Natural Resources
Conservation Service

Ecological site VX161B01X503
Ustic Isomesic Forest

Accessed: 04/24/2024

General information

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

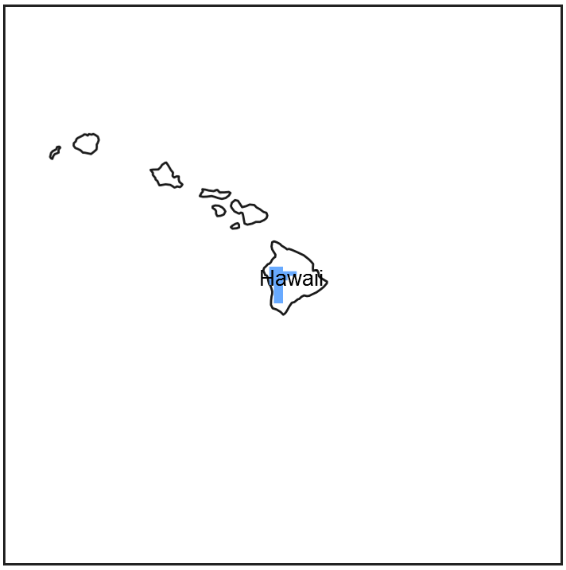

Figure 1. Mapped extent

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

MLRA notes

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

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

Classification relationships

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

Ecological site concept

This ecological site moderately dry koa/mamane forest that runs most of the length of the Kona coast at high elevations from the north-facing slopes of Hualalai southward to Hawaiian Ocean View Estates in South Kona. Much of the area is private land, with large areas held by Kamehameha Schools, the State of Hawaii, The Nature Conservancy, and the Federal government. Much of this ecological site is used for livestock grazing. There is no public road access.

The central concept of the Ustic Isomesic Forest is of well to somewhat excessively drained, very shallow to very deep soils formed in deposits of highly decomposed plant material or volcanic ash, either of which may be found over pahoehoe (flat lava flows) or within the spaces of aa (cobbly lava flows). Most lava flows are young, ranging from 750 to 5,000 years old, but flows at Puuwaawaa and Puuanahulu are about 100,000 years old. Annual air temperatures and rainfall create cool (isomesic), seasonally dry (ustic) soil conditions. The temperature and moisture conditions override the diverse soil characteristics to the extent that a clearly definable ecological site exists across all the soil types within it. The tall (80 feet or 25 meters) tree overstory consists of koa (*Acacia koa*) and ohia lehua (Metrosideros polymorpha), a secondary tree overstory with mamani (Sophora chrysophylla), naio (Myoporum sandwicense), sandalwood (*Santalum paniculatum*), and kolea (Myrsine lanaiensis). Many species of native shrubs, vines, forbs, ferns, grasses, and sedges can be found in this ecological site. The much older soils of Puuwaawaa support the same species plus wingleaf soapberry or manele (*Sapindus saponaria*) in the overstory and a number of other species that are rare or nonexistent elsewhere on the Big Island except (in some cases) on the opposite side of the island in Ecological Site F160XY500 Mauna Loa Udic Forest. The occurrence of these species here is likely due to their being protected from lava flows for 100,000 years.

Associated sites

VX161B01X500	**Ustic Isothermic Forest** F161BY500 Ustic Isothermic Forest is a tropical dry forest that borders F161BY503 at lower elevations to the north and northwest.
VX161B01X502	**Kona Weather Udic Forest** F161BY502 Kona Weather Udic Forest is a rain forest that borders F161BY503 at lower elevations to the west.
VX160X01X006	**Isomesic Savanna** R160XY006 Isomesic Savanna borders F161BY503 on younger lava flows at similar elevations and on younger or similar-aged flows at higher elevations.
VX161B01X001	**Dry Ustic Isomesic Shrubland** R161BY001 Dry Ustic Isomesic Shrubland is a shrubland that borders F161BY503 at higher elevations primarily on very shallow soils on pahoehoe lava flows.

Similar sites

VX160X01X502	**Isomesic-Cool Isothermic Forest** F160XY502 Isomesic-Cool Isothermic Forest is a similar upper-elevation, koa dominated forest type on Mauna Kea.

Table 1. Dominant plant species

Tree	(1) *Acacia koa* (2) *Santalum paniculatum*
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

F161BY503HI

Physiographic features

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

Table 2. Representative physiographic features

Landforms	(1) Shield volcano (2) Ash flow (3) Lava flow
Flooding duration	Extremely brief (0.1 to 4 hours)
Flooding frequency	None to occasional
Ponding frequency	None
Elevation	2,000–7,000 ft
Slope	2–55%
Water table depth	60 in
Aspect	N, W

Climatic features

There are no climate stations near this ecological site with complete data sets suitable for automatically filling the data boxes and charts below.

The estimates in the following text are based on modeled climate maps and incomplete and/or historic data sets from multiple stations compiled by NRCS Hawaii Soil Survey.

Average annual rainfall ranges from 20 to 50 inches (500 to 1250 millimeters). Most of the rainfall occurs from January through July in the northern 1/3 of the ecological site and from April through October in the southerly 2/3 of the ecological site. Average annual temperatures range from 50 to 63 degrees F (10 to 17 degrees C). Frost free and freeze free periods are 365 days per year.

Air temperature in Hawaii is buffered by the surrounding ocean so that the range in temperature through the year is narrow. This creates “iso-“ soil temperature regimes in which mean summer and winter temperatures differ by less than 6 degrees C (11 degrees F).

Hawaii lies within the trade wind zone. Significant amounts of moisture are picked up from the ocean by trade winds up to an altitude of more than 6000 feet (very roughly 2000 meters). As the trade winds from the northeast are forced up the mountains of the island their moisture condenses, creating rain on the windward slopes; the leeward side of the island receives little of this moisture. Above approximately 6000 feet elevation there is a temperature inversion at the boundary between moist air and higher, drier air. Average annual temperatures decrease at a slower rate above the inversion than below it. Easily observed vegetation changes occur within a short distance at the inversion layer.

On the leeward side of the island, particularly in the Kona area, a “Kona weather pattern” exists. Heating of the land during the day pulls moist ocean air up the mountain slopes that produces clouds and rain in the afternoon. A cool breeze moves down the slopes at night. This weather pattern is strongest during the summer, creating rainfall during the summer season.

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

Reference: Giambelluca and Schroeder 1998.

Table 3. Representative climatic features

Frost-free period (average)	0 days
Freeze-free period (average)	0 days
Precipitation total (average)	0 in

Influencing water features

There are no water features influencing this site.

Soil features

Typical soils are of three types: highly decomposed plant materials in a`a or over pahoehoe; shallow to deep, rapidly weathered volcanic ash deposited on aa or pahoehoe; and very shallow, rapidly weathered volcanic ash deposited over pahoehoe. Most landscape surfaces in this ecological site are young (generally 750 to 5,000 years old). the youngest surfaces (lava flows from 750-3,000 years old) have soils that are derived primarily from highly decomposed plant materials. Older surfaces (lava flows >3,000 years old) are usually covered with soils with much higher ash content than younger soils. Surfaces on Puuwaawaa cone and Puuanahulu are approximately 100,000 years old and are covered with very deep ash soils. These differences in age and/or ash content affect the nature of the plant community as well as the trafficability by humans and livestock (and therefore disturbance history) of a given site. Ash soils and organic soils on pahoehoe have been favored as pasture areas due to easy access by humans and livestock.

Available water capacity in most soils ranges from 1 to 4 inches. Waawaa soils, which occur on Puuwaawaa cone and Puuanahulu, have available water capacity of 6 inches. Available water capacity refers to the volume of water available to plants in the upper 40 inches of soil, including rocks, at field capacity. Soil temperature regimes are isomesic. Soil moisture regimes are ustic (soil moisture control section is dry in some or all parts for 90 or more cumulative days in normal years).

The volcanic ash soils of the Island of Hawaii are derived mostly from basaltic ash that varies relatively little in chemical composition (Hazlett and Hyndman 1996; Vitousek 2004). Most of these volcanic ash soils are classified as Andisols, which have these general management characteristics: ion exchange capacity that varies with pH, but mostly retaining anions such as nitrate; high phosphorus adsorption, which restricts phosphorus availability to plants; excellent physical properties (low bulk density, good friability, weak stickiness, stable soil aggregates) for cultivation, seedling emergence, and plant root growth; resistance to compaction and an ability to recover from compaction following repeated cycles of wetting and drying; and high capacity to hold water that is available to plants. These characteristics are due to the properties of the parent material, the clay-size noncrystalline materials formed by weathering, and the soil organic matter accumulated during soil formation (Shoji et al. 1993).

Andisols formed on pahoehoe lava can be very shallow to very deep. Pahoehoe is referred to as a “lithic contact,” which is a boundary between soil and underlying material that is coherent, continuous, difficult to dig with a spade, and contains few cracks that can be penetrated by roots (Soil Survey Staff 1999). Pahoehoe is typically very limiting to root penetration due to the spacing and size of cracks. However, this characteristic of pahoehoe is variable, and there are many instances of stands of large trees growing on very shallow and shallow ash soils over pahoehoe.

