

# Ecological site VX165X01X002

## Cool Isothermic Udic 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.

### MLRA notes

Major Land Resource Area (MLRA): 165X–Subhumid Intermediate Mountain Slopes

This MLRA occurs in the State of Hawaii on the islands of Molokai, Oahu, and Kauai. Elevation ranges from 400 to 3,700 feet (120 to 1,130 meters). It is on leeward, drier, intermediate mountain slopes on rolling slopes that are dissected by many steep and very steep gulches. The geology is basic igneous rock (primarily basalt). Interfluves are influenced volcanic ash. Average annual precipitation ranges from 25 to 60 inches (635 to 1,525 millimeters). Most of the rainfall occurs from November through March. Average annual air temperature is 61 to 74 degrees F (16 to 23 degrees C), with little seasonal variation. Dominant soils are Inceptisols, Ultisols, Oxisols, Andisols, and Spodosols with an isothermic, soil temperature regime and ustic or udic soil moisture regimes. Vegetation consists of forest, grassland, and shrubland.

### Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 165 - Subhumid Intermediate Mountain Slopes.

### Ecological site concept

This ecological site is situated on the northwestern slopes of the island of Kauai and the upper slopes of the Waianae Mountains on the island of Oahu between elevations of 1000 to 3500 feet (308 to 1075 meters). Most of the land is in government ownership. The best accessibility is at Kokee State Park on Kauai.

The central concept of the Cool Isothermic Udic Forest is of well drained, weathered,

moderately deep and deep soils formed residuum from basalt and/or in volcanic ash. Annual air temperatures and rainfall are associated with warm (isothermic) soils that are moist for much of the year (udic). There is frequent cloud cover over much of the area. This climate supports vegetation that is transitional between species adapted for dry and moist habitats, creating a zone of very high plant species diversity. This zone is often referred to as “mesic forest” in botanical literature, and, on Kauai and Oahu, is referred to as “diverse mesic forest.” There are no tree species that can be classified as dominant across the entire ecological site, although dominant species do occur locally.

## Associated sites

VX165X01X001	<p><b>Isothermic Ustic Naturalized Grassland</b></p> <p>The Isothermic Ustic Naturalized Grassland adjoins this ecological site on Kauai, but is at lower elevations and is warmer and drier. It supports species associated with typical dry forest rather than the mix of dry and moist habitat species occurring in this ecological site.</p>
VX164X01X005	<p><b>Somewhat Poorly Drained Organic Surface Forest</b></p> <p>The Somewhat Poorly Drained Organic Surface Forest adjoins this ecological site on Kauai, but is at the same or higher elevations and is cooler and wetter. It has somewhat poorly drained soils, so it supports species associated with rainforest rather than the dry-moist transitional forest of this ecological site.</p>

## Similar sites

VX158X01X005	<p><b>Naturalized Grassland 50 to 90 inch PZ Ohia lehua/kikuyugrass (Metrosideros polymorpha/Pennisetum clandestinum)</b></p> <p>The Naturalized Grassland, 50 to 90 Inch Precipitation Zone has similar rainfall but warmer temperatures than this ecological site. It has transitional dry-to-wet habitat plant species but, probably for biogeographical reasons (isolated from certain areas by terrain, environment, and occurring on some different islands) does not exhibit the same high species diversity as this ecological site.</p>
VX159A01X403	<p><b>Isohyperthermic Udic Naturalized Grassland (Guineagrass / Desmodium)</b></p> <p>The Isohyperthermic Naturalized Grassland, 60-90 Inch PZ has similar rainfall but warmer temperatures than this ecological site. It has transitional dry-to-wet habitat plant species but, probably for biogeographical reasons occurring on different, geologically-younger islands) does not exhibit the same high species diversity as this ecological site.</p>

**Table 1. Dominant plant species**

Tree	(1) <i>Alectryon macrococcus</i> (2) <i>Diospyros sandwicensis</i>
Shrub	(1) <i>Strongylodon ruber</i>
Herbaceous	Not specified

## Legacy ID

F165XY002HI

## 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).

**Table 2. Representative physiographic features**

Landforms	(1) Shield volcano > Lava flow (2) Shield volcano > Ash field (3) Shield volcano > Ridge
Runoff class	Medium to high
Flooding frequency	None
Ponding frequency	None
Elevation	305–1,067 m
Slope	0–90%
Water table depth	152 cm
Aspect	NW, N, E

**Table 3. Representative physiographic features (actual ranges)**

Runoff class	Not specified
Flooding frequency	Not specified
Ponding frequency	Not specified
Elevation	305–1,280 m
Slope	Not specified
Water table depth	Not specified

## Climatic features

Summary for this ecological site

Average annual precipitation ranges from 50 to 80 inches (1250 to 2000 millimeters). Extremes go as low as 40 inches (1000 millimeters) and as high as 100 inches (2500 millimeters); at these ranges, the area is grading into dry forest with koa or higher-elevation moist forest. Most of the precipitation falls from October through April. Average

annual temperature is about 60 degrees F (16 degrees C) on most of the area. Afternoon cloud cover is occurs most days, ameliorating temperature and evapotranspiration.

