

Ecological site VX159A01X500

Well Drained Udic and Perudic Forest

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General information

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

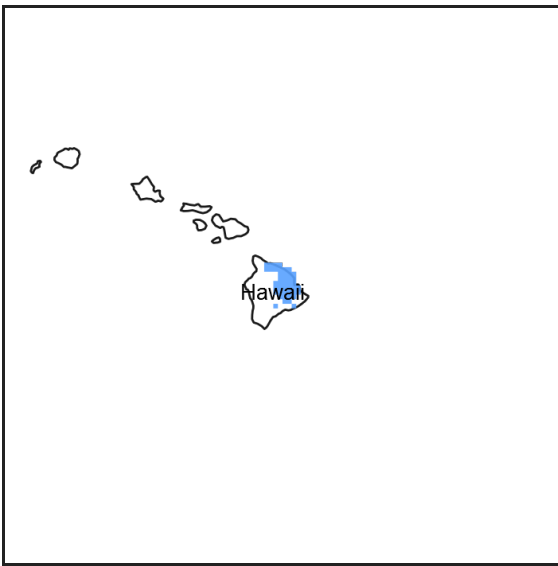


Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 159A–Humid and Very Humid Volcanic Ash Soils on Low and Intermediate Rolling Mountain Slopes

This MLRA occurs in the State of Hawaii on the windward, wetter sides of the islands of Hawaii and Maui. Elevation ranges from near sea level to 6,000 feet (about 2000 meters). Topography is rolling mountain slopes that have been eroded by steep-sided gulches. In most of the area, volcanic ash is underlain by basic igneous rocks, although in some areas volcanic ash was deposited over cinders. Average annual precipitation in most of the area ranges from 120 to 200 inches (3000 to 5000 millimeters); extremes range from 70 inches to 300 inches (1750 to 7500 millimeters). Rainfall is well-distributed throughout the year with an enhanced rainy season from November through April. 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 or isohyperthermic soil temperature regime and udic or perudic soil moisture regime. Native vegetation consists of medium to tall statures rain forest and open bogs.

Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 159A - Humid and Very Humid Volcanic Ash Soils on Low and Intermediate Rolling Mountain Slopes.

Ecological site concept

This extensive ecological site represents the tall-stature, moist forest in the mauka areas of the windward sides of Mauna Kea and Mauna Loa. It exists on private, State, and Federal lands. The continuity is broken mauka of Hilo by younger lava flows from Mauna Kea that have covered the typical deep and very deep volcanic ash soils of the ecological site.

This ecological site, or a related ecological site, also may occur on Maui; field work has yet to be completed.

The central concept of this ecological site is of fertile, moderately well to well drained, deep to very deep Andisols formed in deposits of volcanic ash ranging from 11,000 to 300,000 years old. Annual 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

VX159A01X504	Moderately Well Drained Perudic Forest At some high elevation, wetter locations, this ecological site is associated with F159AY504 Isothermic Perudic Forest. The two ecological sites co-occur within some soil map units but on different soils within the map units. F159AY504 has wetter (perudic) soils that produce a more open, shorter canopy that allows enough light to reach the ground for growth of thickets of uluhe fern.
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Similar sites

VX161B01X502	Kona Weather Udic Forest Kona Weather Udic Forest, F161BY502, occurs above the Kona coast of the Big Island and in a different MLRA. Soils in F161BY502 are generally younger than those in F159AY500. Soils formed in volcanic ash are similar to those in F159AY500; however, F161BY502 contains some organic soils. Rainfall amounts are similar in the two ESs, but annual maxima occur at different times of year. Vegetation and ecological dynamics are similar between the two ESs.
VX159B01X500	Udic Forest The ecological site Udic Forest occurs above the Kau coast of the Big Island and in a different MLRA. Climate and soils are very similar to F159AY500, resulting in very similar vegetation and ecological dynamics. Rainfall amounts overlap between the two ESs, but F159BY500 is generally drier than F159AY500.

Table 1. Dominant plant species

Tree	(1) <i>Acacia koa</i> (2) <i>Metrosideros polymorpha</i>
Shrub	(1) <i>Cibotium menziesii</i>
Herbaceous	(1) <i>Freycinetia arborea</i>

Legacy ID

F159AY500HI

Physiographic features

This ecological site primarily occurs on volcanic ash fields on sloping mountainsides of shield volcanoes. Ash fields range from deep to very deep on the underlying lava.

Table 2. Representative physiographic features

Landforms	(1) Lava flow (2) Volcano (3) Mountain slope
Flooding frequency	None
Ponding frequency	None
Elevation	50–6,400 ft
Slope	0–35%
Ponding depth	0 in
Water table depth	60 in
Aspect	NE, E

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 11 degrees F (6 degrees C).

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. At approximately 6000 feet elevation there is a temperature inversion at the boundary between moist air and higher, drier air. Above the inversion layer, average annual temperatures decrease at a slower rate than below it and average annual precipitation decreases abruptly. Easily observed vegetation changes occur within a short distance at the inversion layer.

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

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

Reference: Giambelluca and Schroeder 1998.

In this ecological site, 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 April, with March being the wettest month. Average annual air temperature ranges from 54 to 71 degrees F (12 to 22 degrees C). In a typical year, temperature and moisture allow plant growth in all seasons.

Table 3. Representative climatic features

Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	104 in

Climate stations used

- (1) KULANI CAMP 79 [USC00515011], Hilo, HI
- (2) PAAUILO 221 [USC00517312], Paauilo, HI

Influencing water features

This ecological site contains perennial streams in very deep, steep-sided gulches. The sides and bottoms of these gulches are dominated by alien trees, particularly African tulip tree (*Spathodea campanulata*), Alexandrian palm (*Archontophoenix alexandrae*), kukui (*Aleurites moluccana*), and gunpowder tree (*Trema orientalis*).

Soil features

Most soils in this ecological site formed in basaltic volcanic ash that varies relatively little in chemical composition (Hazlett and Hyndman 1996; Vitousek 2004)). These ash soils are classified as Andisols, which have these general 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).

Considerable soil erosion occurred where there was long-term sugar cultivation; this probably resulted in loss of some soil productive capacity. Reduced growth of same-aged eucalyptus grown on adjoining plots at fence lines between former sugar lands and uncultivated pasture lands provides anecdotal evidence of this.

These Andisols are mostly deep to very deep and present few limitations to the growth of native, exotic, or pasture vegetation regardless of whether the underlying lava rock is pahoehoe or aa.

Olaa soils are moderately deep soils that comprise a very small area of this ecological site. Kahaluu soils are very shallow to shallow soils that comprise a small area of this ecological site. This series represents the driest, shallowest range of soils in this ecological site and in places is transitional to neighboring ecological sites.

The lava rock fragments that constitute aa range in size from gravel to stones, but are primarily gravel and cobbles. 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. 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. These soils may present some tillage difficulties when significant amounts of coarse rock fragments are present near or on the surface.



Figure 6. Honokaa soil profile.

Table 4. Representative soil features

Parent material	(1) Basic volcanic ash–basalt
Surface texture	(1) Hydrous silt loam (2) Medial silty clay loam
Drainage class	Somewhat poorly drained to well drained
Permeability class	Slow to rapid
Soil depth	10–60 in

Surface fragment cover <=3"	0–10%
Surface fragment cover >3"	0–10%
Available water capacity (0-40in)	5–13 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Subsurface fragment volume <=3" (Depth not specified)	0–25%
Subsurface fragment volume >3" (Depth not specified)	0–50%

Ecological dynamics

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

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

Natural Disturbances

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

A lava flow obviously destroys all the vegetation it covers. Regrowth of vegetation through primary succession and formation of new soil proceed at widely varying rates depending on flow age, local climate, lava type (aa or pahoehoe), and proximity of vegetation seed sources. Flows located in warm, moist climates are rapidly colonized 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 ("islands" of surfaces not covered by lava) occur, revegetation is hastened by the proximity of seed sources from intact vegetation stands nearby.

It has been estimated that about 40% of the surface of Mauna Loa has been covered by lava in the past 1,000 years (Wagner et al. 1999). On the northeastern slopes of Mauna Loa, near Saddle Road west of Hilo, are lava flows that occurred within the past several centuries. The vegetation on these young flows still shows the effects of burial by lava and subsequent recovery via primary succession. However, the degree of recovery varies due to the factors discussed in the previous paragraph. Many of these sites currently exhibit less-developed soils and vegetation communities that currently fall within the outer ranges of the concept of 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 widespread disturbance in this ecological site. Large parts of the Hamakua uplands were burned by wildfires in the early 20th century, but these fires likely were caused by humans and spread via introduced grass species.

