Ecological site VX159B01X500
Udic Forest

Accessed: 05/19/2024

General information

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

MLRA notes

Major Land Resource Area (MLRA): 159B–Subhumid and Humid Low and Intermediate Mountain Slopes

This MLRA occurs in the State of Hawaii in the Kau District on the Big Island of Hawaii. Elevation ranges from near sea level to 6,000 feet (about 2000 meters). Slopes are gentle to moderate. Topography is moderately dissected, gently sloping to rolling slopes on the side of Mauna Loa volcano. Basaltic lava underlies a mantle of basic, weathered, volcanic ash. Average annual precipitation ranges from 50 to 100 inches (1250 to 2500 millimeters). Rainfall is well-distributed throughout the year with an enhanced rainy season from November through March. Average annual air temperatures range from 54 to 73 degrees F (12 to 23 degrees C) with little seasonal variation. The dominant soil order is Andisols with an isothermic soil temperature regime and udic soil moisture regime. Native vegetation consists of tall-stature rain forest that includes ohia lehua, koa, and hapuu.

Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 159B - Subhumid and Humid Low and Intermediate Mountain Slopes.

Ecological site concept

This ecological site represents the tall stature, moist forest in the mauka areas of the Kau District of the Big Island. Most of the ecological site is within the Kau State Forest Reserve. Some of it is within the Kahuku Ranch portion of Hawaii Volcanoes National Park that is mauka of South Point, and some is on private ranchland makai of the State Forest Reserve. Good examples are accessible on Mountain House Road and on the trail beginning near the old airstrip mauka of Pahala.

The central concept of the Udic Forest is of fertile, moderately well to well drained, deep to very deep Andisols formed in deposits of volcanic ash ranging from 1,500 to 10,000 years old. Annual air temperatures and rainfall create warm (isothermic), moist (udic) soil conditions conducive to plant growth for all or most of the year. These sites support tall-stature 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.

Associated sites

VX160X01X504	**Ustic-Dry Udic Forest** F160XY504 Ustic-Dry Udic Forest is a drier forest bordering F159BY500 site on the southwest and northeast in narrow zones of drier local climate.
VX160X01X006	**Isomesic Savanna** R160XY006 Isomesic Savanna is an ohia lehua/shrub/grass savanna bordering F159AY500 at higher elevations above the climate inversion layer.

Similar sites

VX159A01X500	**Well Drained Udic and Perudic Forest** F159AY500 Deep and Very Deep Volcanic Ash Forest occurs on similar soils to those of F159BY500 but on the north and northeast slopes of the island. Rainfall amounts overlap somewhat between the two ecological sites, but F159AY contains areas with higher rainfall. Vegetation communities are very similar.

Table 1. Dominant plant species

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

Legacy ID

F159BY500HI

Physiographic features

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

Table 2. Representative physiographic features

Landforms	(1) Shield volcano (2) Mountain slope (3) Lava flow
Flooding duration	Very brief (4 to 48 hours)
Flooding frequency	None to occasional
Ponding frequency	None
Elevation	1,200–6,400 ft
Slope	1–60%
Ponding depth	0 in
Water table depth	60 in
Aspect	SE

Climatic features

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. Above approximately 6000 feet elevation there is a temperature inversion at the boundary between moist air and higher, drier air. Average annual temperatures decrease at a slower rate above the inversion than below it. Easily observed vegetation changes occur within a short distance at the inversion layer between this ecological site and R160XY006 Isomesic Savanna.

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.

Average annual precipitation ranges from 50 to 140 inches (1250 to 3500 millimeters). Rainfall is well-distributed throughout the year with an enhanced rainy season from November through March. Average annual temperature ranges from 54 to 71 degrees F (12 to 22 degrees C).

Table 3. Representative climatic features

Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	103 in

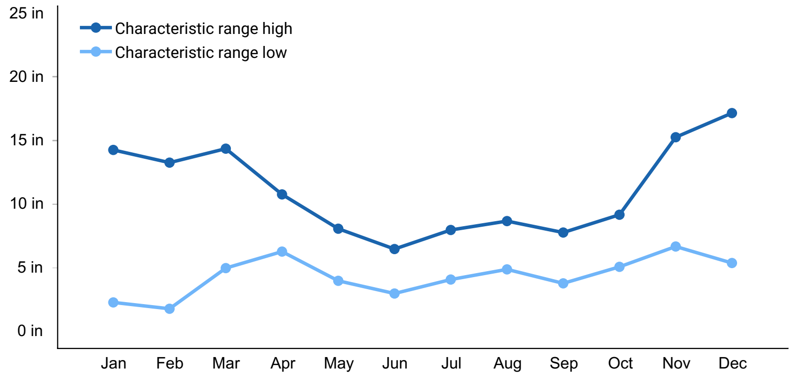

Figure 1. Monthly precipitation range

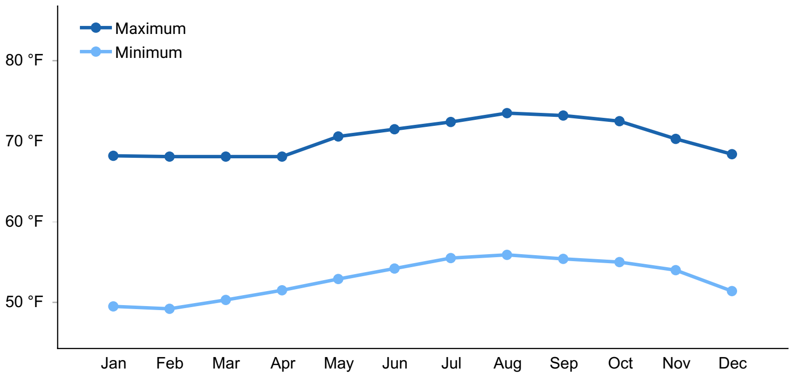

Figure 2. Monthly average minimum and maximum temperature

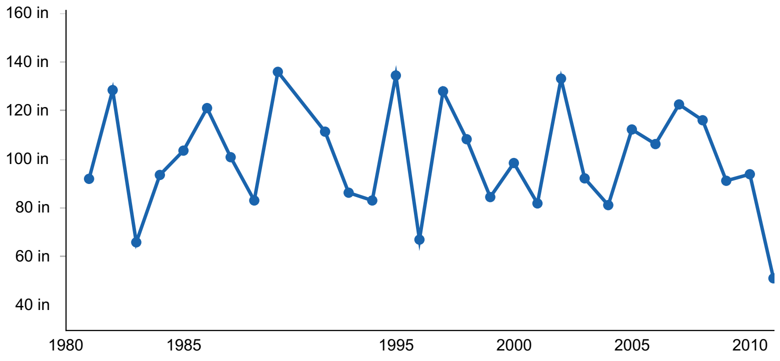

Figure 3. Annual precipitation pattern

Climate stations used

- (1) HAWAII VOL NP HQ 54 [USC00511303], Hawaii National Park, HI

Influencing water features

There are no water features influencing this site.

Soil features

The soils in this ecological site formed in basaltic volcanic ash deposited over aa lava, pahoehoe lava, or pumice over volcanic rock. There is also a small area of alluvium deposited over pahoehoe lava (Fluvents, soil map unit 557).

The Na Manua Haalou area, on the western mauka boundary of Kau Forest Reserve, contains Puali soils exhibiting the wetter range of characteristics of the soil series, as evidenced by common to many redoximorphic concentrations. This area receives additional water runoff from surrounding, higher elevation pahoehoe flows. Because this area is in the higher, drier part of the ES, this received runoff does not appear to raise the water table enough to change the vegetation very much; the vegetation fits within the concept of the ecological site.

The 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).

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 or weedy vegetation, and it seems to make no difference whether the underlying 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.

Figure 5. Alapai soil.

Table 4. Representative soil features

Parent material	(1) Basaltic volcanic ash–basalt
Surface texture	(1) Hydrous silt loam (2) Sandy clay loam
Family particle size	(1) Loamy
Drainage class	Somewhat poorly drained to somewhat excessively drained
Permeability class	Very slow to moderately rapid

Soil depth	2–60 in
Surface fragment cover <=3"	0–40%
Surface fragment cover >3"	0–25%
Available water capacity (0-40in)	1–11 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	4.2–7.3
Subsurface fragment volume <=3" (Depth not specified)	2–95%
Subsurface fragment volume >3" (Depth not specified)	0–90%

Ecological dynamics

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

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

Natural Disturbances

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

A lava flow obviously destroys all the vegetation it covers. Regrowth of vegetation through primary succession and formation of new soil proceed at widely varying rates depending on flow age, local climate, lava type (aa or pahoehoe), and proximity of seed sources. Flows located in warm, moist climates 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.