### General principles

Air temperature in the Hawaiian Islands 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).

Two seasons can be defined during the year: a winter season from October through April and a summer season from May through September. Summer has warmer temperatures, steadier and stronger trade winds, few widespread rainstorms, and generally lower average monthly rainfall than winter. The Kona Coast of Hawaii (the "Big Island") is the only area where summer rainfall exceeds winter rainfall. Differences in rainfall amounts between winter and summer are most marked in low elevation dry areas; wetter areas exhibit less seasonal variation in rainfall.

The islands lie within the trade wind zone. Moisture is picked up from the ocean by trade winds to an altitude of about 6,000 feet (1850 meters). As the trade winds from the northeast are forced up the islands' mountains their moisture condenses, creating rain on the windward slopes; the leeward sides of the island receive little of this moisture. The zones of highest rainfall on the windward flanks of the highest mountains (more than 10,000 feet or 3075 meters), which include Mauna Kea, Mauna Loa, and Haleakala, occur at elevations of 2,000 to 4,000 feet (615 to 1230 meters). A temperature inversion that fluctuates between about 5,000 and 7,000 feet (1540 to 2150 meters) on these three highest mountains creates a boundary between lower moist air and higher dry air. Above the inversion, rainfall is scant, skies are usually clear, humidity is low, and temperatures can drop below freezing. On West Maui, Kauai, Molokai, Oahu, and Lanai, where the mountains are all lower than 6,000 feet (1850 meters), the highest rainfall amounts occur along or near the summits. The moist trade winds usually flow across these lower mountains and around the higher mountains. Lanai is sheltered from the trade winds by the much larger island of Maui, putting it in a rain shadow during trade wind weather; rainfall on Lanai is uncharacteristically low for Hawaii.

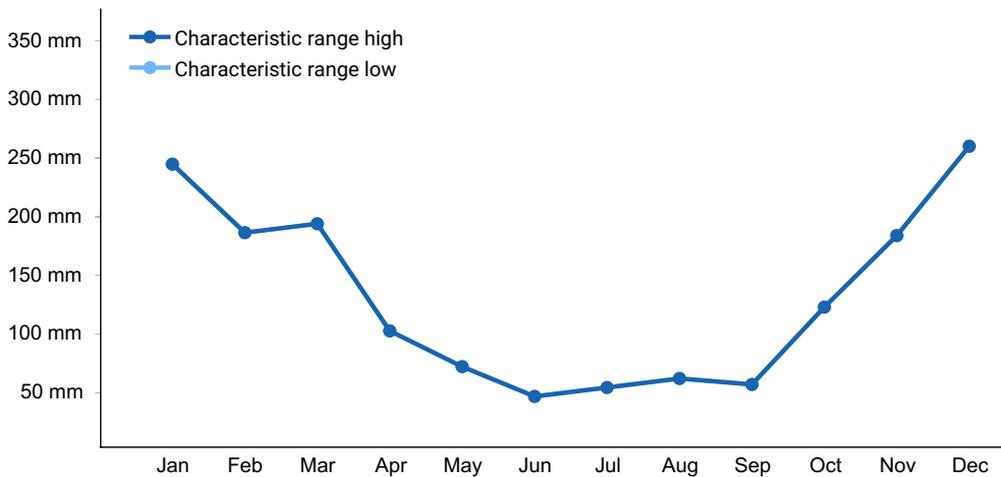
Besides the trade winds discussed above, other rainfall sources on the Hawaiian Islands include: a) Widespread winter storms that usually approach the islands from the west, producing heavy rainstorms that primarily affect the leeward sides but can envelope much larger areas; b) "Naulu storms" (Leopold 1948) caused by local convergence of sea breezes and trade winds to produce summertime cumulus clouds, resulting in infrequent, short-duration, high-intensity rainfall and afternoon shade over leeward dry areas; and c) Fog drip, particularly important to areas with relatively low rainfall, that adds a significant amount of water to areas where clouds intersect mountains (Juvik and Nullet 1993; Western Regional Climate Center).