The lava rock fragments that constitute aa range in size from gravel (2 mm to 76 mm, or up to 3 inches) to stones (250 mm to 600 mm, or 10 to 25 inches), but are primarily gravel and cobbles (76 mm to 250 mm, or 3 to 10 inches). Below the layer of rock fragments is massive lava called “bluerock.” The interstices between rock fragments of Andisols formed in aa are filled with soil from the surface to the blue rock at the bottom of the soil. Some Andisols in aa have few or no rock fragments in the upper horizons, while others may have large amounts of rock fragments in all horizons and on the soil surface.

Soils that are moderately deep (20 to 40 inches, or 50 to 100 cm) or deeper over underlying lava appear to present few or no limits on native, pasture, or weedy vegetation, and it seems to make no difference whether the lava rock is pahoehoe or aa. However, these soils may present some tillage difficulties when formed in aa and containing significant amounts of coarse rock fragments near the surface.

The organic soils of the Island of Hawaii are classified as Histosols. They were formed mainly in organic material consisting of highly decomposed leaves, twigs, and wood with small amounts of basic volcanic ash, cinders, and weathered lava; this is called highly decomposed parent material. Some of these soils contain slightly or moderately decomposed parent material, especially at or near the soil surface.

Unlike many organic soils such as peat or muck that form in long-term water-saturated conditions, these organic soils form by accumulation and transformation of litter on dry surfaces of lava rock or in gaps between lava rocks. These organic soils are referred to as litter or an O horizon.

All of the Histosols on the Big Island are classified as “euic,” which means they have relatively high base saturation as indicated by a pH of 4.5 or higher; most Big Island Histosols have pH well above this minimum.

Histosols on pahoehoe lava tend to be shallow (less than 20 inches or 50 centimeters) or very shallow (less than 10 inches or 25 centimeters). Pahoehoe is referred to as a “lithic contact,” which is a boundary between soil and underlying material that is coherent, continuous, difficult to dig with a spade, and contains few cracks that can be penetrated by roots (Soil Survey Staff 1999). Pahoehoe is typically very limiting to root penetration due to the spacing and size of cracks. However, this characteristic of pahoehoe is variable, and there are many instances of large trees growing on very shallow and shallow soils over pahoehoe. When depth of soil to pahoehoe is less than 18 cm (7.2 inches), the soil is referred to as “micro.”

The lava rock fragments that constitute aa range in size from gravel (2 mm to 76 mm, or up to 3 inches) to stones (250 mm to 600 mm, or 10 to 25 inches), but are primarily gravel and cobbles (76 mm to 250 mm, or 3 to 10 inches). Below the layer of rock fragments is massive lava called “bluerock.” The interstices between rock fragments of Histosols formed in aa are filled with soil material from the surface to a particular depth, often moderately deep (20 to 40 inches, or 50 to 100 centimeters), but sometimes shallower or deeper depending on the soil series. Between this soil material-filled horizon and the bluerock the interstices contain little or no soil material. However, live roots are often present in this horizon. These soils often support dense forests with large trees despite their unusual conformation. In order to observe the natural state of the soil, one must carefully disassemble the lava rock fragments so as not to allow the soil materials to fall into the gaps below.

Table 4. Representative soil features

Parent material	(1) Volcanic ash–basalt (2) Organic material–trachyte
Surface texture	(1) Medial silt loam (2) Ashy sandy loam
Family particle size	(1) Loamy
Drainage class	Moderately well drained to excessively drained
Permeability class	Moderately slow to moderately rapid
Soil depth	5–60 in
Surface fragment cover <=3"	0–60%
Surface fragment cover >3"	0–50%
Available water capacity (0-40in)	1–6 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	4.5–8.4

Subsurface fragment volume <=3" (Depth not specified)	0–65%
Subsurface fragment volume >3" (Depth not specified)	0–95%

Ecological dynamics

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

Natural Disturbances

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

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

Regrowth of vegetation through primary succession and formation of new soil proceed at widely varying rates depending on flow age, local climate, lava type (aa or pahoehoe), and proximity of seed sources. Flows located in cool, relatively dry climates such as this are gradually colonized by the nitrogen-fixing lichen Stereocaulon vulcani, followed soon by vascular plants including ohia lehua trees. In these environments, vegetation can be established in periods measured in decades. Still cooler locations at higher elevations revegetate more slowly. Cobbly aa lava provides safe sites for seed germination as well as sites that promote plant rooting and soil accumulation in the gaps between cobbles. This is a more favorable situation for revegetation and soil development than flat, bare pahoehoe lava. Where lava flows are narrow or where kipukas (areas of land surrounded by younger lava) occur, revegetation is hastened by the proximity of seed sources from intact vegetation stands nearby.

In general, younger flows have received smaller inputs of volcanic ash than older flows. Soil parent materials on these younger soils typically consist of decomposed organic material with small amounts of volcanic ash. Soils on older flows are more likely to be mineral soils composed largely of volcanic ash. The original vegetation on organic versus mineral soils may have been different to some extent. These differences are difficult to discern today because of human disturbances. Also, some areas with mineral soils are in kipukas that receive runoff from surrounding younger flows. This extra moisture does not generally create aquic soil conditions but alters plant growing conditions to some extent. In the lowest elevations of this ecological site, these kipukas can be part of ecological site F161BY502 Kona Weather Udic Forest.

Vegetation can be killed by erupted layers of ash depending on the temperature of the ash and the depth of accumulation. However, vegetation sometimes survives ash flows (Vitousek 2004). Vegetation rapidly recovers because ash flow deposits possess physical and chemical properties favorable to plant growth, including high water holding capacity, high surface area, rapid weathering, and favorable mineral nutrient content. New soils develop very rapidly in ash deposits, and further soil development is facilitated in turn by the rapidly-developing vegetation (Shoji et al. 1993). Future ash falls may occur here; past ash flows are old enough for soils and vegetation to have developed to the typical range for this ecological site.

To some extent, lava flows may start wildfires, but this is not a frequent occurrence. Wildfires may also be ignited by lightning.

Wind throw of vegetation can occur during hurricanes or other high wind events. As some of the soils of this ecological site are very shallow or shallow, wind throw may be an important disturbance factor.

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, such as this ecological site, would have been much less affected, but may have been affected by factors such as inadvertently introduced plant diseases and seed predation by the introduced Pacific rat (Athens 1997).

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

The Polynesians introduced dogs, Pacific rats, and small pigs to the islands. Cattle, sheep, horses, goats, and larger European pigs were introduced in the final decades of the 18th century. These animals ranged free on the islands, becoming very numerous and destructive by the early decades of the 19th century. 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).

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. Much of the original forest of this ecological site has been cleared and planted with introduced grasses for livestock grazing, and the remaining native plant stands have been highly disturbed.

Some of the mountain sandalwood (*Santalum paniculatum*) was cut from these forests and shipped to China by the 1840s. This ecological site currently contains the largest individuals and stands of this tree species. However, some harvesting has continued into the early 21st century on private lands.

By the second quarter of the 19th Century, immense herds of livestock were present in the area. Throughout the middle and late 1800s, efforts at control of the introduced herbivores continued, but with only minimal success (Henke 1929). Currently, areas used by domestic livestock are fenced and managed for forage grasses.

