4	–
	koa	ACKO	*Acacia koa*	1–3	–
	hapu'u	CIGL	*Cibotium glaucum*	1–3	–
Shrub/Vine					
5	**Naturalized Shrubs and Trees**			11–45	
	anil de pasto	INSU	*Indigofera suffruticosa*	1–2	–
	Peruvian groundcherry	PHPE4	*Physalis peruviana*	–	–
	guava	PSGU	*Psidium guajava*	–	–
	castorbean	RICO3	*Ricinus communis*	–	–
	West Indian raspberry	RURO	*Rubus rosifolius*	–	–
	Brazilian peppertree	SCTE	*Schinus terebinthifolius*	–	–
	Jerusalem cherry	SOPS	*Solanum pseudocapsicum*	–	–
	balloonplant	ASPH2	*Asclepias physocarpa*	–	–

Table 27. Community 2.2 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	12.2–27.4	0–25	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	1.8–4.6	0–5	–	–
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	4–12.2	0–1	–	–
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–6.1	0–1	–	–
mango	MAIN3	*Mangifera indica*	Introduced	9.1–18.3	0–1	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	6.1–9.1	–	–	–
wild coffee	PSYCH	*Psychotria*	Native	4–6.1	–	–	–

Table 28. Community 2.2 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.3–0.6	35–45
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.3–0.6	25–35
kikuyugrass	PECL2	*Pennisetum clandestinum*	Introduced	0.2–0.3	15–25
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	0.6–0.9	1–10
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	0.6–0.9	1–10
digitgrass	DIER	*Digitaria eriantha*	Introduced	0.3–0.6	1–5
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.2–0.3	1–5
flatsedge	CYPER	*Cyperus*	Introduced	0.3–0.6	1–5
manyspike flatsedge	CYPO	*Cyperus polystachyos*	Native	0.3–0.6	0–1
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.2–0.3	0–1
Forb/Herb					
climbing dayflower	CODI5	*Commelina diffusa*	Introduced	0.2–0.3	0–1
shameplant	MIPU8	*Mimosa pudica*	Introduced	0.2–0.3	0–1
soft elephantsfoot	ELMO5	*Elephantopus mollis*	Introduced	0.3–0.6	–
ticktrefoil	DESMO	*Desmodium*	Introduced	0.3–0.6	–
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	0–1
Shrub/Subshrub					
dogtail	BUAS	*Buddleja asiatica*	Introduced	0.9–1.8	0–0.5
Tree					
guava	PSGU	*Psidium guajava*	Introduced	1.5–2.4	1–5
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	1.5–3	–
Vine/Liana					
sweet granadilla	PALI8	*Passiflora ligularis*	Introduced	1.5–12.2	–
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	0.6–0.9	–

Table 29. Community 2.3 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	15.2–27.4	0–25	–	–
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–6.1	5–10	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–6.1	1–5	–	–
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	4–12.2	0–1	–	–
Scotch attorney	CLRO	*Clusia rosea*	Introduced	4–9.1	0–1	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–9.1	0–1	–	–
mango	MAIN3	*Mangifera indica*	Introduced	9.1–18.3	0–1	–	–

Table 30. Community 2.3 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	35–45
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.2–0.3	25–35
kikuyugrass	PECL2	*Pennisetum clandestinum*	Introduced	0.2–0.6	15–25
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	0.6–0.9	5–10
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	0.6–0.9	5–10
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.2–0.3	3–5
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	0.3–0.6	3–5
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.2–0.3	1–2
flatsedge	CYPER	*Cyperus*	Introduced	0.2–0.6	1–2
manyspike flatsedge	CYPO	*Cyperus polystachyos*	Native	0.3–0.6	1–2
Forb/Herb					
spreading snakeroot	AGRI2	*Ageratina riparia*	Introduced	0.3–0.6	3–5
shameplant	MIPU8	*Mimosa pudica*	Introduced	0.2–0.3	1–5
climbing dayflower	CODI5	*Commelina diffusa*	Introduced	0.2–0.3	1–2
ticktrefoil	DESMO	*Desmodium*	Introduced	0.3–0.6	–
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	5–15
parasitic maiden fern	THPA4	*Thelypteris parasitica*	Introduced	0.3–0.6	0–1
Shrub/Subshrub					
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	0.6–1.5	0–2
lantana	LACA2	*Lantana camara*	Introduced	0.6–1.2	0–2
dogtail	BUAS	*Buddleja asiatica*	Introduced	0.6–1.8	0–1
soapbush	CLHI3	*Clidemia hirta*	Introduced	0.6–0.9	0–1
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	10–20
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	0.6–4	1–10
guava	PSGU	*Psidium guajava*	Introduced	0.6–2.4	1–5
Scotch attorney	CLRO	*Clusia rosea*	Introduced	0.6–4	0–0.5
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	0.6–4	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	0.6–4	–
Vine/Liana					
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	0.6–1.2	0–2
shoofly	CADE15	*Caesalpinia decapetala*	Introduced	0.6–1.5	0–2
sweet granadilla	PALI8	*Passiflora ligularis*	Introduced	0.3–15.2	–