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 ash accumulations in this ecological site are currently so old that there are no visible effects due to ash fall at the present time.

Most of the surfaces of Mauna Kea within this ecological site range from tens of thousands to hundreds of thousands of years old, with small areas having been covered by fresh lava in the past 11,000 years. All of these Mauna Kea flows are covered with volcanic ash. Vegetation and soils on these flows have recovered to a point at which they fit comfortably within the central concept of the ecological site.

Wind throw of vegetation can occur during hurricanes or other high wind events. As the soils of this ecological site are deep to very deep, wind throw may not be as important here as in some other ecological sites.

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 and animals, and wood harvesting. Higher elevation forests would have been much less affected, but may have been affected by factors such as inadvertently introduced plant diseases and seed predation by the introduced Pacific rat (Athens 1997).

A broad band of unforested agricultural land in this ecological site stretched along the Hamakua coast from Waipio to Hilo Bay during Polynesian times; forest started three to five miles in from the sea (McElDowney 1983; Maly and Maly 2004). Kukui trees, introduced to Hawaii by the Polynesians, covered parts of this area (Craighill and Handy 1991). Although this area was cleared long ago and no remnant native forests remain, it is included in this ecological site. Based on soils, climate, and the introduced vegetation that currently occurs there, it seems likely that the native vegetation in this area would have been similar to that described for this ecological site. However, it is doubtful that koa (*Acacia koa*) trees occupied this low-elevation area. Koa trees currently occur naturally as low as 1200 feet (370 meters) elevation in this area. It seems likely that koa would have occupied lower elevations than this in the past. However, stands of healthy koa trees currently do not occur close to sea level on the Big Island. It is possible that these lower elevation forests contained wet-habitat lama (*Diospyros sandwicensis*), hala or Tahitian screw pine (*Pandanus tectorius*), and bird's nest ferns (*Asplenium nidus*) in addition to the species listed on the table for State 1 Reference State.

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. Additionally, packs of feral dogs had become established, as confirmed by reports of their depredations on sheep. 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. Today, some forest sites in this ecological site still lack tree ferns due to pulu harvesting.

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

Large parts 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. Anecdotal evidence of the loss of fertile upper soil horizons is provided by eucalyptus plantations where trees were planted at the same time on former sugar plantation lands and adjoining ranch lands separated from each other by fences. Same-aged trees are much larger on the less-eroded ranch side of the fence.

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 highly 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. Among the major weeds are strawberry guava or waiawi (*Psidium cattleianum*), faya tree (*Morella faya*), Koster's curse or soapbush (*Clidemia hirta*), Asian melastome (*Melastoma candida*), christmasberry or Brazilian peppertree (*Schinus terebinthifolius*), kahili ginger or Kahila garland-lily (*Hedychium gardnerianum*), and introduced grasses. Guineagrass (*Urochloa maxima*) and kikuyugrass (*Pennisetum clandestinum*) grasslands become infested with unpalatable grasses, shrubs, and trees under improper management or abandonment.

State and transition model

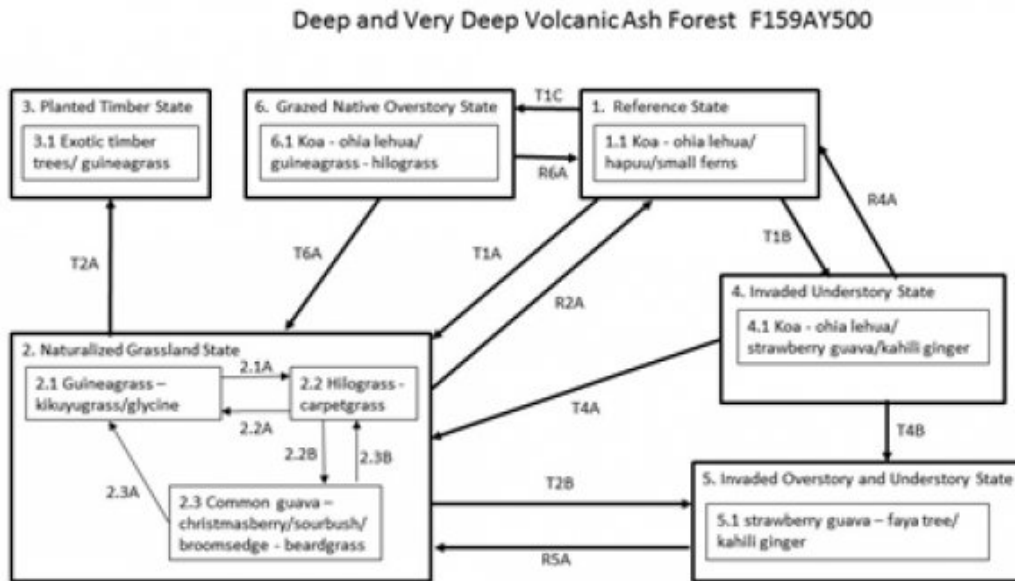


Figure 7. STM for F159AY500

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. State 1 will transition into State 2, Grassland State, by either active clearing by humans or by heavy foraging over time by feral ungulates. It can transition into State 4, Invaded Understory State, by gradual weed invasion, which is exacerbated by feral ungulates.

Community 1.1 Koa - `ohi`a lehua/hapu`u/small ferns



Figure 8. Reference Community Phase 12/06/08 D Clausnitzer MU956



Figure 9. Aerial view with recent lava flow 9/15/08 D Clausnitzer



Figure 10. View of the two upper strata 3/27/07 D Clausnitzer MU851



Figure 11. Within the tree fern stratum D Clausnitzer generic photo



Figure 12. The lowest stratum 3/27/07 D Clausnitzer MU851



Figure 13. The forest floor 1/5/10 D Clausnitzer generic photo



Figure 14. Forest floor close-up 9/14/09 D Clausnitzer generic photo



Figure 15. Heavy koa phyllode litter, Humuula Trail 9/14/09 D Clausnitzer generic photo



Figure 16. Downed tree 3/27/07 D Clausnitzer MU851



Figure 17. Young lava flow vegetation D Clausnitzer generic photo

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 are common both on the ground and on trees. All three Big Island tree fern species are present. These forests have standing live timber of 800 to 5700 cubic feet per acre, with a representative value of about 3000 cubic feet per acre. Typical low values are about 1500 cubic feet per acre. 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 25 feet (4 to 8 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. At forest edges near recent lava flows or in small kipukas, the plant communities have been seared by heat and, in some cases, burned by wildfires ignited by hot lava. Species richness and plant statures vary considerably in these locations. It is even possible to find two clear variations of the Reference Community present within one small kipuka. In general, these areas contain ohia lehua without koa, a sparse understory of kopiko, hapuu, small native ferns, and a scattering of other tree, shrub, and vine species. Plant statures across the board are smaller than those found in mature forest. Soils fall within the range of the soil series concept but may differ somewhat from the type location description.

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 secondary canopy contains about 15 tree species, the most common of which are kopiko or wild coffee (*Psychotria* spp.), hame (*Antidesma* spp.), olapa or olapalapa (*Cheirodendron trigynum*), kolea lau nui (*Myrsine lessertiana*), and pilo or woodland mirrorplant (*Coprosma rhynchocarpa*). The palm native to this ecological site, loulu or louulu (*Pritchardia lanigera*), is rare but may have been more abundant in the past.

The tertiary canopy 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. This canopy contains about 25 species of small trees.

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, about 8 small shrub species, about 11 forb species, about 5 vines (some prostrate, some climbing, some both), 3 common sedges, and over 30 species of ferns and fern allies.