The heaviest rains are brought by winter storms. The greatest amounts of storm rainfall do

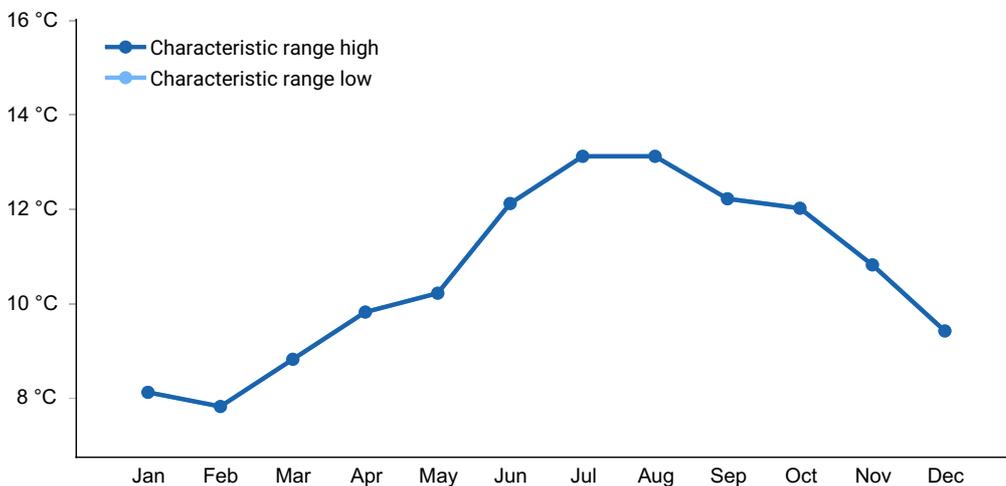
not always occur in areas with the highest average rainfall, and a storm may bring half of the mean annual rainfall to a dry area in one day.

**Table 4. Representative climatic features**

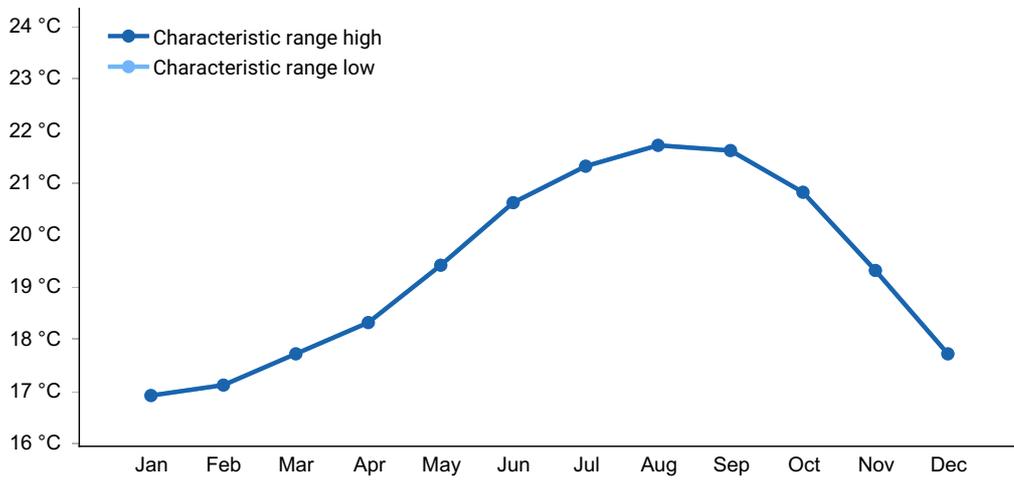
Frost-free period (characteristic range)	365 days
Freeze-free period (characteristic range)	365 days
Precipitation total (characteristic range)	1,270-2,032 mm
Frost-free period (actual range)	365 days
Freeze-free period (actual range)	365 days
Precipitation total (actual range)	1,016-2,540 mm
Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	1,575 mm



