



Vegetation Mapping Inventory Project

Kalaupapa National Historical Park

Natural Resource Report NPS/PACN/NRR—2014/819



ON THE COVER

The cliffs, valleys, and peninsula of Kalaupapa National Historical Park.
Photograph by: Kass Green

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Executive Summary

This report details the methods used and results of the vegetation inventory for Kalaupapa National Historical Park (KALA). KALA's unique vegetation spans 4,340 ha (10,726 ac) on the Hawaiian Island of Moloka'i's isolated northern peninsula, cliffs, coastal waters, and islets. The park's isolated location, rich cultural history, and extreme topographic and climatic conditions combine to create a spectacularly beautiful and unique national park. The vegetation inventory was a team effort managed by the National Park Service (NPS) Pacific Island Network (PACN) and staffed by personnel from the NPS, University of Hawaii (UH), Cogan Technology, Inc. (CTI), NatureServe, and Kass Green & Associates (KGA).

The objective of a vegetation inventory is to "produce high-quality, standardized maps and associated data sets of vegetation and other land-cover occurring within parks" in support of resource assessment, park management and conservation needs (NPS 2013c). NPS vegetation inventories rely on a 12 Step Guidance Document which outlines the tasks to be completed in a NPS vegetation inventory:

1. Review Existing Data and "Best Practices" to Develop a Brief Proposal (1-5 pages) to Develop a Park or Network Vegetation Inventory Study Plan
2. Planning and Scoping to Gather the Detailed Information Needed to Develop the Study Plan
3. Develop and Submit a Detailed Study Plan for Approval of Funding
4. Field Plot Data Collection (for the Ecological Classification)
5. Develop Vegetation Classification, Vegetation Type Descriptions, and Field Key
6. Develop Mapping Model (Calibration)
7. Acquire and Prepare Imagery
8. Imagery Analysis / Imagery Classification
9. Geographic Information System (GIS) Project Preparation
10. Validation of Thematic Accuracy of Map Products
11. Formal Accuracy Assessment (AA)
12. Deliver Final Reports, GIS Database and Required Products (NPS 2013c).

Following completion of the first three steps, the NPS collected 135 vegetation classification plots at KALA which were analyzed by NatureServe to create a key and descriptions for the 47 vegetation associations at KALA. To ensure data compatibility throughout the NPS and other agencies the National Vegetation Classification Standard, Version 2 was used to characterize KALA's vegetation.

Next, Digital Globe Quickbird and Worldview2 imagery of KALA were obtained from the US Department of Agriculture (USDA). During the calibration trip to KALA by KGA and PACN staff, 4 additional vegetation associations were discovered and added to the key.

Following the calibration trip, KGA segmented the imagery using eCognition software and labeled the segments using the imagery, ancillary data sets, and Classification and Regression Tree analysis

to create a preliminary map. The preliminary map was reviewed by PACN staff and assessed in the field by KGA staff. Manual edits based on the comments and validation trip were made to the preliminary map to create KALA's draft vegetation map.

Next, PACN personnel collected 241 accuracy assessment (AA) samples of KALA's vegetation. The sample labels were compared to the draft map labels at each sample location to create an error matrix. PACN and KGA personnel reviewed the AA data and decided which associations would be collapsed into map classes for creation of KALA's final vegetation map, resulting in 39 vegetation map classes and 6 non vegetated land use classes. Overall accuracy of KALA's final vegetation map is 84%.

Acknowledgments

The production of this vegetation inventory for an important historic site required the enthusiasm and energy of many people over several years. The authors gratefully acknowledge the dedication of all involved in the production of this report.

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Guy Hughes, formerly of KALA and currently of Jean Latitte National Historical Park and Preserve, contributed expert knowledge to the sampling design resulting in a cost effective and comprehensive plan that captured all of KALA's vegetation variation. He also conducted classification field work and provided an invaluable review of the draft vegetation map which improved the accuracy and usefulness of this product.

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Introduction

Vegetation Classification and Mapping, Kalaupapa National Historical Park

Vegetation classification and mapping of National Park Service (NPS) units is one of the twelve resource inventories tasked to the Service's Inventory and Monitoring Program (I&M). In 2006, the NPS I&M began planning for vegetation inventories of the NPS units in the Pacific Island Network (PACN). Over the next several years, NPS personnel collected classification plot data for the PACN units, and NatureServe was retained to analyze the field data for developing the vegetation association keys and descriptions for each. In 2006, PACN retained Cogan Technology, Inc. (CTI) to design the sampling plan (Step 2) for Hawai'i Volcanoes National Park (HAVO) and several other PACN units. In 2009, PACN contracted with Kass Green & Associates (KGA) (DBA The Alta Vista Company) to design the sampling plan for Kalaupapa National Historical Park (KALA), Haleakelā National Park (HALE) and the National Park of American Samoa (NPSA) and to create the vegetation maps and analyze the accuracy of KALA, HAVO, HALE, and NPSA. In 2011, PACN contracted University of Hawaii (UH) staff to lead the accuracy assessment (AA) work with NPS staff at NPSA, HAVO, KALA and HALE.

This report details the methods used and results of the vegetation inventory for KALA. Spanning 4,340 ha (10,726 ac) on the Hawaiian Island of Moloka'i's isolated northern peninsula, cliffs, coastal waters, and islets, KALA's unique vegetation ranges from coastal native *Sida fallax* and *Wikstroemia uva-ursi* shrublands; to expanses of invasive species such as *Lantana camara*, *Psidium cattleianum*, *Syzygium cumini*, and *Schinus terebinthifolius*; to almost pristine forests of *Diospyros sandwicensis* and *Metrosideros polymorpha*; to one of the last remaining groves of Hawai'i's native *Pritchardia hillebrandii* fan palms. The park's isolated location, rich cultural history, and extreme topographic and climatic conditions combine to create a spectacularly beautiful and unique national park.

This report on the vegetation of KALA is organized as follows:

- The remainder of this first section presents an overview of the NPS I&M Program, I&M's PACN, the NPS Guidance for vegetation inventories, and the National Vegetation Classification Standard (NVCS). The section concludes with an overview of the roles and responsibilities of the team members who contributed to the KALA vegetation inventory and presents the timeline for the project.
- The second section provides a brief summary of the setting and history of KALA and reviews prior vegetation studies completed for the park.
- The third section details the vegetation classification and mapping methods used to inventory the park's vegetation and to assess the accuracy of the resulting maps. This section's organization parallels that of the NPS Twelve Step Guidance Document (NPS 2013b).
- The fourth section presents the results of the classification, mapping, and accuracy assessment efforts.
- The final section discusses the results and reviews lessons learned.
- The appendices provide several documents critical for the effective use of the vegetation maps, including the association and map keys and descriptions.

National Park Service Inventory and Monitoring Program

Overview

In 1998, Congress mandated the creation of the NPS Natural Resource I&M Program to:

- Inventory NPS natural resources to determine their nature and status.
- Monitor park ecosystems to better understand their dynamic nature and condition and provide reference points for comparison with other environments.
- Establish natural resource inventory and monitoring as a standard practice throughout the National Park System that transcends traditional program, activity, and funding boundaries.
- Integrate natural resource inventory and monitoring information into NPS planning, management, and decision making.
- Share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives (NPS 2013a).

The I&M Program is charged with establishing 12 basic resource inventories of species occurrence and distribution on 270 NPS units which have been organized into 32 ecoregional networks as illustrated in Figure 1. Specific inventories include:

- Natural Resource Bibliography
- Base Cartography Data
- Air Quality Data
- Air Quality Related Values
- Climate
- Geologic Resources
- Soil Resources
- Water Body Location and Classification
- Baseline Water Quality Data
- Vegetation
- Species Lists
- Species Occurrence and Distribution

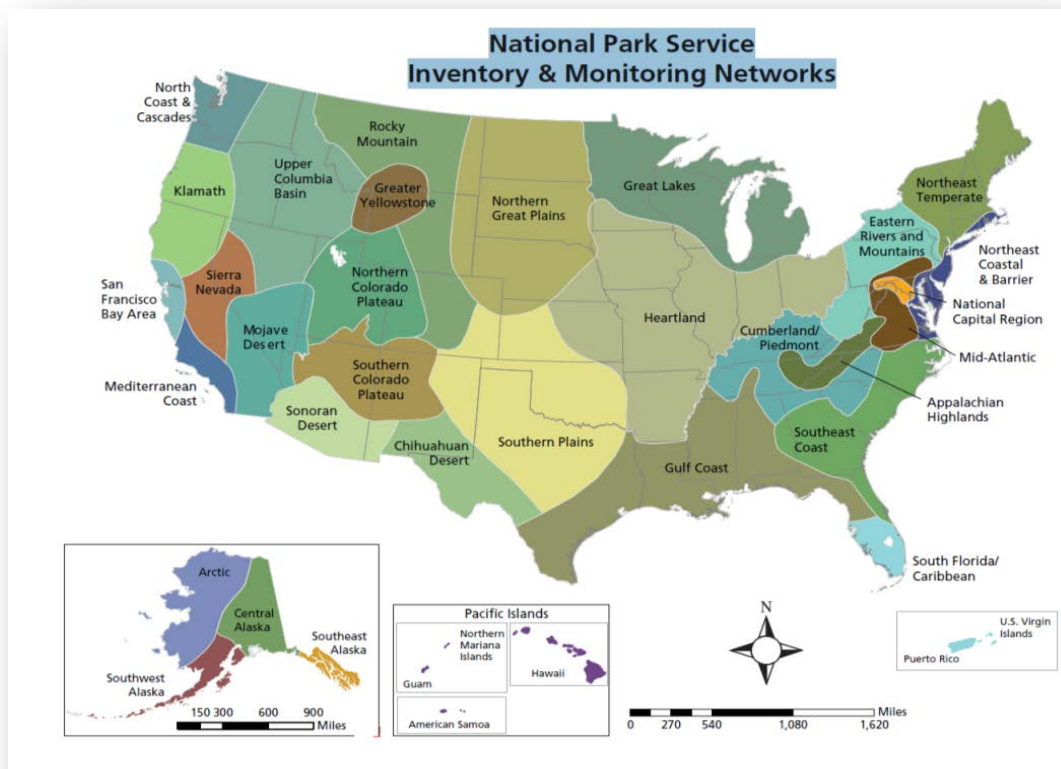


Figure 1. National Park Service Networks.

NPS Guidance for Vegetation Inventories

The objective of a vegetation inventory is to; “produce high-quality, standardized maps and associated data sets of vegetation and other land-cover occurring within parks” in support of resource assessment, park management and conservation needs (NPS 2013c). By the end of 2013, the NPS has classified and mapped the vegetation of 173 national park units. Vegetation inventory on 94 additional units is in process.

NPS Vegetation Inventories rely on a 12 Step Guidance Document which outlines each step to be taken in the process of implementing a vegetation inventory. The Guidance captures the “best management practices” and provides examples and standards for developing vegetation maps and associated databases (NPS 2013b). The 12 steps of a NPS vegetation inventory are:

1. Review Existing Data and "Best Practices" to Develop a Brief Proposal (1-5 pages) to Develop a Park or Network Vegetation Inventory Study Plan
2. Planning and Scoping to Gather the Detailed Information Needed to Develop the Study Plan
3. Develop and Submit a Detailed Study Plan for Approval of Funding
4. Field Plot Data Collection (for the Ecological Classification)

5. Develop Vegetation Classification, Vegetation Type Descriptions, and Field Key
6. Develop Mapping Model (Calibration)
7. Acquire and Prepare Imagery
8. Imagery Analysis / Imagery Classification
9. Geographic Information System (GIS) Project Preparation
10. Validation of Thematic Accuracy of Map Products
11. Formal Accuracy Assessment (AA)
12. Deliver Final Reports, GIS Database and Required Products (NPS 2013c)

National Vegetation Classification Standard

In 1994, the NPS GIS Division began five prototype park mapping efforts, and funded the first development of uniform vegetation classification concepts with the Nature Conservancy. By 1997, the US Geological Survey (USGS) Center for Biological Informatics and the NPS shared the development and project support that later became the NPS Vegetation Inventory Program (VIP) under the NPS Natural Resource I&M. The objective of this program was to create a Service-wide process for mapping that uses the best available technologies, uses the developing taxonomic concepts that form a hierarchical classification standard and methodology, and meets the management needs of the Parks.