Table 5. Soil surface cover

Tree basal cover	3-6%
Shrub/vine/liana basal cover	1-3%
Grass/grasslike basal cover	0-1%
Forb basal cover	0.1-1.0%
Non-vascular plants	5-10%
Biological crusts	0%
Litter	60-80%
Surface fragments >0.25" and <=3"	0-1%
Surface fragments >3"	0-1%
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)	1-3%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	1-3%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-1 per acre
Tree snag count** (hard***)	0-1 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%
>0.5 <= 1	0-1%	0-1%	0%	0%
>1 <= 2	0-1%	1-5%	0-1%	0-1%
>2 <= 4.5	0-1%	1-5%	–	–
>4.5 <= 13	3-10%	5-10%	–	–
>13 <= 40	60-90%	1-1%	–	–
>40 <= 80	20-80%	–	–	–
>80 <= 120	0-1%	–	–	–
>120	–	–	–	–

State 2

Naturalized Grassland State

The elevation range of the forest found in the Reference State does not coincide perfectly with the elevation range of the dominant grass species within the Grassland State. In some areas at the higher elevation range of this ecological site, kikuyugrass (*Pennisetum clandestinum*) replaces guineagrass as the dominant species. More detailed information, including forage production estimates, about these kikuyugrass grasslands can be found in Ecological Site Description F160XY502 Isomesic-Cool Isothermic 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). Guinea grass 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 18. Good condition guineagrass D Clausnitzer generic photo



Figure 19. Well-managed hilograss pasture Chinchuk Road 5/28/08 D Clausnitzer generic photo



Figure 20. Signalgrass pasture Chinchuk Road 5/28/08 D Clausnitzer generic photo

The dominant grass species in this pasture type is guineagrass that has volunteered or been seeded on old sugarcane plantations. In some higher elevation areas, kikuyugrass was planted and became naturalized.

Kikuyugrass spreads mostly by rhizomes and stolons. For further information about kikuyugrass production and management, please refer to Ecological Site Description F160XY502 Isomesic-Cool Isothermic Forest. Guinea grass 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.

Forest understory. Guinea grass 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 guinea grass 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 guinea grass stands by careful grazing management.

Table 8. Ground cover

Tree foliar cover	0-5%
Shrub/vine/liana foliar cover	1-3%
Grass/grasslike foliar cover	80-90%
Forb foliar cover	1-2%
Non-vascular plants	0%
Biological crusts	0%
Litter	25-35%
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 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%	1-5%	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 22. Overgrazed guineagrass with shorter species D Clausnitzer generic photo



Figure 23. Invaded by *Andropogon virginicus*, Kaiwiki soil D Clausnitzer 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 spikeseed (*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	30-50%
Forb basal cover	0.1-1.0%
Non-vascular plants	0.1-1.0%
Biological crusts	0%
Litter	40-60%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%

Water	0%
Bare ground	5-10%

Table 11. Woody ground cover

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

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

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

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

Table 12. Canopy structure (% cover)

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

Community 2.3

Common guava - christmasberry/sourbush/broomsedge - beardgrass



Figure 24. Overgrazed grassland with common guava D Clausnitzer generic photo

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 naturalized 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*) and West Indian raspberry or thimbleberry (*Rubus rosifolius*) form small thickets. Shrubs such as sourbush or cure for all (*Pluchea carolinensis*) and lantana (*Lantana camara*), along with small trees such as common guava (*Psidium guajava*), christmasberry or Brazilian peppertree (*Schinus terebinthifolius*), and fayatree or firetree (*Morella faya*) 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 13. Soil surface cover

Tree basal cover	0.0-0.1%
Shrub/vine/liana basal cover	0.1-1.0%
Grass/grasslike basal cover	30-40%
Forb basal cover	0.1-1.0%
Non-vascular plants	0.0-0.1%
Biological crusts	0%
Litter	40-50%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	10-20%

Table 14. 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%	0-1%	10-20%	1-2%
>1 <= 2	0%	0-1%	20-30%	1-2%
>2 <= 4.5	0-1%	5-10%	20-30%	3-5%
>4.5 <= 13	5-10%	1-2%	—	0-1%
>13 <= 40	—	—	—	—
>40 <= 80	—	—	—	—
>80 <= 120	—	—	—	—
>120	—	—	—	—

Pathway 2.1A Community 2.1 to 2.2



Guineagrass -
kikuyugrass/glycine

Hilograss - carpetgrass

Plant Community 2.1 degrades to Plant Community 2.2 by continuous grazing that weakens preferred grass species and legumes in relation to less-preferred forage species such as Hilograss, narrowleaf carpetgrass, and sedges.

Pathway 2.2A Community 2.2 to 2.1



Hilograss - carpetgrass

Guineagrass -
kikuyugrass/glycine

Plant Community 2.2 can be upgraded to Plant Community 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. Re-establishment of legume species may be needed if they have been eliminated.

Pathway 2.2B Community 2.2 to 2.3



Hilograss - carpetgrass

Common guava -
christmasberry/sourbush/broo
msedge - beardgrass

Plant Community 2.2 degrades to Plant Community 2.3 by long-term continuous grazing. Guineagrass cover is greatly reduced and largely replaced by low-value forage grasses. Weedy forbs such as spiny amaranth, introduced blackberries, and introduced shrubs such as sourbush increase in the low-stature grasses that come to dominate the interspaces between guineagrass clumps. Broomsedge and beardgrass can become the most abundant grass species.

Pathway 2.3A Community 2.3 to 2.1



Common guava -
christmasberry/sourbush/broo
msedge - beardgrass

Guineagrass -
kikuyugrass/glycine

Plant Community 2.3 can be upgraded to Plant Community 2.1 by a combination of weed control and prescribed grazing. Weeds such as alien 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 desirable grass species have reestablished adequately to support grazing. Thereafter, the grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

Pathway 2.3B Community 2.3 to 2.2



Common guava -
christmasberry/sourbush/broo
msedge - beardgrass



Hilograss - carpetgrass

Plant Community 2.3 can be upgraded to Plant Community 2.2 by controlling weedy forbs and shrubs with mowing and herbicides. Undesirable broomsedge and beardgrass can be reduced by mowing before seedset and by increasing soil pH by liming. Without a prescribed grazing plan, further improvement to Plant Community 2.1 should not be expected.

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. However, if native koa are planted and managed properly, future restoration in the direction of the Reference State would be facilitated. There also is the possibility that some introduced timber species may provide a favorable environment for eventual restoration of native species.

Community 3.1 Exotic timber trees/guineagrass



Figure 25. Eucalyptus with guineagrass understory, Hamakua mauka D
Clausnitzer generic photo



Figure 26. Eucalyptus with strawberry guava understory, Paauilo mauka 12/28/06 D Clausnitzer generic photo



Figure 27. Heavy eucalyptus litter, Hamakua mauka 3/29/10 D Clausnitzer generic photo

This community is typically managed in the long term for economic returns. Many introduced timber species grow extremely 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 the hybrid *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 macrophylla*), tropical ash or shamel ash (*Fraxinus uhdei*), 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 shade and the density and chemical composition of the tree litter. Strawberry guava can form dense stands beneath any timber species.

Table 15. Soil surface cover

Tree basal cover	4-5%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0.1-1.0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	85-90%
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 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)	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** (soft***)	

* 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 (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	0%	0%	0%
>0.5 <= 1	0%	0%	0%	0%
>1 <= 2	0%	0%	5-10%	0-1%
>2 <= 4.5	0-1%	0%	10-80%	0%
>4.5 <= 13	0-1%	–	–	–
>13 <= 40	0-1%	–	–	–
>40 <= 80	85-90%	–	–	–
>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 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 28. Strawberry guava understory 12/28/06 D Clausnitzer MU956

This community phase 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 somewhat diminished. Kopiko or wild coffee (*Psychotria* spp.) is 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*), traces of small kopiko, some peperomia (*Peperomia* spp.) at ground level, an occasional ieie vine (*Freydenetia 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 18. Soil surface cover

Tree basal cover	2-3%
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	5-10%
Biological crusts	0%
Litter	50-80%

Surface fragments >0.25" and <=3"	0.1-1.0%
Surface fragments >3"	0.1-1.0%
Bedrock	0%
Water	0%
Bare ground	5-10%

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)	2-5%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	0-1%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	
Tree snag count** (hard***)	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 20. Canopy structure (% cover)

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

Community 5.1 Strawberry guava - faya tree/kahili ginger



Figure 29. Strawberry guava stand with remnant hapuu 12/6/06 D Clausnitzer MU955



Figure 30. "Prison bar" strawberry guava infestation D Clausnitzer generic photo



Figure 31. Strawberry guava roots exposed by bulldozer D Clausnitzer generic photo



Figure 32. Closeup of exposed strawberry guava root system 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*) can potentially emerge through the canopy of moderate stature species.

A few remnant ohia lehua and koa trees often remain as emergents above the canopy of introduced species, but no seedling or saplings are likely to be survive.