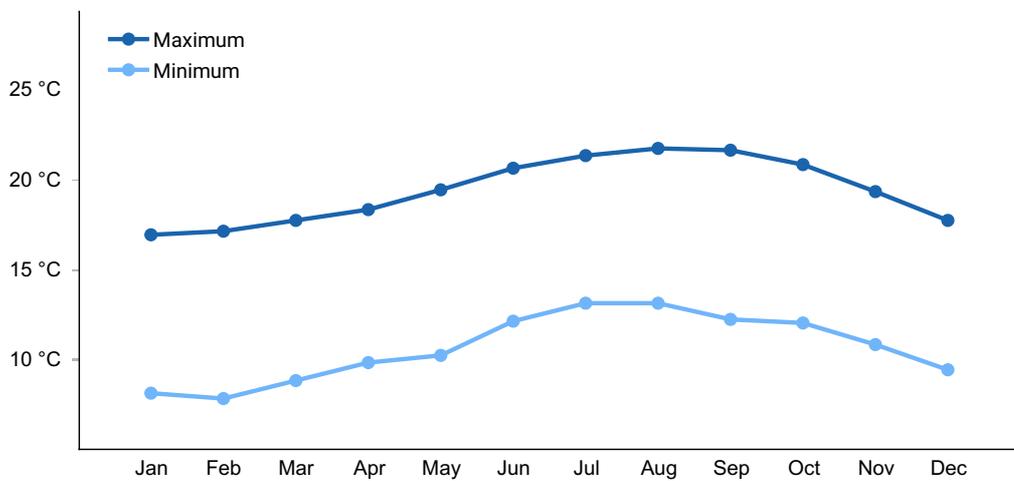
**Figure 1. Monthly precipitation range**



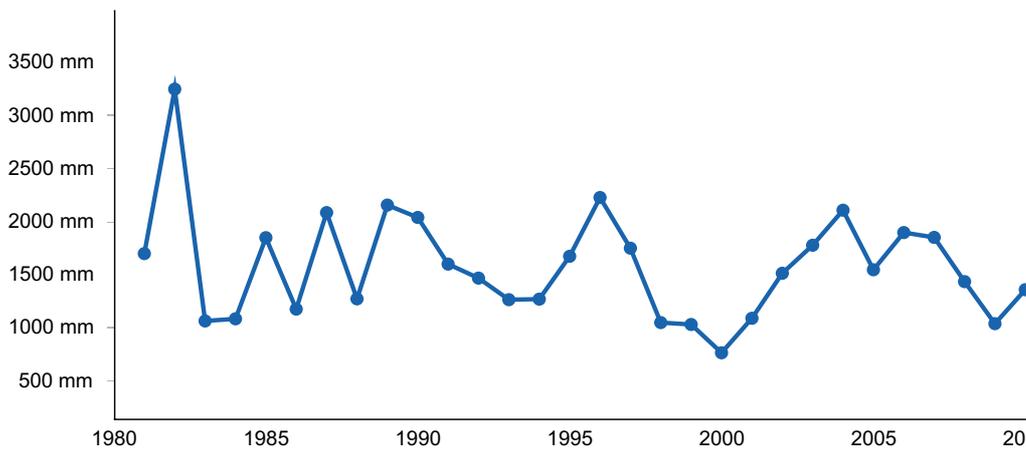
**Figure 2. Monthly minimum temperature range**



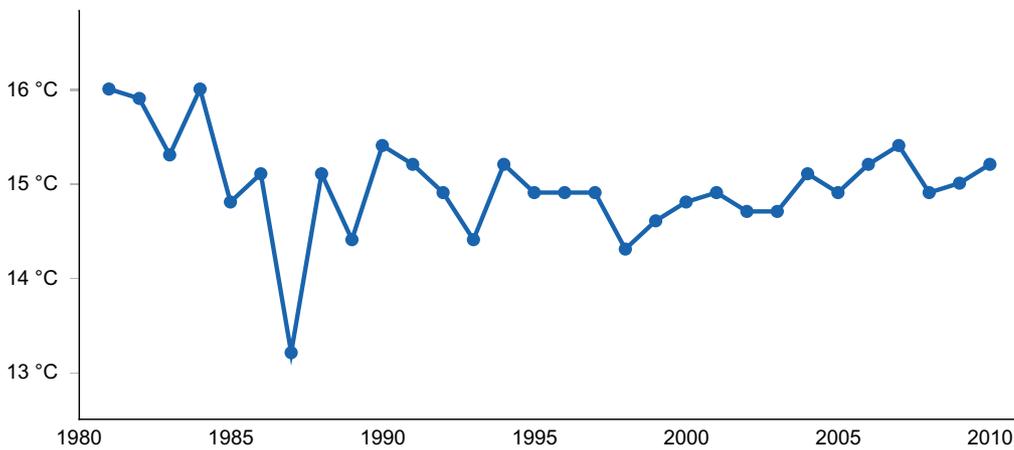
**Figure 3. Monthly maximum temperature range**



**Figure 4. Monthly average minimum and maximum temperature**



**Figure 5. Annual precipitation pattern**



**Figure 6. Annual average temperature pattern**

## **Climate stations used**

- (1) KANALOHULUHULU 1075 [USC00513099], Hanapepe, HI

## **Influencing water features**

Swamps, marshes, perennial streams and intermittent streams are all associated with this ecological site.

