# Ecological site VX166X01X501
# Placorthod 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): 166X–Very Stony Land and Rock Land

This MLRA occurs in the State of Hawaii on the islands of Maui, Kahoolawe, Lanai, Molokai, Oahu, Kauai, and Niihau. Elevation ranges from sea level to 8,000 feet (0 to 2,440 meters). The terrain encompasses stony complex slopes and rocky gulches (USDA-NRCS, 2006). The geology is extrusive basic igneous rock (primarily basalt) that are weathered in some areas. Some interfluves are mantled with weathered volcanic ash. Average annual precipitation ranges from 17 to 39 inches (430 to 990 millimeters) (Giambelluca et al., 2013). Extreme average annual precipitation ranges from 10 to 107 inches (254 to 2,720 millimeters). Most of the rainfall occurs from November through March, much of it during kona storms. Average annual air temperatures ranges from 70 to 75 degrees F (21 to 24 degrees C) with little seasonal variation (Giambelluca et al., 2014). Extreme annual air temperatures range from 48 to 82 degrees F (9 to 28 degrees C). Dominant soils are Mollisols, Aridisols, and Entisols with an isohyperthermic, isothermic, or isomesic soil temperature regimes and ustic or aridic soil moisture regimes (USDA-NRCS, 2006). Vegetation consists of forbs, grasses, and shrubs with some trees. Most of the plant species typically encountered are introduced species that have become naturalized in Hawaii. However, areas within this MLRA are critical habitat for rare, threatened, or endangered plant species.

## Classification relationships

This ecological site occurs within Major Land Resource Area (MLRA) 166 - Very Stony Land and Rock Land. The Aha Moku System, which dates back to the 9th century and has been passed down through oral tradition and generational wisdom, effectively sustains Hawaii's natural ecosystems and environment (DLNR, 2024). This site-specific and resource-based approach balances land and ocean resources essential for fostering healthy, thriving communities. Grounded in Native Hawaiian generational knowledge, the Aha Moku System emphasizes community consultation to prioritize the health and welfare of Hawaii’s natural and cultural resources. It is rooted in the concept of 'ahupua'a, the traditional system of land and ocean management in Hawaii. For collaboration, this ecological framework encompasses the following mokus: Molokai Moku Acres: Kona (1,691) and Ko’olau (200). Lanai Moku Acres: Lahaina (316).

## Ecological site concept

This ecological site is forest on the moist, narrow ridgetops of Lanai and the ridgetops and upper slopes of the east Molokai mountains. It is within state lands. There is limited access on Lanai along the Lanaihale trail. Access on Molokai is limited to trails. An ironstone sheet or placic horizon which is impermeable to roots and water occurs at about 21 inches (53 centimeters) depth (USDA-SCS, 1972). The soils are very strongly acid (pH 4.5 to 4.8) throughout. It is this shallow, impermeable, placic horizon combined with the acidic nature of these soils which results in soils that have low water holding capacity and low nutrient availability. As such, the native vegetation is expressed as a low to medium stature rain forest with gnarled, many-branched trees, lots of shrubs and ferns, and many epiphytes (Hawaii Division of Forestry and Wildlife, 1991; Hobdy, 1993; Liebherr, 2009; Wagner et al., 1999; Wood, 1998). Rainfall is well distributed throughout the year and is supplemented by fog drip (Ekern, 1964).

## Associated sites

| | |
|---|---|
| VX158X01X005 | **Naturalized Grassland 50 to 90 inch PZ Ohia lehua/kikuyugrass (Metrosideros polymorpha/Pennisetum clandestinum)**<br><br>The Naturalized Grassland 50 to 90 Inch Precipitation Zone Ecological Site (R158XY005HI) co-occurs with this ecological site on Molokai. It occurs at lower and drier elevations which lacks the shallow ironstone layer of this ecological site. It supports vegetation that is transitional between dry and moist habitat types rather than the gnarled, low stature rainforest of this ecological site. |
| VX164X01X004 | **Epiaquic Forest**<br><br>The Epiaquic Forest Ecological Site (F164XY004HI) is adjacent to this ecological site on Molokai, where it generally occurs at higher and wetter elevations than this ecological site. Both sites have a shallow ironstone layer, but the Epiaquic Forest is poorly drained rather than well drained, causing gleyed soils that are lacking in this ecological site. The two ecological sites share some species, but the Epiaquic Forest should have more obligate wetland species and more a more open, shorter stature overstory than this ecological site. |