State and transition model

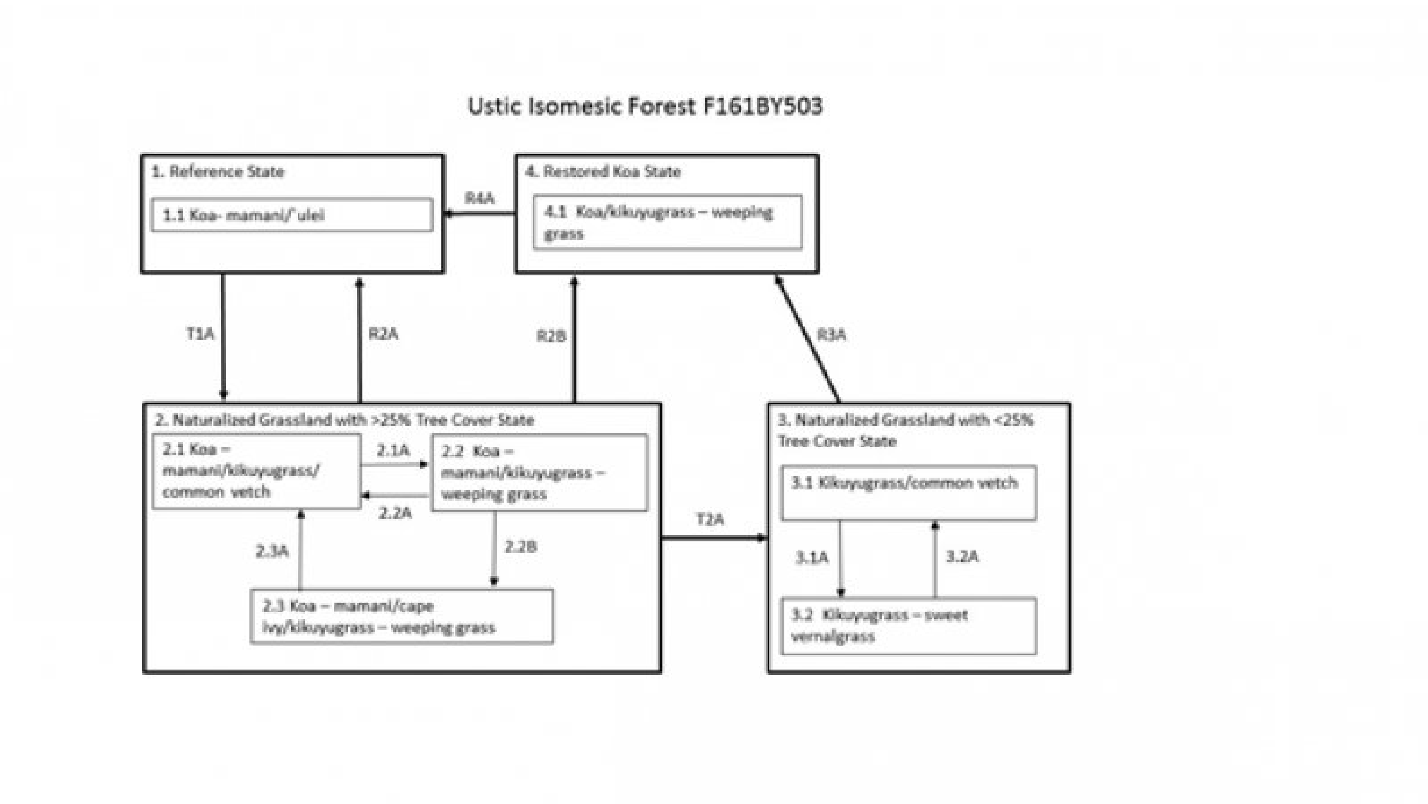

Figure 4. State and Transition Diagram F161BY503

State 1
Reference State

The Reference State consists of one community phase. There is a distinctive subtype of this phase present on Puuwaawaa and Puuanahulu that, although much disturbed, contains additional plant species similar to those found in ecological site F160XY500 Deep Volcanic Ash Kipuka Forest. Throughout this ecological site, much of the original forest has been cleared or otherwise disturbed. Description of this state is based on extensive observations of remnant forest stands and fenced restoration areas, scattered examples of the various plant species, and historical descriptions.

Community 1.1
Koa - mamani/`ulei

Figure 5. Reference community. D Clausnitzer generic photo

Figure 6. Reference community canopy. D Clausnitzer generic photo

This is forest with an open or closed upper canopy of koa (*Acacia koa*) trees up to 80 feet (24 meters) tall, a secondary canopy of multiple species 20 to 50 feet tall, and an understory of shrubs, vines, grasses, and forbs. These forests typically have standing live timber of 1200 to 2000 cubic feet per acre, with a representative value of about 1600 cubic feet per acre. On Huikau soils (soil map unit 476), which are coarse and cindery and in dry environments, standing live timber can be as low as 600 to 1200 cubic feet per acre, with a representative value of about 900 cubic feet per acre. On the very deep soils of Puuwaawaa cone, standing live timber ranges from 2000 to 3200 cubic feet per acre, with a representative value of about 2800 cubic feet per acre. These amounts represent recent measurements of standing live trees that are probably much lower than the amounts present in the original, undisturbed forests. Joseph Rock (1913) observed in mauka Kona that this ecological site had already been "ravaged by livestock" and contained "a rank growth of weeds." He saw "giant koa trees" up to 80 feet (25 meters) tall, although many of them were dead. Beneath the koa canopy were "exceedingly numerous" *Delissea undulata* that grew to 35 feet (11 meters) tall, along with aalii (*Dodonaea viscosa*) growing as straight trees 25 feet (8 meters) tall and 8 inches (3 centimeters) in diameter. Nohoanu (*Geranium cuneatum*) was plentiful. Also present were pawale (*Rumex giganteus*), mauu laili (*Sisyrinchium acre*), Silene spp., *Lipochaeta subcordata*, popolo ku mai (*Solanum incompletum*), and dense stands of ulei (*Osteomeles anthyllidifolia*). All of these species are now reduced in abundance, rare, or extinct in the area. There is a distinct subtype of this community phase located at the extreme northern end of the ecological site on Puuwaawaa and Puuanahulu in North Kona, and of which only remnants remain. It is distinguished from the main community phase by having soapberry (*Sapindus saponaria*) trees as a major part of the overstory composition and by higher plant diversity. Puuwaawaa cone and Puuanahulu share the same deep volcanic ash soil type. However, Puuwaawaa is at an elevation of about 3500 feet (1075 meters) and has about 30 inches (75 centimeters) of annual rainfall, while Puuanahulu is at an elevation of about 2000 feet (615 meters) and has about 25 inches (63 centimeters) of annual rainfall. The vegetation on Puuwaawaa cone bears similarities to that of Ecological Site F160XY500 Deep Volcanic Ash Kipuka Forest, which is in kipukas near the town of Volcano and on the opposite side of the island. Joseph Rock described the vegetation of Puuanahulu this way: "Adjoining Puuwaawaa on the north is another interesting strip of land called Puuanahulu. The plant formation on this land is very similar to that of Puuwaawaa, but harbors species of trees which can not be found in the latter locality. In this respect the vegetation approaches very much that of Kapua or Manuka in South Kona." The last sentence of the quote indicates that Puuanahulu shared more species with the surrounding dry forest than did Puuwaawaa cone. Refer to the description of Ecological Site F161BY500 Ustic Isothermic Forest for more information. Additionally, a few koaia (*Acacia koa*ia) grow on the steep slope of Puuanahulu; this species is otherwise absent from the Ustic Isothermic Forest.

Forest overstory. The overstory consists of ohia lehua (Metrosideros polymorpha) and koa (Acacia koa), and, on Puuwaawaa and Puuanahulu, soapberry (Sapindus saponaria). Beneath this is a secondary canopy mostly consisting of mountain sandalwood (Santalum paniculatum), naio (Myoporum sandwicense), tree form aalii (Dodonaea viscosa), dryland kolea (Myrsine lanaiensis), and mamani (Sophora chrysophylla).

Forest understory. The most common understory species are mountain pilo or mirrorplant (Coprosma montana), pukiawe (Styphelia tameiameiae), aalii (Dodonaea viscosa), kukaenene (Coprosma ernodioides), ulei or Hawaii hawthorn (Osteomeles anthyllidifolia), Stenogyne microphylla, about eight small fern/fern ally species, and about nine grass/grasslike species.

Table 5. Soil surface cover

Tree basal cover	2-3%
Shrub/vine/liana basal cover	1-2%
Grass/grasslike basal cover	0.0-0.5%
Forb basal cover	0.0-0.5%
Non-vascular plants	0-1%
Biological crusts	0-1%
Litter	50-80%
Surface fragments >0.25" and <=3"	0-60%
Surface fragments >3"	0-50%
Bedrock	0-1%
Water	0%
Bare ground	0.5-1.0%

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***)	1-10 per acre
Tree snag count** (hard***)	1-5 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%	1-1%	0%	0-1%
>0.5 <= 1	0%	1-1%	1-2%	1-2%
>1 <= 2	0-1%	2-3%	3-4%	3-5%
>2 <= 4.5	1-1%	5-15%	–	–
>4.5 <= 13	5-30%	5-15%	–	–
>13 <= 40	25-55%	0-1%	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

State 2
Naturalized Grassland with >25% Tree Cover State

This state is comprised of three grassland community phases that have an open canopy of remnant native trees.

Trees provide shade and protection from the elements to livestock. Where shade is denser, cool season (C3), introduced meadow ricegrass or weeping grass (*Microlaena stipoides*) to become dominant over warm season (C4) forage grasses in some areas. Very little tree regeneration occurs, so the trees eventually die out over many years. Community phase 2.1 typically consists of kikuyugrass (*Pennisetum clandestinum*) with an admixture of legumes. Meadow ricegrass may dominate in shady areas. Continuous grazing that does not allow favored forage species time to recover from defoliation results in community phase 2.2, which is dominated by lower value forage species but contains enough remnant kikuyugrass to allow for a transition back to phase 2.1 with prescribed grazing. Removal of livestock leads to community phase 2.3, which consists of dense cover of native and/or introduced shrubs, remnant grasses, and seedlings and saplings of native and/or introduced trees.

Community 2.1
Koa - mamani/kikuyugrass/common vetch

Figure 7. Kikuyugrass under native tree canopy. 8/4/05 D Clausnitzer MU135

The dominant grass species in this pasture type is kikuyugrass, although pangolagrass (*Digitaria eriantha*) also has been planted on some sites. Pastures may include introduced leguminous forbs as well as a small admixture of cool season grass species. Large native trees are common.

Forest overstory. The most common trees are ohia lehua (Metrosideros polymorpha), koa (Acacia koa), and mamani (Sophora chrysophylla). Soapberry (Sapindus saponaria) trees are present on Puuwaawaa cone in North Kona.