The VIP adopted the U.S. National Vegetation Classification (USNVC) (Grossman et al. 1998) as a basis for the *a priori* definition of vegetation units to be inventoried. The USNVC has since been revised by NatureServe and in 2008 the Federal Geographic Data Committee (FGDC) formally adopted the rules and structure of the National Vegetation Classification Standard (NVCS; FGDC 2008).

Use of a standardized vegetation classification system, such as the NVCS helps to ensure data compatibility throughout the NPS and other agencies. This is critical for a systematic inventory and classification of the nation's biological resources to foster efficient stewardship and prioritize conservation efforts. The NVCS is being used for vegetation classification and mapping projects at PACN parks. It evolved from the original USNVC, which was developed jointly by The Nature Conservancy (TNC), the National Park Service and U.S. Geological Survey, NatureServe, and the Natural Heritage Program network over more than two decades (TNC and ESRI 1994a; Grossman et al. 1998).

The NVCS is a hierarchical system that allows for vegetation classification at multiple scales. There are eight levels with specific criteria set for each level as summarized in Table 1. The upper three levels are based on climate and physiognomic characteristics that reflect geographically widespread (global) topographic and edaphic factors. The middle three levels focus largely on broad sets of diagnostic plant species and habitat factors along regional-to-continental topographic, edaphic, and disturbance gradients. These middle levels have been drafted and are undergoing peer review. The lower two levels, as in the original USNVC, are the alliance and association and are distinguished by differences in local floristic composition. The broader alliances are physiognomically distinct groups of plant associations sharing one or more differential or diagnostic species (Mueller-Dombois and

Ellenberg 1974). These are commonly the dominant(s) found in the uppermost strata of vegetation. The plant association is the fundamental base unit of the classification, and following the International Botanical Congress of 1910, is defined as a community of definite floristic composition (i.e., a repeating assemblage of species), uniform physiognomy, and habitat conditions (Mueller-Dombois and Ellenberg 1974).

In addition, there is a category of classification confidence used in the classification of vegetation types for park units in PACN: Provisional (FGDC 2008). Provisional types are types where a clear effort has been made to apply the USNVC to vegetation units that do not appear to be covered by the concepts of known units for the area being classified (FGDC 2008). These types have not yet formally accepted into the USNVC through the peer review process and are designated as “Provisional” in the name (FGDC 2008).

The USNVC is maintained by NatureServe and the network of affiliated Natural Heritage Programs and Conservation Data Centers for use by government agencies and the public. The USNVC database allows for tracking of vegetation at all scales and provides narrative descriptions of many alliances and associations. Descriptions of Macrogroups and Groups are being written in three phases. Phase 1 descriptions are currently undergoing peer review, in a collaborative process with the Ecological Society of America’s Panel on Vegetation Classification (<http://esa.org/vegweb2>) and the USGS sponsored USNVC.org website (<http://usnvc.org/>). The content of the NatureServe database is available to the public and is regularly updated through NatureServe Explorer (<http://www.natureserve.org/explorer>).

Associations are generally the same as the original USNVC, although revisions have begun in certain areas such as PACN projects. Substantial revisions of the alliances have begun and will continue in the future. For KALA, Macrogroups, Groups, and plant associations have been developed for this project and NatureServe will continue vegetation hierarchical unit review and revision as other PACN vegetation inventory projects are completed. Although NatureServe’s documentation of vegetation alliances and associations is the most accessible national listing (www.natureserve.org/explorer), the data within the USNVC are not complete, and projects such as this one constantly add to the documentation and listing of USNVC types.

NVC associations and alliances are commonly used for vegetation inventory projects. Their use within the VIP facilitates effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other federal and state agencies. These vegetation maps and associated information support a wide variety of resource assessment, park management, and planning needs. In addition they can be used to provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental conditions and ecological processes across the landscape.

Table 1. Summary of USNVC hierarchy levels and criteria for natural vegetation.

Heirarchy Level	Criteria
-----------------	----------

Upper:	Physiognomy plays a predominant role.
L1 – Formation Class	Broad combinations of general dominant growth forms that are adapted to basic temperature (energy budget), moisture, and substrate/aquatic conditions.
L2 - Formation Subclass	Combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate/aquatic conditions.
L3 – Formation	Combinations of dominant and diagnostic growth forms that reflect global macroclimatic factors as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.
Mid:	Floristics and physiognomy play predominant roles.
L4 – Division	Combinations of dominant and diagnostic growth forms and a broad set of diagnostic plant species that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.
L5 – Macrogroup	Combinations of moderate sets of diagnostic plant species and diagnostic growth forms, that reflect biogeographic differences in composition and sub-continental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.
L6 – Group	Combinations of relatively narrow sets of diagnostic plant species (including dominants and co-dominants), broadly similar composition, and diagnostic growth forms that reflect regional mesoclimate, geology, substrates, hydrology and disturbance regimes.
Lower:	Floristics plays a predominant role.
L7 – Alliance	Diagnostic species, including some from the dominant growth form or layer, and moderately similar composition that reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes.
L8 – Association	Diagnostic species, usually from multiple growth forms or layers, and more narrowly similar composition that reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.

Project Partners' Roles and Responsibilities

The vegetation classification and mapping of KALA was managed by the NPS's PACN and carried out by a mixture of NPS employees, UH cooperators, and contractors including NatureServe, KGA, and CTI. The roles of each organization in the implementation of the 12 vegetation inventory steps are summarized in Table 2. The following paragraphs provide a brief introduction to the organizations and a summary of their responsibilities in the KALA vegetation inventory.

Pacific Island Network, Inventory and Monitoring Program

PACN (<http://science.nature.nps.gov/im/units/pacn/>) was established to provide an efficient means of carrying out expanded natural resource inventory and monitoring activities for all 11 national park units scattered across the Pacific Ocean as illustrated in Figure 2. PACN personnel include scientists, data management staff, biological technicians, volunteers, and administrative staff supplying reliable, organized and retrievable information about the Pacific Island parks.

Currently PACN contains a mixture of both small and large parks including Ala Kahakai National Historic Trail (ALKA), American Memorial Park (AMME), KALA, HALE, Kaloko-Honokōhau National Historical Park (KAHO), NPSA, Pu'ukoholā Heiau National Historic Site (PUHE),

Pu‘uhonua o Hōnaunau National Historical Park (PUHO), HAVO, and War in the Pacific National Historical Park (WAPA). The larger parks, HAVO, HALE, and KALA are located on the islands of Hawai‘i, Maui, and Moloka‘i, respectively and World War II Valor in the Pacific National Monument (VALR) (formally the USS Arizona Memorial) is located on the island of O‘ahu. The NPSA spans three American Samoa Islands and the smaller parks, PUHO, PUHE, and KAHO along with the ALKA are located on the big island of Hawai‘i. AMME is located on the island of Saipan, and WAPA is located on Guam. All of the parks in the PACN occur on remote islands ranging from approximately 4,000 to 10,000 km (2,500 to 6,200 mi) west and southwest of the United States mainland.

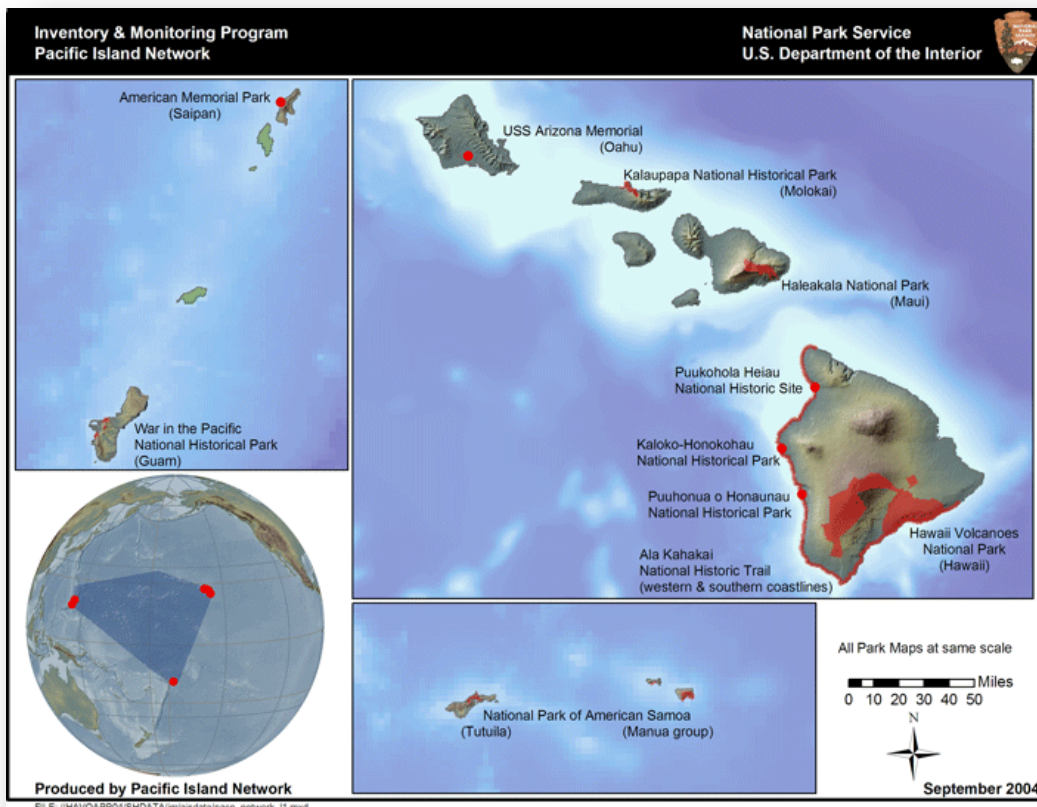


Figure 2. Map of national park units within the Pacific Island Network. Source: <http://science.nature.nps.gov/im/units/pacn/parks/index.cfm#map>

PACN is involved in numerous activities such as organizing and cataloging data, data analysis and synthesis, modeling, providing data and expertise to park planners, providing data and expertise for resource assessments and resource stewardship strategies, and contributing to performance reporting. PACN is a key source and supplier of reliable, organized, and retrievable information about the Pacific Island park units. Their primary responsibilities include facilitating baseline inventories, collecting, managing, analyzing, and reporting long-term data on vital signs (measurements of

resource condition), and effectively delivering data and information on resource condition to park managers, planners, interpreters, and other key audiences (NPS 2013d).

Besides managing the KALA project, PACN personnel and volunteers also were integrally involved in every step of the vegetation inventorying process. Data and reports for PACN projects can be accessed online at: <http://science.nature.nps.gov/im/units/pacn/index.cfm>.

NatureServe

NatureServe is a non-profit conservation organization whose mission is to provide the scientific basis for effective conservation action. NatureServe collects and manages detailed local information on plants, animals, and ecosystems, and also develops information products, data management tools, and conservation services to help meet local, national, and global conservation needs. NatureServe ecology staff in the western U.S. have been engaged in various roles in some three dozen NPS vegetation mapping efforts over the past 15 years. For the KALA project, NatureServe analyzed the classification field plot data to create the vegetation field key (Appendix C), and wrote the vegetation association descriptions (Appendix D) which are the products of Step 5, and wrote portions of this final report (part of Step 12). NatureServe staff also assisted in map calibration field work and provided mapping support during conference calls throughout much of the project. The NatureServe ecologist's time in field with the mapping team provided valuable insights in how to improve the field key to associations and clarify classification issues with the mapping team.

Kass Green & Associates

In 2009, KGA was chosen by the NPS to map the vegetation of KALA using a NVCS compliant classification. KGA is a woman owned small firm that consults on remote sensing and GIS technology and policy issues to private, educational, and public organizations. KGA revolutionized vegetation association mapping from high resolution imagery through the introduction of object oriented image classification using image segmentation and classification and regression tree analysis. For the KALA mapping project, KGA prepared the sampling plan for the field plot data collection (part of Step 4), collaborated with PACN to develop the mapping model (Step 6), worked with PACN and US Department of Agriculture Natural Resource Conservation Service (USDA NRCS) to acquire and prepare the satellite imagery used in the project (Step 7), classified the imagery (Step 8), prepared the GIS project (Step 9), validated the vegetation map (Step 10), analyzed the accuracy assessment data collected by NPS personnel (part of Step 11), and led the preparation of this final report and development of the GIS database and required products (Step 12).