Table 31. Community 3.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
shamel ash	FRUH	*Fraxinus uhdei*	Introduced	21.3–25.9	85–95	–	–
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–6.1	25–40	–	–
shamel ash	FRUH	*Fraxinus uhdei*	Introduced	4–12.2	1–5	–	–
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	4–6.1	1–5	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–6.1	1–3	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–12.2	0–1	–	–
Scotch attorney	CLRO	*Clusia rosea*	Introduced	4–12.2	0–1	–	–
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	4–12.2	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	12.2–18.3	–	–	–

Table 32. Community 3.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	0.2–0.3	3–5
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.3–0.6	3–5
Forb/Herb					
Kahila garland-lily	HEGA	*Hedychium gardnerianum*	Introduced	0.6–1.5	0–30
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	5–10
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	0.3–0.6	0–1
hammock fern	BLOC	*Blechnum occidentale*	Introduced	0.3–0.6	0–1
rough maidenhair	ADHI	*Adiantum hispidulum*	Introduced	0.3–0.6	0–1
parasitic maiden fern	THPA4	*Thelypteris parasitica*	Introduced	0.3–0.6	0–1
Shrub/Subshrub					
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	0.6–4	2–10
soapbush	CLHI3	*Clidemia hirta*	Introduced	0.6–3	2–6
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	1.5–4	15–25
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–1.5	1–5
Scotch attorney	CLRO	*Clusia rosea*	Introduced	0.6–4	0–2
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	0.6–4	0–2
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	0.6–4	0–2
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	0.6–4	0.1–1
wild coffee	PSYCH	*Psychotria*	Native	0.6–4	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	1.5–2.4	–
Vine/Liana					
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	0.6–1.5	1–5
sweet granadilla	PALI8	*Passiflora ligularis*	Introduced	0.6–15.2	0–1
'ie'ie	FRAR	*Freycinetia arborea*	Native	0.3–1.5	–

Table 33. 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	4–6.1	10–25	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–6.1	5–20	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	15.2–27.4	10–20	–	–
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	4–18.3	3–5	–	–
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	4–6.1	3–5	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–9.1	0–1	–	–
wild coffee	PSYCH	*Psychotria*	Native	4–9.1	0.5–1	–	–
shamel ash	FRUH	*Fraxinus uhdei*	Introduced	4–15.2	0–1	–	–
mango	MAIN3	*Mangifera indica*	Introduced	4–12.2	0–1	–	–
punktree	MEQU	*Melaleuca quinquenervia*	Introduced	6.1–12.2	0–1	–	–
velvet tree	MICA20	*Miconia calvescens*	Introduced	4–6.1	0–0.5	–	–
quinine	CIPU	*Cinchona pubescens*	Introduced	4–6.1	–	–	–