## **Soil features**

The soils in this ecological site all formed in weathered residuum with or without additions of volcanic ash. They are in the soil orders of Andisols, Oxisols, Ultisols, and Inceptisols. The soils are well drained. Soil depths are moderately deep to deep. Soil temperature regimes are isothermic (warm) but at the lower extreme of this regime over much of the ecological site. Soil moisture regimes are udic (in which the soil is not dry in any part for as long as 90 cumulative days in normal years). The soils are relatively old and weathered. Surface textures range from silty clay or clay or are medial in the Andisols.

KOKEE and PAAIKI soils are in the Andisols soil order. Kokee soils have pH of 5.0 or lower and are allic, meaning they contain high amounts of dissolved aluminum that can interfere with plant root growth. They also have an umbric surface horizon, which contains high amounts of organic carbon with low base saturation. Paaiki soils have pH of 4.8 to 5.8. They have subsurface horizons with oxic properties, meaning highly weathered, low fertility, low ion exchange capacity, and possibly low water holding capacity due to cementation of clay sized particles into “pseudosand.”

Both Kokee and Paaiki soils have andic properties that 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 relative to their apparent texture. 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).

KUNUWEIA soils are in the Oxisols soil order. Both surface and subsurface soils have pH of about 4.9. Oxisols have a highly weathered subsurface horizon with the oxic properties described above for Kokee and Paaiki soils. Kunuweia soils are ferritic, meaning more than 40 percent of the fine earth fraction of the soil is composed of iron oxide. They are particularly low in plant nutrients; the vegetation depends on recycling of nutrients from the subsoil to the surface by plants.

TROPOHUMULTS occur on Oahu and are in the Ultisols soil order. The unique properties common to Ultisols are an argillic horizon (containing clay translocated from overlying horizons) and a low supply of bases, particularly in the lower horizons. The cation-exchange capacity in Ultisols is moderate or low. The decrease in base saturation with increasing depth reflects cycling of bases by plants or additions in fertilizers. In soils that have not been cultivated, the highest base saturation is normally in the few centimeters directly beneath the surface. The clayey subsurface horizons can retain substantial amounts of water, much of it available to plants. Kunuweia soils are in the suborder Humults, which have at least 1.5 percent organic matter in the upper part of the argillic horizon. Ultisols tend to form in moist climates that promote weathering of soil materials and leaching of base cations, resulting in strongly to extremely acid soils. However, some Ultisols occurring in less wet climates obtained their ultic characteristics by forming under wetter ancient climates.

DYSTRANDEPTS occur on Oahu. They are in the Inceptisols soil order, meaning they are soils that have so far developed only minor defining horizonation. However, the materials in which they formed may be old and weathered. As their taxonomic name implies, they have andic properties, as described above. They are also “dystric,” meaning they have low cation exchange capacity. Their pH ranges from 5.1 to 6.0.

**Table 5. Representative soil features**

Parent material	(1) Residuum–igneous rock (2) Basic volcanic ash
Surface texture	(1) Silty clay loam (2) Very gravelly clay loam (3) Loam
Family particle size	(1) Medial (2) Clayey (3) Clayey-skeletal
Drainage class	Well drained

Permeability class	Very slow to slow
Depth to restrictive layer	102–183 cm
Soil depth	102–183 cm
Surface fragment cover ≤3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	12.7–17.78 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	3.6–6
Subsurface fragment volume ≤3" (0-101.6cm)	3–27%
Subsurface fragment volume >3" (0-101.6cm)	2%

## 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 natural fires, landslides, and wind throw. Natural fires caused by lightning are very rare. Steeper areas can undergo landslides. Wind throw of vegetation can occur during hurricanes or other high wind events.

### 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. These 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 percent 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 percent 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. Less accessible areas may have been affected by factors such as inadvertently introduced plant diseases and seed predation 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 decade the 18th century. These animals ranged free on the islands, becoming very numerous and destructive by the early decades of the 19th century.

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 human-caused fires.

The most important human disturbances in the ecological site are foraging and trampling by feral ungulates, human-caused fires, and invasion by introduced plant and animal species. Much of the previously-disturbed area is now dominated by forests of introduced species.