Primarily at the mauka (highest elevation) boundaries of this ecological site and below the climate inversion layer are lava flows that are younger than typical. The vegetation on these younger flows still shows the effects of burial by lava and subsequent recovery via primary succession. These flows soon develop into ecological site R160XY006 Isomesic Savanna. Over time (probably 500 to 750 years) these areas acquire a denser stand of ohia lehua that begins to shade out the characteristic understory species of the Isomesic Savanna. Eventually they will transform into F159BY500 (this ecological site).

Heat from nearby lava flows sears and kills vegetation and can ignite wildfires that may carry to some extent. These effects can be seen in vegetation growing near the edges of recent flows. However, natural wildfire caused by lava or by lightning is probably not a frequent disturbance in this ecological site.

Vegetation can be killed by erupted layers of ash from volcanic vents, depending on the temperature of the ash and the depth of accumulation. However, vegetation sometimes survives ash flows (Vitousek 2004). Vegetation rapidly recovers because ash flow deposits possess physical and chemical properties favorable to plant growth, including high water holding capacity, high surface area, rapid weathering, and favorable mineral nutrient content. New soils develop very rapidly in ash deposits, and further soil development is facilitated in turn by the rapidly-developing vegetation (Shoji et al. 1993). The different ash accumulations in this ecological site may account for some of the vegetation variability, particularly in species composition (koa versus ohia lehua) of the overstory.

Wind throw of vegetation can occur during hurricanes or other high wind events. This disturbance probably opens the canopy periodically and creates vegetation variations.

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).

Areas within the lower elevations of this ecological site are known to have been inhabited and cultivated prior to European discovery. For example, evidence exists for human habitation in the Wood Valley area (Craighill et al. 1991).

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

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

The Polynesians introduced dogs, Pacific rats, and small pigs to the islands. Cattle, sheep, horses, goats, and larger European pigs were introduced in the final decades of the 18th century. These animals ranged free on the islands, becoming very numerous and destructive by the early decades of the 19th century. By 1851, records reported severe overstocking of pastures, lack of fences, and large numbers of feral livestock (Henke 1929).

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

Parts of the lower elevations of this ecological site were cleared for sugar plantations in the 19th century; these plantations were active into the late 20th century. Plantation activities caused extensive soil erosion, which is confirmed by areas of accumulation of this eroded soil at lower elevations. Also, forests at the upper boundaries of sugar plantations were affected by harvesting of firewood and intrusion of wildfires from the sugar lands into the forest.

With abandonment of the sugar plantations, guineagrass (*Urochloa maxima*), which had been a roadside weed in the plantations, rapidly spread through the fields. Guineagrass is a tall, densely-growing, and highly competitive species that also provides excellent forage for cattle, and it facilitated the transition of former sugar lands to grazing lands.

Through the 20th and into the 21st centuries, increases in human populations with attendant land development, as well as accelerated introduction of non-native mammals, birds, reptiles, amphibians, invertebrates, plants, and microorganisms, have brought about dramatic changes to wild ecosystems in Hawaii. This ecological site evolved without the presence of large mammals or the regular occurrence of fires. Much of the original forest area remains. However, the native plant community in many areas has been disturbed and in some places destroyed due to agriculture, urban development, establishment of exotic timber trees, domestic and feral ungulate foraging, and invasion by introduced species. Introduced plant species are capable of completely and permanently replacing native forest.

Foraging by feral cattle and pigs or forest clearing and abandonment facilitate invasion by weeds. However, introduced weeds appear able to successfully invade native stands regardless of human or ungulate disturbances. Major weeds include strawberry guava, christmasberry, kahili ginger, and introduced grasses. Guineagrass and kikuyugrass grasslands become infested with unpalatable grasses, shrubs, and trees under improper management or abandonment.

State and transition model

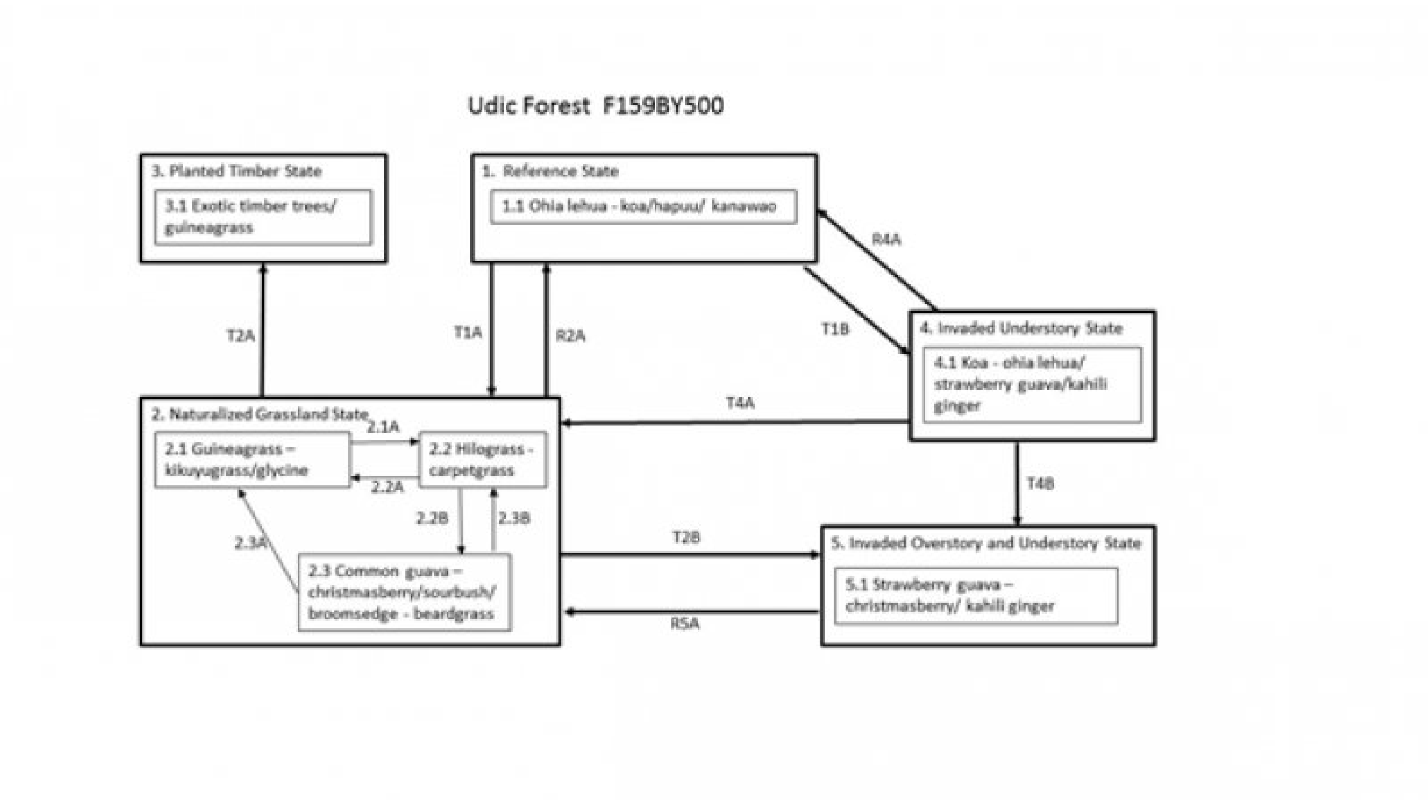

Figure 6. STM F159BY500

State 1
Reference State

The Reference State consists of one plant community. Under a regime of natural disturbances, this community has probably been stable through post-glacial time frames and from a broad-scale spatial perspective. A matrix of variations in canopy cover and species composition in all canopy levels is observable. This matrix variability does not appear to be connected to soils, climate, or landscape features, but rather is probably due to wind throw, deaths of large trees, and other chance occurrences.

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

Figure 7. Reference State 7/15/04 D Clausnitzer MU514

Figure 8. View above hapuu canopy 8/6/04 D Clausnitzer MU515

Figure 9. View above hapuu canopy 8/17/04 D Clausnitzer MU515

Figure 10. View below hapuu canopy. No date, D Clausnitzer, no location.