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 21. Soil surface cover

Tree basal cover	1-4%
Shrub/vine/liana basal cover	0.1-1.0%
Grass/grasslike basal cover	0.0-0.1%
Forb basal cover	0.0-0.1%
Non-vascular plants	3-5%
Biological crusts	0%
Litter	70-90%
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 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)	0-0%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	0-0%
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.

State 6 Grazed Native Overstory State

This state consists of remnant native tree species forming an overstory with well-managed, relatively weed-free grasses. The overstory may have existed for some time, or may be in the process of forming where residual koa seeds are present in the soil.

Community 6.1 Koa - `ohi`a lehua/guineagrass - hilograss



Figure 33. Native overstory with grazed understory, Hamakua 3/21/08 D Clausnitzer MU970



**Figure 34. Young koa emerging through guineagrass, Paauilo mauka
12/28/06 D Clausnitzer MU961**



**Figure 35. Native akala invading kikuyu grassland Humuula Trail 9/14/09 D
Clausnitzer generic photo**

This community phase is not common, but it presents good opportunities for restoration of the Reference Community Phase, or a facsimile of it, where it exists. It typically occurs in two forms. The first is where grazing has maintained a non-weedy grass understory beneath a remnant overstory of native trees that has not yet begun to senesce. The second is in grasslands in which a residual seed bank of koa trees existed and cattle were not present to browse the emerging small koa. In the first form, careful grassland management maintained low weed densities on the site. In both forms, it is advantageous for restoration if neighboring sites do not support high weed densities. It also is advantageous if the grassland is dominated by shorter-statured species such as hilograss or common carpetgrass rather than guineagrass. In the second form, even tall guineagrass grasslands will eventually be invaded and dominated by introduced woody shrubs and trees.

Forest overstory. The forest overstory is variable, depending on the history of the site. It may consist of: large, scattered koa and/or ohia lehua trees; stands of varying sized trees in varying densities across the site, possibly with ohia lehua, koa, olapa, papala, hapuu, pilo, and other species typical of the Reference Community Phase; or, scattered young koa trees that have managed to germinate from the residual seed bank and emerge through the grass cover.

Forest understory. The understory consists primarily of the common dominant grass species from community phases 2.1 and 2.2 of this ecological site, primarily guineagrass, common carpetgrass, and hilograss. Regeneration of native trees is not possible until livestock have been removed.

Where lower-stature grasses such as common carpetgrass or hilograss are dominant, it is common to find native fern genera such as Diplazium and Dryopteris spreading through the understory and sometimes achieving high densities. Be careful not to confuse the native hoio or Hawaii twinsorus fern (*Diplazium sandwichianum*) with the introduced hoio (*Diplazium esculentum*).

Table 23. Soil surface cover

Tree basal cover	0.1-1.0%
Shrub/vine/liana basal cover	0.0-0.1%
Grass/grasslike basal cover	40-50%
Forb basal cover	0.1-1.0%
Non-vascular plants	0%
Biological crusts	0%
Litter	40-50%
Surface fragments >0.25" and <=3"	0.0-0.1%
Surface fragments >3"	0.0-0.1%
Bedrock	0%
Water	0%
Bare ground	1-5%

Table 24. 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)	–
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	–
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-2 per acre
Tree snag count** (soft***)	0-3 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 25. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-1%	40-60%	0-1%
>0.5 <= 1	–	0-1%	20-30%	0-1%
>1 <= 2	–	0-1%	10-15%	0-1%
>2 <= 4.5	–	0-1%	5-10%	–
>4.5 <= 13	–	–	–	–
>13 <= 40	1-5%	–	–	–
>40 <= 80	5-30%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Transition T1A State 1 to 2

State 1, Reference State, can be converted to State 2, Naturalized Grassland State, by clearing the forest with

heavy machinery. Most grasslands in this ecological site were originally cultivated for sugar cane and later converted to grassland. At the highest, coolest elevations of the ecological site, kikuyugrass and/or pangolagrass have been planted. At lower elevations where grasslands are on old sugarcane plantations, guineagrass (a former weed in the plantations) has volunteered and now dominates. Some grasslands may originally have been cleared by large numbers of feral and/or domestic livestock consuming the understory, including tree seedlings and saplings. This process would have left numerous large trees standing if not cut for timber. Large wildfires in the early 20th century also cleared some forest remnants.

Transition T1B

State 1 to 4

State 1, Reference State, can be converted to State 4, Invaded Understory State, by gradual replacement of the understory by shrubs, vines, grasses, and trees that outcompete the native understory species and hinder or prevent their reproduction. Some introduced vines can directly kill native plants, including large trees. This process is accelerated by ungulate foraging that helps introduced weed seeds, enhances weed germination by soil disturbance, and directly destroys native plants.

Transition T1C

State 1 to 6

This transition occurs by either clearing of native forest by machinery or gradual removal of native forest understory and elimination of native plant reproduction by long-term ungulate grazing.

Restoration pathway R2A

State 2 to 1

It may be possible to restore State 2, Naturalized Grassland State, to a plant community resembling State 1, Reference State, by intensive restoration practices followed by long-term maintenance. Control of grasses and any weeds currently in the grassland by mowing and herbicides must precede establishment of native species. Weed control would be a long-term process to maintain the site after establishment. Many weeds are shade-tolerant and would be able to invade the site even after canopy closure of native plants. Domestic and feral ungulates must be fenced out of the restoration site. However, managed grazing by domestic ungulates outside the fence would be useful to manage weedy vegetation outside the perimeter. Increasing shade from restored tree species may eventually cause a shift from C4 (warm-season) grass dominance (typically guineagrass or kikuyugrass) to C4 or C3 (cool-season) shade-tolerant grasses (typically meadow ricegrass, hilograss, or carpetgrass). This shade tolerant grass layer can be very dense and detrimental to establishment of native plants. Suppression of these grasses by herbicides and/or mulch (cardboard works well) until native plant litter begins to cover the grass.

Transition T2A

State 2 to 3

State 2, Naturalized Grassland State, may be converted to State 3, Planted Timber State, by controlling grasses and weedy shrubs by herbicides and/or mowing prior to and after planting of timber species (usually eucalyptus species).

Transition T2B

State 2 to 5

State 2, Naturalized Grassland State, may be converted to State 5, Invaded Overstory and Understory State, by abandonment. Common weed tree species are strawberry guava, christmasberry, faya tree, and common guava. Seeds of these species as well as weedy understory species are spread by mammals and birds.

Restoration pathway R4A

State 4 to 1

State 5, Invaded Understory State, may be restored to a plant community resembling State 1, Reference State. Before restoration of native understory plants, invasive understory plants must be eliminated by herbicide weed

control and brush management practices. Also, feral and domestic ungulates must be excluded from the restoration site by a fence, and any remaining ungulates within the fenced site must be eliminated. If feral pigs are present, an intensive, short-term program must be employed to eliminate their population; otherwise, their rate of increase will outpace control efforts. Key native plant species that have been eliminated or greatly reduced in numbers generally must be restored by replanting. Long-term maintenance of the site using herbicides, hand-weeding, mulching, and fence repair is required.

Transition T4A State 4 to 2

State 4, Invaded Understory State, can be converted to State 2, Naturalized Grassland State, Pasture by mechanical clearing of introduced plants and remnant native understory plants. Native overstory trees may be harvested for timber, knocked down and piled, or left to provide shade for livestock. If leaving large native trees for shade, care must be taken to not damage roots within about 20 feet (6 meters) of the trees. Introduced pasture grass species 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

State 4, Invaded Understory State, transitions to State 5, Invaded Overstory and Understory State, over time. The native ohia lehua and koa trees that remain in the overstory are unable to successfully regenerate in the shady and highly competitive environment of the weedy understory. Eventually the native overstory 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, followed by herbicide control of re-emerging invasive species. Introduced grasses may then be seeded or sprigged into the site. Herbicide applications, mowing, and careful grazing practices will be necessary during and after pasture establishment to control reemerging weed species.

Restoration pathway R6A State 6 to 1

This restoration occurs by removal of ungulates from the site, eventual removal of forage grasses by mowing, mulching, and herbicide application, replanting native species, and eventual natural reproduction by native species.

Transition T6A State 6 to 2

This transition occurs either by elimination of native tree reproduction by long-term ungulate grazing or by weed invasion of abandoned sites.