## Similar sites

| | |
|---|---|
| VX164X01X001 | **Gleyed Soil Forest**<br><br>The Gleyed Soil Forest Ecological Site (F164XY001HI) is similar to this ecological site because both sites have a shallow to somewhat shallow ironstone layer that is impermeable to roots and water, and both have forests which are stunted in stature (short or medium). F164XY001HI differs by occurring at higher elevations where conditions are wetter and by having soils comprised of poorly drained peat or muck, underlain by gleyed (gray and anaerobic) silty clay, while this ecological site has well drained soils formed from material weathered from basic igneous rock. |

**Table 1. Dominant plant species**

| | |
|---|---|
| Tree | (1) *Metrosideros polymorpha*<br>(2) *Cheirodendron trigynum* |
| Shrub | (1) *Freycinetia arborea* |
| Herbaceous | Not specified |

## Legacy ID

F166XY501HI

## Physiographic features

This ecological site occurs on weathered basaltic lava flows on ridges and upper mountain slopes (USDA-SCS, 1972).

**Table 2. Representative physiographic features**

| | |
|---|---|
| Landforms | (1) Shield volcano > Ridge<br>(2) Shield volcano > Mountain slope |
| Runoff class | Medium to high |

| | |
|---|---|
| Flooding frequency | None |
| Ponding frequency | None |
| Elevation | 380 – 1,140 m |
| Slope | 0 – 20 % |
| Water table depth | 180 cm |
| Aspect | E, S |

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

| | |
|---|---|
| Runoff class | Not specified |
| Flooding frequency | Not specified |
| Ponding frequency | Not specified |
| Elevation | 180 – 1,140 m |
| Slope | Not specified |
| Water table depth | Not specified |

## Climatic features

SUMMARY FOR THIS ECOLOGICAL SITE
Rainfall statistics were determined from University of Hawaii's Rainfall Atlas Raster Data (Giambelluca et al., 2013). Most of the precipitation falls from October through April. Representative (20th and 80th percentiles) values for annual average precipitation range from 56 to 100 inches (142 to 254 centimeters) while actual (10th and 90th percentiles) values range from 35 to 101 inches (89 to 257 centimeters). Extreme values range from 29 to 105 inches (74 to 267 centimeters). The mean annual precipitation is 74 inches (188 centimeters), and the median annual average precipitation is also 74 inches (188 centimeters). Landscapes are shrouded in fog or overcast during much of the day throughout the year, which reduces evapotranspiration and adds additional moisture from condensation of fog on vegetation, possibly as much as equaling the amount from rainfall (Ekern, 1964; Juvik and Nullett, 1993). Located in the rain shadow of Maui, Lanai is relatively dry. A large portion of the water in the island’s aquifer comes from fog drip pulled from clouds by trees and ferns in upper elevations.

Temperature statistics were determined from University of Hawaii's Surface Temperature Raster Data (Giambelluca et al., 2014). Representative (20th and 80th percentiles) values for annual temperatures range from 63 to 70 degrees F (17 to 21 degrees C) while actual (10th and 90th percentiles) values range from 63 to 72 degrees F (17 to 22 degrees C). Extreme values range from 60 to 73 degrees F (16 to 23 degrees C). The mean annual temperature is 66 degrees F (19 degrees C) and the median annual temperature is also 66 degrees F (19 degrees C).

No suitable Western Region Climate Stations occur in or near this ecological site (WRCC, 2020). The data in the climate normals tables below are from the University of Hawaii.

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).