Figure 11. View at ground level 9/9/05 D Clausnitzer MU512

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 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 and ferns. Vines, particularly ieie, are common both on the ground and on trees. These forests have standing live timber of 300 to 5900 cubic feet per acre, with a representative value of about 5000 cubic feet per acre. Typical low values are about 1500 cubic feet per acre. The lowest values of 300 to 800 cubic feet per acre on steep, continually eroding soils, and in the drier extremes of this ecological site. Canopy cover of ohia lehua and koa in the upper canopy varies on the microscale from about 10% to 80%, with a representative value of 40 to 50% on a macroscale. Secondary canopy cover of medium-stature tree species is typically about 20%, concentrated in the 30 to 40 feet (9 to 12 meters) height range. Cover of the tertiary tree fern canopy is usually in the range of 60% to 90%, mostly between 13 to 20 feet (4 to 6 meters) tall. Koa and ohia lehua do not reproduce successfully in the shady understory of intact forest. Tree ferns, medium-stature tree species, and shrubs reproduce and grow well in the understory. The ground layer of small ferns is typically dense and diverse in the absence of introduced ungulates. A heavy litter layer that appears to inhibit establishment of small plants is usually present on the soil surface. In particular, dead tree fern fronds produce a coarse, thick, heavy litter layer. Koa phyllodes create a firm, continuous litter layer. Phyllodes are petioles (leaf stalks) that are adapted to function as leaves on mature koa trees.

Forest overstory. The uppermost forest canopy consists of ohia lehua or a combination of ohia lehua and koa. There seems to be no consistent relationship between dominant tree canopy composition and soil type, rainfall, elevation, or any other environmental variable. Neither overstory species grows well in shade. Primary succession in Hawaii typically results in an initial forest overstory of ohia lehua, often consisting of roughly even-aged cohorts. It is likely that long-term disturbance history controls koa occurrence. Koa is a fast growing, opportunistic species that is able to take advantage of temporary openings in the forest canopy. Wind fall, nearby lava flows, or death of ohia lehua population cohorts would provide the conditions for koa expansion where their seeds are present. Koa also can reproduce by sprouting from near-surface roots.

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

The tertiary canopy contains small trees but is dominated by three species of hapuu or tree ferns: hapuu (Cibotium glaucum), hapuu ii or hapuu li (Cibotium menziesii), and hapuu or Chamisso’s manfern (Cibotium chamissoi). Cibotium glaucum is the most abundant, followed by C. menziesii; C. chamissoi is the least abundant.

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 over 30 species of ferns and fern allies.

Table 5. Soil surface cover

Tree basal cover	2-5%
Shrub/vine/liana basal cover	0.0-0.1%
Grass/grasslike basal cover	0.0-0.1%
Forb basal cover	0.0-0.1%
Non-vascular plants	3-5%
Biological crusts	0%
Litter	80-90%
Surface fragments >0.25" and <=3"	0.1-1.0%
Surface fragments >3"	0.1-1.0%
Bedrock	0%
Water	0%
Bare ground	0.0-0.1%

Table 6. Woody ground cover

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

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

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

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

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	0%	0%	0-1%
>0.5 <= 1	0%	0-1%	0-1%	0%
>1 <= 2	0-1%	0-1%	0%	0%
>2 <= 4.5	0-1%	3-5%	–	–
>4.5 <= 13	30-60%	5-10%	–	–
>13 <= 40	60-70%	–	–	–
>40 <= 80	30-40%	–	–	–
>80 <= 120	5-10%	–	–	–
>120	–	–	–	–

State 2
Naturalized Grassland State

This state is comprised of three community phases. Most of the grasslands are on former sugar plantations where guineagrass was an agricultural weed. Guineagrass now has taken over these lands as the dominant species. Kikuyugrass is the dominant grass, sometimes with pangolagrass, in some higher elevation areas where these species have been planted. Most of these areas are now being reforested. Some parts of Kapapala Ranch appear to be in a transitional area between guineagrass and kikuyugrass dominance. Information on these kikuyugrass/pangolagrass pastures can be found in Ecological Site Description F160XY504 Ustic-Dry Udic Forest. This state consists of three grassland community phases. These phases are maintained by grazing, which keeps preferred species from becoming too tall, 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. Prescribed burning generally is not allowed due to high risks to structures, fences, and native forest stands. Wildfires caused by lightning or arson sometimes occur. They are very intense and difficult to contain, because guineagrass produces huge amounts of fuel and grows to a height of almost 10 feet (3 meters), while kikuyugrass produces large amounts of fuel and has rhizomes that can smolder underground for days, sometimes reigniting a surface fire. Most of the grasslands in this ecological site are on former sugar plantations where guineagrass (*Urochloa maxima*) was a species of roadsides and waste areas (Earl Spence, rancher and manager, personal communication). Guineagrass now has taken over these lands as the dominant forage grass. All grass, sedge, forb, vine, shrub, and tree species found in this state have been introduced to Hawaii by humans within the past two centuries, either inadvertently or intentionally. Scattered, remnant native trees, either koa or ohia lehua, sometimes occur in these naturalized grasslands, but they are unable to reproduce without protection from ungulates and control of grasses and weeds. Occasionally, western brackenfern (*Pteridium aquilinum*) and uluhe or Old World forkedfern (*Dicranopteris linearis*) occur; both of these fern species are native to Hawaii. Community Phase 2.1 mostly consists of guineagrass, sometimes with an admixture of glycine or perennial soybean (*Neonotonia wightii*). Continuous grazing that does not allow the preferred forage species to recover from defoliation results in Community Phase 2.2, which is dominated by lower value grass species but contains enough remnant guineagrass to allow for a shift back to Plant Community 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 alien shrubs and tree saplings. Improvement of this Plant Community requires weed control followed by prescribed grazing.

Community 2.1
Guineagrass - kikuyugrass/glycine

Figure 12. Guineagrass grassland makai of Kau SF, D Clausnitzer, generic photo.

Figure 13. Grazed guineagrass, Kau SF boundary, D Clausnitzer, generic photo.

The dominant grass species in this pasture type is guineagrass that has volunteered in old sugarcane plantations. In higher elevation areas in Kahuku and Keauhou, kikuyugrass and sometimes pangolagrass have been planted. Guineagrass is very productive and nutritious for livestock. Careful management of this caespitose (bunch-forming) grass is required to maintain it at an efficient height (two to four feet) while maintaining sufficient ground coverage by leaves, litter, and grass clumps to protect the soil from erosion and to suppress weed growth. The normal total annual production (all types and species of plants) of the grasslands in this community phase is about 14,000 lb/acre of forage. Above normal production is about 16,000 lb/acre; below normal production is about 10,000 lb/acre).

Forest understory. This community phase is not forest, despite the automated default heading printed above this section, but rather a naturalized grassland that occurs where forests have been cleared.

Guineagrass is very competitive with other plants when properly managed and can comprise 85 to nearly 100% of the total production on a site. Forbs, shrubs, tree seedlings, and other grass species can occur in the interspaces between guineagrass bunches but are insignificant in their share of total production in well-managed sites. They are kept in check by competition with guineagrass and foraging and trampling by livestock. Perennial soybean or glycine (Neonotonia wightii), a competitive (and potentially weedy in forests), climbing legume vine, and three-flowered ticktrefoil (Desmodium triflorum), a prostrate legume, are desirable forage species that can be maintained within guineagrass stands by careful grazing management.

Table 8. Ground cover

Tree foliar cover	0-1%
Shrub/vine/liana foliar cover	1-2%
Grass/grasslike foliar cover	80-90%

Forb foliar cover	1-2%
Non-vascular plants	0%
Biological crusts	0%
Litter	30-40%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	1-5%

Table 9. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0%	0%	0-1%
>0.5 <= 1	–	0-1%	0%	1-2%
>1 <= 2	–	0-1%	5-10%	1-2%
>2 <= 4.5	–	1-2%	85-90%	1-2%
>4.5 <= 13	–	–	1-5%	–
>13 <= 40	–	–	–	–
>40 <= 80	0-10%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Community 2.2
Hilograss - carpetgrass

Figure 15. Grassland with low value grasses. D Clausnitzer, makai of Kau FR, generic photo.

This community phase is dominated by grass and grasslike species with lower forage value than guineagrass. 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 understory. The most abundant grasses are hilograss (Paspalum conjugatum), common carpetgrass (Axonopus fissifolius), and shortleaf spikesedge (Kyllinga brevifolia), all of which have lower stature and are much less productive than guineagrass. Significant amounts (around 20% canopy cover) of guineagrass remain, but it is grazed low and is scattered across the site. Desirable forage legumes have been grazed out. Height of weedy trees, shrubs, ferns, vines, and forbs is low, and the combined cover of all these species is about 5 to 20%.