Table 2. Roles and responsibilities for the KALA vegetation inventory project.

	NPS PACN	NatureServe	Kass Green & Associates	Cogan Technologies
1. & 2. Planning and Scoping	✓			✓
3. Study Plan	✓			✓
4. Classification Field Plot Data Collection	✓		✓	
5. Vegetation Classification, Descriptions & Field Key	✓	✓		
6. Develop Mapping Model	✓		✓	
7. Acquire and Prepare Imagery	✓		✓	
8. Imagery Analysis / Classification			✓	
9. GIS Project Preparation			✓	
10. Validation	✓		✓	
11. Formal Accuracy Assessment	✓		✓	
12. Final Reports, GIS Database & Required Products	✓	✓	✓	

Kalaupapa National Historical Park

Location and Setting

KALA on the island of Moloka‘i, Hawaii, rises from the coastal waters and volcanic shield of the Makana lua peninsula to the lowlands, cliffs and rims of the Wai‘ale‘ia, Waihānau, and Waikolu Valleys (Figures 3-7). KALA is outstandingly beautiful, ecologically diverse and culturally rich. As illustrated in Figure 8, KALA is also a park whose boundaries encompass a complex pattern of land ownership which includes various Departments of the State of Hawaii, private land owners, the Roman Catholic Church and the Hawaii Conference Foundation. The NPS relies on cooperative agreements to manage the cultural and natural resources of the park’s 4,340 terrestrial and marine ha (10,726 ac), while owning outright only nine ha (23 ac; Fung and SWCA 2010).

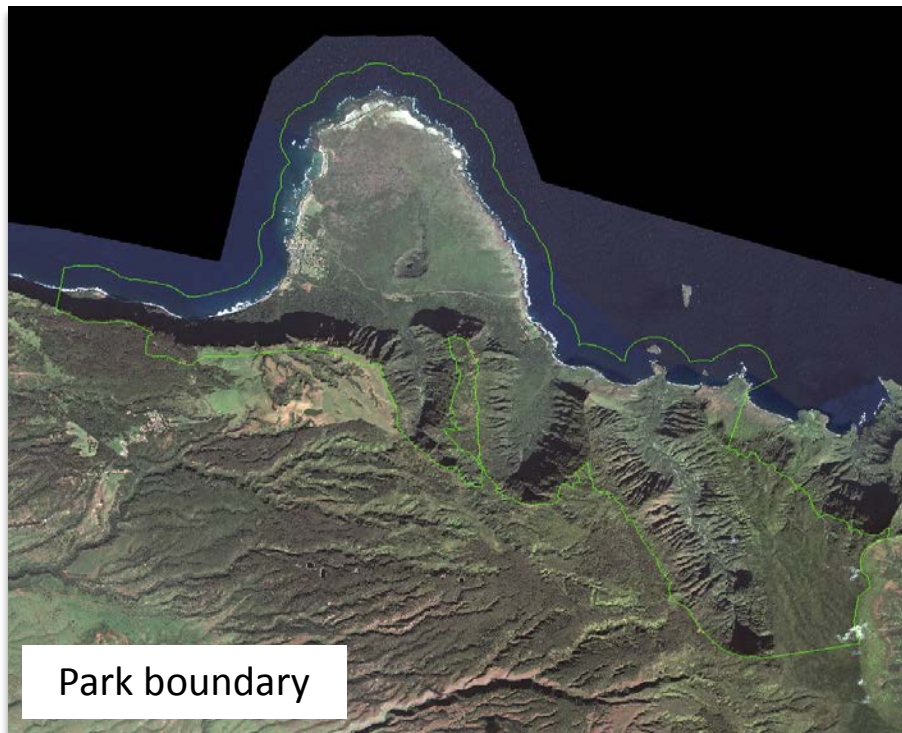


Figure 3. Worldview2 true color satellite imagery of KALA and surroundings.



Figure 4. USGS topographic map of KALA and surroundings showing the extreme terrain variability of the park.



Figure 5. Looking north towards the peninsula from the *Schinus terebinifolius* and *Psidium cattleianum* covered cliff sides and *Aleurites moluccana* and *Syzygium cumini* valley floor of Waihānau Valley.



Figure 6. Kalaupapa Settlement and Kauhakō Crater on the Makana lua peninsula of KALA. Much of the vegetation of the peninsula is dominated by invasive species such as *Schinus terebinifolius*, *Lantana camara*, *Syzygium cumini*, and *Leucaena leucocephala*.



Figure 7. Looking south from the mouth of the Waikolu Valley towards *Diospyros sandwicensis* and *Metrosideros polymorpha* forested cliff sides.

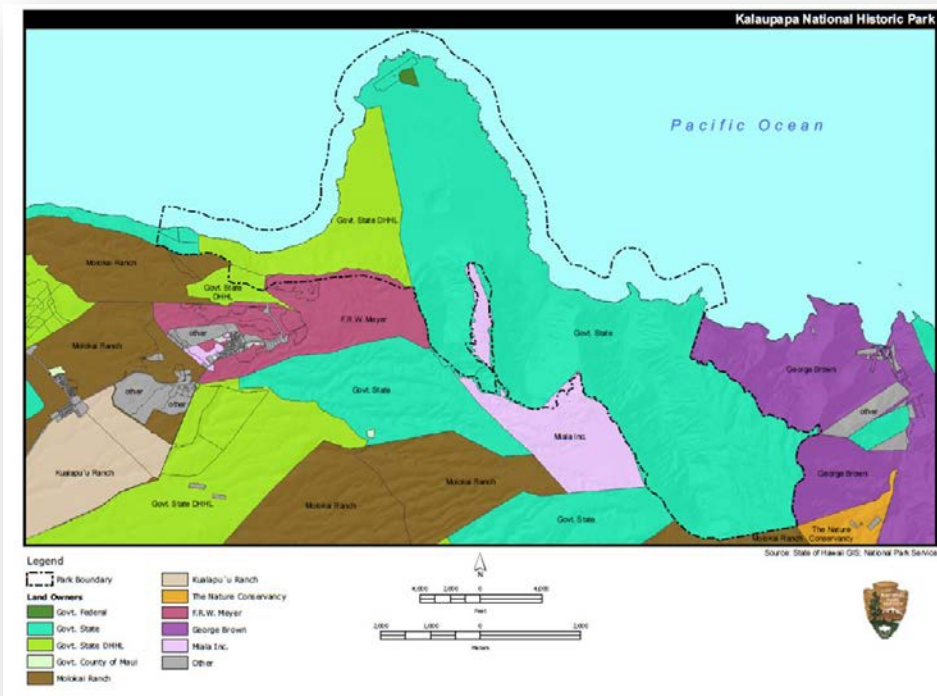


Figure 8. Land ownership of KALA and surrounding areas. Source: Fung and SWCA 2010.

Weather is highly variable across the park because of the park's extreme topographical diversity. Jutting northward into the sea, the peninsula is dry and windy with a median rainfall of 63.5 cm (25 in) per year; whereas the cliff tops of the three valleys are often shrouded in fog and clouds with a median rainfall of 1,180 cm (72 in) per year (Fung and SWCA 2010).

History

From approximately 1000 to 1865, Hawaiians occupied three districts within the park boundaries; Makana lua, Kalawao and Waikolu. Remnants of rock walls, heiau, and other structures built by the early residents can still be seen throughout the park as shown in Figure 9 (Kelley 2000). However by the 1860s the population of native Hawaiians had fallen to about 140 as a result of multiple epidemics brought to the Hawaiian Islands from abroad (NPS 2013e).

In 1865 King Kamehameha V approved legislation named “An Act to Prevent the Spread of Leprosy” which sought to isolate people with leprosy (now named Hansen’s disease) from the rest of the population of Hawaii. The Act directed the Minister of the Interior, “to reserve and set apart any land or portion of land now owned by the Government, for a site or sites of an establishment or establishments to secure the isolation and seclusion of such leprous persons as in the opinion of the Board of Health or its agents, may, by being at large, cause the spread of leprosy.” Kalaupapa was chosen as the site for the leprosy settlement because of its extreme isolation, abundant fresh water, arable land, and surrounding ocean, rich with sea food. Hawaiians living at Kalaupapa prior to the Act were forced to leave (NPS 2013e).



Figure 9. Ancient rock walls on the KALA peninsula.

In 1866 the first patients with Hansen's disease were left at Kalaupapa, during the next 100 years approximately 8,000 people were exiled there (Fung and SWCA 2010). A hospital and housing were built along with research facilities, churches, and maintenance buildings, all significantly changing the landscape of the peninsula. With the discovery of drug therapies eliminating the chance of contagion of Hansen's disease, the policy of isolating patients ended in 1969. Many patients left Kalaupapa while others decided to live out their lives there. In 1976 the Kalaupapa Settlement received designation as a National Historic Landmark District and in 1980, Public Law 95-565 was enacted which created KALA. Over the last 45 years the patient population has shrunk to a handful. Now, most of the people residing in Kalaupapa are NPS or State of Hawaii employees.

Vegetation Studies at Kalaupapa National Historical Park

The most comprehensive review of vegetation studies conducted within KALA can be found in the NPS publication *Assessment of Natural Resources and Watershed Conditions for Kalaupapa National Historical Park* (Fung and SWCA 2010). In addition to citing numerous small site specific studies, the publication also cites several reports which identified or mapped the vegetation of portions or all of KALA's native and non-native plants along eight transects in the Natural Area Reserve (NAR).

- Jacobi's (1989) use of aerial photography and field visits to map the upland plant communities of the Island of Moloka'i.
- Canfield's (1990) identification, description, and mapping of the vegetation associations of KALA's coastal spray zone.
- Funk's (1991) description and vegetation map of 20 plant communities of KALA.
- Wood and Hughes' (2003) creation of plant checklists for 32 sites in KALA.
- Wood's (2008) description of the vegetation of the Kūka'iwa'a peninsula.
- Wysong et al.'s (2008) vascular plant inventory, voucher collections, and electronic herbarium for the park.
- USGS and the NPS's 2007 cooperation to create a draft vegetation map for use in the *Assessment of Natural Resources and Watershed Conditions for Kalaupapa National Historical Park* (Fung and SWCA, 2010).
- The NPS's detailed vegetation maps of areas of the settlement which depict individual plant species in the area.

One vegetation map seems to have been missed by the Fung and SWCA authors. In 2005, the National Oceanic and Atmospheric Administration (NOAA 2005) used high resolution satellite imagery and field reconnaissance to create a lifeform map of all of Moloka'i, including KALA.

Vegetation Classification and Mapping Methods

This section of the report reviews the methods used to implement the 12 steps of the NPS vegetation inventory at KALA. The methods are presented step by step; however, Step 6 (Development of the Mapping Model) was moved to follow accuracy assessment.

Development of the Proposal and Study Plan (Steps 1-3)

In 2006, the PACN contracted with CTI to create the draft report, *Vegetation Classification and Mapping Recommendations, Pacific Island Network* (Cogan 2007). CTI met with PACN personnel to document park needs, existing data, and current efforts. The report summarized their findings and was the basis for a 2007 proposal from PACN to the National Vegetation Mapping Program for the initiation of vegetation mapping of PACN parks.

In 2009, CTI and NPS personnel cooperated to develop the *Vegetation Classification and Inventory Work Plan* which identifies the tasks required, provides a timeline, and details cost estimates for vegetation mapping on each PACN national park (Cogan and Kudray 2009).

Classification Sampling Design and Data Collection (Step 4)

Introduction

The fourth step in a vegetation inventory is the collection of field plot data to 1) “to serve as the raw data from which to build the park ecological classification, and thus, the map classification, and (2) as a permanent record of the floristic characteristics of each vegetation type” (NPS 2013c). Two tasks are required to collect field data: creation of a sampling design which guides field personnel in the placement of field plot locations, and actual collection of the field data.

Sampling Design

The vegetation classification plot sampling design for KALA was developed by KGA in 2010. It relies on the Department of Interior’s (DOI) 1994 *Field Methods for Vegetation Mapping* which directs that “representative polygons for each vegetation type will be selected for sampling across the park based on the stratification of each type across the different biophysical environments” (TNC and ESRI 1994a). “Representative polygons” were developed using image segmentation and GIS modeling. The resulting sampling design coverage is a GIS shape file which relies on a combination of spectral variation and access to guide field crews. The underlying assumptions behind the sampling coverage are:

1. Variation in vegetation of interest to the NPS is highly correlated with variation in aspect, elevation, slope, and imagery spectral response.
2. Access cost is an important variable for determining the location of field samples.