Table 34. Community 4.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	0.2–0.3	3–5
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.2–0.3	3–5
guineagrass	URMA3	*Urochloa maxima*	Introduced	0.6–0.9	0–1
Forb/Herb					
Kahila garland-lily	HEGA	*Hedychium gardnerianum*	Introduced	0.6–1.5	1–10
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	0.3–0.6	0.5–1
buzzy lizzy	IMWA	*Impatiens walleriana*	Introduced	0.3–0.6	0–1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	15–25
Krauss' spikemoss	SEKR	*Selaginella kraussiana*	Introduced	0–0.1	0–5
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	0.3–0.6	0–1
parasitic maiden fern	THPA4	*Thelypteris parasitica*	Introduced	0.3–0.6	0–1
hammock fern	BLOC	*Blechnum occidentale*	Introduced	0.3–0.6	0–1
rough maidenhair	ADHI	*Adiantum hispidulum*	Introduced	0.3–0.6	–
spleenwort	ASPLE	*Asplenium*	Native	0.3–0.6	–
Japanese netvein hollyfern	CYFA2	*Cyrtomium falcatum*	Introduced	0.3–0.6	–
Shrub/Subshrub					
soapbush	CLHI3	*Clidemia hirta*	Introduced	0.6–1.5	5–15
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	0.6–4	5–15
night jessamine	CENO	*Cestrum nocturnum*	Introduced	0.6–0.9	–
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	5–15
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	0.6–4	5–10
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	0.6–4	0–1
guava	PSGU	*Psidium guajava*	Introduced	1.2–2.4	0–1
octopus tree	SCAC2	*Schefflera actinophylla*	Native	0.6–4	0–1
wild coffee	PSYCH	*Psychotria*	Native	1.5–4	0–1
velvet tree	MICA20	*Miconia calvescens*	Introduced	0.6–4	0–0.5
shamel ash	FRUH	*Fraxinus uhdei*	Introduced	0.6–4	0–0.5
quinine	CIPU	*Cinchona pubescens*	Introduced	0.6–4	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	1.5–3	0–1
Vine/Liana					
shoofly	CADE15	*Caesalpinia decapetala*	Introduced	0.6–1.8	1–5
sweet granadilla	PALI8	*Passiflora ligularis*	Introduced	0.3–12.2	0–1
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	0.6–1.2	0–1
'ie'ie	FRAR	*Freycinetia arborea*	Native	0.3–4.6	0–1

Table 35. Community 5.1 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	4–6.1	35–45	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–6.1	5–15	–	–
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	4–15.2	1–5	–	–
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	4–6.1	1–5	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–12.2	0–1	–	–
Scotch attorney	CLRO	*Clusia rosea*	Introduced	4–12.2	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	12.2–24.4	0–1	–	–
wild coffee	PSYCH	*Psychotria*	Native	4–6.1	0–1	–	–
velvet tree	MICA20	*Miconia calvescens*	Native	4–6.1	0–0.5	–	–

Table 36. 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	0.3–0.6	1–5
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	0.3–0.6	1–5
Forb/Herb					
Kahila garland-lily	HEGA	*Hedychium gardnerianum*	Introduced	0.6–1.5	1–10
buzzy lizzy	IMWA	*Impatiens walleriana*	Introduced	0.2–0.3	0–1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	0.3–0.6	3–5
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	0.3–0.6	0–1
rough maidenhair	ADHI	*Adiantum hispidulum*	Introduced	0.3–0.6	0–1
parasitic maiden fern	THPA4	*Thelypteris parasitica*	Introduced	0.3–0.6	0–1
hammock fern	BLOC	*Blechnum occidentale*	Introduced	0.3–0.6	0–1
Shrub/Subshrub					
soapbush	CLHI3	*Clidemia hirta*	Introduced	0.6–1.5	5–15
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	0.6–4	5–15
velvet tree	MICA20	*Miconia calvescens*	Introduced	0.6–4	0–0.5
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–4	15–30
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	0.6–4	3–10
African tuliptree	SPCA2	*Spathodea campanulata*	Introduced	0.6–4	0–1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	0.6–4	0–1
Scotch attorney	CLRO	*Clusia rosea*	Introduced	0.6–4	0–1
wild coffee	PSYCH	*Psychotria*	Native	0.6–4	0–1
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	1.5–3	0–1
Vine/Liana					
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	0.6–1.2	1–3
sweet granadilla	PALI8	*Passiflora ligularis*	Introduced	0.3–15.2	0–1
'ie'ie	FRAR	*Freycinetia arborea*	Native	0.3–3	–