Table 10. Soil surface cover

Tree basal cover	0.0-0.1%
Shrub/vine/liana basal cover	0.0-0.1%
Grass/grasslike basal cover	30-40%
Forb basal cover	0.1-1.0%
Non-vascular plants	0%
Biological crusts	0%
Litter	50-60%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	3-5%

Table 11. Canopy structure (% cover)

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

Community 2.3
Common guava - christmasberry/sourbush/broomsedge - beardgrass

Figure 16. Grassland invaded by woody species 4/25/06 D Clausnitzer MU553.

This community phase is dominated by grass species with little or no forage value. Guineagrass typically comprises a small portion (roughly 5% canopy cover) of the grasses present, but sometimes is more abundant but of low stature. 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 large, introduced tree species are present. Bare soil is 10% or more of the ground surface. The abundance of immature trees with potential mature heights of 20 to over 100 feet (6 to over 30 meters) presents a strong risk of losing the grassland to weedy forest. Improving the grazing regime is extremely unlikely to shift this phase to a more productive grassland phase due to the abundance of weeds. Frequent mowing is not worthwhile; it will keep shrubs and trees in check but will do little to improve the grass and forb community. Herbicide treatments are needed to reduce weed abundance. Reseeding of guineagrass may be needed, along with removal of livestock until guineagrass has reassumed dominance.

Forest understory. Hilograss, common carpetgrass, broomsedge bluestem (Andropogon virginicum), and beardgrass or Colombian bluestem (Schizachyrium condensatum) are the most abundant grasses. Sawtooth blackberry (Rubus argutus), yellow Himalayan raspberry (Rubus ellipticus), and West Indian raspberry or thimbleberry (Rubus rosifolius) form small thickets. Shrubs such as cure for all or sourbush (Pluchea carolinensis), along with small trees such as common guava (Psidium guajava) 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 albizia or peacocksplume (Falcataria moluccana) are often present.

Table 12. Soil surface cover

Tree basal cover	0.1-1.0%
Shrub/vine/liana basal cover	0.1-1.0%
Grass/grasslike basal cover	30-40%
Forb basal cover	0.1-0.2%
Non-vascular plants	0%
Biological crusts	0%
Litter	50-60%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	5-10%

Table 13. Canopy structure (% cover)

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

Pathway 2.1A
Community 2.1 to 2.2

Guineagrass - kikuyugrass/glycine

Hilograss - carpetgrass

Community phase 2.1 degrades to phase 2.2 by continuous grazing that weakens preferred guineagrass or kikuyugrass and legumes in relation to less desirable forage species such as hilograss, common carpetgrass, and sedges.

Pathway 2.2A
Community 2.2 to 2.1

Hilograss - carpetgrass

Guineagrass - kikuyugrass/glycine

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. The grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing. Invading broomsedge and beardgrass may be controlled by mowing their seed stalks before seed set and by liming to increase soil pH.

Pathway 2.2B
Community 2.2 to 2.3

Hilograss - carpetgrass

Common guava - christmasberry/sourbush/broomsedge - beardgrass

Community phase 2.2 degrades to phase 2.3 by long-term continuous grazing. Guineagrass cover is greatly reduced and largely replaced by lower-value forage grasses. Weedy forbs such as spiny amaranth, introduced blackberries, and introduced shrubs such as sourbush have increased. Broomsedge and beardgrass often are the most abundant grass species.

Pathway 2.3A
Community 2.3 to 2.1

Common guava - christmasberry/sourbush/broomsedge - beardgrass

Guineagrass - kikuyugrass/glycine

Community phase 2.3 can be converted to phase 2.1 by a combination of weed control and prescribed grazing.

Weeds such as introduced blackberries, sourbush, and spiny amaranth are not controllable by domestic livestock and must be killed with herbicide. The grazing prescription will require removal of livestock from the pasture until guineagrass has reestablished adequately to support grazing. Thereafter, the grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

Pathway 2.3B
Community 2.3 to 2.2

Common guava - christmasberry/sourbush/broomsedge - beardgrass

Hilograss - carpetgrass

Herbicidal weed control measures, liming, and mechanical brush control can reduce the densities of weedy shrubs, forbs, and grasses. However, these measures alone will not bring about guineagrass dominance without changes in the grazing regime.

State 3
Planted Timber State

This state consists of one community phase, which is a plantation of introduced timber tree species that have been established on former sugarcane or grazing lands. With typical management, it is not susceptible to unplanned transitions or restorations to other states.

Community 3.1
Exotic timber trees/guineagrass

Figure 17. Eucalyptus plantation mauka of Pahala, D Clausnitzer, generic photo.

This community is typically managed in the long term for economic returns. Many introduced timber species will potentially grow well in the environment of this ecological site, where they also may be free of pests that are present in their native habitats.

Forest overstory. Various species of Eucalyptus are most commonly planted, including hybrids (primarily E. grandis x urophylla), grand eucalyptus (E. grandis), rainbow gum (E. deglupta), red gum (E. robusta), and blue gum (E. saligna). Other valuable species can be planted, including African mahogany (Khaya senegalensis), Honduran mahogany (Swietenia microphylla), toon or Australian red cedar (Toona ciliata), and Spanish cedar (Cedrela odorata). Other species are also possible. Consult with NRCS, the University of Hawaii Extension Forester, or a private consultant to ensure that noninvasive species are selected and that species are planted in suitable elevation ranges. Few introduced timber species are suitable for the full elevation range of this ecological site.

Koa is a valuable, fast-growing native tree that can be planted on these sites. 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. Guineagrass is usually abundant beneath the timber trees; despite being shaded by trees, it can form a nearly continuous canopy cover and attain heights of 3 to 4.5 feet (1 to 1.5 meters). Guineagrass appears to be partially suppressed beneath mature stands of Eucalyptus species, possibly due to the density and chemical composition of the tree litter. Strawberry guava can form dense stands beneath any timber species.

Table 14. Soil surface cover

Tree basal cover	3-5%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	1-2%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	75-90%
Surface fragments >0.25" and <=3"	0.1-1.0%
Surface fragments >3"	0.1-1.0%
Bedrock	0%
Water	0%
Bare ground	1-5%

Table 15. 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)	0-1%
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	0-1%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	–
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	
Tree snag count** (hard***)	1-2 per acre

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

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

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

Table 16. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	0%	0%	0%
>0.5 <= 1	0%	0%	0%	0%
>1 <= 2	0%	0%	1-10%	0%
>2 <= 4.5	0-1%	–	2-60%	0%
>4.5 <= 13	0-1%	–	–	–
>13 <= 40	0-1%	–	–	–
>40 <= 80	85-95%	–	–	–
>80 <= 120	1-5%	–	–	–
>120	–	–	–	–

State 4
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 depending on 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
Koa - `ohi`a lehua/strawberry guava/kahili ginger

Figure 18. Weed-invaded understory, Kau SF, D Clausnitzer, generic photo.

Figure 19. Pig damage to soil surface. D Clausnitzer, generic photo.

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.

Forest overstory. The overstory consists of ohia lehua and/or koa. Secondary canopy native species are usually somewhat diminished. Wild coffee or kopiko (Psychotria spp.) is usually the most common native species remaining in the secondary canopy.

Forest understory. The only native species remaining in the lower canopy levels are a few hapuu (Cibotium glaucum) or hapuu li (Cibotium menziesii), and traces of small wild coffee or kopiko, 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 is usually 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 17. Soil surface cover

Tree basal cover	3-5%
Shrub/vine/liana basal cover	1-2%
Grass/grasslike basal cover	0.0-0.1%
Forb basal cover	0.0-0.1%
Non-vascular plants	1-5%
Biological crusts	0%
Litter	80-85%
Surface fragments >0.25" and <=3"	0.1-1.0%
Surface fragments >3"	0.1-1.0%
Bedrock	0%
Water	0%
Bare ground	0.0-0.1%

Table 18. 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 acre
Tree snag count** (hard***)	1-3 per acre

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

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

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

Table 19. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	0%	2-3%	0-1%
>0.5 <= 1	0%	0%	3-5%	1-5%
>1 <= 2	0-1%	0-1%	1-2%	10-20%
>2 <= 4.5	5-10%	5-10%	–	0%
>4.5 <= 13	10-20%	10-20%	–	–
>13 <= 40	30-50%	1-5%	–	–
>40 <= 80	10-20%	–	–	–
>80 <= 120	10-20%	–	–	–
>120	–	–	–	–

State 5
Invaded Overstory and Understory State

This state is comprised of one plant community dominated by introduced species in both the overstory and understory. Understory vegetation usually is very sparse to nonexistent. 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. 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 worth exploring.