First, a coarse image segmentation was run on the KALA Quickbird 2005 high resolution imagery in eCognition software, and non-vegetated segments identified from the NOAA 2005 High Resolution Land Cover shape files (NOAA 2005) were eliminated from the coverage. Next, the aspect, slope, elevation, and spectral mean and standard deviation of each segment were input into the ordination

software package, PC-Ord. Then, a Ward's complete linkage Euclidian clustering algorithm was run on the segment data to cluster the segments into groups that are similar in slope, aspect, elevation, and spectral response. The result was coverage with the segments labeled according to their similarity in aspect, slope, elevation, and spectral response group. The group coverage was then combined with an access coverage which ranked the relative difficulty of accessing a given polygon given its steepness and distance from roads or trails. The combined coverage was used by local PACN personnel to identify locations for field sampling.

Field Data Collection

Field crews were composed of PACN ecologists with plant community sampling experience in the Pacific Islands and other landscapes. The sampling goal was to collect between three and five classification plots in every plant association within KALA. However, some common associations were sampled more often and some rare types were sampled less often. An effort was made to achieve a good spatial distribution of plots across the landscape and to capture the full range of variation of each association.

When a representative stand of vegetation was located, a relevé macroplot was established to record stand characteristics; transitional areas such as ecotones were usually avoided unless they exceeded the project minimum mapping unit (MMU) of 0.5 ha (1 ac). Highly disturbed areas were also avoided unless they supported a distinct plant community. Classification plots were generally located in stands exceeding the MMU; however a few plots were sampled in smaller patches if the vegetation was rare and distinctive (such as coastal strand sites). All plots were circular with a radius of 11.28 meters and a plot area of 400m² which is consistent with VIP guidelines (TNC and ESRI 1994b). Measuring tapes were used to establish the sampling area and the plot shape was adjusted as needed to sample linear bands of vegetation in drainage bottoms or other confined sites. Plot size and shape were recorded for all plots.

Following the establishment of each plot, environmental data were recorded on the plot field forms (See Appendix A for the field form). Environmental data included: elevation, slope, aspect, landform, topographic position, soil texture and drainage, hydrologic (flooding) regime, and evidence of disturbance or wildlife use. The unvegetated surface was estimated and recorded as percent cover of: bedrock, litter and duff, wood, bare soil, large rocks (>10 cm), small rocks (0.2-10 cm), sand (0.1-2 mm), lichens, and mosses. Next the vegetation was visually divided into strata, with the height and canopy cover of the dominant vegetation estimated for each stratum. Within each stratum, all taxa within the plot area were identified and the foliar cover of each taxon was estimated using cover classes (Table 3).

Table 3. Cover classes and vegetation strata.

Cover scales	Vegetation strata
T 0–1%	T1 Emergent Canopy:
P >1–5%	T2 Main Canopy
1 >5–15%	T3 Subcanopy
2 >15–25%	S1 Tall Shrubs
3 >25–35%	S2 Short Shrubs
4 >35–45%	S3 Dwarf-shrubs
5 >45–55%	H1 Herbaceous (Graminoids)
6 >55–65%	H2 Herbaceous (Forbs)
7 >65–75%	H3 Herbaceous (Ferns)
8 >75–85%	H4 Herbaceous (Tree seedlings)
9 >85–95%	A1 Floating-leaved aquatics
10 >95%	A2 Submerged-leaved aquatics

Quality Control

Upon completion of the plot data collection, plot data were entered into the PLOTS 2.0 database by PACN staff. The PLOTS database is the standard NPS VIP database which uses Microsoft Access. The database mirrors the standard field form with fields and tables that match all of the data recorded on the field forms. Following data entry, error checking was performed to minimize errors associated with duplicate entries or erroneously selected plant or association names or types. Next, the database was converted to meet NatureServe standards and all of the plant taxonomy was standardized to the the USDA. Unknown species, especially those with high cover were identified and mostly resolved as were other taxonomic issues including grouping subspecies and varieties judged to be ecologically similar. All digital data were subjected to a second quality check (QC) to eliminate data entry errors. The final classification to KALA's USNVC association, along with the Elcode, was added as an attribute for each plot, and these were incorporated into the master database maintained by PACN data management. Figure 10 shows the distribution of classification plots at KALA.

Development of Vegetation Classification, Vegetation Type Descriptions and Field Key (Step 5)

Introduction

The primary dataset used for the vegetation classification of KALA included 135 classification plots and observation points collected between 2009 and 2011 by PACN. These data consisted of 310 taxa and eleven strata for a total of 436 unique species-strata records (pseudo species). The number of pseudo species was reduced to 348 by combining some of the strata, taxa subspecies and varieties, and eliminating some taxa if deemed uninformative. These were classified using standard quantitative techniques including cluster analysis, ordination, summary statistics and indicator species analysis. Each sample from the KALA dataset was reviewed and assigned to an existing NVC association (only 2 existing associations) if possible and when not, a new association or local community type was developed. Species throughout the report are documented based on PACN taxonomic standard and all differences to NatureServe are identified with a footnote. Preferred PACN names for all species encountered in this project are presented in Appendix B. Following the

map calibration and validation trips, four associations were added to account for vegetation types discovered or known to exist at KALA, but not sampled during the classification field work (e.g. *Cocos nucifera* Coastal Strand Woodland, *Pritchardia hillebrandii* Coastal Mesic Forest).

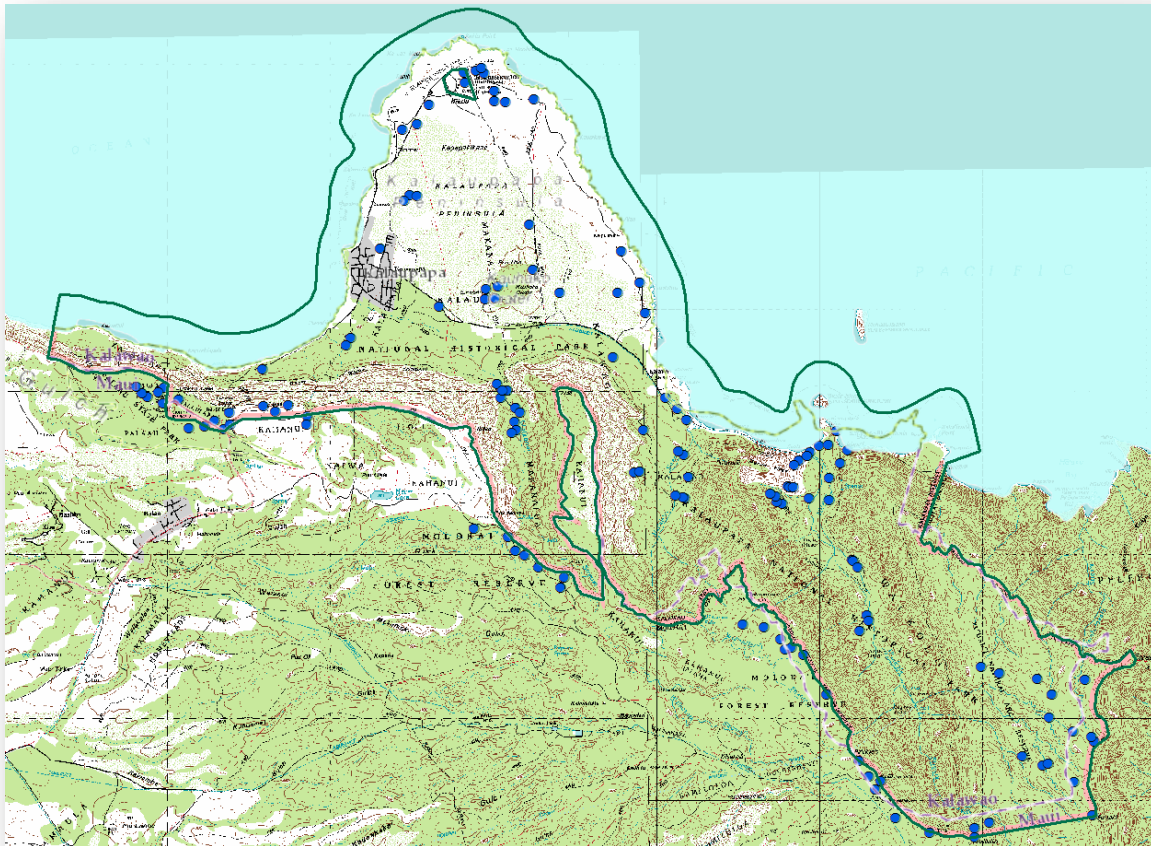


Figure 10. Distribution of classification plots at KALA.

Data Preparation and Screening

All 135 classification plots (108 full plots and 27 observation points) collected in the field were used in the data analysis. Prior to data analysis, standard screening and preparations were performed to facilitate the interpretation of results such as looking for data transcription errors and data entry errors like duplicate species records, synonymy of scientific names, species records without plant symbols or missing cover data. Using field data records, standard taxonomic information and database queries, species records were updated wherever possible. Species strata data were also reviewed to ensure species were consistently given the same strata or life-form code: Grasses and grass-like herbaceous plants- H1, Forbs- H2, most Ferns- H3. Woody species form distinct strata. Tree species were recorded as Emergent (T1), Main canopy (T2), Sub canopy (T3), and Seedling (H4). Tree ferns were treated as trees, usually as T3. Shrub strata included Tall shrub (S1), Short shrub (S2), Dwarf-shrub (S3). Mosses and lichens formed the non-vascular stratum (N). These strata are briefly defined in NVCSv.2 document (FGDC 2008). For more discussion on strata see Jennings et al. (2009) and Tart et al (2005).

After species data review was complete a dataset was created for multivariate analysis. This dataset was reviewed further to identify and delete records determined to be not informative in the analysis such as “unknown species”, species identified only to genus or family, some taxa if recorded only once with low cover value. In some cases, cover of a woody species was recorded with multiple strata codes (T1, T2, T3) or (S1, S2, S3) within a single plot. While this reflected the canopy structure of the plot, for analysis these strata were simplified into a single T or S abundance measure with cover values combined using methods outlined below. The formula used to combine cover values was as follows: $A' = A + (B * (1 - A))$ to combine two layers and $A' + (C * (1 - A'))$ to combine a third, where A, B and C equaled species percent cover in each strata. These formulae account for overlapping canopies. A simple summation, especially in tropical rainforests, would have resulted in an overestimate of the total tree cover. This formula was used to create an algorithm written in Microsoft Access to facilitate this step. This was a relatively minor issue at KALA as only 52 records were combined. Finally, the dataset was exported in list format from the PLOTS database, and then imported directly into a matrix for analysis using PC-Ord (McCune and Mefford 1999) after species names and cover classes were formatted to meet PC-Ord requirements.

Multivariate Analysis

Vegetation classification was accomplished through a multivariate analysis of the plot data using standard techniques including cluster analysis, ordination, and indicator species analysis. Cluster analysis was performed using Lance-Williams Flexible-Beta linkage method (beta value = -0.25) and the Bray-Curtis dissimilarity measure. Ordination was performed using nonmetric multi-dimensional scaling (NMS) using Sorenson (Bray-Curtis) distance measure (Figure 11).

Multiple cluster analyses were performed on full dataset using group membership levels of 20, 30, 40, 50, and 60. Cluster analysis results were entered back into the database with the plot data for each membership level. This was a very useful technique to organize plots for ecological review, allowing the analyst to easily sort plots and compare cluster analysis results of different group membership levels. Some classification plots form ecologically meaningful clusters at low membership levels such as *Scaevola taccada* Coastal Dry Shrubland¹, while others groups are not evident until a higher membership level is used, such as the many different associations of *Metrosideros polymorpha* dominated and co-dominated forests.

With a small dataset such as at KALA it was possible to evaluate each plot individually during the classification review process that combines quantitative and qualitative analyses using floristic and ancillary data such as elevation, moisture zone, topographic position, substrate, or field crew comments. Each sample was assigned to an existing NVC association, or a new NVC association or local community type [Park Special] depending on the number of plots and the ecologist's confidence. After plots were initially classified, additional cluster analyses were conducted on subsets of the dataset to validate results such as the forest plots below (Table 4 and Figure 12).