Forest understory. Warm season (C4) grasses comprise most of the understory. Kikuyugrass, pangolagrass, and dallisgrass (Paspalum dilatatum) are the most important species, in decreasing order. Common velvetgrass (Holcus lanatus) and orchardgrass (Dactylis glomerata) are the most important cool season (C3) grasses; as a group, these species are a minor component of the grassland. Important legumes are common vetch (Vicia sativa), white clover (Trifolium repens), lowhop clover (Trifolium procumbens), and kaimi clover (Desmodium canum). Where tree shade favors it, meadow ricegrass (Microlaena stipoides) can be abundant.

Community 2.2
Koa - mamani/kikuyugrass - weeping grass


Figure 9. Site near old koa sawmill. 8/26/05 D Clausnitzer generic photo

This community phase has significant cover of grasses of relatively low forage value. Desirable forage legumes have been grazed out. Large ohia, koa, and mamani trees are present.

Forest overstory. The most common trees are ohia lehua (Metrosideros polymorpha), koa (Acacia koa), and mamani (Sophora chrysophylla). Soapberry (Sapindus saponaria) trees are present on Puuwaawaa cone in North Kona.

Forest understory. Grasses with relatively low forage value such as sweet vernalgrass (Anthoxanthum odoratum) are abundant, and there is increased cover of weedy forbs. Meadow ricegrass is abundant where shade gives it a competitive advantage. Kikuyugrass is common but not dominant.

Table 8. Soil surface cover

Tree basal cover	1-2%
Shrub/vine/liana basal cover	0.5-1.0%
Grass/grasslike basal cover	30-40%
Forb basal cover	0.0-0.2%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	50-60%
Surface fragments >0.25" and <=3"	0-10%
Surface fragments >3"	0-25%
Bedrock	0-2%
Water	0%
Bare ground	3-5%

Table 9. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	–
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	0-2%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-4 per acre

Tree snag count** (hard***)	0-8 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 10. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	1-1%	1-2%	0-1%
>0.5 <= 1	–	1-1%	40-60%	1-1%
>1 <= 2	–	1-1%	20-30%	5-10%
>2 <= 4.5	–	5-10%	–	–
>4.5 <= 13	–	0-1%	–	–
>13 <= 40	–	–	–	–
>40 <= 80	25-75%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Community 2.3
Koa - mamani/cape ivy/kikuyugrass - weeping grass

Figure 10. Mostly weeping grass due to shade. 8/4/05 D Clausnitzer MU135

Community phase 2.3 consists of dense cover of native and/or introduced shrubs, invasive vines, remnant grasses, and seedlings and saplings of native and/or introduced trees under a canopy of large native trees. In locations where weedy, introduced plants are low in abundance, the native shrubs pukiawe (*Styphelia tameiameiae*) and aalii (*Dodonaea viscosa*) are common.

Forest overstory. The most common trees are ohia lehua (Metrosideros polymorpha), koa (Acacia koa), and mamani (Sophora chrysophylla). Soapberry (Sapindus saponaria) trees are present on Puuwaawaa cone in North Kona.

Forest understory. The native shrubs aalii (Dodonaea viscosa) and pukiawe (Styphelia tameiameiae) may be present; the introduced shrub sourbush (Pluchea carolinensis) is common. Invasive vines are often abundant; these include German ivy (Delairea odorata), banana poka (Passiflora mollissima), and large roving sailor (Lophospermum erubescens). A large number of introduced forb species are present. Kikuyugrass (Pennisetum clandestinum) may still be common but not dominant, along with sweet vernalgrass (Anthoxanthum odoratum). Crimson fountaingrass (Pennisetum setaceum) is invading this area and may become a serious problem in the future.

Table 11. Soil surface cover

Tree basal cover	1-2%
Shrub/vine/liana basal cover	0-3%
Grass/grasslike basal cover	25-40%
Forb basal cover	0.0-0.5%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	50%
Surface fragments >0.25" and <=3"	0-30%
Surface fragments >3"	0-30%
Bedrock	1-2%
Water	0%
Bare ground	1-2%

Table 12. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	–
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	0-2%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-3 per acre
Tree snag count** (hard***)	0-8 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 13. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-10%	5-10%	0-1%
>0.5 <= 1	–	1-10%	40-50%	3-5%
>1 <= 2	0%	1-1%	20-30%	3-5%
>2 <= 4.5	0%	3-5%	–	3-5%
>4.5 <= 13	25-35%	0-1%	–	–
>13 <= 40	40-50%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Pathway 2.1A
Community 2.1 to 2.2

Koa - mamani/kikuyugrass/common vetch

Koa - mamani/kikuyugrass - weeping grass

This community phase changes to phase 2.2 by continuous grazing that weakens preferred forage grasses and legumes in relation to poorer forage species and weedy forbs.

Pathway 2.2A
Community 2.2 to 2.1

Koa - mamani/kikuyugrass - weeping grass

Koa - mamani/kikuyugrass/common vetch

This community phase changes to phase 2.1 by prescribed grazing. A prescribed grazing plan provides for intensive but temporary grazing of pastures that ensures that cattle consume some low-value forage species along with preferred forages and allows preferred forages time to recover from defoliation. Kikuyugrass is very competitive and adapted to grazing and is able to recover with proper management. The grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

Pathway 2.2B
Community 2.2 to 2.3

Koa - mamani/kikuyugrass - weeping grass

Koa - mamani/cape ivy/kikuyugrass - weeping grass

This community phase changes to phase 2.3 by removal of ungulates and absence of fire. These conditions allow shrubs and small trees to gain dominance.

Pathway 2.3A
Community 2.3 to 2.1

Koa - mamani/cape ivy/kikuyugrass - weeping grass

Koa - mamani/kikuyugrass/common vetch

This community phase changes to phase 2.1 by a combination of herbicidal weed control, prescribed grazing, brush management, and replanting of desirable forage species. The grazing prescription will require removal of livestock from the pasture until seeded or sprigged forage species have reestablished adequately to support grazing. Intensive weed control will be necessary. Thereafter, the grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

State 3
Naturalized Grassland with <25% Tree Cover State

This state consists of three community phases that are grassland with either a sparse canopy of native trees or no trees at all. The lack of shade prevents the cool season (C3) introduced grass meadow ricegrass or weeping grass (*Microlaena stipoides*) from becoming abundant. Community phase 3.1 typically consists of kikuyugrass (*Pennisetum clandestinum*) with an admixture of legumes. Continuous grazing that does not allow favored forage species time to recover from defoliation results in community phase 3.2, which is dominated by lower value forage species but contains enough remnant kikuyugrass to allow for a transition back to phase 2.1 with prescribed grazing. Removal of livestock leads to community phase 3.3, which consists of native and/or introduced shrubs, remnant grasses, and invasive vines.

Community 3.1
Kikuyugrass/common vetch

Figure 11. Kikuyugrass with sparse trees. 4/20/07 D Clausnitzer MU341

The dominant grass species in this pasture type is kikuyugrass, although pangolagrass (*Digitaria eriantha*) also has been planted on some sites. Pastures may include introduced leguminous forbs as well as a small admixture of cool season grass species.

Forest overstory. Where trees are present, the most common species are ohia lehua (Metrosideros polymorpha), koa (Acacia koa), and mamani (Sophora chrysophylla). Soapberry (Sapindus saponaria) trees may be present on Puuwaawaa.

Forest understory. Warm season (C4) grasses comprise most of the understory. Kikuyugrass, pangolagrass, and dallisgrass (Paspalum dilatatum) are the most important species. Common velvetgrass (Holcus lanatus) and orchardgrass (Dactylis glomerata) are the most important cool season (C3) grasses, but as a group these species are a minor component of the grassland. Important legumes are common vetch (Vicia sativa), white clover (Trifolium repens), lowhop clover (Trifolium procumbens), kaimi clover (Desmodium canum), and Spanish clover (Desmodium uncinatum).

Community 3.2
Kikuyugrass - sweet vernalgrass

Figure 13. Kikuyugrass and fountaingrass. 4/20/07 D Clausnitzer MU341

This community phase has significant cover of grasses of relatively low forage value. Desirable forage legumes have been grazed out.

Forest overstory. Where trees are present, the most common species are ohia lehua (Metrosideros polymorpha), koa (Acacia koa), and mamani (Sophora chrysophylla). Soapberry (Sapindus saponaria) trees may be present on Puuwaawaa.

Forest understory. Grasses with relatively low forage value such as sweet vernalgrass (Anthoxanthum odoratum) are abundant, and there is increased cover of weedy forbs. Kikuyugrass is common but not dominant.

Table 14. Soil surface cover

Tree basal cover	0.0-0.5%
Shrub/vine/liana basal cover	0.0-0.5%
Grass/grasslike basal cover	25-30%
Forb basal cover	0.0-0.5%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	40-60%
Surface fragments >0.25" and <=3"	0-40%
Surface fragments >3"	0-40%
Bedrock	1-2%
Water	0%
Bare ground	3-5%

Table 15. Woody ground cover

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

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

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

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

Table 16. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0%	20-40%	1-2%
>0.5 <= 1	–	0-1%	20-40%	3-5%
>1 <= 2	–	0-1%	5-10%	3-5%
>2 <= 4.5	–	1-10%	–	–
>4.5 <= 13	0-5%	–	–	–
>13 <= 40	0-25%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Pathway 3.1A
Community 3.1 to 3.2


Kikuyugrass/common vetch


Kikuyugrass - sweet vernalgrass

This community phase changes to phase 3.2 by continuous grazing that weakens preferred forage grasses and legumes in relation to poorer forage species and weedy forbs.