Community 5.1
Strawberry guava - christmasberry/kahili ginger

Figure 20. Albizia overstory with guineagrass understory. D Clausnitzer, generic photo.

It is possible that shifts will eventually occur in the introduced species that dominate the site, particularly if tall stature, competitive tree species are present. This would change the mix of species present and may affect soil chemistry (e.g. nitrate availability or organic matter), but would not represent a transition to another state. Sites that are completely dominated by dense stands of strawberry guava typically show no indications (death or partial death of stands; 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, christmasberry, or common guava can dominate a given site initially, but strawberry guava generally will become dominant over time. 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 tree often remain as emergents above the canopy of introduced species, but no seedling or saplings are likely 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.

Scattered individuals of remnant native species such as kopiko, hapuu, and uluhe may remain in the understory.

Table 20. Soil surface cover

Tree basal cover	2-4%
Shrub/vine/liana basal cover	1-2%
Grass/grasslike basal cover	0.1-1.0%
Forb basal cover	0.0-0.1%
Non-vascular plants	3-5%
Biological crusts	0%
Litter	80-85%
Surface fragments >0.25" and <=3"	0.1-1.0%
Surface fragments >3"	0.1-1.0%
Bedrock	0%
Water	0%
Bare ground	3-5%

Table 21. 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)	1-2%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-1 per acre
Tree snag count** (hard***)	2-3 per acre

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

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

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

Table 22. Canopy structure (% cover)

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

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 pasture grasses will thrive. Grasslands that were cleared by machinery may have broad cleared areas and isolated islands of trees that later grew in the shelter of slash piles. At higher, cooler elevations kikuyugrass and/or pangolagrass have been planted. At lower elevations where pastures are on old sugarcane plantations, guineagrass (a former weed in the plantations) has volunteered.

Transition T1A
State 1 to 2

Transition T1B
State 1 to 4

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

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 grasses species and the many opportunistic plant species that will invade the site. Weed control is be a perpetual process to capture and maintain the site, with the intensity of control depending on the proximity of weed seed sources. Animal foraging (domestic and feral) must be eliminated by excluding all ungulates from the restoration site, but domestic ungulates would be useful to initially reduce grass cover and afterward to manage vegetation outside the restoration site perimeter. Extensive planting of native species would follow. Increased shade from trees growing on the site causes a shift from C4 (warm-season) grass dominance (typically guineagrass or kikuyugrass) to C3 (cool-season) shade-tolerant grasses, typically meadow ricegrass. Meadow ricegrass stands can be dense and detrimental to establishment of native plants. 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. Biodegradable mulch such as cardboard covered with plant litter is very useful.

Transition T2A
State 2 to 3

State 2 Naturalized Grassland may be converted to State 3 Planted Timber State by mechanical site preparation and planting of timber species (usually eucalyptus) and weed control.

Transition T2B
State 2 to 5

Abandonment of State 2 Naturalized Grassland leads to rapid invasion by introduced tree species that take over from the initial growth of grasses and invasion of weedy forbs, vines, and shrubs. The most common tree species are silk oak, christmasberry, albizia, and common guava.

Restoration pathway R4A
State 4 to 1

It is possible to restore a facsimile of State 1 Reference State from State 4 Invaded Understory State. Before restoration of native plants, alien 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 converted 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 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.

Restoration pathway R5A
State 5 to 2

State 5 Invaded Overstory and Understory State may be restored to State 2 Naturalized Grassland State 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 pasture establishment to control reemerging weed species.

Additional community tables

Table 23. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
koa	ACKO	*Acacia koa*	Native	40–90	0–40	24–50	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	50–90	25–30	16–40	–
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	20–45	5–15	–	–
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	13–35	2–5	–	–
mirrorplant	COPRO	*Coprosma*	Native	13–25	2–5	–	–
volcanic melicope	MEVO	*Melicope volcanica*	Native	13–20	0–1	–	–
kukaemoa	MECL	*Melicope clusiifolia*	Native	13–20	0–1	–	–
wild coffee	PSYCH	*Psychotria*	Native	13–35	0.1–1	–	–
olomea	PESA3	*Perrottetia sandwicensis*	Native	13–20	0.1–1	–	–
Hawai'i holly	ILAN	*Ilex anomala*	Native	13–40	0.1–1	–	–
lo'ulu	PRLA4	*Pritchardia lanigera*	Native	20–40	0–0.1	–	–
'ohe mauka	TEOA	*Tetraplasandra oahuensis*	Native	13–20	0–0.1	–	–
Tree Fern							
hapu'u	CIGL	*Cibotium glaucum*	Native	13–25	35–50	–	–
hapu'u li	CIME8	*Cibotium menziesii*	Native	13–25	5–10	–	–
Chamisso's manfern	CICH	*Cibotium chamissoi*	Native	13–20	0–0.1	–	–

Table 24. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
Hawai'i birdcatching sedge	UNUN	*Uncinia uncinata*	Native	0.5–1	0.1–1
Hawai'i sedge	CAAL12	*Carex alligata*	Native	1–2	0.1–1
rush	JUNCU	*Juncus*	Native	1–2	0–0.1
Hawai'i woodrush	LUHA2	*Luzula hawaiiensis*	Native	0.5–1	0–0.1
Forb/Herb					
pua'akuhinia	ASME4	*Astelia menziesiana*	Native	0.5–1	0.1–1
bog stenogyne	STCA9	*Stenogyne calaminthoides*	Native	0.5–1	0.1–1
peperomia	PEPER	*Peperomia*	Native	0.5–1	0.1–1
Fern/fern ally					
alpine woodfern	DRWA	*Dryopteris wallichiana*	Native	2–3	1–5
kolokolo	GRTE	*Grammitis tenella*	Native	0.5–1	0.1–1
weeping fern	LETH6	*Lepisorus thunbergianus*	Native	0.5–1	0.1–1
Hawai'i potato fern	MADO	*Marattia douglasii*	Native	1–2	0–1
Boston swordfern	NEEX	*Nephrolepis exaltata*	Native	1–2	0.1–1
akolea	ATMI	*Athyrium microphyllum*	Native	1–2	0.1–1
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	2–4	0.1–1
Hawai'i twinsorus fern	DISA3	*Diplazium sandwichianum*	Native	2–4	0.1–1
kilaw	DRGL3	*Dryopteris glabra*	Native	1–2	0.1–1