¹USNVC name *Scaevola sericea* modified to *Scaevola taccada* based on taxonomy of Wagner et al. (2012).

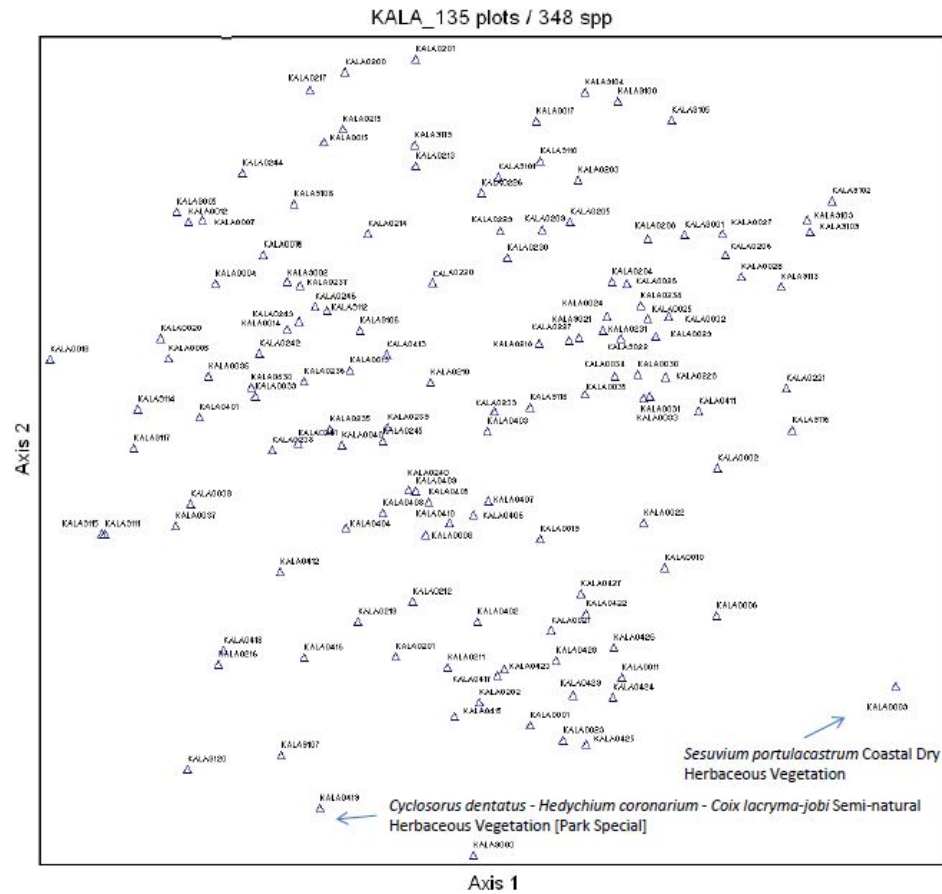


Figure 11. NMS ordination of full KALA dataset. Note single plot type outliers such as *Sesuvium portulacastrum* Coastal Dry Herbaceous Vegetation (CEGL008098) or observations points that often only have few dominant species recorded (Observation points have 9000 series numbering).

Table 4. List of KALA forest types shown in the cluster dendrogram in Figure 11.

ELCODE	Association Name	Number of Samples
CEGL008008	<i>Metrosideros polymorpha</i> - <i>Cheirodendron</i> spp. / (<i>Cibotium</i> spp.) Montane Wet Forest	11
CEGL008026	<i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest	3
CEGL008032	<i>Pandanus tectorius</i> Coastal Mesic Forest	2
CEGL008041	<i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland	5
CEGL008111	<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	11
CEGL008115	<i>Aleurites moluccana</i> Lowland Wet Forest	3
CEGL008116	<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	7
CEGL008142	<i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland	7
CEGL008143	<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation	6
CEGL008144	<i>Eucalyptus</i> spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional]	2
CEGL008147	<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	4
CEGL008148	<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	14
CEGL008152	<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	2
CEGL008182	<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	5
CEGL008183	<i>Diospyros sandwicensis</i> - (<i>Psidium</i> spp.) Lowland Mesic Woodland	2
CEPS009650	<i>Metrosideros waialealae</i> var. <i>fauriei</i> Woodland [Park Special]	3
CEPS009651	<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	2

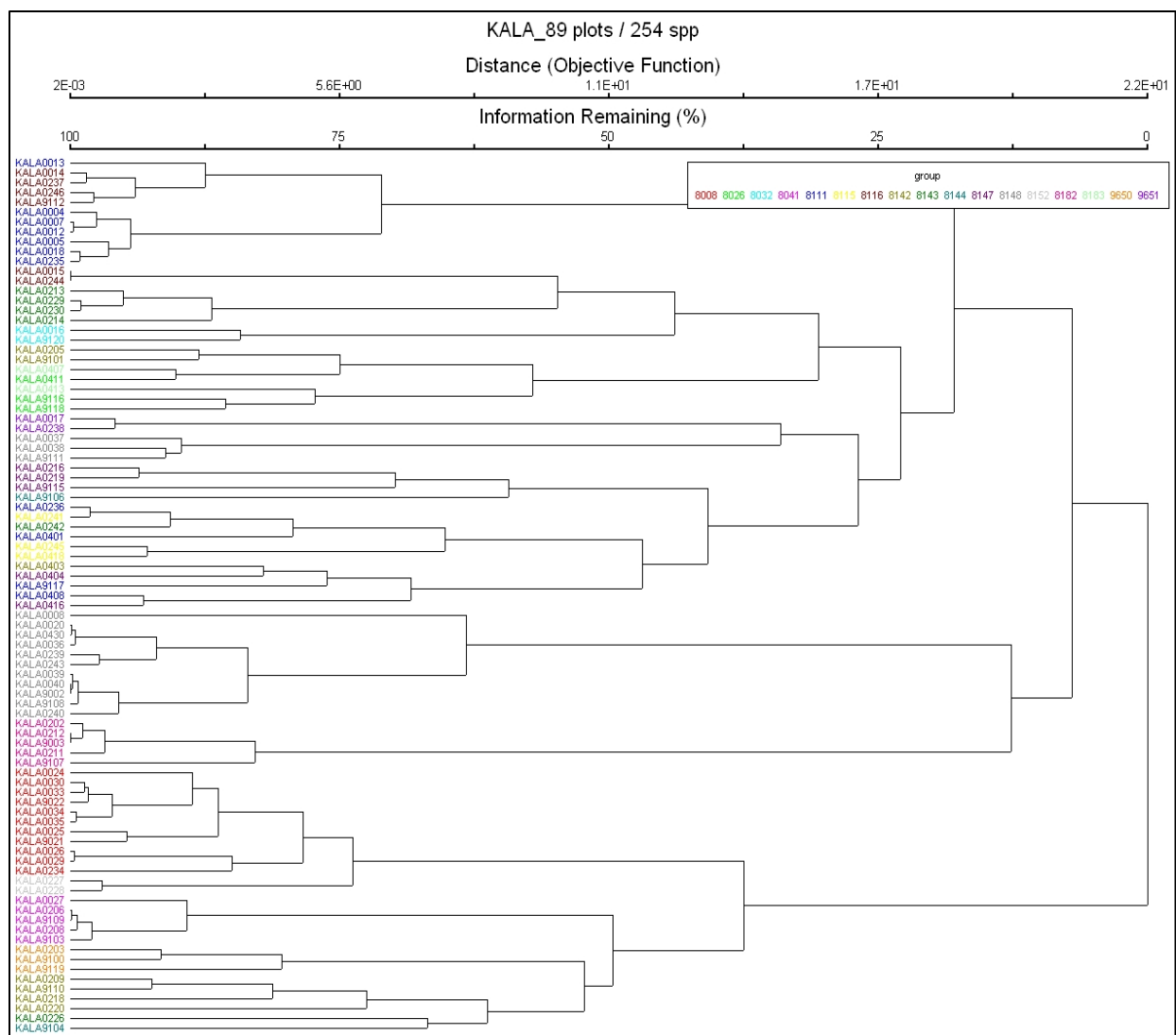


Figure 12. Cluster dendrogram of classification plot data from forest associations at KALA.

After cluster analysis was completed, indicator species analyses were conducted to see what species had high fidelity to 22 groups representing vegetation types with 2 or more full plots. Indicator Species Analysis calculates the relative frequency and relative abundance of species by group (multiplied together this value becomes the Indicator Value). A Monte Carlo test is run to see the significance of the indicator value. (Null Hypothesis = $IV_{\max}$ is no larger than would be expected by chance). A species must have both high fidelity and high abundance to be significant. Species with high indicator value were reviewed and helped inform the development of the field key.

The individual plot review was especially important as the KALA dataset had relatively few plots across a highly diverse landscape with many habitats ranging from coastal strand to montane rainforest. Issues encountered during plot review included, numerous associations were represented by only a single plot, and low elevation plots with significant cover of non-native species. High cover

of non-native species requires close evaluation to determine if the plot was a poor condition native type or if it represented a complete conversion to a non-native dominated (semi-natural) type.

The draft classification was reviewed by PACN and the local ecologist and was tested along with the field key to associations and local descriptions during map segmentation and validation field work. Information was collected during the map calibration and validation field work that led to the refinement of the existing classification and the addition of four new vegetation types. This combination of PACN reviews and additional field work created an iterative process to finalizing the vegetation classification.

Development of Vegetation Association Descriptions and Key

NatureServe ecologists wrote park specific (called “local”) plant association descriptions for selected communities based on plot information collected for each type. Descriptive information included the range of cover of consistently present species along with a list of commonly recorded species. Environmental data was also used to describe the typical setting including the range in elevation, slope, aspect, and soil characteristics for each association. Draft local descriptions were reviewed by PACN staff and edits incorporated by NatureServe ecologists into final local descriptions as part of the NVC. These local descriptions were then updated and finalized by NatureServe and delivered to PACN.

PACN staff then modified some of the local descriptions to match their plant taxonomic standard for this report because the NatureServe plant taxonomic standard is different than the standard used by PACN. NatureServe uses Kartesz (1999), which is very similar to USDA PLANTS. PACN modified scientific names based on the taxonomy of the Manual of the Flowering Plants of Hawaii (Wagner et al. 1999), Hawaii’s Fern and Fern Allies (Palmer 2003), and Hawaiian Vascular Plant Updates: A Supplement to the Manual of the Flowering Plants of Hawai‘i and Hawai‘i’s Fern and Fern Allies (Wagner et al. 2012). Plant common names (non-scientific names) were standardized by PACN staff and inserted into the KALA vegetation classification (Table 4), the field key to associations (Appendix C) and the local descriptions (Appendix D). Species names in the classification, field key, and descriptions of this report that do not match those posted on the NatureServe website are identified with a footnote.

Drafts and final dichotomous field keys to associations were developed from similar information as the local descriptions, such as diagnostics species from plot data summaries of each vegetation type and vegetation analysis results. However, field keys need to be more inclusive, as the plot data collected are only a small selection of the total range of variation one may see in the field. Therefore, the key is based on the classified information, but is not restricted to maximal or minimal percent covers, and has couplets that allow for new associations not previously described. Draft field keys were reviewed by PACN staff and the mapping team and then updated and finalized by NatureServe ecologists. The field key was then used during the calibration and validation field work by the mapping team. Comments and suggestions from the mapping team were used by NatureServe ecologists to improve the field key which evolved over the course of the project as new types were discovered and added to the classification, and variation within each vegetation type was better understood (Appendix C).

Acquire and Prepare Imagery (Step 7)

Multiple imagery data sets were used in the KALA vegetation mapping project, including Worldview2 8 band optical imagery from 2010 and 2011, Quickbird 4 band optical imagery from 2005, Landsat 7 band imagery from 2003 and, interferometric synthetic aperture radar imagery flown by Intermap.