Pathway 3.2A
Community 3.2 to 3.1


Kikuyugrass - sweet vernalgrass


Kikuyugrass/common vetch

This community phase changes to phase 3.1 by prescribed grazing. A prescribed grazing plan provides for intensive but temporary grazing of pastures that ensures that cattle consume some low-value forage species along with preferred forages and allows preferred forages time to recover from defoliation. Kikuyugrass is very competitive and adapted to grazing and is able to recover with proper management. The grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

State 4
Restored Koa State

This state consists of one community phase. Koa seeds may remain viable in the soil for decades and can be induced to germinate by scarifying, or scraping, the soil surface with a bulldozer. If mature koa trees are present, suckers from their roots can quickly grow into spaces with sufficient sunlight. Thinning is necessary once the koa reach sufficient stature.

Community 4.1
Koa/kikuyugrass - weeping grass

Figure 14. Young koa restoration site. 2/5/07 D Clausnitzer generic photo

Figure 15. Koa seedlings on scarified and herbicided site. D Clausnitzer generic photo

This community phase consists of a dense stand of small to medium stature koa trees that have resprouted or been planted in grassland. There may or may not be large native trees present, depending on whether the grassland was in State 2 or State 3 previously. As the tree canopy closes, kikuyugrass will be outcompeted and replaced by meadow ricegrass, which persists unless killed by herbicide or deeper shade conditions and heavy tree litter. Other native plant species will begin to grow in the understory if a seed source is nearby.

Forest overstory. Large ohia lehua (Metrosideros polymorpha), koa (Acacia koa), and mamani (Sophora chrysophylla) may be present, with soapberry (Sapindus saponaria) on Puuwaawaa.

Forest understory. Young koa trees are the most abundant plants in the understory. Kikuyugrass and, if sufficient shade is present, meadow ricegrass typically are the dominant grasses. Native shrubs including aalii (Dodonaea viscosa) and pukiawe (Styphelia tameiameiae) may naturally return to the site. Other native species may be present as a seed source or they must be restored to the site.

Table 17. Soil surface cover

Tree basal cover	0.5-2.0%
Shrub/vine/liana basal cover	0-1%
Grass/grasslike basal cover	25-30%
Forb basal cover	5-15%
Non-vascular plants	0-1%

Biological crusts	0%
Litter	40-50%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-20%
Bedrock	0-1%
Water	0%
Bare ground	0-1%

Table 18. Woody ground cover

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

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0%	0-1%	30-40%	0-1%
>0.5 <= 1	0%	0-1%	30-40%	1-2%
>1 <= 2	0-1%	1-1%	5-10%	5-10%
>2 <= 4.5	0-1%	0-1%	–	2-5%
>4.5 <= 13	1-5%	0-1%	–	–
>13 <= 40	80-90%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Transition T1A
State 1 to 2

This state will transition to State 2 Naturalized Grassland with >25% Tree Cover by removing the native understory, either by heavy equipment or, more gradually, by continuous cattle grazing. Preferred forage grasses are then established by sprigging or seeding.

Restoration pathway R2A
State 2 to 1

This state may be restored to a facsimile of State 1 Reference. Herbicidal weed control must be applied to forage species and the many opportunistic weed species that invade the site. Weed control would be a perpetual process to maintain the site. All ungulates must be excluded from the restoration site by a suitable fence. Domestic ungulates would be useful to manage vegetation outside the restoration site perimeter. Extensive planting of native species would follow. In some areas there may be a residual koa seed bank that could be encouraged to sprout by herbicide treatment of grasses followed by soil scarification by heavy machinery. Increased shade from trees growing on the site will cause a shift from warm season (C4) introduced grasses to cool season (C3), shade-tolerant meadow ricegrass (*Microlaena stipoides*). Meadow ricegrass can be almost as detrimental as kikuyugrass to establishment of native plants, so it must be controlled by herbicide.

Transition T2A
State 2 to 3

This state will transition to State 3 Native Grassland with <25% Tree Cover by intense wildfire. Alternatively, long term grazing will greatly reduce reproductive success of native trees, leading to gradual loss of the trees through natural mortality.

Restoration pathway R2B
State 2 to 4

Koa trees can rapidly form a dense stand on these sites from seed bank germination stimulated by mechanical soil scarification, root suckering from remnant koa, and/or replanting. Herbicidal control of weeds, including forage grasses, facilitates this process.

Restoration pathway R3A
State 3 to 4

Koa trees can rapidly form a dense stand on these sites from seed bank germination stimulated by mechanical soil scarification, root suckering from remnant koa, and/or replanting. Control of weeds, including forage grasses, facilitates this process.

Restoration pathway R4A
State 4 to 1

This state may be restored to a facsimile of State 1 Reference either by gradual reinvasion of the site from nearby native seed sources or by replanting. Koa may be restored by scarifying any remaining soil seed bank. Weed control will be necessary to eliminate weeds that are present or invade the site, as well as to reduce grass cover. Ungulates must be excluded from the site by a suitable fence.

Additional community tables

Table 20. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
koa	ACKO	*Acacia koa*	Native	13–40	10–30	18–57	–
mamani	SOCH	*Sophora chrysophylla*	Native	13–20	5–20	–	–
naio	MYSA	*Myoporum sandwicense*	Native	13–25	1–10	–	–
Lanai colicwood	MYLA3	*Myrsine lanaiensis*	Native	13–25	1–5	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	13–40	1–5	10–17	–
mountain sandalwood	SAPA7	*Santalum paniculatum*	Native	13–30	0–5	4–9	–
alpine mirrorplant	COMO3	*Coprosma montana*	Native	13–20	0.5–1	–	–
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	13–20	0–1	–	–
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	13–25	0.5–1	–	–
cheesewood	PITTO	*Pittosporum*	Native	13–25	0–1	–	–
leechleaf delissea	DEUN2	*Delissea undulata*	Native	13–20	–	–	–
alpine sandmat	CHOL3	*Chamaesyce olowaluana*	Native	13–20	–	–	–

Table 21. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
hardstem lovegrass	ERAT	*Eragrostis atropioides*	Native	1–2	0–1
mountain lovegrass	ERLE3	*Eragrostis leptophylla*	Native	1–2	0–1
flatsedge	CYPER	*Cyperus*	Native	1–2	0–1
pili uka	TRGL3	*Trisetum glomeratum*	Native	1–2	0–1
Pacific bentgrass	AGAV	*Agrostis avenacea*	Native	1–2	0–1
alpine hairgrass	DENU6	*Deschampsia nubigena*	Native	1–2	0–1
Oahu sedge	CAWA	*Carex wahuensis*	Native	1–2	0–1
Hawai'i woodrush	LUHA2	*Luzula hawaiiensis*	Native	0.5–1	0–1
Forb/Herb					
hinahina	GECU	*Geranium cuneatum*	Native	0.5–1	0–1
'ena'ena	PSSA8	*Pseudognaphalium sandwicensium*	Native	1–2	0–1
grassland nehe	LISU6	*Lipochaeta subcordata*	Native	1–2	0–0.5
Hawai'i blue-eyed grass	SIAC2	*Sisyrinchium acre*	Native	1–2	0–0.5
'uki'uki	DISA6	*Dianella sandwicensis*	Native	1–2	0–0.5
catchfly	SILEN	*Silene*	Native	1–2	–
Hawai'i stingingnettle	HESA5	*Hesperocnide sandwicensis*	Native	1–2	–
Fern/fern ally					
western brackenfern	PTAQ	*Pteridium aquilinum*	Native	1–2	0–1
spleenwort	ASPLE	*Asplenium*	Native	1–2	0–1
alpine woodfern	DRWA	*Dryopteris wallichiana*	Native	1–2	0–1
palapalai	MIST4	*Microlepia strigosa*	Native	1–2	0–1
Cretan brake	PTCR2	*Pteris cretica*	Native	0.5–1	0–0.5
dotted polypody	POPE5	*Polypodium pellucidum*	Native	0.5–1	0–0.5