## **State and transition model**

## Cool Isothermic Udic Forest F165XY002HI

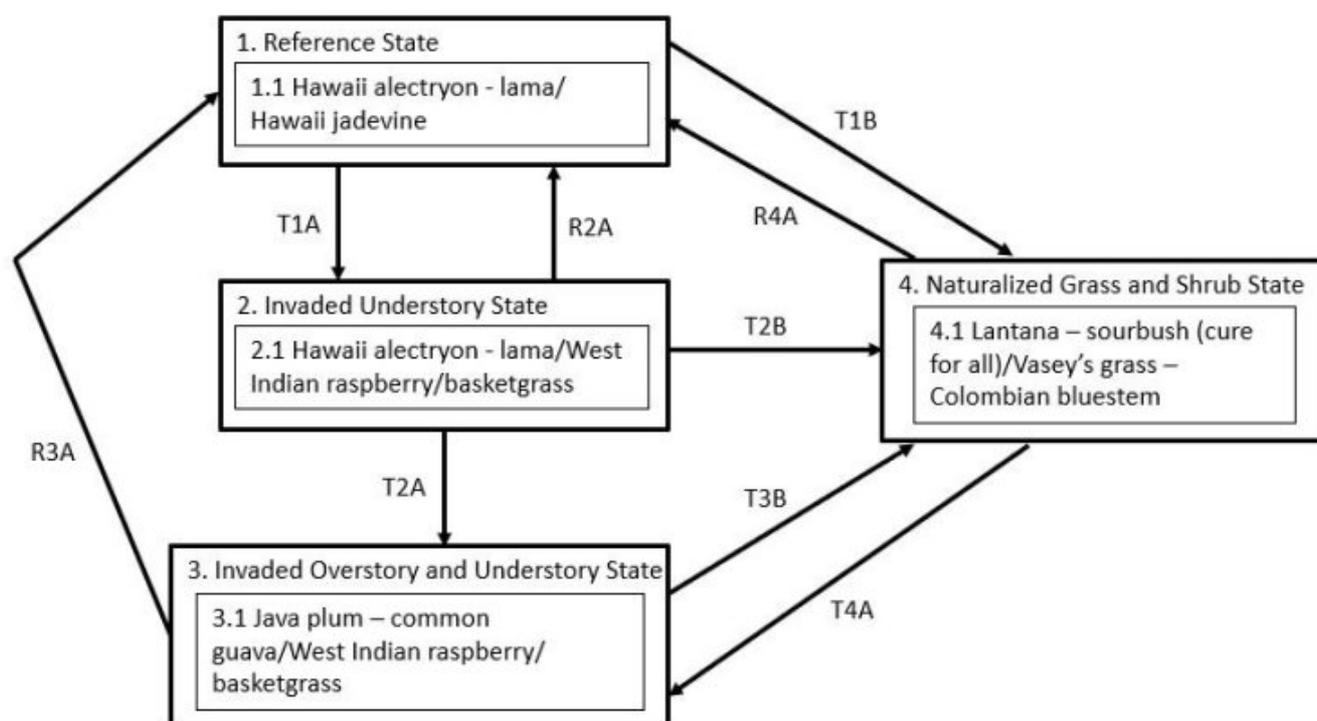


Figure 7. State and Transition Model for the Cool Isothermic Udic Forest (F165XY002HI).

### State 1 Reference State

This state consists of one community phase that is closed canopy forest up to 50 feet (15 meters) tall. Vegetation is transitional between species adapted for dry and moist habitats, creating a zone of very high plant species diversity. This zone is often referred to as “mesic forest” in botanical literature, and, on Kauai and Oahu, is referred to as “diverse mesic forest.” There are no tree species that can be classified as dominant across the entire ecological site, although some species do occur locally. When cleared by landslide, hurricane, fire, or long-term, heavy ungulate browsing, this state transitions to State 4 Naturalized Grass and Shrub unless the disturbed site is completely surrounded by native vegetation. Gradual invasion by weedy, introduced plant species brings a transition to State 2 Invaded Understory.

### Community 1.1 Hawaii alectryon – lama/Hawaii jadevine

The community is a highly diverse forest of medium stature (30 to 40 feet or 9 to 12 meters) with some emergent trees up to 70 feet (21 meters) tall, closed overstory and a sparse understory of shrubs, vines, and ferns. Some common or distinctive overstory trees are lama (*Diospyros sandwicensis*), Hawaii alectryon (*Alectryon macrococcus*), ridged pteralyxia (*Pteralyxia macrocarpa*), koa (*Acacia koa*), ohia lehua (*Metrosideros*

*polymorpha*), and mehamehame (*Flueggea neowawraea*). Shrubs are diverse but not abundant in the understory. Vines are common, including Hawaii jadevine (*Strongylodon ruber*), maile (*Alyxia stellata*), and Canavalia species. Hawaii birdnest fern (*Asplenium nidus*) occurs as an epiphyte.