Additional community tables

Table 26. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
'ohi'a lehua	MEPO5	<i>Metrosideros polymorpha</i>	Native	75–100	10–80	24–40	–
koa	ACKO	<i>Acacia koa</i>	Native	80–100	0–80	24–48	–
olapalapa	CHTR2	<i>Cheirodendron trigynum</i>	Native	25–30	3–10	–	–
kolea lau nui	MYLE2	<i>Myrsine lessertiana</i>	Native	25–30	1–5	–	–
woodland mirrorplant	CORH	<i>Coprosma rhynchocarpa</i>	Native	16–20	1–5	–	–
wild coffee	PSYCH	<i>Psychotria</i>	Native	20–25	1	–	–
olapalapa	CHTR2	<i>Cheirodendron trigynum</i>	Native	35–40	0.1–1	–	–
Hawai'i holly	ILAN	<i>Ilex anomala</i>	Native	35–40	0.1–1	–	–
'ohi'a lehua	MEPO5	<i>Metrosideros polymorpha</i>	Native	30–40	0–0.1	–	–
koa	ACKO	<i>Acacia koa</i>	Native	35–40	0–0.1	–	–
Tree Fern							
hapu'u	CIGL	<i>Cibotium glaucum</i>	Native	15–20	30–50	–	–
hapu'u li	CIME8	<i>Cibotium menziesii</i>	Native	15–20	5–15	–	–
hapu'u	CIGL	<i>Cibotium glaucum</i>	Native	25–30	3–5	–	–
hapu'u li	CIME8	<i>Cibotium menziesii</i>	Native	25–30	1–3	–	–
Chamisso's manfern	CICH	<i>Cibotium chamissoi</i>	Native	15–20	0.1–1	–	–
Chamisso's manfern	CICH	<i>Cibotium chamissoi</i>	Native	25–30	0–0.1	–	–

Table 27. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
korthal mistletoe	KORTH	<i>Korthalsella</i>	Native	0.5–1	0.1–1
Oahu sedge	CAWA	<i>Carex wahuensis</i>	Native	0.5–1	0.1–1
Hawai'i sedge	CAAL12	<i>Carex alligata</i>	Native	1–2	0.1–1
Hawai'i birdcatching sedge	UNUN	<i>Uncinia uncinata</i>	Native	0.5–1	0.1–1
Forb/Herb					
Hawai'i twinsorus fern	DISA3	<i>Diplazium sandwichianum</i>	Native	2–3	1–2
bog stenogyne	STCA9	<i>Stenogyne calaminthoides</i>	Native	0.5–1	0.1–1
peperomia	PEPER	<i>Peperomia</i>	Native	0.5–1	0.1–1
pua'akuhinia	ASME4	<i>Astelia menziesiana</i>	Native	0.5–1	0.1–1
Hawai'i pokeweed	PHSA2	<i>Phytolacca sandwicensis</i>	Native	1–2	0–0.1
Hawai'i stenogyne	STMA3	<i>Stenogyne macrantha</i>	Native	0.5–1	0–0.1
mohihi	STSC4	<i>Stenogyne scrophularioides</i>	Native	0.5–1	0–0.1
Hawai'i phyllostegia	PHFL6	<i>Phyllostegia floribunda</i>	Native	0.5–1	0–0.1
kiponapona	PHRA6	<i>Phyllostegia racemosa</i>	Native	0.5–1	0–0.1
streambed phyllostegia	PHVE4	<i>Phyllostegia vestita</i>	Native	0.5–1	0–0.1
Laupahoehoe phyllostegia	PHWA3	<i>Phyllostegia warshaueri</i>	Native	0.5–1	0–0.1

'ohe	JOAS	<i>Joinvillea ascendens</i>	Native	1–2	0–0.1
Fern/fern ally					
alpine woodfern	DRWA	<i>Dryopteris wallichiana</i>	Native	1–2	1–5
akolea	ATMI	<i>Athyrium microphyllum</i>	Native	1–2	1–3
sadleria	SADLE	<i>Sadleria</i>	Native	1–3	0.1–1
graceful kihifern	ADPI	<i>Adenophorus pinnatifidus</i>	Native	0.5–1	0.1–1
wahini noho mauna	ADTA	<i>Adenophorus tamariscinus</i>	Native	0.5–1	0.1–1
fringed spleenwort	ASSC8	<i>Asplenium schizophyllum</i>	Native	0.5–1	0.1–1
Hawai'i woodfern	DRHA	<i>Dryopteris hawaiiensis</i>	Native	1–2	0.1–1
Pacific woodfern	DRSA	<i>Dryopteris sandwicensis</i>	Native	2–3	0.1–1
onetooth woodfern	DRUN	<i>Dryopteris unidentata</i>	Native	1–2	0.1–1
kolokolo	GRTE	<i>Grammitis tenella</i>	Native	0.5–1	0.1–1
weeping fern	LETH6	<i>Lepisorus thunbergianus</i>	Native	0.5–1	0.1–1
loulou	COPI3	<i>Coniogramme pilosa</i>	Native	0.5–1	0.1–1
Old World forkedfern	DILI	<i>Dicranopteris linearis</i>	Native	3–6	0.1–1
Cretan brake	PTCR2	<i>Pteris cretica</i>	Native	0.5–1	0.1–1
waimakanui	PTEX	<i>Pteris excelsa</i>	Native	0.5–1	0.1–1
Hawai'i umbrella fern	STOW	<i>Sticherus owhyensis</i>	Native	1–5	0.1–1
palapalai	MIST4	<i>Microlepia strigosa</i>	Native	1–2	0.1–1
spleenwort	ASPLE	<i>Asplenium</i>	Native	1–3	0.1–1
rainforest spleenwort	ASNO4	<i>Asplenium normale</i>	Native	1–2	0.1–1
royal tonguefern	ELCR2	<i>Elaphoglossum crassifolium</i>	Native	0.5–1	0.1–1
ekaha	ELHI3	<i>Elaphoglossum hirtum</i>	Native	0.5–1	0.1–1
island lacefern	NORU	<i>Nothoperanema rubiginosum</i>	Native	1–2	0.1–1
Old World adderstongue	OPPEP	<i>Ophioglossum pendulum ssp. pendulum</i>	Native	0.5–1	0.1–1
Hawai'i air fern	PNSA	<i>Pneumatopteris sandwicensis</i>	Native	1–2	0.1–1
ohiaku	HYRE	<i>Hymenophyllum recurvum</i>	Native	0.2–0.5	0.1–1
Boston swordfern	NEEX	<i>Nephrolepis exaltata</i>	Native	1–2	0.1–1
flatfork fern	PSCO3	<i>Psilotum complanatum</i>	Native	0.5–1	0.1–0.2
vandenboschia	VANDE	<i>Vandenboschia</i>	Native	0.2–0.5	0.1–0.2
scrambling fern	DIPI3	<i>Diplopterygium pinnatum</i>	Native	1–5	0–0.1
whisk fern	PSNU	<i>Psilotum nudum</i>	Native	0.5–1	0.1
western brackenfern	PTAQ	<i>Pteridium aquilinum</i>	Native	1–2	0–0.1
Chinese creepingfern	ODCH	<i>Odontosoria chinensis</i>	Native	1–2	0–0.1
Hawai'i potato fern	MADO	<i>Marattia douglasii</i>	Native	1–2	–
Shrub/Subshrub					
kanawao	BRAR6	<i>Broussaisia arguta</i>	Native	3–8	3–8
Waimea pipturus	PIAL2	<i>Pipturus albidus</i>	Native	4–8	0.1–1
'ilihia	CYPL5	<i>Cyrtandra platyphylla</i>	Native	2–3	0–1
cyrtandra	CYRTA	<i>Cyrtandra</i>	Native	1–3	0–1
ohelo kau la'au	VACA8	<i>Vaccinium calycinum</i>	Native	2–4	0.1–1
naupaka kuahiwi	SCCH3	<i>Scaevola chamissoniana</i>	Native	2–3	0.1–1
pukiawe	STTA	<i>Styphelia tameiameia</i>	Native	2–5	0–0.1
leaves of the forest	TROR6	<i>Troriphaea</i>	Native	5–8	0–0.1