All high resolution imagery was obtained either from the NPS or from the USDA NRCS National Geospatial Center of Excellence in Fort Worth, Texas. NRCS ordered 1:12,000 terrain corrected and georeferenced imagery from Digital Globe for all of the Hawaii Islands. NRCS mosaiced the imagery to provide continuous imagery by USGS quadrangle and to remove clouds and shadows where possible. Digital Globe 1:12,000 product standards maintain no more than 10-12 m positional error for Quickbird data, and 3-6 m positional error for Worldview2 data. Table 5 presents information on the high resolution imagery data sets used to map the vegetation of KALA.

Upon receipt of imagery, KGA reviewed the data sets for quality and registration. KALA's steepness caused deep shadowing in some areas which made having multiple data sets from different dates extremely valuable. However, all optical image data sets exhibited deep, impenetrable shadows in the steep canyons of KALA. While the Worldview2 imagery is much less shadowed than the Quickbird imagery, the ravines of the northeast face of Wai'ale'ia Valley are deeply shadowed or imperfectly mosaiced in all image data sets. Figure 13 shows both the Quickbird and Worldview2 imagery of this area.

Table 5. High resolution imagery used to map KALA vegetation.

KALA Quickbird Imagery		
Nadir Spatial Resolution: 61 cm panchromatic, 2.44 m multispectral		
DOQQ_Name	USDA_Name	Image Date
Kamalo NW	m2115650_sw	12/13/2005
Kamalo WC	m2115658_nw	12/13/2005
Kaunakakai EC	m2115657_ne	12/13/2005
Kaunakakai NE	m2115649_se	12/13/2005
Kaunakakai NW	m2115649_sw	12/13/2005
KALA WorldView 2 imagery		
Nadir Spatial Resolution: 46 cm panchromatic, 1.8 m multispectral		
Image Name		Image Date
Tile 1		6/22/2010
Tile 2		1/22/2011
Tile 3		2/24/2011
Tile 4		4/28/2011

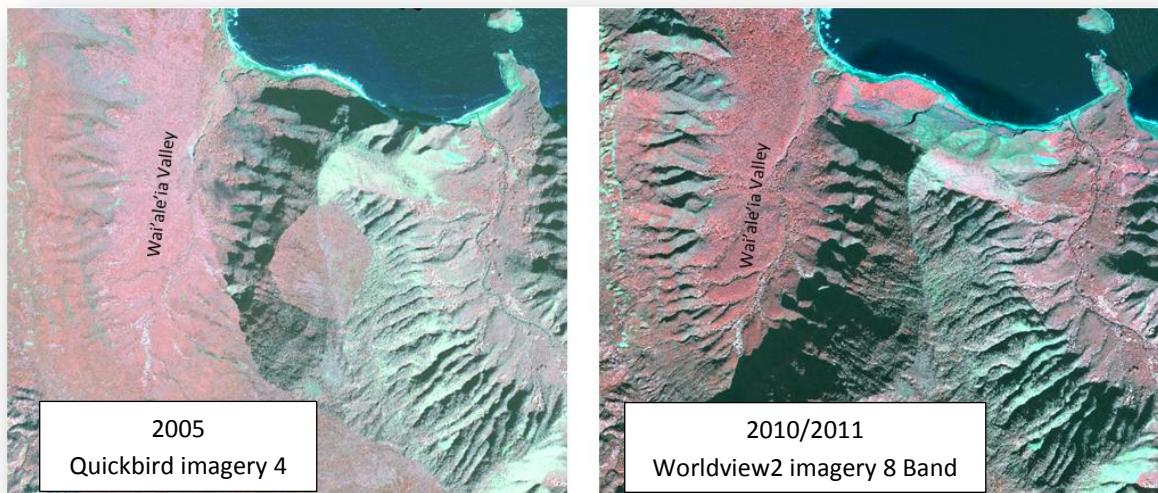


Figure 13. Side by side comparison of high-resolution imagery of KALA showing the deep shadowing of Wai'ale'ia Valley northwest slopes in both images.

Imagery Analysis / Classification (Step 8)/ GIS Project Preparation (Step 9)

Introduction

Using remotely sensed data and ancillary information to map vegetation type is effective only because a high correlation exists between variation in the imagery and ancillary data, and variation in vegetation as specified by the classification scheme. When the vegetation on the ground changes the spectral response of the imagery and the classes of the ancillary data also change. Using remotely sensed data and ancillary information to map land cover and land use requires understanding what factors cause variation on the ground and how the imagery and ancillary information represent those variations. Therefore, vegetation mapping requires completion of three basic steps:

- Developing a classification scheme to specify the type of land cover and land use characteristics to be detected and mapped,
- Controlling all variation in the imagery and ancillary information that is not related to variation in the classification scheme, and
- Capturing and classifying all the variation that is related to the variation in the classification scheme.

Since early last century these steps have been completed through the manual photo interpretation of remotely sensed data to delineate and identify vegetation by relying on seven indicators of vegetation type; color, tone, texture, location, context, height, and shape of the feature of interest (Spurr, 1948). While a mainstay for decades, manual interpretation can be extremely time consuming, costly, and inconsistent. Semi-automated classification involves data exploration to establish relationships between the imagery, ancillary information, and features on the ground. Semi-automated methods can be more cost effective and consistent than manual interpretation by allowing computer data

analysis to label the easily identified features, thereby focusing the skilled remote sensing analysts' efforts on difficult and complex features. This project employed semi-automated techniques.

Innovations over the last decade have resulted in the development of the semi-automated classification method of object oriented classification. Object oriented image classification classifies image objects (polygons) instead of single pixels, allowing for the incorporation of not only texture, tone, and color, but also shape and context into the creation of vegetation data. Object oriented classification closely mimics manual interpretation by creating vegetation polygons, yet brings substantial increase to the speed of map production, consistency, accuracy, and detail. While powerful in the classification of medium resolution data (e.g. Landsat), object oriented classification is pivotal for semi-automated classification of high resolution airborne imagery, (such as Quickbird and Worldview imagery) because of the mixture of shadow and illuminated features in the imagery and the need to group pixels together to map vegetation classes instead of individual vegetation features such as individual trees.

This project's semi automated techniques included object oriented image segmentation, classification and regression tree (CART) analysis, local expertise, field data collection, manual image interpretation and editing, and GIS modeling to create a vegetation map for KALA.

Image Segmentation

KGA employed Trimble's (formally Definiens) eCognition software (<http://www.ecognition.com/>) to segment the high resolution imagery into spectrally unique objects. Similar to the manual delineation of polygons in photo interpretation, segmentation algorithms delineate digital imagery into groups of pixels, called objects or segments, which have more spectral variation *between* than *within* segments, based on a user defined set of inputs. Automated segmentation improves on manual delineation by forcing consistency and increasing detail in the delineation process.

Because KALA is a medium sized park, segments were generated for the entire park at the same time. Two segmentations were run on the KALA imagery: one on the 2005 Quickbird imagery prior to the calibration trip, and a second segmentation on the 2010-11 Worldview2 imagery, as the Worldview2 imagery was received after the calibration trip. Because of its higher spatial resolution, the Worldview2 segments were used as the objects to be labeled in CART. Table 6 presents the input bands and eCognition parameters used to create the KALA segments from the Worldview2 imagery. At the end of the mapping process, delineations between adjacent segments with the same map and modifier class were dissolved to create map vegetation polygons.

Table 6. Input bands and eCognition parameters for the KALA Worldview2 image segmentation.

Input Image Bands	Weight	Shape	Compactness	Scale	Number of Segmentation Cycles
WV2 Coastal band	1	0.3	0.7	100	10
WV2 Red Edge band	1				
WV2 Red band	1				
WV2 Green band	1				
WV2 Blue band	1				
WV2 Yellow band	1				
WV2 NIR texture 9x9	2				
WV2 NIR texture 20x20	1				

Collect and Process Ancillary Data

Since the beginnings of photo interpretation over 100 years ago, the key indicators of vegetation type have been the color, tone, texture, location, context, height and shape of the feature of interest (Spurr 1948). While many of these indicators can be derived from remotely sensed data (i.e. color, tone, texture, shape, and height), others such as location and context must be derived from ancillary data. Data ancillary to the imagery are critical to vegetation map creation because they can capture causes of variation in vegetation type that are not captured by the imagery.

The NPS supplied KGA Team with numerous geodatabases of ancillary data. KGA also acquired multiple data sets and created several ancillary data layers. Measures of each segment's color, tone, and texture were derived from the QuickBird, Worldview, and Landsat TM imagery. Measures of shape were obtained from the eCognition segment shape outputs. Location information was acquired from ancillary data layers such as digital elevation models (DEM), stream and shoreline coverages, climate zones, and soil. Table 7 summarizes ancillary data used in the KALA vegetation mapping project.

Once the independent variable layers were created or acquired, they were reviewed for quality and registration. Verification and co-registration of ancillary data and imagery is an important task which ensures that the independent variables being sampled are associated with the vegetation class of interest. Following review, several ancillary data sets were rejected for use in CART and were used as reference data only. For example, the feature height data set derived from subtracting the ifSAR Digital Surface Model (DSM) from the National Elevation Dataset (NED) Digital Terrain Model (DTM) were rejected because it contained negative numbers (i.e. in some cases the DSM has lower elevations than the DTM).

Table 7. Ancillary data sources for CART independent variables and reference data.

Dataset	Description	File Type	Used For	Source
Climate Zones	deliniation of climate zones	vector	CART	NPS
Distance from shore	needs to be created from NOAA lifeform	vector	CART	NPS
DSM from IfSAR	from IfSAR, 5m resolution	raster	CART	USDA
eCognition shape variables	derived from eCognition segment shape indices	vector	CART	derived from segments
Erosion potential	Surgo soils layer	vector	CART	NPS
Image texture	texture bands created from satellite imagery NIR bands	raster	CART	derived from satellite imagery
In or out of Park	derived from NPS park boundary	vector	CART	derived from NPS boundary file
Landsat imagery	2003 Landsat	raster	CART	USGS
NED aspect	Aspect created from NED OEM	raster	CART	derived from NED
NED OEM	NED 10m OEM	raster	CART	USGS
NED slope degree	Slope created from NED OEM in degrees	raster	CART	derived from NED
NED slope percent	Slope created from NED OEM in percent	raster	CART	derived from NED
QuickBird 4 bands	8 bit,50cm resolution	raster	CART	NPS
Soil type	Surgo soils layer	vector	CART	NPS
Vegetation/feature height	IfSAR DSM- NED DTM	raster	CART	derived from IfSAR imagery
Wetlands	Wetlands	vector	CART	NPS
WorldView2 8 bands	8 bit and 16 bit, 30cm resolution	raster	CART	USDA
2006 high resolution C-CAP	NOAA CCAP high resolution land cover	raster	reference	NOAA
Aspect	derived from IfSAR DTM	raster	reference	derived from IfSAR imagery
Contours	derived from IfSAR	vector	reference	derived from IfSAR imagery
DRGs	topography	raster	reference	NPS
DTM from IfSAR	from IfSAR,5m resolution	raster	reference	USDA
Hillshade,two versions	derived from IfSAR DTM	raster	reference	derived from IfSAR imagery
KALA veg	vegetation map of KALA from 1989	vector	reference	USGS
KALAvég2	vegetation map of KALA from 2007	vector	reference	NPS
NOAA field data	field sites and photos collected for lifeform map	vector	reference	NPS
NOAA lifeform	lifeform map derived from high resolution imagery	raster	reference	NOAA
roads and trails	roads and trails	vector	reference	NPS
Slope degree	derived from IfSAR DTM	raster	reference	derived from IfSAR imagery
Slope percent	derived from IfSAR DTM	raster	reference	derived from IfSAR imagery

Next, each independent variable layer was intersected with the segment layer in ArcGIS and segment zonal statistics for each layer (usually the mean and the standard deviation) were created for each variable for each segment. A relational database of each sample segment's dependent variable (i.e. vegetation association or map class) and independent variables (from either eCognition or ArcGIS) was created in Microsoft Access.

Other ancillary data depicting the vegetation of the project area from earlier or smaller scale projects were also acquired but used only as reference data in map review, and not in CART analysis. Legacy vegetation data included the NPS observation and classification field plots, Jacobi's 1989 upland vegetation map (Jacobi, 1989), Jacobi and Hughes vegetation maps created in 2007 for the *Assessment of Natural Resources and Watershed Conditions for Kalaupapa National Historical Park* (Fung and SWCA, 2010), NOAA's 2005 lifeform map, transect data collected for the long term monitoring program, and Canfield's (1990) coastal spray zone map.