The islands lie 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 about 6,000 feet (1,829 meters). As the trade winds from the northeast are forced up the mountains of the islands their moisture condenses, creating rain on the windward slopes; the leeward sides of the island receive little of this moisture (USDA-SCS, 1972; Western Regional Climate Center, 2020).

Hawaiian indigenous understanding recognized two seasons: Kau or Kauwela (dry season), and Ho`oilo (wet season). During Kau, the sun is directly overhead, days are long and warm, and the trade winds are stronger and more consistent; Kau started on the first new moon in May when the Pleiades set at sunrise (Handy et al., 1991). During Ho’oilo (wet season) the sun is declined toward the south, days are shorter, temperatures cooler and winds more variable and generally started with the first new moon in November. Ho’oilo is also the season when extensive low-pressure systems often approach the islands from the west, producing heavy rainstorms that primarily affect the leeward sides, but can envelope the entire island. (Malo, 1903; Handy et al., 1991; Sanderson, 1993). Differences in rainfall amounts between winter and summer are most marked in low elevation dry areas; wetter areas exhibit less seasonal variation in rainfall (USDA-SCS, 1972; Western Regional Climate Center, 2020).

On the windward sides of the islands, cool, moist air at higher elevations descends toward the ocean where it meets the trade winds; this process brings rainfall, often at night, to lower elevation areas (USDA-SCS, 1972; Western Regional Climate Center, 2020).

Extensive low-pressure systems often approach the islands from the west, producing heavy rainstorms that primarily affect the leeward sides, but can envelope the entire island. These major storms occur most frequently between October and March (USDA-SCS, 1972; Western Regional Climate Center, 2020).

Because Lanai is small and relatively smooth, the geographic distribution of its rainfall is not as spotty as on the larger rugged islands. Rainfall varies widely from year to year. There is a well-marked dry season during summer. December is the wettest month and July the driest in most locations. Heavy downpours during a single kona storm commonly account for a considerable part of the annual rainfall, and in some of the arid sections a single rain may contribute as much as 80 percent of the annual total. Because the island is not sheltered by other islands on the southerly side, kona storms are unobstructed. Sudden local heavy showers called naulu fall during times when neither the trade winds nor the kona winds blow. A naulu shower is caused by a cloud that forms off the south or west coast and then moves inland, dropping its moisture apparently as a result of local convection currents. Naulu showers are reported to occur chiefly in the afternoon during hot weather. Strong trade winds funneled from Maui and Molokai increase evaporation of moisture and contribute to soil erosion, particularly on the western side of Lanai (Hobdy, 1993; Western Regional Climate Center, 2020).

**Table 4 Representative climatic features**

| | |
|---|---|
| Frost-free period (characteristic range) | 370 days |
| Freeze-free period (characteristic range) | 370 days |
| Precipitation total (characteristic range) | 1,420-2,540 mm |
| Frost-free period (actual range) | 370 days |
| Freeze-free period (actual range) | 370 days |
| Precipitation total (actual range) | 890-2,570 mm |
| Frost-free period (average) | 370 days |
| Freeze-free period (average) | 370 days |

| | |
|---|---|
| Precipitation total (average) | 1,880 mm |

### Influencing water features

Number of National Wetland Inventory (NWI) features overlapping ecological site: Riverine (27), freshwater forested/shrub wetland (6), and lake (1) (USFSW, 2023).

Number of National Hydrologic Dataset (NHD) features overlapping ecological site: lake/pond (2) (USGS, 2019).

### Soil features

Only one soil component (Kahanui) is associated with this ecological site.

Kahanui soils are classified Placorthods. This series consists of moderately deep (but nearly in the shallow depth category), well drained silty clay that formed in material weathered from basic igneous rock (USDA-SCS, 1972). There is a weakly developed ironstone sheet at about 21 inches (52 centimeters) depth which is impermeable to roots and water except through cracks. The soil temperature regime is isothermic, and the soil moisture regime is udic. Soil reaction is very strongly acid (pH 4.5 to 4.8) throughout.