Pacific woodfern	DRSA	*Dryopteris sandwicensis*	Native	2–4	0.1–1
Hawai'i umbrella fern	STOW	*Sticherus owhyensis*	Native	1–4	0.1–1
royal tonguefern	ELCR2	*Elaphoglossum crassifolium*	Native	0.5–1	0.1–1
ekaha	ELHI3	*Elaphoglossum hirtum*	Native	0.5–1	0.1–1
palapalai	MIST4	*Microlepia strigosa*	Native	1–3	0.1–1
spleenwort	ASPLE	*Asplenium*	Native	1–3	0.1–1
piipiilau manamana	ASLO5	*Asplenium lobulatum*	Native	1–3	0.1–1
vandenboschia	VANDE	*Vandenboschia*	Native	0.5–1	0.1–1
Hudson's air fern	PNHU	*Pneumatopteris hudsoniana*	Native	1–3	0.1–1
Hawai'i air fern	PNSA	*Pneumatopteris sandwicensis*	Native	1–3	0.1–1
flatfork fern	PSCO3	*Psilotum complanatum*	Native	0.5–1	0.1–1
whisk fern	PSNU	*Psilotum nudum*	Native	0.5–1	0.1–1
Cretan brake	PTCR2	*Pteris cretica*	Native	0.5–1	0.1–1
waimakanui	PTEX	*Pteris excelsa*	Native	0.5–1	0.1–1
wahini noho mauna	ADTA	*Adenophorus tamariscinus*	Native	0.5–1	0.1–1
palaihinahina	HYLA2	*Hymenophyllum lanceolatum*	Native	0.5–1	0–0.1
Chinese creepingfern	ODCH	*Odontosoria chinensis*	Native	1–2	0–0.1
false beech fern	PSKE	*Pseudophegopteris keraudreniana*	Native	1–10	0–0.1
ama'u	SAPA11	*Sadleria pallida*	Native	2–5	0–0.1
globular maiden fern	THGL	*Thelypteris globulifera*	Native	1–3	0–0.1
loulu	COPI3	*Coniogramme pilosa*	Native	1–2	0–0.1
Shrub/Subshrub					
kanawao	BRAR6	*Broussaisia arguta*	Native	2–8	1–10
Kauai clermontia	CLCL	*Clermontia clermontioides*	Native	2–6	0–1
Waimea pipturus	PIAL2	*Pipturus albidus*	Native	2–13	0.1–1
'ilihia	CYPL5	*Cyrtandra platyphylla*	Native	1–3	0.1–1
cyrtandra	CYRTA	*Cyrtandra*	Native	1–3	0.1–1
ohelo kau la'au	VACA8	*Vaccinium calycinum*	Native	2–6	0.1–1
labordia	LABOR	*Labordia*	Native	2–4	0–0.1
largeflower false lobelia	TRGR8	*Trematolobelia grandifolia*	Native	2–6	0–0.1
koli'i	TRMA8	*Trematolobelia macrostachys*	Native	2–6	0–0.1
Kaiholena cyanea	CYST5	*Cyanea stictophylla*	Native	2–8	0–0.1
naupaka	SCAEV	*Scaevola*	Native	2–4	0–0.1
anini	EUSA6	*Eurya sandwicensis*	Native	2–3	0–0.1
'aku 'aku	CYTR6	*Cyanea tritomantha*	Native	2–8	0–0.1
kuhi'aikamo'owahie	LOHY	*Lobelia hypoleuca*	Native	2–5	0–0.1
hillside clermontia	CLLI3	*Clermontia lindseyana*	Native	2–6	0–0.1
smallflower clermontia	CLPA8	*Clermontia parviflora*	Native	2–13	0–0.1
Tree					
olapalapa	CHTR2	*Cheirodendron trigynum*	Native	2–13	0.1–1
olomea	PESA3	*Perrottetia sandwicensis*	Native	2–13	0.1–1
Hawai'i holly	ILAN	*Ilex anomala*	Native	2–13	0.1–1
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	2–13	0.1–1
wild coffee	PSYCH	*Psychotria*	Native	2–13	0.1–1

cheesewood	PITTO	*Pittosporum*	Native	5–13	0.1–1
mirrorplant	COPRO	*Coprosma*	Native	2–13	0.1–1
ha'a	ANPL2	*Antidesma platyphyllum*	Native	2–13	0.1–1
hame	ANPU2	*Antidesma pulvinatum*	Native	2–13	0.1–1
variable starviolet	HETE21	*Hedyotis terminalis*	Native	2–13	0.1–1
volcanic melicope	MEVO	*Melicope volcanica*	Native	2–13	0–0.1
kukaemoa	MECL	*Melicope clusiifolia*	Native	2–13	0–0.1
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	2–13	0–0.1
koa	ACKO	*Acacia koa*	Native	2–13	0–0.1
'ahakea	BOTI	*Bobea timonioides*	Native	2–13	0–0.1
olona	TOLA	*Touchardia latifolia*	Native	2–10	0–0.1
hopue	URGL	*Urera glabra*	Native	2–10	0–0.1
kokea lau li'i	MYSA2	*Myrsine sandwicensis*	Native	2–13	0–0.1
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	2–13	25–40
hapu'u li	CIME8	*Cibotium menziesii*	Native	2–13	1–5
Chamisso's manfern	CICH	*Cibotium chamissoi*	Native	2–13	0–0.1
Vine/Liana					
Hawai'i blackberry	RUHA	*Rubus hawaiensis*	Native	2–4	0.1–1
Maile	ALST11	*Alyxia stellata*	Native	2–8	0.1–1
Hawai'i greenbrier	SMME	*Smilax melastomifolia*	Native	2–30	0.1–1
'ie'ie	FRAR	*Freycinetia arborea*	Native	2–40	0.1–1
kilioe	EMPA	*Embelia pacifica*	Native	2–4	0–0.1
Hawai'i phyllostegia	PHFL6	*Phyllostegia floribunda*	Native	0.5–1	0–0.1
velvet phyllostegia	PHVE8	*Phyllostegia velutina*	Native	1–2	0–0.1
Hawai'i jadevine	STRU4	*Strongylodon ruber*	Native	1–40	0–0.1

Table 25. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Naturalized Warm Season Tallgrasses**			11200–14000	
	guineagrass	URMA3	*Urochloa maxima*	11200–14000	–
	elephant grass	PEPU2	*Pennisetum purpureum*	0–140	–
2	**Naturalized Warm Season Midgrasses**			0–700	
	kikuyugrass	PECL2	*Pennisetum clandestinum*	0–500	–
	digitgrass	DIER	*Digitaria eriantha*	0–200	–
	shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	0–140	–
	hilograss	PACO14	*Paspalum conjugatum*	0–140	–
	Vasey's grass	PAUR2	*Paspalum urvillei*	0–140	–
	Colombian bluestem	SCCO10	*Schizachyrium condensatum*	0–140	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	0–140	–
	smut grass	SPIN4	*Sporobolus indicus*	0–140	–
	broomsedge bluestem	ANVI2	*Andropogon virginicus*	0–140	–
Forb					
3	**Naturalized Forbs**			140–700	
	threeflower ticktrefoil	DETR4	*Desmodium triflorum*	140–420	–
	perennial soybean	NEWI2	*Neonotonia wightii*	140–420	–
	common sowthistle	SOOL	*Sonchus oleraceus*	0–140	–
	lilac tasselflower	EMSO	*Emilia sonchifolia*	0–140	–
	spiny amaranth	AMSP	*Amaranthus spinosus*	0–140	–
Shrub/Vine					
4	**Naturalized Shrubs and Small Trees**			140–700	
	cure for all	PLCA10	*Pluchea carolinensis*	0–140	–
	guava	PSGU	*Psidium guajava*	0–140	–
	castorbean	RICO3	*Ricinus communis*	0–140	–
	Brazilian peppertree	SCTE	*Schinus terebinthifolius*	0–140	–

Table 26. Community 2.2 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
hilograss	PACO14	*Paspalum conjugatum*	Introduced	1–2	15–25
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.5–2	10–25
guineagrass	URMA3	*Urochloa maxima*	Introduced	2–5	10–25
kikuyugrass	PECL2	*Pennisetum clandestinum*	Introduced	1–2	5–15
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.5–1	1–5
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	2–3	1–5
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	2–3	1–5
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	1–2	1–5
sweet vernalgrass	ANOD	*Anthoxanthum odoratum*	Introduced	1–2	0.1–1
wild sugarcane	SASP	*Saccharum spontaneum*	Introduced	4–6	0–1
manyspike flatsedge	CYPO	*Cyperus polystachyos*	Native	0.5–1	0.1–1
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.5–1	0.1–1
Forb/Herb					
lilac tasselflower	EMSO	*Emilia sonchifolia*	Introduced	1–2	0.1–1
common sowthistle	SOOL	*Sonchus oleraceus*	Introduced	1–2	0.1–1
spiny amaranth	AMSP	*Amaranthus spinosus*	Introduced	1–2	0.1–1
common sheep sorrel	RUAC3	*Rumex acetosella*	Introduced	1–2	0.1–1
pinkhead smartweed	POCA21	*Polygonum capitatum*	Introduced	0.2–0.5	0.1–1
climbing dayflower	CODI5	*Commelina diffusa*	Introduced	0.5–1	0.1–1
ticktrefoil	DESMO	*Desmodium*	Introduced	0.5–2	0–0.1
bull thistle	CIVU	*Cirsium vulgare*	Introduced	1–3	0–0.1
spreading snakeroot	AGRI2	*Ageratina riparia*	Introduced	1–2	0–0.1
soft elephantsfoot	ELMO5	*Elephantopus mollis*	Introduced	1–2	0–0.1
hairy cat's ear	HYRA3	*Hypochaeris radicata*	Introduced	0.5–1	0–0.1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	0.1–1
western brackenfern	PTAQ	*Pteridium aquilinum*	Native	1–2	0–0.1
Old World forkedfern	DILI	*Dicranopteris linearis*	Native	1–2	0–0.1
Shrub/Subshrub					
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	2–6	1–2
Tree					
guava	PSGU	*Psidium guajava*	Introduced	4–10	1–2
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	2–8	1–2
silkoak	GRRO	*Grevillea robusta*	Introduced	1–2	0–0.1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	1–2	0–0.1
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	1–4	0–0.1
Vine/Liana					
sawtooth blackberry	RUAR2	*Rubus argutus*	Introduced	2–4	0.1–1
yellow Himalayan raspberry	RUEL3	*Rubus ellipticus*	Introduced	2–4	0.1–1
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	2–4	0.1–1