largeflower raise lobelia	TRGR6	<i>Trematolobelia grandifolia</i>	Native	5-6	0-0.1
small treefern	CYPA7	<i>Cyathea parvula</i>	Native	5-6	0-0.1
'aku 'aku	CYTR6	<i>Cyanea tritomantha</i>	Native	5-6	0-0.1
Laupahoehoe cyrtandra	CYTI	<i>Cyrtandra tintinnabula</i>	Native	2-3	0-0.1
forest cyrtandra	CYGI3	<i>Cyrtandra giffardii</i>	Native	1-2	0-0.1
anini	EUSA6	<i>Eurya sandwicensis</i>	Native	2-4	0-0.1
au	HEAC3	<i>Hedyotis acuminata</i>	Native	2-3	0-0.1
paleflower labordia	LATI2	<i>Labordia tinifolia</i>	Native	2-3	0-0.1
hillside clermontia	CLLI3	<i>Clermontia lindseyana</i>	Native	5-6	0-0.1
smallflower clermontia	CLPA8	<i>Clermontia parviflora</i>	Native	5-6	0-0.1
pele clermontia	CLPE2	<i>Clermontia peleana</i>	Native	5-6	0-0.1
clermontia	CLERM	<i>Clermontia</i>	Native	5-6	0-0.1
Hawai'i mirrorplant	COCY3	<i>Coprosma cymosa</i>	Native	3-4.5	0-0.1
'ilihia	CYPL5	<i>Cyrtandra platyphylla</i>	Native	4-5	0-0.1
Tree					
olapalapa	CHTR2	<i>Cheirodendron trigynum</i>	Native	10-13	1
olapalapa	CHTR2	<i>Cheirodendron trigynum</i>	Native	3-4.5	1
wild coffee	PSYCH	<i>Psychotria</i>	Native	10-13	1
papala	CHARP	<i>Charpentiera</i>	Native	3-4.5	0-1
woodland mirrorplant	CORH	<i>Coprosma rhynchocarpa</i>	Native	10-13	1
ha'a	ANPL2	<i>Antidesma platyphyllum</i>	Native	3-4.5	0-1
hopue	URGL	<i>Urera glabra</i>	Native	15-20	0.1-1
wild coffee	PSYCH	<i>Psychotria</i>	Native	3-4.5	0.1-1
manono	HEHI8	<i>Hedyotis hillebrandii</i>	Native	10-13	0.1-1
variable starviolet	HETE21	<i>Hedyotis terminalis</i>	Native	8-12	0.1-1
olomea	PESA3	<i>Perrottetia sandwicensis</i>	Native	3-4.5	0.1-1
olomea	PESA3	<i>Perrottetia sandwicensis</i>	Native	12-16	1
olomea	PESA3	<i>Perrottetia sandwicensis</i>	Native	8-12	0.1-1
Hawai'i holly	ILAN	<i>Ilex anomala</i>	Native	10-13	0.1-1
kolea lau nui	MYLE2	<i>Myrsine lessertiana</i>	Native	10-13	0.1-1
hame	ANPU2	<i>Antidesma pulvinatum</i>	Native	3-4.5	0-1
ha'a	ANPL2	<i>Antidesma platyphyllum</i>	Native	10-13	0.1-1
hame	ANPU2	<i>Antidesma pulvinatum</i>	Native	10-13	0.1-1
papala	CHARP	<i>Charpentiera</i>	Native	10-13	0.1-1
woodland mirrorplant	CORH	<i>Coprosma rhynchocarpa</i>	Native	3-4.5	0.1-1
neneleau	RHSA2	<i>Rhus sandwicensis</i>	Native	10-13	0-0.1
kolea lau nui	MYLE2	<i>Myrsine lessertiana</i>	Native	3-4.5	0.1
Hawai'i holly	ILAN	<i>Ilex anomala</i>	Native	3-4.5	0-0.1
Remy's gardenia	GARE	<i>Gardenia remyi</i>	Native	10-13	0-0.1
kapu melicope	MERA2	<i>Melicope radiata</i>	Native	9-12	0-0.1
lo'ulu	PRLA4	<i>Pritchardia lanigera</i>	Native	22-25	0-0.1
kokea lau li'i	MYSA2	<i>Myrsine sandwicensis</i>	Native	5-8	0-0.1
island yellowwood	OCHA	<i>Ochrosia haleakalae</i>	Native	7-10	0-0.1
aulu	PISA5	<i>Pisonia sandwicensis</i>	Native	10-15	0-0.1

Hawai'i pilo kea	PLRE4	<i>Platydesma remyi</i>	Native	8–12	0–0.1
manono	HEHI8	<i>Hedyotis hillebrandii</i>	Native	3–4.5	–
'ohi'a lehua	MEPO5	<i>Metrosideros polymorpha</i>	Native	3–4.5	–
variable starviolet	HETE21	<i>Hedyotis terminalis</i>	Native	3–4.5	–
koa	ACKO	<i>Acacia koa</i>	Native	10–13	–
koa	ACKO	<i>Acacia koa</i>	Native	3–4.5	–
'ohi'a lehua	MEPO5	<i>Metrosideros polymorpha</i>	Native	10–13	–
Tree Fern					
hapu'u	CIGL	<i>Cibotium glaucum</i>	Native	10–15	15–40
hapu'u li	CIME8	<i>Cibotium menziesii</i>	Native	10–15	2–10
hapu'u	CIGL	<i>Cibotium glaucum</i>	Native	2–5	1–3
hapu'u li	CIME8	<i>Cibotium menziesii</i>	Native	2–5	0.1–1
Chamisso's manfern	CICH	<i>Cibotium chamissoi</i>	Native	10–15	0–0.1
Vine/Liana					
'ie'ie	FRAR	<i>Freycinetia arborea</i>	Native	1–40	1–3
Hawai'i blackberry	RUHA	<i>Rubus hawaiensis</i>	Native	2–4	0.1–1
Hawai'i greenbrier	SMME	<i>Smilax melastomifolia</i>	Native	1–30	0.1–1
Maile	ALST11	<i>Alyxia stellata</i>	Native	1–15	0.1–1
kilioe	EMPA	<i>Embelia pacifica</i>	Native	1–6	0–0.1

Table 28. 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			11900–14000	
	guineagrass	URMA3	<i>Urochloa maxima</i>	11900–14000	–
	elephant grass	PEPU2	<i>Pennisetum purpureum</i>	0–140	–
2	Naturalized Warm Season Midgrasses			0–140	
	kikuyugrass	PECL2	<i>Pennisetum clandestinum</i>	0–300	–
	Colombian bluestem	SCCO10	<i>Schizachyrium condensatum</i>	0–140	–
	smut grass	SPIN4	<i>Sporobolus indicus</i>	0–140	–
	broomsedge bluestem	ANVI2	<i>Andropogon virginicus</i>	0–140	–
	Rhodes grass	CHGA2	<i>Chloris gayana</i>	0–140	–
	hairy crabgrass	DISA	<i>Digitaria sanguinalis</i>	0–140	–
	East Indian crabgrass	DISE6	<i>Digitaria setigera</i>	0–140	–
	Indian goosegrass	ELIN3	<i>Eleusine indica</i>	0–140	–
	shortleaf spikeseedge	KYBR	<i>Kyllinga brevifolia</i>	0–140	–
	rose Natal grass	MERE9	<i>Melinis repens</i>	0–140	–
	hilograss	PACO14	<i>Paspalum conjugatum</i>	0–140	–
	Vasey's grass	PAUR2	<i>Paspalum urvillei</i>	0–140	–
Forb					
3	Naturalized Forbs			140–700	
	threeflower ticktrefoil	DETR4	<i>Desmodium triflorum</i>	140–420	–
	perennial soybean	NEWI2	<i>Neonotonia wightii</i>	140–420	–
	common sowthistle	SOOL	<i>Sonchus oleraceus</i>	0–140	–
	spiny amaranth	AMSP	<i>Amaranthus spinosus</i>	0–140	–
	sensitive partridge pea	CHNI2	<i>Chamaecrista nictitans</i>	0–140	–
	smooth rattlebox	CRPAO	<i>Crotalaria pallida var. obovata</i>	0–140	–
	lilac tasselflower	EMSO	<i>Emilia sonchifolia</i>	0–140	–
	Christmas candlestick	LENE	<i>Leonotis nepetifolia</i>	0–140	–
	shameplant	MIPU8	<i>Mimosa pudica</i>	0–140	–
Shrub/Vine					
4	Naturalized Shrubs and Small Trees			140–700	
	anil de pasto	INSU	<i>Indigofera suffruticosa</i>	140–420	–
	threelobe false mallow	MACO6	<i>Malvastrum coromandelianum</i>	0–140	–
	cure for all	PLCA10	<i>Pluchea carolinensis</i>	0–140	–
	guava	PSGU	<i>Psidium guajava</i>	0–140	–
	castorbean	RICO3	<i>Ricinus communis</i>	0–140	–
	Brazilian peppertree	SCTE	<i>Schinus terebinthifolius</i>	0–140	–
	balloonplant	ASPH2	<i>Asclepias physocarpa</i>	0–140	–