**Table 5. Representative soil features**

| | |
|---|---|
| Parent material | (1) Igneous rock |
| Surface texture | (1) Silty clay<br>(2) Gravelly silty clay |
| Family particle size | (1) Very-fine |
| Drainage class | Well drained |
| Permeability class | Very slow |
| Depth to restrictive layer | 50 cm |
| Soil depth | 50 – 180 cm |
| Surface fragment cover <=3" | Not specified |
| Surface fragment cover >3" | Not specified |
| Available water capacity<br>(0-101.6cm) | 5.08 cm |

| | |
|---|---|
| Calcium carbonate equivalent (0-101.6cm) | Not specified |
| Electrical conductivity (0-101.6cm) | Not specified |
| Sodium adsorption ratio (0-101.6cm) | Not specified |
| Soil reaction (1:1 water) (0-25.4cm) | 4.5 – 4.8 |
| Subsurface fragment volume <=3" (0-101.6cm) | 0 – 20 % |
| Subsurface fragment volume >3" (0-101.6cm) | Not specified |

## 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

Possible natural disturbances are drought, hurricanes and, in some locations, landslides (Hobdy, 1993).

HUMAN DISTURBANCES

Humans arrived in the Hawaiian Islands 1,200 to 1,500 years ago. Their population gradually increased so that by 1,600 A.D. at least 80 percent of all the lands in Hawaii below about 1,500 feet (457 meters) in elevation had been extensively altered by humans (Kirch, 1982). This ecological site occurs well above that elevation. However, this ecological site may have been affected by factors such as inadvertently introduced plant diseases and seed predation by the introduced Pacific Rat (Athens, 1997).

Approximately 50 percent (1,276 acres) of this 2,549-acre ecological site overlaps with the modeled "Intensive Agroforestry" agroecological system (Lincoln et al., 2023). Intensive Agroforestry was a managed tree cropping system which resulted in native forests becoming “replaced over time by Polynesian introduced trees, such as ‘ulu (breadfruit), kukui (candlenut), and ‘ohi‘a‘ai (mountain apple; Syzygium malaccense), along with some shade tolerant crops and native species in the understory (Handy et al., 1972; Meilleur et al., 2004; Lincoln, 2020)” (Lincoln et al., 2023, p. 06).

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 (Henke, 1929). The most destructive introduced animals in this remote ecological site have been feral pigs and cattle.

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.

The main disturbances in this ecological site are due to feral pigs, deer, mouflon sheep, and goats that disturb the soil and directly consume native plants and rats that consume seeds. Some plant species introduced since the arrival of Europeans in Hawaii thrive in this ecological site and have spread rapidly over large areas, competing with native plants. Common invasive plant species are the shrub soapbush or Koster’s curse (Clidemia hirta), strawberry guava (Psidium cattleianum), firetree or faya (Morella faya), broom teatree or manuka (Leptospermum scoparium), and grey sheoak or longleaf ironwood (Casuarina glauca). The forb Colombian waxweed (Cuphea carthagenensis) is present. West Indian raspberry (Rubus rosifolius) is common. Some common introduced and invasive grass and sedges are hilograss (Paspalum conjugatum) and glenwoodgrass (Sacciolepis indica) (Hawaii Division of Forestry and Wildlife, 1991; Hobdy, 1993; Liebherr, 2009; Wagner et al., 1999; Wood, 1998).

## State and transition model

**Figure 1. State-and-transition model diagram for the Placorthod Forest (F166XY501HI)**

## Additional community tables

**Table 6. Community 1.1 plant community composition**

| Group | Common Name | Symbol | Scientific Name | Annual Production () | Foliar Cover (%) |
|---|---|---|---|---|---|

**Table 7. Community 2.1 plant community composition**

| Group | Common Name | Symbol | Scientific Name | Annual Production () | Foliar Cover (%) |
|---|---|---|---|---|---|

## Other references

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## DEFINITIONS

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

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.

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

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.

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.

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.

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.

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 or a soil.

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

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

Torric soil moisture regime: See Aridic soil moisture regime.

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

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

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

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### Rangeland health reference sheet

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

| | |
|---|---|
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| 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:**