Table 27. Community 2.3 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	6–13	1–2	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	20–40	0–0.1	–	–

Table 28. Community 2.3 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.5–1	15–25
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.5–2	15–25
common carpetgrass	AXFI	*Axonopus fissifolius*	Introduced	0.5–2	15–25
broomsedge bluestem	ANVI2	*Andropogon virginicus*	Introduced	1–3	5–10
Colombian bluestem	SCCO10	*Schizachyrium condensatum*	Introduced	1–3	5–10
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	1–2	2–5
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.5–1	3–5
manyspike flatsedge	CYPO	*Cyperus polystachyos*	Native	0.5–1	0.1–1
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.5–1	0.1–1
guineagrass	URMA3	*Urochloa maxima*	Introduced	1–2	0.1–1
kikuyugrass	PECL2	*Pennisetum clandestinum*	Introduced	0.5–1	0.1–1
Forb/Herb					
spiny amaranth	AMSP	*Amaranthus spinosus*	Introduced	1–3	5–10
pinkhead smartweed	POCA21	*Polygonum capitatum*	Introduced	0.1–0.5	0.1–1
spreading snakeroot	AGRI2	*Ageratina riparia*	Introduced	1–2	0.1–1
soft elephantsfoot	ELMO5	*Elephantopus mollis*	Introduced	1–2	0.1–1
lilac tasselflower	EMSO	*Emilia sonchifolia*	Introduced	1–2	0.1–1
common sowthistle	SOOL	*Sonchus oleraceus*	Introduced	1–2	0.1–1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	0.1–1
Shrub/Subshrub					
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	2–5	5–10
Tree					
guava	PSGU	*Psidium guajava*	Introduced	4–13	5–10
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–13	1–2
silkoak	GRRO	*Grevillea robusta*	Introduced	4–13	0–0.1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	2–4	0–0.1
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	2–4	0–0.1
Vine/Liana					
sawtooth blackberry	RUAR2	*Rubus argutus*	Introduced	2–4	1–5
yellow Himalayan raspberry	RUEL3	*Rubus ellipticus*	Introduced	2–4	1–5
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	2–4	1–5

Table 29. Community 3.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
gum	EUCAL	*Eucalyptus*	Introduced	50–90	85–95	–	–

Table 30. Community 3.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
guineagrass	URMA3	*Urochloa maxima*	Introduced	2–3	5–60
weeping grass	MIST	*Microlaena stipoides*	Introduced	1–2	0.1–1
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	1–2	0.1–1
hilograss	PACO14	*Paspalum conjugatum*	Introduced	1–2	0.1–1
Forb/Herb					
Kahila garland-lily	HEGA	*Hedychium gardnerianum*	Introduced	2–3	0–0.1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	0.1–1
Shrub/Subshrub					
soapbush	CLHI3	*Clidemia hirta*	Introduced	1–2	0–0.1
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	2–10	0–1
parrotweed	BOFR2	*Bocconia frutescens*	Introduced	4–10	0–0.1
Vine/Liana					
shoofly	CADE15	*Caesalpinia decapetala*	Introduced	2–3	0–0.1
yellow Himalayan raspberry	RUEL3	*Rubus ellipticus*	Introduced	2–3	0–0.1
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	2–3	0–0.1

Table 31. Community 4.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	13–25	10–30	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	40–90	10–20	–	–
koa	ACKO	*Acacia koa*	Native	40–90	1–20	–	–
wild coffee	PSYCH	*Psychotria*	Native	15–30	0.1–1	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	20–40	0.1–1	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	13–20	0.1–1	–	–
silkoak	GRRO	*Grevillea robusta*	Introduced	25–60	0–0.1	–	–

Table 32. Community 4.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	1–2	1–5
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.5–2	1–5
guineagrass	URMA3	*Urochloa maxima*	Introduced	2–4	0–1
weeping grass	MIST	*Microlaena stipoides*	Introduced	1–2	0.1–1
Kahila garland-lily	HEGA	*Hedychium gardnerianum*	Introduced	2–4	0.1–1
Forb/Herb					
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	1–2	0.1–1
Japanese thimbleweed	ANHU	*Anemone hupehensis*	Introduced	2–3	0–0.1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	10–25
parasitic maiden fern	THPA4	*Thelypteris parasitica*	Introduced	1–2	0.1–1
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	1–2	0.1–1
Japanese netvein hollyfern	CYFA2	*Cyrtomium falcatum*	Introduced	1–2	0–0.1
rough maidenhair	ADHI	*Adiantum hispidulum*	Introduced	0.5–1	0–0.1
spleenwort	ASPLE	*Asplenium*	Native	1–2	0–0.1
Shrub/Subshrub					
soapbush	CLHI3	*Clidemia hirta*	Introduced	2–6	5–15
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	2–13	10–15
night jessamine	CENO	*Cestrum nocturnum*	Introduced	2–8	0.1–1
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–13	5–15
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	2–4	1–5
wild coffee	PSYCH	*Psychotria*	Native	4–13	0.1–1
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–13	0.1–1
guava	PSGU	*Psidium guajava*	Introduced	4–13	0.1–1
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–13	0–1
silkoak	GRRO	*Grevillea robusta*	Introduced	4–13	0–0.1
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	4–13	0–1
Vine/Liana					
'ie'ie	FRAR	*Freycinetia arborea*	Native	1–30	0–1
yellow Himalayan raspberry	RUEL3	*Rubus ellipticus*	Introduced	2–4	0.1–1
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	2–3	0.1–1

Table 33. Community 5.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	13–25	15–25	–	–
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	13–20	1–3	–	–
silkoak	GRRO	*Grevillea robusta*	Introduced	40–60	0.1–1	–	–
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	20–40	0.1–1	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	40–80	0–1	–	–
koa	ACKO	*Acacia koa*	Native	40–80	0–1	–	–
wild coffee	PSYCH	*Psychotria*	Native	13–25	0.1–1	–	–
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	30–60	0–0.1	–	–
parrotweed	BOFR2	*Bocconia frutescens*	Introduced	13–20	0–0.1	–	–

Table 34. Community 5.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
basketgrass	OPHI	*Oplismenus hirtellus*	Introduced	1–2	3–5
hilograss	PACO14	*Paspalum conjugatum*	Introduced	0.5–1	3–5
weeping grass	MIST	*Microlaena stipoides*	Introduced	0.5–1	0.1–1
Forb/Herb					
Kahila garland-lily	HEGA	*Hedychium gardnerianum*	Introduced	2–3	0.1–1
Philippine ground orchid	SPPL	*Spathoglottis plicata*	Introduced	1–2	0.1–1
Japanese thimbleweed	ANHU	*Anemone hupehensis*	Introduced	2–3	0–0.1
Fern/fern ally					
scaly swordfern	NEHI	*Nephrolepis hirsutula*	Introduced	1–2	15–25
golden polypody	PHAU6	*Phlebodium aureum*	Introduced	1–2	0.1–1
rough maidenhair	ADHI	*Adiantum hispidulum*	Introduced	1–2	0.1–1
parasitic maiden fern	THPA4	*Thelypteris parasitica*	Introduced	1–2	0.1–1
Japanese netvein hollyfern	CYFA2	*Cyrtomium falcatum*	Introduced	1–2	0.1–1
Shrub/Subshrub					
soapbush	CLHI3	*Clidemia hirta*	Introduced	2–6	10–15
princess-flower	TIUR	*Tibouchina urvilleana*	Introduced	2–13	10–15
night jessamine	CENO	*Cestrum nocturnum*	Introduced	2–8	0.1–1
Tree					
strawberry guava	PSCA	*Psidium cattleianum*	Introduced	4–13	10–25
octopus tree	SCAC2	*Schefflera actinophylla*	Introduced	4–13	0.1–1
parrotweed	BOFR2	*Bocconia frutescens*	Introduced	4–13	0.1–1
Brazilian peppertree	SCTE	*Schinus terebinthifolius*	Introduced	4–13	0.1–1
guava	PSGU	*Psidium guajava*	Introduced	4–13	0–0.1
wild coffee	PSYCH	*Psychotria*	Native	4–13	0–0.1
peacocksplume	FAMO	*Falcataria moluccana*	Introduced	4–13	0–0.1
silkoak	GRRO	*Grevillea robusta*	Introduced	4–13	0–0.1
Tree Fern					
hapu'u	CIGL	*Cibotium glaucum*	Native	4–8	0–0.1
Vine/Liana					
shoofly	CADE15	*Caesalpinia decapetala*	Introduced	2–6	1–5
yellow Himalayan raspberry	RUEL3	*Rubus ellipticus*	Introduced	2–5	3–5
West Indian raspberry	RURO	*Rubus rosifolius*	Introduced	2–5	0.5–1