Table 37. Community 6.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
Australian redcedar	TOCI	*Toona ciliata*	Introduced	24.4–27.4	85–90	–	–
Australian redcedar	TOCI	*Toona ciliata*	Introduced	12.2–24.4	5–10	–	–
Australian redcedar	TOCI	*Toona ciliata*	Introduced	4–12.2	0–1	–	–
olomea	PESA3	*Perrottetia sandwicensis*	Native	4–5.5	0–1	–	–
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	4–7.6	0–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	24.4–27.4	–	–	–

Table 38. Community 6.1 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	1–5
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	0.2–0.3	1–5
Forb/Herb					
peperomia	PEPER	*Peperomia*	Native	0.2–0.3	0–1
Fern/fern ally					
alpine woodfern	DRWA	*Dryopteris wallichiana*	Native	0.3–0.6	1–5
palapalai	MIST4	*Microlepia strigosa*	Native	0.3–0.6	0–2
Hawai'i air fern	PNSA	*Pneumatopteris sandwicensis*	Native	0.3–0.6	0–2
Boston swordfern	NEEX	*Nephrolepis exaltata*	Native	0.3–0.6	0–1
royal tonguefern	ELCR2	*Elaphoglossum crassifolium*	Native	0.2–0.3	0–1
spleenwort	ASPLE	*Asplenium*	Native	0.3–0.6	0–1
Japanese netvein hollyfern	CYFA2	*Cyrtomium falcatum*	Native	0.3–0.6	–
Tree					
Waimea pipturus	PIAL2	*Pipturus albidus*	Native	0.6–4	0–1
Australian redcedar	TOCI	*Toona ciliata*	Introduced	0.6–4	0–1
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	0.6–2.4	0–1
wild coffee	PSYCH	*Psychotria*	Native	0.6–4	0–1
olomea	PESA3	*Perrottetia sandwicensis*	Native	0.6–4	0–1
Hawai'i holly	ILAN	*Ilex anomala*	Native	0.6–4	0–1
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	0.6–4	0–1
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	0.6–4	0–1
mirrorplant	COPRO	*Coprosma*	Native	1.5–3	–
koa	ACKO	*Acacia koa*	Native	0.3–0.6	–
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	0.6–2.4	45–55
Vine/Liana					
'ie'ie	FRAR	*Freycinetia arborea*	Native	0.3–15.2	0–1
Maile	ALST11	*Alyxia stellata*	Native	0.3–1.5	0–1
Hawai'i blackberry	RUHA	*Rubus hawaiensis*	Native	0.6–0.9	–
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	0.6–0.9	–

Animal community

Native Wildlife
This ecological site provides habitat for the following native birds: elepaio (Chasiempis sandwichensis), amakihi (Hemignathus virens), apapane (Himatione sanguinea), and iiwi (Vestiaria coccinea) omao (Myadestes obscurus), akepa (Loxops coccineus), akiapolaau (Hemignathus wilsoni). It 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).

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

Introduced Wildlife

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

Feral pigs, sheep, goats and cattle are common. They provide hunting opportunities but are very destructive to native vegetation. Public sport hunting typically does not have a major impact on their populations, 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 amounts 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 on this site 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 the plant community is to be maintained. Herbaceous forage can be deficient in protein during the drier months.

Hydrological functions

Where this ecological site is covered with deep ash soils, infiltration, runoff, and soil erosion conditions are good on well-vegetated sites.

Temporary water flows in shallow gulches occur after heavy rains.

Much of the ecological site consists of soils formed in crevices between cobbles in aa lava flows; these soils accept water at high rates, leading to negligible to very low runoff rates on all slopes. Very shallow soils formed over pahoehoe exhibit negligible runoff in depressions on gentle slopes and high to very high runoff on steeper slopes.

Recreational uses

Hiking, hunting, and bird watching are common recreational uses in this ecological site. Good examples of the Reference Community can be accessed by foot trails in State Forests. Public roads provide access to the other community phases.

Wood products

There is potential for production of timber by both noninvasive introduced species and native koa.

Very little site index information is available for Hawaiian forests, as tropical trees typically do not form annual tree rings from which tree age can be estimated. Long-term measurements have been made of some tree plantations, primarily on introduced timber species and on a limited number of soils.

Other products

The Reference State can provide limited harvests of maile (Alyxia stellata) vines for leis and edible ferns.

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.

$CaCO_3$ 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.

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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):**

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

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

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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:**