### **Dominant plant species**

- Hawaii'i alectryon (*Alectryon macrococcus*), tree
- lama (*Diospyros sandwicensis*), tree
- Hawaii'i jadevine (*Strongylodon ruber*), shrub

## **State 2**

### **Invaded Understory State**

This state consists of one community phase. It retains the diverse native overstory of the Reference State. However, introduced trees, shrubs, vines, grasses, forbs, and ferns produce a dense understory of competitive vegetation that severely inhibits reproduction of native species. Activity of feral ungulates further reduces native plant abundance and produces disturbed soil patches that promote weed invasion. Eventually, this state transitions to State 3 Invaded Overstory and Understory through growth of introduced tree species.

### **Community 2.1**

#### **Hawaii alectryon - lama/West Indian raspberry/basketgrass**

While native trees dominate the overstory, introduced species create a dense understory. This understory greatly inhibits reproduction of native tree species. Seedlings and saplings of common guava (*Psidium guajava*), Formosa koa or small Philippine Acacia (*Acacia confusa*), kukui or Indian walnut (*Aleurites moluccana*), faya or firetree (*Morella faya*), and Java plum (*Syzygium javanicum*) are increasingly abundant. Lantana (*Lantana camara*) and West Indian raspberry (*Rubus rosifolius*) are able to form a sparse to dense understory depending on light availability. Basketgrass (*Oplismenus hirtellus*) and cathedral bells (*Kalanchoe pinnata*), a forb, are able to grow densely in low light conditions.

### **Dominant plant species**

- Hawaii'i alectryon (*Alectryon macrococcus*), tree
- lama (*Diospyros sandwicensis*), tree
- West Indian raspberry (*Rubus rosifolius*), shrub
- basketgrass (*Oplismenus hirtellus*), grass

## **State 3**

### **Invaded Overstory and Understory State**

This state consists of one community phase dominated by introduced species in both the

overstory and understory. Some individual native trees may persist for their lifetime. The diversity of weedy trees, shrubs, vines, ferns, and herbs is high and the species mix is variable.

### **Community 3.1**

#### **Java plum – common guava/West Indian raspberry/basketgrass**

Remnant native trees persist until they die but do not successfully reproduce. The introduced species present on different sites varies. Monotypic or mixed stands of Java plum (*Syzygium cumini*), Formosan koa or small Philippine acacia (*Acacia confusa*), kukui or Indian walnut (*Aleurites moluccana*), and faya or firetree (*Morella faya*) develop. The understory varies among locations but may consist of different combinations or monotypic stands of lantana (*Lantana camara*), common guava (*Psidium guajava*), West Indian raspberry (*Rubus rosifolius*). Introduced grass species such as orchardgrass (*Dactylis glomerata*), molassesgrass (*Melinis minutifolia*), basketgrass (*Oplismenus hirtellus*), or Colombian bluestem (*Schizachyrium condensatum*) are present and vary with elevation, rainfall, and light conditions.

#### **Dominant plant species**

- Java plum (*Syzygium cumini*), tree
- guava (*Psidium guajava*), tree
- West Indian raspberry (*Rubus rosifolius*), shrub
- basketgrass (*Oplismenus hirtellus*), grass

### **State 4**

#### **Naturalized Grass and Shrub State**

This state consists of one community phase consisting primarily of weedy shrubs, forbs, and grasses. Seedlings of introduced tree species are usually present and will attain dominance if fire does not set them back.

### **Community 4.1**

#### **Lantana – sourbush (cure for all)/Vasey's grass – Colombian bluestem**

This community phase contains a wide diversity of mostly introduced species. Taller trees are typically sparse to absent. Species that thrive in conditions of abundant sunlight quickly invade a cleared site. The particular species present varies depending on local seed availability and timing of arrival on the site. Seedlings of the introduced tree species in the overstory of State 3 will usually be present. Common shrubs and vines are lantana (*Lantana camara*), koa haole or white leadtree (*Leucaena leucocephala*) (actually a small tree), sourbush or cure for all (*Pluchea carolinensis*), and West Indian raspberry (*Rubus rosifolius*). Some possible forbs are narrowleaf plantain (*Plantago lanceolata*), asthmaweed (*Conyza bonariensis*), soft elephantsfoot (*Elephantopus mollis*), Latin American fleabane (*Erigeron karvinskianus*), and cathedral bells (*Kalanchoe pinnata*).