Table 29. Community 2.2 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
hilograss	PACO14	<i>Paspalum conjugatum</i>	Introduced	0.5–1	15–25
guineagrass	URMA3	<i>Urochloa maxima</i>	Introduced	2–4	15–25

common carpetgrass	AXFI	<i>Axonopus fissifolius</i>	Introduced	0.5–1	15–25
broomsedge bluestem	ANVI2	<i>Andropogon virginicus</i>	Introduced	1–2	3–10
Colombian bluestem	SCCO10	<i>Schizachyrium condensatum</i>	Introduced	1–2	1–10
marsh bristlegrass	SEPA10	<i>Setaria parviflora</i>	Introduced	0.5–1	1–10
shortleaf spikeseedge	KYBR	<i>Kyllinga brevifolia</i>	Introduced	0.5–1	1–5
rose Natal grass	MERE9	<i>Melinis repens</i>	Introduced	0.5–1	0.1–1
Vasey's grass	PAUR2	<i>Paspalum urvillei</i>	Introduced	2–3	0.1–1
kikuyugrass	PECL2	<i>Pennisetum clandestinum</i>	Introduced	0.5–1	0.1–1
Rhodes grass	CHGA2	<i>Chloris gayana</i>	Introduced	0.5–2	0.1–1
hairy crabgrass	DISA	<i>Digitaria sanguinalis</i>	Introduced	0.5–1	0.1–1
East Indian crabgrass	DISE6	<i>Digitaria setigera</i>	Introduced	0.5–1	0.1–1
Indian goosegrass	ELIN3	<i>Eleusine indica</i>	Introduced	0.5–1	0.1–1
smut grass	SPIN4	<i>Sporobolus indicus</i>	Introduced	0.5–1	0.1–1
wild sugarcane	SASP	<i>Saccharum spontaneum</i>	Introduced	3–6	0–0.1
Forb/Herb					
climbing dayflower	CODI5	<i>Commelina diffusa</i>	Introduced	0.5–1	0.1–1
smooth rattlebox	CRPAO	<i>Crotalaria pallida</i> var. <i>obovata</i>	Introduced	1–2	0.1–1
lilac tasselflower	EMSO	<i>Emilia sonchifolia</i>	Introduced	1–2	0.1–1
common sowthistle	SOOL	<i>Sonchus oleraceus</i>	Introduced	1–2	0.1–1
threelobe false mallow	MACO6	<i>Malvastrum coromandelianum</i>	Introduced	1–2	0.1–1
balloonplant	ASPH2	<i>Asclepias physocarpa</i>	Introduced	2–3	0.1–1
sensitive partridge pea	CHNI2	<i>Chamaecrista nictitans</i>	Introduced	0.5–1	0.1–1
shameplant	MIPU8	<i>Mimosa pudica</i>	Introduced	0.5–1	0.1–1
Christmas candlestick	LENE	<i>Leonotis nepetifolia</i>	Native	1–2	0.1–1
spiny amaranth	AMSP	<i>Amaranthus spinosus</i>	Introduced	1–2	0.1–1
threeflower ticktrefoil	DETR4	<i>Desmodium triflorum</i>	Introduced	–	0–0.1
spreading snakeroot	AGRI2	<i>Ageratina riparia</i>	Introduced	0.5–1	0–0.1
Fern/fern ally					
scaly swordfern	NEHI	<i>Nephrolepis hirsutula</i>	Introduced	1–2	0.1–1
western brackenfern	PTAQ	<i>Pteridium aquilinum</i>	Native	1–2	0–0.1
Old World forkedfern	DILI	<i>Dicranopteris linearis</i>	Native	0.5–2	0–0.1
Shrub/Subshrub					
cure for all	PLCA10	<i>Pluchea carolinensis</i>	Introduced	1–4	0.1–1
anil de pasto	INSU	<i>Indigofera suffruticosa</i>	Introduced	1–2	0.1–1
castorbean	RICO3	<i>Ricinus communis</i>	Introduced	2–5	0.1–1
Tree					
guava	PSGU	<i>Psidium guajava</i>	Introduced	2–4.5	0.1–1
Brazilian peppertree	SCTE	<i>Schinus terebinthifolius</i>	Introduced	2–5	0.1–1
African tuliptree	SPCA2	<i>Spathodea campanulata</i>	Introduced	2–3	0–0.1
firetree	MOFA	<i>Morella faya</i>	Introduced	1–4	0–0.1
octopus tree	SCAC2	<i>Schefflera actinophylla</i>	Introduced	1–2	0–0.1
peacocksplume	FAMO	<i>Falcataria moluccana</i>	Introduced	2–4	0–0.1
Vine/Liana					

sawtooth blackberry	RUAR2	<i>Rubus argutus</i>	Introduced	1–4	0.1–1
West Indian raspberry	RURO	<i>Rubus rosifolius</i>	Introduced	1–4	0.1–1

Table 30. Community 2.3 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
common carpetgrass	AXFI	<i>Axonopus fissifolius</i>	Introduced	0.5–1	15–25
hilograss	PACO14	<i>Paspalum conjugatum</i>	Introduced	0.5–1	15–25
broomsedge bluestem	ANVI2	<i>Andropogon virginicus</i>	Introduced	1–3	5–15
Colombian bluestem	SCCO10	<i>Schizachyrium condensatum</i>	Introduced	1–3	5–15
marsh bristlegrass	SEPA10	<i>Setaria parviflora</i>	Introduced	1–2	1–5
guineagrass	URMA3	<i>Urochloa maxima</i>	Introduced	2–4	1–5
shortleaf spikeseedge	KYBR	<i>Kyllinga brevifolia</i>	Introduced	0.5–1	1–5
smut grass	SPIN4	<i>Sporobolus indicus</i>	Introduced	0.5–1	0.1–1
rose Natal grass	MERE9	<i>Melinis repens</i>	Introduced	1–2	0.1–1
Rhodes grass	CHGA2	<i>Chloris gayana</i>	Introduced	1–2	0.1–1
hairy crabgrass	DISA	<i>Digitaria sanguinalis</i>	Introduced	1–2	0.1–1
East Indian crabgrass	DISE6	<i>Digitaria setigera</i>	Introduced	1–2	0.1–1
Indian goosegrass	ELIN3	<i>Eleusine indica</i>	Introduced	0.5–1	0.1–1
Vasey's grass	PAUR2	<i>Paspalum urvillei</i>	Introduced	2–3	0.1–1
Forb/Herb					
spiny amaranth	AMSP	<i>Amaranthus spinosus</i>	Introduced	2–4	1–5
spreading snakeroot	AGRI2	<i>Ageratina riparia</i>	Introduced	0.5–2	0.1–1
balloonplant	ASPH2	<i>Asclepias physocarpa</i>	Introduced	2–4.5	0.1–1
sensitive partridge pea	CHNI2	<i>Chamaecrista nictitans</i>	Native	0.1–0.5	0.1–1
shameplant	MIPU8	<i>Mimosa pudica</i>	Introduced	0.1–0.5	0.1–1
climbing dayflower	CODI5	<i>Commelina diffusa</i>	Native	0.2–0.5	0.1–1
smooth rattlebox	CRPAO	<i>Crotalaria pallida</i> var. <i>obovata</i>	Native	0.5–3	0.1–1
lilac tasselflower	EMSO	<i>Emilia sonchifolia</i>	Introduced	0.5–2	0.1–1
common sowthistle	SOOL	<i>Sonchus oleraceus</i>	Introduced	0.5–2	0.1–1
threelobe false mallow	MACO6	<i>Malvastrum coromandelianum</i>	Native	2–4	0.1–1
Christmas candlestick	LENE	<i>Leonotis nepetifolia</i>	Introduced	1–2	0.1–1
Fern/fern ally					
scaly swordfern	NEHI	<i>Nephrolepis hirsutula</i>	Introduced	0.5–2	0.1–1
Shrub/Subshrub					
cure for all	PLCA10	<i>Pluchea carolinensis</i>	Introduced	2–5	3–5
lantana	LACA2	<i>Lantana camara</i>	Introduced	1–4.5	3–5
castorbean	RICO3	<i>Ricinus communis</i>	Introduced	3–5	0.1–1
Tree					
guava	PSGU	<i>Psidium guajava</i>	Introduced	4.5–8	5–10
firetree	MOFA	<i>Morella faya</i>	Introduced	2–12	1–5
guava	PSGU	<i>Psidium guajava</i>	Introduced	1–4.5	1–2
firetree	MOFA	<i>Morella faya</i>	Introduced	2–6	0.1–1
octopus tree	SCAC2	<i>Schefflera actinophylla</i>	Introduced	1–4.5	0.1–1