Trans-Pecos cliffbrake	PETE2	*Pellaea ternifolia*	Native	0.5–1	0–0.2
maidenhair spleenwort	ASTR2	*Asplenium trichomanes*	Native	0.5–1	0–0.1
Shrub/Subshrub					
Hawai'i hawthorn	OSAN	*Osteomeles anthyllidifolia*	Native	2–5	1–10
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	2–13	1–5
pukiawe	STTA	*Styphelia tameiameiae*	Native	2–5	1–5
'aiakanene	COER3	*Coprosma ernodeoides*	Native	0.5–2	1–5
Mauna Loa beggarticks	BIME	*Bidens menziesii*	Native	2–4	1–2
pawale	RUGI	*Rumex giganteus*	Native	2–4	0–1
yellow ‘ilima	SIFA	*Sida fallax*	Native	1–3	0.5–1
ohelo 'ai	VARE	*Vaccinium reticulatum*	Native	1–3	0.5–1
Hawai'i false ohelo	WIPH2	*Wikstroemia phillyreifolia*	Native	1–2	0–1
pukamole	LYMA3	*Lythrum maritimum*	Native	1–2	0–0.5
lava dubautia	DUCI	*Dubautia ciliolata*	Native	2–5	0–0.5
thorny popolo	SOIN	*Solanum incompletum*	Native	1–3	–
Tree					
naio	MYSA	*Myoporum sandwicense*	Native	2–13	1–20
mamani	SOCH	*Sophora chrysophylla*	Native	2–13	1–5
alpine mirrorplant	COMO3	*Coprosma montana*	Native	2–13	1–5
alpine sandmat	CHOL3	*Chamaesyce olowaluana*	Native	2–13	0–1
Lanai colicwood	MYLA3	*Myrsine lanaiensis*	Native	2–13	0–1
koa	ACKO	*Acacia koa*	Native	2–13	0–1
kolea lau nui	MYLE2	*Myrsine lessertiana*	Native	2–13	0–0.5
Australasian catchbirdtree	PIBR3	*Pisonia brunoniana*	Native	2–13	0–0.5
cheesewood	PITTO	*Pittosporum*	Native	2–13	0–0.5
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	2–13	–
mountain sandalwood	SAPA7	*Santalum paniculatum*	Native	2–13	–
Vine/Liana					
littleleaf stenogyne	STMI3	*Stenogyne microphylla*	Native	1–4	1–5
queen coralbead	COOR11	*Cocculus orbiculatus*	Native	1–3	0–1
Maile	ALST11	*Alyxia stellata*	Native	1–4	0–1
Hawai'i blackberry	RUHA	*Rubus hawaiensis*	Native	2–3	0–1
lava bur cucumber	SIAN4	*Sicyos anunu*	Native	2–5	0–1

Table 22. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Naturalized Warm Season Grasses**			1710–2280	
	kikuyugrass	PECL2	*Pennisetum clandestinum*	600–1026	–
	dallisgrass	PADI3	*Paspalum dilatatum*	85–228	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	17–68	–
	smut grass	SPIN4	*Sporobolus indicus*	17–45	–
2	**Naturalized Cool Season Grasses and Grasslikes**			570–950	
	sweet vernalgrass	ANOD	*Anthoxanthum odoratum*	29–95	–
	orchardgrass	DAGL	*Dactylis glomerata*	29–95	–
	common velvetgrass	HOLA	*Holcus lanatus*	29–95	–
	perennial ryegrass	LOPE	*Lolium perenne*	6–48	–
	weeping grass	MIST	*Microlaena stipoides*	17–48	–
	Oahu flatsedge	CYHY2	*Cyperus hypochlorus*	11–38	–
	shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	6–29	–
	annual bluegrass	POAN	*Poa annua*	6–19	–
	Kentucky bluegrass	POPR	*Poa pratensis*	6–19	–
Forb					
3	**Naturalized Forbs**			190–380	
	white clover	TRRE3	*Trifolium repens*	2–15	–
	garden vetch	VISA	*Vicia sativa*	2–15	–
	field clover	TRCA5	*Trifolium campestre*	2–11	–
	Carolina geranium	GECA5	*Geranium carolinianum*	0–4	–
	narrowleaf plantain	PLLA	*Plantago lanceolata*	0–4	–
	tropical whiteweed	AGCO	*Ageratum conyzoides*	0	–
	bull thistle	CIVU	*Cirsium vulgare*	0	–
	climbing dayflower	CODI5	*Commelina diffusa*	0	–

Table 23. Community 2.2 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
koa	ACKO	*Acacia koa*	Native	20–40	25–75	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	20–40	0–10	–	–
mamani	SOCH	*Sophora chrysophylla*	Native	13–20	1–5	–	–
mountain sandalwood	SAPA7	*Santalum paniculatum*	Native	13–30	0–2	–	–
Lanai colicwood	MYLA3	*Myrsine lanaiensis*	Native	13–20	0–1	–	–

Table 24. Community 2.2 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
kikuyugrass	PECL2	*Pennisetum clandestinum*	Introduced	0.5–1	35–45
sweet vernalgrass	ANOD	*Anthoxanthum odoratum*	Introduced	1–2	15–25

smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.5–1	1–5
annual bluegrass	POAN	*Poa annua*	Introduced	0.2–0.5	1–5
common velvetgrass	HOLA	*Holcus lanatus*	Introduced	1–2	1–5
crimson fountaingrass	PESE3	*Pennisetum setaceum*	Introduced	1–2	0–2
rose Natal grass	MERE9	*Melinis repens*	Introduced	1–2	0–1
Kentucky bluegrass	POPR	*Poa pratensis*	Introduced	1–2	0–1
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	1–2	0–1
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.5–1	0–0.5
Oahu flatsedge	CYHY2	*Cyperus hypochlorus*	Native	1–2	0–0.5
densetuft hairsedge	BUCA2	*Bulbostylis capillaris*	Introduced	1–2	0–0.5
brome fescue	VUBR	*Vulpia bromoides*	Introduced	0.5–1	0–0.5
rescuegrass	BRCA6	*Bromus catharticus*	Introduced	1–2	–
Forb/Herb					
narrowleaf plantain	PLLA	*Plantago lanceolata*	Introduced	0.2–0.5	1–5
Madagascar ragwort	SEMA15	*Senecio madagascariensis*	Introduced	0.5–1	1–5
father-and-child plant	EUJA6	*Euchiton japonicus*	Introduced	–	1–2
spreading snakeroot	AGRI2	*Ageratina riparia*	Introduced	0.5–1	0–1
stinking strawflower	HEFO4	*Helichrysum foetidum*	Introduced	1–2	0–1
Australasian geranium	GEHO5	*Geranium homeanum*	Introduced	0.5–1	0–1
porterweed	STACH2	*Stachytarpheta*	Introduced	1–3	0–1
lilac tasselflower	EMSO	*Emilia sonchifolia*	Introduced	1–2	0–1
Peruvian groundcherry	PHPE4	*Physalis peruviana*	Introduced	2–3	0–1
common sheep sorrel	RUAC3	*Rumex acetosella*	Introduced	0.5–1	0–1
oxeye daisy	LEVU	*Leucanthemum vulgare*	Introduced	1–2	0–1
southern rockbell	WAMA	*Wahlenbergia marginata*	Introduced	0.5–1	0–1
Jerusalem cherry	SOPS	*Solanum pseudocapsicum*	Introduced	2–3	0–1
telegraphweed	HEGR7	*Heterotheca grandiflora*	Introduced	2–3	0–1
Virginia pepperweed	LEVI3	*Lepidium virginicum*	Introduced	0.5–1	0–0.5
common St. Paul's wort	SIOR2	*Sigesbeckia orientalis*	Introduced	0.5–1	0–0.5
horehound	MAVU	*Marrubium vulgare*	Introduced	0.5–1	0–0.5
muster John Henry	TAMI3	*Tagetes minuta*	Introduced	0.5–1	0–0.5
common mullein	VETH	*Verbascum thapsus*	Introduced	2–3	0–0.5
bull thistle	CIVU	*Cirsium vulgare*	Introduced	2–3	0–0.5
Fern/fern ally					
rough maidenhair	ADHI	*Adiantum hispidulum*	Introduced	0.5–1	–
Japanese netvein hollyfern	CYFA2	*Cyrtomium falcatum*	Introduced	1–2	–
Shrub/Subshrub					
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	2–4	1–5
pukiawe	STTA	*Styphelia tameiameiae*	Native	2–5	1–5
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	2–5	0.5–1
Tree					
mamani	SOCH	*Sophora chrysophylla*	Native	2–13	0–1
mountain sandalwood	SAPA7	*Santalum paniculatum*	Native	8–13	0–1
Lanai colicwood	MYLA3	*Myrsine lanaiensis*	Native	5–13	0–1

Vine/Liana					
Cape-ivy	DEOD	*Delairea odorata*	Introduced	1–20	0–2
Mexican twist	LOER3	*Lophospermum erubescens*	Introduced	1–2	0–1
sawtooth blackberry	RUAR2	*Rubus argutus*	Introduced	2–3	0–1

Table 25. Community 2.3 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
koa	ACKO	*Acacia koa*	Native	25–40	25–75	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	25–40	0–10	–	–
mamani	SOCH	*Sophora chrysophylla*	Native	13–18	0–5	–	–
mountain sandalwood	SAPA7	*Santalum paniculatum*	Native	13–25	0–1	–	–
Lanai colicwood	MYLA3	*Myrsine lanaiensis*	Native	13–20	0–1	–	–