Some of the common grasses are orchardgrass (*Dactylis glomerata*) at higher elevations, molassesgrass (*Melinis minutifolia*) at lower elevations, Vasey's grass (*Paspalum urvillei*), and Colombian bluestem (*Schizachyrium condensatum*).

### **Dominant plant species**

- lantana (*Lantana camara*), shrub
- cure for all (*Pluchea carolinensis*), shrub
- Vasey's grass (*Paspalum urvillei*), grass
- Colombian bluestem (*Schizachyrium condensatum*), grass

### **Transition T1A**

#### **State 1 to 2**

State 1 Reference transitions to State 2 Invaded Understory by the very aggressive, introduced weed species present in this ecological site invading intact native forest and gradually replacing native species in the understory. This invasion is greatly facilitated by feral pigs, deer, goats, and cattle that damage and consume native plants, disturb the soil, and spread weed seeds.

### **Transition T1B**

#### **State 1 to 4**

State 1 Reference can transition to State 4 Naturalized Grass and Shrub by burning or mechanically clearing the forest with and later abandoning the site.

### **Restoration pathway R2A**

#### **State 2 to 1**

State 2 Invaded Understory may be restored to a facsimile of State 1 Reference. Construction of a suitable fence and removal of all ungulates are necessary. Intensive weed control must then be initiated and maintained in the long term. In some cases, large amounts of dead weed biomass must be dealt with by removal or decomposition. Reintroduction of missing native species will be necessary.

### **Transition T2A**

#### **State 2 to 3**

State 2 Invaded Understory transitions to State 3 Invaded Over and Understory through the process of fast-growing introduced trees inhibiting reproduction of native plants and gradually growing into and through the overstory. This process is accelerated by feral pigs and cattle directly damaging native plants and promoting the spread of weeds by disturbing the soil and spreading weed seeds.

## **Transition T2B**

### **State 2 to 4**

When cleared by landslide, hurricane, fire, or long-term, heavy ungulate browsing, State 2 Invaded Understory transitions to State 4 Naturalized Grass and Shrub when sources of weed seeds are present.

## **Restoration pathway R3A**

### **State 3 to 1**

State 3 Invaded Overstory and Understory can be converted to State 1 Reference by removing introduced trees or killing them in place, maintaining aggressive weed control measures, removing and excluding ungulates, and planting native species.

## **Transition T3B**

### **State 3 to 4**

State 3 Invaded Overstory and Understory transitions to State 4 Naturalized Grass and Shrub State if the site is cleared or burned in the presence of sources of weed seeds.

## **Restoration pathway R4A**

### **State 4 to 1**

State 4 Naturalized Grass and Shrub State can be restored to State 1 Reference by weed control, removal and exclusion of ungulates, and re-establishment of native species.

## **Transition T4A**

### **State 4 to 3**

State 4 Naturalized Grass and Shrub transitions to State 3 Invaded Overstory and Understory due to the presence of fast-growing, introduced tree species; wildfire may prevent this from occurring.

## **Additional community tables**

## **Other references**

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## DEFINITIONS

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

**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.

**CaCO<sub>3</sub> 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, duration, and depth 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.

**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.

**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.

**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.

**Oxisols:** Soils characteristic of humid, tropical or subtropical regions that formed on land surfaces that have been stable for a long time. In Hawaii, they typically occur on islands or parts of islands that have been volcanically inactive for a long time. Oxisols are highly weathered, consist largely of quartz, kaolin clays, and aluminum oxides, and have low ion exchange capacity and loamy or clayey texture.

**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.

**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.

**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.

Spodosols: Soils with a spodic B horizon that has an accumulation of black or reddish amorphous materials that have a high pH-dependent ion exchange capacity, coarse texture, and few base cations. Above the spodic horizon there often is a light-colored albic horizon that was the source of the amorphous materials in the spodic horizon.

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.

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 the Hawaiian Islands, it is associated with forests in which hapuu (tree ferns) are usually moderately to highly abundant.

Ultisols: Soils that have been intensively leached and weathered. They have a B horizon that has accumulated clay that has translocated there from higher horizons. They have moderate to low cation exchange capacity and low base saturation. The highest base saturation normally is in the few centimeters directly beneath the surface due to cycling of bases by plants.

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

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## **Rangeland health reference sheet**

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate.

Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	03/22/2026
Approved by	Kendra Moseley
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

## Indicators

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

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

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

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

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

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

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

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

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

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

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

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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:

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

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

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

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16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a**

**dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

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**17. Perennial plant reproductive capability:**

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