peacocksplume	FAMO	<i>Falcataria moluccana</i>	Introduced	4–6	0.1–1
Brazilian peppertree	SCTE	<i>Schinus terebinthifolius</i>	Introduced	2–4.5	0.1–1
Brazilian peppertree	SCTE	<i>Schinus terebinthifolius</i>	Introduced	4.5–10	0.1–1
African tuliptree	SPCA2	<i>Spathodea campanulata</i>	Introduced	4–7	0.1–1
small Philippine acacia	ACCO	<i>Acacia confusa</i>	Introduced	5–7	0.1–1
Vine/Liana					
sawtooth blackberry	RUAR2	<i>Rubus argutus</i>	Introduced	2–5	0.1–1
West Indian raspberry	RURO	<i>Rubus rosifolius</i>	Introduced	2–5	0.1–1

Table 31. 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	<i>Eucalyptus</i>	Introduced	70–90	85–90	–	–

Table 32. Community 3.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
guineagrass	URMA3	<i>Urochloa maxima</i>	Introduced	1–4	20–80
weeping grass	MIST	<i>Microlaena stipoides</i>	Introduced	0.5–1	0.1–1
hilograss	PACO14	<i>Paspalum conjugatum</i>	Introduced	0.5–1	0.1–1
Forb/Herb					
Kahila garland-lily	HEGA	<i>Hedychium gardnerianum</i>	Introduced	2–4	0–0.1
Fern/fern ally					
scaly swordfern	NEHI	<i>Nephrolepis hirsutula</i>	Introduced	1–2	0.1–1
Shrub/Subshrub					
soapbush	CLHI3	<i>Clidemia hirta</i>	Introduced	1–2	0–0.1
Tree					
strawberry guava	PSCA	<i>Psidium cattleianum</i>	Introduced	2–10	0–0.1
Vine/Liana					
West Indian raspberry	RURO	<i>Rubus rosifolius</i>	Introduced	1–2	0–0.1

Table 33. 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	<i>Psidium cattleianum</i>	Introduced	20–30	25–40	–	–
strawberry guava	PSCA	<i>Psidium cattleianum</i>	Introduced	5–13	10–20	–	–
'ohi'a lehua	MEPO5	<i>Metrosideros polymorpha</i>	Native	40–70	5–15	20–30	–
koa	ACKO	<i>Acacia koa</i>	Native	40–70	5–15	20–30	–
strawberry guava	PSCA	<i>Psidium cattleianum</i>	Introduced	2–4.5	3–6	–	–
wild coffee	PSYCH	<i>Psychotria</i>	Native	20–30	0.1–1	–	–
wild coffee	PSYCH	<i>Psychotria</i>	Native	2–4.5	0–0.1	–	–
fig	FICUS	<i>Ficus</i>	Introduced	0.5–4.5	0–0.1	–	–
fig	FICUS	<i>Ficus</i>	Introduced	30–70	–	–	–
Tree Fern							
hapu'u	CIGL	<i>Cibotium glaucum</i>	Native	5–14	0.1–1	–	–
hapu'u li	CIME8	<i>Cibotium menziesii</i>	Native	5–14	0–1	–	–
Cooper's cyathea	CYCO18	<i>Cyathea cooperi</i>	Introduced	5–10	0–0.1	–	–

Table 34. Community 4.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
common carpetgrass	AXFI	<i>Axonopus fissifolius</i>	Introduced	0.5–1	0.1–1
weeping grass	MIST	<i>Microlaena stipoides</i>	Introduced	0.5–2	0.1–1
palmgrass	SEPA6	<i>Setaria palmifolia</i>	Introduced	0.5–2	0–0.1
Forb/Herb					
Kahila garland-lily	HEGA	<i>Hedychium gardnerianum</i>	Introduced	2–4.5	0.1–1
dotted smartweed	POPU5	<i>Polygonum punctatum</i>	Introduced	0.5–2	0.1–1
peperomia	PEPER	<i>Peperomia</i>	Native	0.5–1	0–0.1
Fern/fern ally					
weeping fern	LETH6	<i>Lepisorus thunbergianus</i>	Native	0.5–1	0–0.1
whisk fern	PSNU	<i>Psilotum nudum</i>	Native	0.5–1	0–0.1
Old World forkedfern	DILI	<i>Dicranopteris linearis</i>	Native	1–2	0–0.1
Shrub/Subshrub					
soapbush	CLHI3	<i>Clidemia hirta</i>	Introduced	2–4.5	0.1–1
Vine/Liana					
'ie'ie	FRAR	<i>Freycinetia arborea</i>	Native	0.5–1	0–0.1

Table 35. Community 6.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
'ohi'a lehua	MEPO5	<i>Metrosideros polymorpha</i>	Native	40–70	5–20	–	–
koa	ACKO	<i>Acacia koa</i>	Native	40–60	5–20	–	–
neneleau	RHSA2	<i>Rhus sandwicensis</i>	Native	8–15	1–2	–	–
koa	ACKO	<i>Acacia koa</i>	Native	13–20	0–0.1	–	–
'ohi'a lehua	MEPO5	<i>Metrosideros polymorpha</i>	Native	13–20	0–0.1	–	–

Table 36. Community 6.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
guineagrass	URMA3	<i>Urochloa maxima</i>	Introduced	2–4	50–90
hilograss	PACO14	<i>Paspalum conjugatum</i>	Introduced	0.5–1	20–60
weeping grass	MIST	<i>Microlaena stipoides</i>	Introduced	0.5–1	5–30
kikuyugrass	PECL2	<i>Pennisetum clandestinum</i>	Introduced	1–2	5–20
common carpetgrass	AXFI	<i>Axonopus fissifolius</i>	Introduced	0.5–1	0.1–1
Fern/fern ally					
alpine woodfern	DRWA	<i>Dryopteris wallichiana</i>	Native	1–2	0.1–1
Vine/Liana					
sawtooth blackberry	RUAR2	<i>Rubus argutus</i>	Introduced	2–4	0.1–1
West Indian raspberry	RURO	<i>Rubus rosifolius</i>	Introduced	2–4	0.1–1

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 hawaiiensis*), 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 guineagrass. For kikuyugrass pastures on this ecological site, refer to grazing interpretations in Ecological Site Description F160XY502 Isomesic-Cool Isothermic 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 community phase 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 0.20-0.22 acre/AUM 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-+ acre/AUM 2.56-+ AUM/acre

(note 1) The Forage Value Rating System is not an ecological evaluation of community phase 2.1. It is a utilitarian rating of the existing forage value for that specific plant community.

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

(note 3) Stocking rates vary in accordance with such factors as kind and class of livestock or wildlife, season of use, harvest efficiency 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. However, this site is best utilized for grazing during the major plant growth period described in the “Climate” section. 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 community phase 2.1 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 and Hawaii Volcanoes National Park. 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 not available for Hawaiian forests, as tropical trees 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.

In Reference State native forests, estimates of standing timber ranged from 800 to 2000 cubic feet per acre for ohia lehua and 1500 to 3700 cubic feet per acre for koa.

Other products

The Reference State can provide limited harvests of maile (*Alyxia stellata*; syn. *A. oliviformis*) 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 of 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.

Torrific 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.

Inventory data references

Type locality

Location 1: Hawaii County, HI	
Latitude	19° 55' 59"
Longitude	155° 17' 25"

General legal description	Hawaii County, Island of Hawaii, USGS Quad: Keanakolu. From main (highest) Laupahoehoe Natural Area Reserve gate, drive mauka 2.5 miles. Walk W 100 yards 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:**