Table 26. Community 2.3 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
kikuyugrass	PECL2	*Pennisetum clandestinum*	Introduced	0.5–1	25–35
sweet vernalgrass	ANOD	*Anthoxanthum odoratum*	Introduced	1–2	15–25
smut grass	SPIN4	*Sporobolus indicus*	Introduced	1–2	1–5
crimson fountaingrass	PESE3	*Pennisetum setaceum*	Introduced	1–2	1–5
densetuft hairsedge	BUCA2	*Bulbostylis capillaris*	Introduced	0.5–1	0–1
annual bluegrass	POAN	*Poa annua*	Introduced	0.2–0.5	0–1
Kentucky bluegrass	POPR	*Poa pratensis*	Introduced	1–2	0–1
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	1–2	0–1
common velvetgrass	HOLA	*Holcus lanatus*	Introduced	1–2	0–1
Forb/Herb					
Madagascar ragwort	SEMA15	*Senecio madagascariensis*	Introduced	0.5–1	3–5
spreading snakeroot	AGRI2	*Ageratina riparia*	Introduced	1–2	1–5
stinking strawflower	HEFO4	*Helichrysum foetidum*	Introduced	0.5–1	0–1
oxeye daisy	LEVU	*Leucanthemum vulgare*	Introduced	0.5–1	0–1
common mullein	VETH	*Verbascum thapsus*	Introduced	2–3	0–1
Australasian geranium	GEHO5	*Geranium homeanum*	Introduced	0.2–0.5	0–1
narrowleaf plantain	PLLA	*Plantago lanceolata*	Introduced	0.2–0.5	0–1
porterweed	STACH2	*Stachytarpheta*	Introduced	2–3	0–1
lilac tasselflower	EMSO	*Emilia sonchifolia*	Introduced	1–2	0–1
Peruvian groundcherry	PHPE4	*Physalis peruviana*	Introduced	2–3	0–1
Jerusalem cherry	SOPS	*Solanum pseudocapsicum*	Introduced	2–3	0–1
telegraphweed	HEGR7	*Heterotheca grandiflora*	Introduced	2–3	0–1
horehound	MAVU	*Marrubium vulgare*	Introduced	0.5–1	0–1
bull thistle	CIVU	*Cirsium vulgare*	Introduced	2–3	0–0.5
muster John Henry	TAMI3	*Tagetes minuta*	Introduced	0.5–1	0–0.5
Shrub/Subshrub					
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	2–5	1–5
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	2–4	0–1
pukiawe	STTA	*Styphelia tameiameiae*	Native	2–4	0–1
Tree					
mamani	SOCH	*Sophora chrysophylla*	Native	5–13	0–1
mountain sandalwood	SAPA7	*Santalum paniculatum*	Native	5–13	0–1
Lanai colicwood	MYLA3	*Myrsine lanaiensis*	Native	5–13	0–1
Vine/Liana					
Cape-ivy	DEOD	*Delairea odorata*	Introduced	1–15	15–25
Mexican twist	LOER3	*Lophospermum erubescens*	Introduced	1–2	0–2
sawtooth blackberry	RUAR2	*Rubus argutus*	Introduced	2–4	0–1

Table 27. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Naturalized WarmSeason Grasses**			1710–2280	
	kikuyugrass	PECL2	*Pennisetum clandestinum*	600–1026	–
	dallisgrass	PADI3	*Paspalum dilatatum*	85–228	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	17–68	–
	smut grass	SPIN4	*Sporobolus indicus*	17–45	–
2	**Naturalized Cool Season Grasses and Grasslikes**			570–950	
	sweet vernalgrass	ANOD	*Anthoxanthum odoratum*	29–95	–
	orchardgrass	DAGL	*Dactylis glomerata*	29–95	–
	common velvetgrass	HOLA	*Holcus lanatus*	29–95	–
	perennial ryegrass	LOPE	*Lolium perenne*	6–48	–
	weeping grass	MIST	*Microlaena stipoides*	17–48	–
	Oahu flatsedge	CYHY2	*Cyperus hypochlorus*	11–38	–
	shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	6–29	–
	annual bluegrass	POAN	*Poa annua*	6–19	–
	Kentucky bluegrass	POPR	*Poa pratensis*	6–19	–
Forb					
3	**Naturalized Forbs**			190–380	
	white clover	TRRE3	*Trifolium repens*	2–15	–
	garden vetch	VISA	*Vicia sativa*	2–15	–
	field clover	TRCA5	*Trifolium campestre*	2–11	–
	Carolina geranium	GECA5	*Geranium carolinianum*	0–4	–
	narrowleaf plantain	PLLA	*Plantago lanceolata*	0–4	–
	tropical whiteweed	AGCO	*Ageratum conyzoides*	0	–
	bull thistle	CIVU	*Cirsium vulgare*	0	–
	climbing dayflower	CODI5	*Commelina diffusa*	0	–
Tree					
4	**Native Trees and Shrubs**			950–1330	
	koa	ACKO	*Acacia koa*	143–333	–
	mamani	SOCH	*Sophora chrysophylla*	95–200	–
	mountain sandalwood	SAPA7	*Santalum paniculatum*	76–160	–
	Hawai'i hawthorn	OSAN	*Osteomeles anthyllidifolia*	48–106	–
	'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	48–100	–
	naio	MYSA	*Myoporum sandwicense*	10–67	–
	Florida hopbush	DOVI	*Dodonaea viscosa*	29–67	–
	pukiawe	STTA	*Styphelia tameiameiae*	10–40	–
Shrub/Vine					
5	**Naturalized Shrubs, Vines, and Trees**			1–13	
	West Indian raspberry	RURO	*Rubus rosifolius*	0–1	–
	Peruvian groundcherry	PHPE4	*Physalis peruviana*	0	–

Table 28. Community 3.2 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
koa	ACKO	*Acacia koa*	Native	13–25	0–25	–	–
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	13–30	0–5	–	–
mamani	SOCH	*Sophora chrysophylla*	Native	13–15	0–1	–	–
Lanai colicwood	MYLA3	*Myrsine lanaiensis*	Native	13–20	0–1	–	–
naio	MYSA	*Myoporum sandwicense*	Native	13–20	0–1	–	–
mountain sandalwood	SAPA7	*Santalum paniculatum*	Native	13–15	–	–	–

Table 29. Community 3.2 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
kikuyugrass	PECL2	*Pennisetum clandestinum*	Introduced	0.5–1	30–40
sweet vernalgrass	ANOD	*Anthoxanthum odoratum*	Introduced	–	10–20
common velvetgrass	HOLA	*Holcus lanatus*	Introduced	1–2	3–5
annual bluegrass	POAN	*Poa annua*	Introduced	0.2–0.5	3–5
smut grass	SPIN4	*Sporobolus indicus*	Introduced	0.5–1	3–5
crimson fountaingrass	PESE3	*Pennisetum setaceum*	Introduced	1–2	0–2
rose Natal grass	MERE9	*Melinis repens*	Introduced	1–2	0–0.5
Kentucky bluegrass	POPR	*Poa pratensis*	Introduced	1–2	0–0.5
marsh bristlegrass	SEPA10	*Setaria parviflora*	Introduced	1–2	0–0.5
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.5–1	0–0.5
Oahu flatsedge	CYHY2	*Cyperus hypochlorus*	Native	0.5–1	0–0.5
densetuft hairsedge	BUCA2	*Bulbostylis capillaris*	Introduced	0.5–1	–
brome fescue	VUBR	*Vulpia bromoides*	Introduced	0.5–1	–
rescuegrass	BRCA6	*Bromus catharticus*	Introduced	1–2	–
Forb/Herb					
narrowleaf plantain	PLLA	*Plantago lanceolata*	Introduced	0.2–0.5	1–5
Madagascar ragwort	SEMA15	*Senecio madagascariensis*	Introduced	0.5–1	1–5
spreading snakeroot	AGRI2	*Ageratina riparia*	Introduced	1–2	0–1
stinking strawflower	HEFO4	*Helichrysum foetidum*	Introduced	0.5–1	0–1
common sheep sorrel	RUAC3	*Rumex acetosella*	Introduced	0.2–0.5	0–0.5
oxeye daisy	LEVU	*Leucanthemum vulgare*	Introduced	0.5–1	0–0.5
father-and-child plant	EUJA6	*Euchiton japonicus*	Introduced	0.5–1	0–0.5
porterweed	STACH2	*Stachytarpheta*	Introduced	1–2	0–0.5
Australasian geranium	GEHO5	*Geranium homeanum*	Introduced	0.5–1	0–0.5
lilac tasselflower	EMSO	*Emilia sonchifolia*	Introduced	1–2	–
Peruvian groundcherry	PHPE4	*Physalis peruviana*	Introduced	2–3	–
Jerusalem cherry	SOPS	*Solanum pseudocapsicum*	Introduced	2–3	–
telegraphweed	HEGR7	*Heterotheca grandiflora*	Introduced	2–3	–
Virginia pepperweed	LEVI3	*Lepidium virginicum*	Introduced	0.5–1	–

southern rockbell	WAMA	*Wahlenbergia marginata*	Introduced	0.5–1	–
common mullein	VETH	*Verbascum thapsus*	Introduced	2–3	–
bull thistle	CIVU	*Cirsium vulgare*	Introduced	2–3	–
common St. Paul's wort	SIOR2	*Sigesbeckia orientalis*	Introduced	0.5–1	–
horehound	MAVU	*Marrubium vulgare*	Introduced	0.5–1	–
muster John Henry	TAMI3	*Tagetes minuta*	Introduced	0.5–1	–
Fern/fern ally					
rough maidenhair	ADHI	*Adiantum hispidulum*	Introduced	0.5–1	–
clustered lady's slipper	CYFA	*Cypripedium fasciculatum*	Introduced	0.5–1	–
Shrub/Subshrub					
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	2–4	0–5
pukiawe	STTA	*Styphelia tameiameiae*	Native	2–4	0–5
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	2–4	0–1
Vine/Liana					
sawtooth blackberry	RUAR2	*Rubus argutus*	Introduced	2–3	0–1
Cape-ivy	DEOD	*Delairea odorata*	Introduced	1–10	0–1
Mexican twist	LOER3	*Lophospermum erubescens*	Introduced	0.5–1	0–1