Calibration Trip

Field sampling is the most effective way to understand how remotely sensed and ancillary data may be used to map vegetation because it provides an understanding of:

- causes of vegetation variability, and
- the relationship between vegetation variability and that of the imagery and ancillary data layers.

Collection of field data used to create the KALA vegetation map started with NPS classification field sample collection, continued with KGA calibration and validation sample collection, and ended with NPS formal AA site collection. This section of the report summarizes the calibration trip procedures.

In May of 2012, a five day calibration trip was made to KALA. Two three person crews (composed of NatureServe, PACN staff, and KGA personnel) collected sample segments throughout accessible portions of the park. However, helicopter access by KGA to remote sections of the park was not permitted by the NPS. As a result, Kūka'iwa'a Point and much of the Pu'u Ali'i NAR were not visited in the field by KGA calibration or validation field crews.

The focus of the calibration trips was to capture as much field verified information as possible and to collect samples in vegetation classes that were under represented in the NPS plots and/or were spectrally interesting. Field sample data were collected on Trimble Yumas (Figure 14) and segments were labeled at every opportunity. Segment labeling was implemented by selecting segments from the processing region segment coverage and choosing the vegetation association from a pull down menu in the attribute table. Detailed field sample data were collected for unique vegetation types using the field forms created for the KALA vegetation mapping project. The form automatically provides quality control and calculates the vegetation association of the sample segment using the KGA created Autolabeler program. The form also provides the option of selecting 1-2 alternative acceptable vegetation class label(s) for the site for later analysis.



Figure 14. Field data entry at KALA on the Trimble Yuma.

Guidelines for the selection of calibration field sample segments were:

- *Informational homogeneity* – The sample must represent one and only one vegetation class. Segments including more than one vegetation class were edited to represent only one class.
- *Spectral homogeneity* – The sample should have more between than within segment spectral response.
- *Minimum size* – Samples should be larger than the MMU of 0.5 hectares.
- *Project-wide distribution* – For each class, field personnel attempted to distribute the sites evenly across that class's distribution in the project area.
- *Spectral uniqueness* – Samples were collected of vegetation with spectrally unique characteristics.

Creation of the Classification and Regression Tree (CART) CART Sample Database

Upon return from the field, all calibration data underwent quality control. Each sample was reviewed for data entry or logic errors and segments were edited where needed so that each sample segment represented only one vegetation association. Additionally, NPS classification plots were transformed into sample segments where possible by comparing the segment imagery to the NatureServe plot label. If the NatureServe plot label was an acceptable label for the segment, the segment was given the plot label and it was included as a sample for CART modeling. The NatureServe label was rejected if it appeared to not be representative of the segment (i.e. if the plot label was for a vegetation association below the MMU of 0.5 ha; 1 ac). The result was a combined set of KGA and NPS sample segments. Finally, all NPS classification data were also run through the Autolabeler to check for consistency and errors.

CART Modeling

The KALA vegetation maps were created using a combination of CART modeling and manual editing. CART analysis builds “tree” diagrams for predicting variables from categorical and continuous data (Breiman et al. 1984). It “mines” the sample data and builds rules which are if-then statements in hierarchical “trees” that condition the prediction of vegetation classes. CART is powerful because:

- it can accept both continuous and categorical data inputs
- the results are easy to interpret
- unlike a maximum likelihood classifier, no assumptions are required concerning the distributions of the independent variables
- it identifies simple and complex relationships between variables that other techniques might not uncover, and
- it forces consistency and analytical rigor into the segment labeling process.

CART analysis was performed on the combined NPS and KGA samples using See (<http://www.rulequest.com/see5-info.html>) software. Input variables to CART were the sample segment vegetation associations (the dependent variables), and segment independent variables, such as the various measures from the Worldview2 imagery (e.g., tone, color, segment shape, texture) and ancillary data sets (e.g., Landsat imagery, slope, aspect, elevation, climate, closeness to shore). The CART model was built from the sample segments and then the model was applied to the remaining segments. The resultant CART labels were then imported into ArcGIS. Figure 15 provides a conceptual illustration of how CART analysis works.

Editing

Manual edits were conducted to improve the accuracy of the map resulting from CART modeling. Manual editing was done in ArcMap and involved changing a segment’s boundaries and/or changing a segment’s map label to the more accurate map class. Edits were based on manual interpretation of all image sets, field notes, ancillary data, and legacy vegetation maps and data. For quality control, pull down lists of allowable attribute domains were created for map class editing. Typically, manual editing took place at scales between 1:5,000 and 1:10,000. At times, however, analysts would work at larger scales, especially in riparian and coastal areas.

During editing, modifiers were added to indicate the presence of a species of interest to the park. Modifiers are as follows:

- *Lantana camara* Semi-natural Shrubland with *Senna occidentalis*
- *Psidium cattleianum* Lowland Wet Semi-natural Forest with scattered *Samanea saman*
- *Psidium guajava* Disturbed Understory Semi-natural Forest with scattered *Mangifera indica*
- *Scaevola taccada* Coastal Dry Shrubland¹ with scattered *Tournefortia argentea*
- *Schinus terebinthifolius* Semi-natural Scrub Woodland with scattered *Phoenix dactylifera*
- *Schinus terebinthifolius* Semi-natural Scrub Woodland with *Senna occidentalis*
- *Syzygium cumini* Lowland Mesic Semi-natural Forest with scattered *Samanea saman*

The result of the CART modeling and editing was the KALA preliminary vegetation map which was field checked during the validation trip.

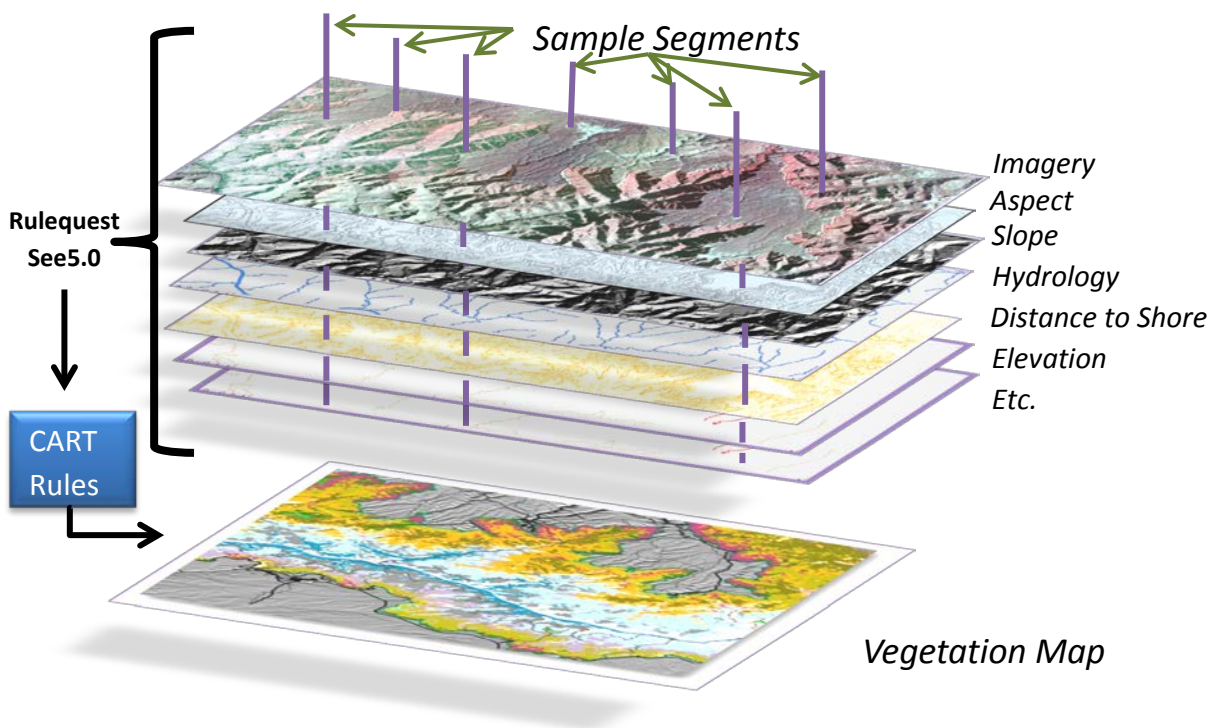


Figure 15. Conceptual illustration of the CART data mining and rule creation process.

Validation (Step 10)

In late October of 2012, KGA personnel returned to KALA to check the preliminary map. One two person crew plus KALA personnel spent five days evaluating the preliminary map. Corrections to the map were made in the field on a Trimble Yuma. Upon return from the field, the preliminary map was sent to the NPS for review. Comments on the preliminary map were then incorporated into the map, additional edits were made, and the draft map was created.

Draft Map and Digital Database Production

In March of 2013, the KALA draft vegetation map (Figure 16) and digital database were delivered to the NPS. The vegetation map feature class attribute tables were formatted according to NPS standards. The following standard fields were included in the attribute tables based on an example table sent to us by the NPS and approved by the NPS after delivery of the data (Table 8).

1. NVC_Elcode – String field, populated with the vegetation association code.
2. Association – String field, populated with the vegetation association name or N/A if no association exists.
3. MapClass_CD – String field, to be populated by the NPS.

4. Map_Class – String field, populated with the vegetation association name if it exists or a map label name when Association is “Undefined”.
5. X_Centroid – Double numeric field, populated with the X centroid coordinate for the polygon in meters.
6. Y_Centroid – Double numeric field, populated with the Y centroid coordinate for the polygon in meters.

Some additional fields were included in the attribute tables that were not specifically requested by the NPS.

1. Poly_ID – Long numeric field, populated with a unique identifier number for the polygon.
2. Hectares – Double numeric field, populated with the polygon area in hectares.
3. One or more String fields populated with special “modifier” attributes for certain polygons.

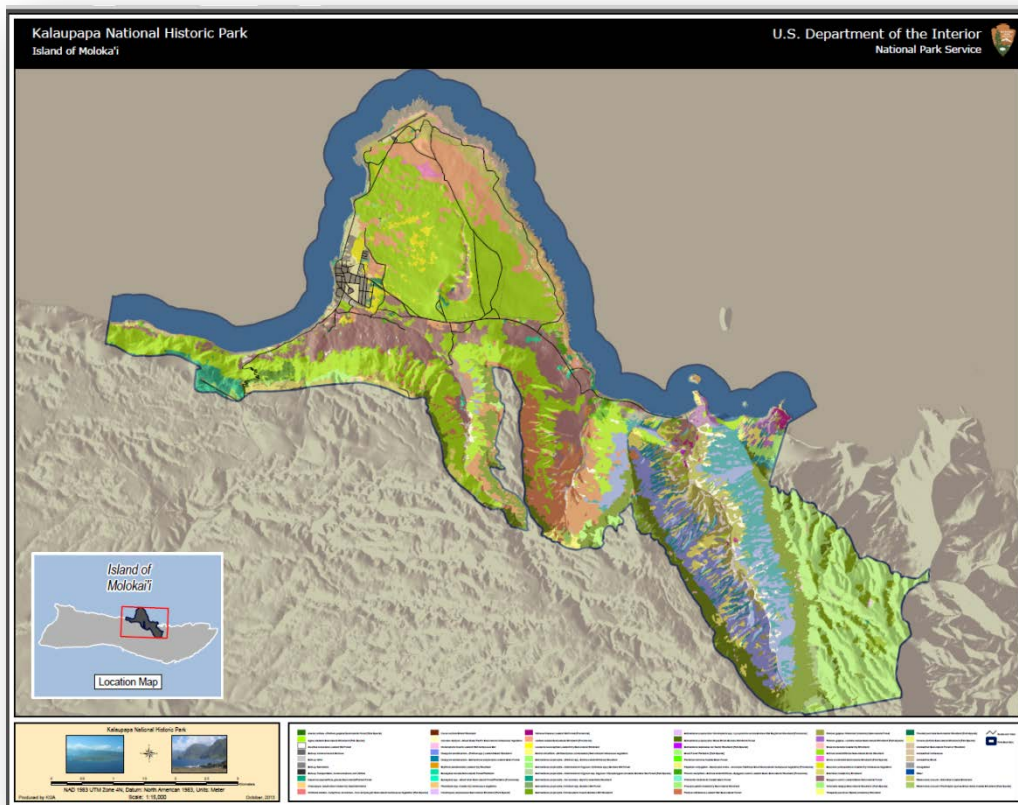


Figure 16. Draft KALA vegetation map.