Animal community

Native Wildlife

This ecological site provides habitat to the following native birds: elepaio (Chasiempis sandwichensis), amakihi (Hemignathus virens), apapane (Himatione sanguinea), and iiwi (Vestiaria coccinea) omao (Myadestes obscurus), Hawaiian crow or alala (Corvus hawaiensis), 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, with guinea grass. For kikuyugrass pastures on this ecological site, refer to grazing interpretations in Ecological site Description F160XY504 Loa Ustic-Dry Udic Forest. The following 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 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) 0.20-0.22 acre/AUM (note 3) 5.13-4.49 AUM/acre

High 0.22-0.26 acre/AUM 4.49-3.85 AUM/acre

Moderate 0.26-0.39 acre/AUM 3.85-2.56 AUM/acre

Low 0.39-+ 2.56-+

(note 1) The Forage Value Rating System is not an ecological evaluation of community phase 2.2. It is a utilitarian rating of the existing forage value for that specific plant community.

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

(3) Stocking rates vary in accordance with such factors as kind and class of livestock or wildlife, season of use, and fluctuations in climate. Figures shown are calculated assuming a 30% adjustment factor to account for harvest efficiency and the "take half – leave half" principle. 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.

Community phase 2.1 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

Water infiltration and retention tend to be high on these deep to very deep volcanic ash soils. The deep, 4-tiered canopy and heavy litter layer of the Reference State keep soil erosion to a minimum.

The tall, dense grass growth in well-managed grassland (community phase 2.1) provides considerable protection against erosion. Phases 2.2 and 2.3 have lower-stature, less dense vegetation and more bare ground that provide somewhat less erosion protection.

States with large amounts of introduced vegetation (States 3, 4, 5, and 6) apparently would provide good erosion protection.

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 excellent potential for production of timber in this ecological site, including eucalyptus and high-value specialty woods such as 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.

CaCO3 equivalent: The amount of free lime in a soil. Free lime exists as solid material and typically occurs in regions with a dry climate.

Canopy cover: The percentage of ground covered by the vertical projection downward of the outermost perimeter of the spread of plant foliage. Small openings within the canopy are included.

Community pathway: A description of the causes of shifts between community phases. A community pathway is reversible and is attributable to succession, natural disturbances, short-term climatic variation, and facilitating practices, such as grazing management.

Community phase: A unique assemblage of plants and associated dynamic soil properties within a state.

Dominant species: Plant species or species groups that exert considerable influence upon a community due to size, abundance, or cover.

Drainage class: The frequency and duration of a water table in a soil. There are seven drainage classes, ranging from “excessively drained” (soils with very rare or very deep water tables) to “well drained” (soils that provide ample water for plant growth but are not so wet as to inhibit root growth) to “very poorly drained” (soils with a water table at or near the surface during much of the growing season that inhibits growth of most plants).

Electrical conductivity (EC): A measure of the salinity of a soil. The standard unit is deciSiemens per meter (dS/m), which is numerically equivalent to millimhos per centimeter (mmhos/cm). An EC greater than about 4 dS/m indicates a salinity level that is unfavorable to growth of most plants.

Friability: A soil consistency term pertaining to the ease of crumbling of soils.

Hydrous: A “soil texture modifier” for volcanic ash soils having a water content at the crop wilting point of 100 percent or more; a soil that holds more water than “medial” or “ashy” soils.

Ion exchange capacity: The ability of soil materials such as clay or organic matter to retain ions (which may be plant nutrients) and to release those ions for uptake by roots.

Isohyperthermic soil temperature regime: A regime in which mean annual soil temperature is 72 degrees F (22 degrees C) or higher and mean summer and mean winter soil temperatures differ by less than 11 degrees F (6 degrees C) at a specified depth.

Isomesic soil temperature regime: A regime in which mean annual soil temperature is 47 degrees F (8 degrees C) or higher but lower than 59 degrees F (15 degrees C) and mean summer and mean winter soil temperatures differ by less than 11 degrees F (6 degrees C) at a specified depth.

Isothermic soil temperature regime: A regime in which mean annual soil temperature is 59 degrees F (15 degrees C) or higher but lower than 72 degrees F (22 degrees C) and mean summer and mean winter soil temperatures differ by less than 11 degrees F (6 degrees C) at a specified depth.

Kipuka: An area of land surrounded by younger (more recent) lava. Soils and plant communities within a kipuka are older than, and often quite different from, those on the surrounding surfaces.

Major Land Resource Area (MLRA): A geographic area defined by NRCS that is characterized by a particular pattern of soils, climate, water resources, and land uses. The island of Hawaii contains nine MLRAs, some of which also occur on other islands in the state.

Makai: a Hawaiian word meaning “toward the sea.”

Mauka: a Hawaiian word meaning “toward the mountain” or “inland.”

Medial: A “soil texture modifier” for volcanic ash soils having a water content at the crop wilting point of 30 to 100 percent; a soil that holds an amount of water intermediate to “hydrous” or “ashy” soils.

Naturalized plant community: A community dominated by adapted, introduced species. It is a relatively stable community resulting from secondary succession after disturbance. Most grasslands in Hawaii are in this category.

Pahoehoe lava: A type of basaltic lava with a smooth, billowy, or rope-like surface and vesicular interior.

Parent material: Unconsolidated and chemically weathered material from which a soil is developed.

Perudic soil moisture regime: A very wet regime found where precipitation exceeds evapotranspiration in all months of normal years. On the island of Hawaii, this regime is found on top of Kohala and on parts of the windward side of Mauna Kea.

pH: The numerical expression of the relative acidity or alkalinity of a soil sample. A pH of 7 is neutral; a pH below 7 is acidic and a pH above 7 is basic.

Phosphorus adsorption: The ability of soil materials to tightly retain phosphorous ions, which are a plant nutrient. Some volcanic ash soils retain phosphorus so strongly that it is partly unavailable to plants.

Reference community phase: The phase exhibiting the characteristics of the reference state and containing the full complement of plant species that historically occupied the site. It is the community phase used to classify an ecological site.

Reference state: A state that describes the ecological potential and natural or historical range of variability of an ecological site.

Restoration pathway: A term describing the environmental conditions and practices that are required to recover a state that has undergone a transition.

Sodium adsorption ratio (SAR): A measure of the amount of dissolved sodium relative to calcium and magnesium in the soil water. SAR values higher than 13 create soil conditions unfavorable to most plants.

Soil moisture regime: A term referring to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa (the crop wilting point) in the soil or in specific horizons during periods of the year.

Soil temperature regime: A defined class based on mean annual soil temperature and on differences between summer and winter temperatures at a specified depth.

Soil reaction: Numerical expression in pH units of the relative acidity or alkalinity or a soil.

State: One or more community phases and their soil properties that interact with the abiotic and biotic environment to produce persistent functional and structural attributes associated with a characteristic range of variability.

State-and-transition model: A method used to display information about relationships between vegetation, soil, animals, hydrology, disturbances, and management actions on an ecological site.

Torric soil moisture regime: See Aridic soil moisture regime.

Transition: A term describing the biotic or abiotic variables or events that contribute to loss of state resilience and result in shifts between states.

Udic soil moisture regime: A regime in which the soil is not dry in any part for as long as 90 cumulative days in normal years, and so provides ample moisture for plants. In Hawaii it is associated with forests in which hapuu (tree ferns) are usually moderately to highly abundant.

Ustic soil moisture regime: A regime in which moisture is limited but present at a time when conditions are suitable for plant growth. In Hawaii it usually is associated with dry forests and subalpine shrublands.

Type locality

Location 1: Hawaii County, HI	
Latitude	19° 14′ 1″
Longitude	155° 30′ 55″
General legal description	USGS Quad: Punaluu. 2.5 miles directly mauka of Pahala in Kau Forest Reserve. Foot trail near upper Paauau Landing Strip. Walk 0.5 mile up trail and then 100 yards to SW into forest.

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

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

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

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

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

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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

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

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

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

17. **Perennial plant reproductive capability:**