Table 30. Community 4.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
koa	ACKO	*Acacia koa*	Native	13–40	80–90	–	–

Table 31. Community 4.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
kikuyugrass	PECL2	*Pennisetum clandestinum*	Introduced	0.5–1	40–60
weeping grass	MIST	*Microlaena stipoides*	Introduced	0.5–1	20–30
sweet vernalgrass	ANOD	*Anthoxanthum odoratum*	Introduced	1–2	15–25
common velvetgrass	HOLA	*Holcus lanatus*	Introduced	1–2	5–10
Kentucky bluegrass	POPR	*Poa pratensis*	Introduced	1–2	0–1
shortleaf spikesedge	KYBR	*Kyllinga brevifolia*	Introduced	0.5–1	0.5–1
Oahu flatsedge	CYHY2	*Cyperus hypochlorus*	Native	0.5–1	0–1
brome fescue	VUBR	*Vulpia bromoides*	Introduced	0.5–1	0–0.5
rescuegrass	BRCA6	*Bromus catharticus*	Introduced	1–2	–
Forb/Herb					
narrowleaf plantain	PLLA	*Plantago lanceolata*	Introduced	0.5–1	3–5
Madagascar ragwort	SEMA15	*Senecio madagascariensis*	Introduced	0.5–1	0–1
oxeye daisy	LEVU	*Leucanthemum vulgare*	Introduced	0.5–1	0–1
spreading snakeroot	AGRI2	*Ageratina riparia*	Introduced	1–2	0–1
common sheep sorrel	RUAC3	*Rumex acetosella*	Introduced	0.5–1	0–0.5
bull thistle	CIVU	*Cirsium vulgare*	Introduced	2–3	0–0.5
Australasian geranium	GEHO5	*Geranium homeanum*	Introduced	0.5–1	0–0.5
father-and-child plant	EUJA6	*Euchiton japonicus*	Introduced	0.5–1	0–0.5
porterweed	STACH2	*Stachytarpheta*	Introduced	2–3	0–0.5
Peruvian groundcherry	PHPE4	*Physalis peruviana*	Introduced	2–3	0–0.5
Jerusalem cherry	SOPS	*Solanum pseudocapsicum*	Introduced	2–3	0–0.5
horehound	MAVU	*Marrubium vulgare*	Introduced	0.5–1	0–0.5
common mullein	VETH	*Verbascum thapsus*	Introduced	2–3	–
Fern/fern ally					
rough maidenhair	ADHI	*Adiantum hispidulum*	Introduced	0.5–1	0–0.5
Japanese netvein hollyfern	CYFA2	*Cyrtomium falcatum*	Introduced	0.5–1	–
Shrub/Subshrub					
Florida hopbush	DOVI	*Dodonaea viscosa*	Native	2–4	0–1
pukiawe	STTA	*Styphelia tameiameiae*	Native	2–4	0–1
cure for all	PLCA10	*Pluchea carolinensis*	Introduced	2–5	0–1
Tree					
koa	ACKO	*Acacia koa*	Native	2–13	1–5
'ohi'a lehua	MEPO5	*Metrosideros polymorpha*	Native	2–10	–
mamani	SOCH	*Sophora chrysophylla*	Native	2–8	–
Vine/Liana					
sawtooth blackberry	RUAR2	*Rubus argutus*	Introduced	1–2	0–1
Cape-ivy	DEOD	*Delairea odorata*	Introduced	1–20	0–1
Mexican twist	LOER3	*Lophospermum erubescens*	Introduced	1–2	0–0.5

Animal community

Native Wildlife

The Reference State of this ecological site can support a variety of native birds, including elepaio (Chasiempis sandwichensis bryani), amakihi (Hemignathus virens), apapane (Himatione sanguinea), and iiwi (Vestiaria coccinea). It also is home to the Hawaiian hoary bat or opeapea (Lasiurus cenarius semotus). These species may be encountered within community phases with native tree cover. Community phases that provide open grassland or savanna-like settings provide habitat for the native Hawaiian owl or pueo (Asio flammeus spp. sandwichensis) and the Hawaiian hawk or io (Buteo solitarius).

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 and sheep are common. They provide hunting opportunities but are destructive to native vegetation. Public sport hunting typically does not have a major impact on their populations; exclusion by fences followed by intensive hunting and trapping within exclusion areas is necessary to eliminate feral animals.

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 phases 2.1 and 3.1. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Sometimes the current plant composition does not entirely match any particular plant community described in this ecological site description. Because of this, a field visit is recommended to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using the following stocking rate information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies may result in an increased stocking rate.

Forage Value Rating (note 1)

Very High (note 2) 0.60-1.60 acre/AUM (note 3) 1.60-0.64 AUM/acre

High 1.60-3.20 acre/AUM 0.64-0.31 AUM/acre

Moderate 3.20-6.30 acre/AUM 0.31-0.16 AUM/acre

Low 6.30-+ acre/AUM 0.16-+ AUM/acre

(note 1) The Forage Value Rating System is not an ecological evaluation of community phases 2.1 and 3.1. It is a utilitarian rating of the existing forage value for that specific plant community.

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

(note 3) Stocking rates vary in accordance with such factors as kind and class of livestock or wildlife, season of use, and fluctuations in climate. Actual use records and on-site inventories for individual sites, together with a determination of the degree to which the sites have been grazed, offer the most reliable basis for developing initial stocking rates.

These plant communities are suitable for grazing by all kinds and classes of livestock, at any season, particularly cattle. This site is suited for grazing by both cow-calf operations and stocker operations. However, sheep can be grazed on this site as well. This site is poorly suited to continuous year-long use if the condition of the plant community is to be maintained. Herbaceous forage can be deficient in protein during the drier months.

Hydrological functions

Most of the community phases of this ecological site are covered by vegetation and probably not prone to excessive soil erosion. Community phases 2.3 and 2.1 have high percentages of bare ground and are prone to excessive erosion.

Recreational uses

Hunting of introduced ungulates and game birds is the most common recreational use. Access by vehicle on gravel or dirt roads and on foot is easy in many areas.

Wood products

Mountain sandalwood was a valuable wood product in the past. Some koa is harvested currently from this ecological site. However, recent reestablishment of koa in limited areas may lead to valuable harvests in the future.

Other products

None.

Other information

Definitions
These definitions have been greatly simplified for brevity and do not cover every aspect of each topic.

Aa lava: A type of basaltic lava having a rough, jagged, clinkery surface and a vesicular interior.

Alluvial: Materials or processes associated with transportation and/or deposition by running water.

Aquic soil moisture regime: A regime in which the soil is free of dissolved oxygen because it is saturated by water. This regime typically exists in bogs or swamps.

Aridic soil moisture regime: A regime in which defined parts of the soil are, in normal years, dry for more than half of the growing season and moist for less than 90 consecutive days during the growing season. In Hawaii it is associated with hot, dry areas with plants such as kiawe, wiliwili, and buffelgrass. The terms aridic and torric are basically the same.

Ash field: a land area covered by a thick or distinctive deposit of volcanic ash that can be traced to a specific source and has well defined boundaries. The term “ash flow” is erroneously used in the Physiographic section of this ESD due to a flaw in the national database.

Ashy: A “soil texture modifier” for volcanic ash soils having a water content at the crop wilting point of less than 30 percent; a soil that holds relatively less water than “medial” and “hydrous” soils.

Available water capacity: The amount of soil water available to plants to the depth of the first root-restricting layer.

Basal area or basal cover: The cross sectional area of the stem or stems of a plant or of all plants in a stand.

Blue rock: The dense, hard, massive lava that forms the inner core of an aa lava flow.

Bulk density: the weight of dry soil per unit of volume. Lower bulk density indicates a greater amount of pore space that can hold water and air in a soil.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Makai: a Hawaiian word meaning "toward the sea."

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Torric soil moisture regime: See Aridic soil moisture regime.

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

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

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

Type locality

Location 1: Hawaii County, HI	
Latitude	19° 32′ 46″
Longitude	155° 48′ 18″

General legal description	On Hokukano Ranch mauka of Capt. Cook, Kona.

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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:**