Formal Accuracy Assessment (Step 11)

Introduction

An important and necessary aspect of this project is the AA; collecting independent ground data determines the usefulness of the vegetation map. As such, users of this product should remember that the GIS mapping and the classification portions of this project were conducted separately from both the plot and AA field data collection.

Thematic maps emphasize spatial variation of one or a small number of geographic distributions. Thematic accuracy is relative to the exact method used to evaluate the variation how well the class names on the map correspond to what is really on the ground. Spatial accuracy quantifies errors in the locations of boundaries. In the case of the VIP however, the spatial/positional accuracy is relative to the accuracy of Quickbird and Worldview2 imagery and allows for the assumption that all products derived from them are well within the NPS national map accuracy standards for 1:12,000-scale maps (± 9 m; 30 ft).

Sampling Design

The thematic accuracy of the vegetation map was assessed using the methodology standards provided by the VIP (TNC and ESRI 1994c). The protocols include a four step AA process consisting of a sample design, sample site selection, data collection, and data analysis. The design of the KALA AA sample followed the five scenarios provided in the 1994 field manual with stratified random targets placed in each map class based on their respective frequency and abundance (Table 8).

AA sample points were generated for each map class using ArcGIS. Polygons less than MMU (0.5 ha) were eliminated from the assessment using a definition query. Polygons classified as water or human made features were also removed. Steep areas ($\geq 70\%$ slope) were identified (intersected with 5 m DEM) and eliminated from the analysis for crew safety. Inaccessible areas, based on road/trail GIS layers and park-specific knowledge, were also eliminated. In order to generate random points across each map class, all single part polygons per map class were dissolved into one multipart polygon feature. Multipart polygons allow selection of individual map classes to generate the required amount of sampling points across the map class spatial extent. Total area for each map class was calculated and the number of AA sample points per association required was identified (Table 9). AA sample points were generated for each map class using the random point generator within the dissolved feature class. Three times the required number of sample points were generated per map class to ensure the creation of enough accessible samples. A 45 m buffer was created around each point using the proximity tool to represent a 0.5 ha (1.2 ac) circle with a 5 m (16 ft) buffer accounting for the horizontal error typically encountered in GPS receivers. A random feature ID was assigned and each buffer was unioned with the previously processed map data. Points identified with buffers $> 90\%$ within map polygons were selected (99 samples). If necessary, buffers were shifted up to 40 m to fit within polygons (61 samples). Some samples had odd shaped (i.e. linear) polygons in which 0.5 ha circles did not fit, 81 were identified as requiring polygon based sampling. Sample points were rejected when buffers intersected other point's buffers to ensure no overlapping samples. AA sample points were randomly selected from the list of acceptable points per map class. Point data were exported from GIS into GPS field devices. For map classes that required polygon based sampling, polygon boundaries excluding map class labels were uploaded to GPS units.

Table 8. VIP Sampling protocol for AA points. Source: Final Draft Accuracy Assessment Procedures, National Park Service 1994.

Scenario	Description	# Polygons	Area (ac)	Recommended # of Samples
A	The class is abundant. It covers more than 50 hectares of the total area and consists of at least 30 polygons. In this case, the recommended sample size is 30.	> 30	> 125	20*
B	The class is relatively abundant. It covers more than 50 hectares of the total area but consists of fewer than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size for this type of class is that sample sites are more difficult to find because of the lower frequency of the class.	< 30	> 125	20
C	The class is relatively rare. It covers less than 50 hectares of the total area but consists of more than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size is that the class occupies a small area. At the same time, however, the class consists of a considerable number of distinct polygons that are possibly widely distributed. The number of samples therefore remains relatively high because of the high frequency of the class.	> 30	< 125	20
D	The class is rare. It has more than 5 but fewer than 30 polygons and covers less than 50 hectares of the area. In this case, the recommended number of samples is 5. The rationale for reducing the sample size is that the class consists of small polygons and the frequency of the polygons is low. Specifying more than 5 sample sites will therefore probably result in multiple sample sites within the same (small) polygon. Collecting 5 sample sites will allow an accuracy estimate to be computed, although it will not be very precise.	5-30	< 125	5
E	The class is very rare. It has fewer than 5 polygons and occupies less than 50 hectares of the total area. In this case, it is recommended that the existence of the class be confirmed by a visit to each sample site. The rationale for the recommendation is that with fewer than 5 sample sites (assuming 1 site per polygon) no estimate of level of confidence can be established for the sample (the existence of the class can only be confirmed through field checking).	< 5	< 125	Visit all and confirm

*Recommended sample size reduced to meet time and cost restraints.

Eleven associations did not occur on the map in areas larger than the MMU thus were not sampled for accuracy assessment:

- *Agave sisalina* Semi-natural Shrubland [Park Special]
- *Cocos nucifera* Strand Woodland
- *Coffea arabica* Semi-natural Forest [Park Special]
- *Cyclosorus dentatus* - *Hedychium coronarium* - *Coix lacryma-jobi* Semi-natural Herbaceous Vegetation [Park Special]²
- *Erythrina sandwicensis* Lowland Dry Woodland
- *Heliotropium amplexicaule* Semi-natural Shrubland [Park Special]
- *Melinis minutiflora* - (*Schizachyrium condensatum*) Semi-natural Herbaceous Vegetation

- *Metrosideros polymorpha* - *Cheirodendron trigynum* ssp. *trigynum* / *Diplopterygium pinnatum* Montane Wet Forest [Park Special]
- *Metrosideros polymorpha* - *Ilex anomala* - *Myrsine lessertiana* Woodland
- *Metrosideros waialealae* var. *fauriei* Woodland [Park Special]
- *Prosopis pallida* Coastal Dry Semi-natural Woodland

Three associations were inaccessible and were not sampled for accuracy assessment:

- *Euphorbia celastroides* Coastal Dry Dwarf-shrubland³
- *Dicranopteris linearis* Wet Herbaceous Mat
- *Hibiscus tiliaceus* Lowland Wet Forest [Provisional]

The following map classes were also not assessed:

- Built-up Commercial and Services
- Built-up Residential
- Built-up Transportation, Communications, and Utilities
- Unvegetated
- Water

²USNVC name *Christella dentata* modified to *Cyclosorus dentatus* based taxonomy of Wagner et al. (2012).

³USNVC name *Chamaesyce celastroides* modified to *Euphorbia celastroides* based on taxonomy of Wagner et al. (2012).

Field Data Collection

From March to June 2013, PACN staff collected 241 AA samples at KALA (Figure 17). Using GPS units, field maps, and compasses, field crews navigated to the target location and assessed the vegetation of the sample (0.5 ha), typically as a circular plot (40 m radius). In areas where boundaries of vegetation follow long, sinewy formations (e.g. along ridge tops) where circular plots did not fit, vegetation was assessed within the polygon boundaries. At each site, field crews recorded the percent cover of dominant plant species by stratum on AA forms (Appendix F). Based on these measurements, crews used the classification key (Appendix C) to identify the vegetation type. The associated description (Appendix D) was reviewed and comments were included where necessary (e.g. main descriptive species missing). In sites where the vegetation matched more than one vegetation type (e.g. percent covers were near the cut-off between physiognomic groups), crews assigned a secondary and in some cases a tertiary field call. Photos were taken in each plot in all cardinal directions (N-E-S-W), and of the canopy, ground and completed data forms. Nearby vegetation, topographic features, or recent disturbance were also recorded. If the crew encountered a vegetation type that was new to the KALA classification, they also completed an environmental field form (Appendix F) and developed a species list for the site.

If the crew could not access the sample (> 12 m from target location) due to steep terrain or dense vegetation, they noted this limitation and assessed the vegetation at the closest proximity. Additionally, crews recorded location data for species with specific historic and/or ecological importance (*Mangifera indica*, *Bambusa* spp., *Phoenix dactylifera*, and *Samanea saman*). These data were specifically requested by the KALA park staff and were added as modifiers to the database when encountered within plots to provide additional information about the landscape.

Quality Control

Accuracy assessment data forms were reviewed for errors, entered into the NPS Microsoft Access database (PLOTS), and proofed for data entry errors by PACN staff. KGA also reviewed the accuracy assessment data for errors and ran the PLOTS data for each sample through the Autolabeler to check for any inconsistencies in sample labeling. A preliminary analysis and description of possible errors were transmitted to the PACN staff and discrepancies in sites were resolved.

Analysis

The AA analyses was completed by:

- reviewing each site's database, scanned field form, and field photos
- running the reference site data through the autolabeler, and
- comparing the site's reference accuracy assessment label to its draft map label, its Autolabeler label, the Worldview high resolution imagery, and validation and calibration field samples and photos.

KGA and PACN then reviewed the AA data and decided if any changes to the data were warranted. Any *post-hoc* changes to AA field calls or substantial changes to the vegetation map based on AA are identified in Appendix G. Next, error matrices were developed as detailed in the NPS National Vegetation Mapping Program's 1994 (NPS 1994) standards as specified in the mapping contract.

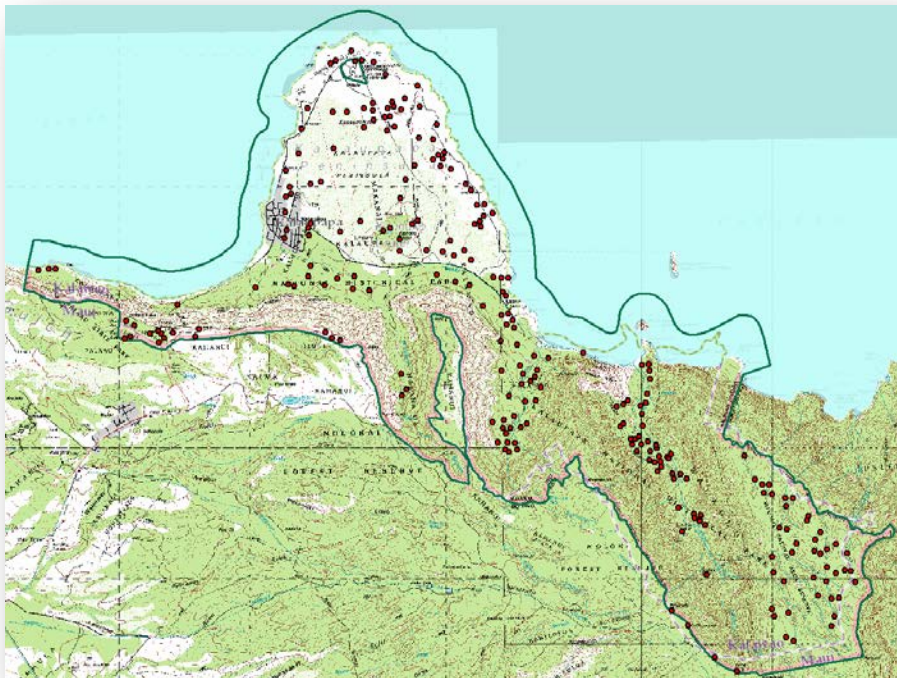


Figure 17. Distribution of KALA accuracy assessment sites.

Develop the Mapping Model (Step 6)

Ideally, when the vegetation association changes due to AA field data, the response of the remotely sensed data and the classes of the ancillary data also change, resulting in a one to one relationship between the associations and map classes. However, because vegetation associations are often distinguished from one another by sub canopy and/or scarce indicator species, it is often impossible to map to the association level, resulting in the need to collapse associations into less detailed map model classes. Therefore, a critical step in the KALA project was the translation of the KALA ecological association descriptions and key into a map key with classes which could be mapped from remotely sensed data and ancillary information.

In many NPS vegetation mapping projects which rely on manual photo interpretation, the development of the mapping model occurs following the collection of the imagery and completion of the calibration trip, when the photo interpreters have developed an understanding of what vegetation associations are distinguishable from the imagery and what need to be collapsed upward into more general map classes. However, the object oriented methods employed by KGA allow for the full incorporation of multiple image data sets and ancillary data into the map creation process, which can support more detail in the vegetation maps and less collapsing of associations into map classes. Therefore, development of the mapping model was implemented following accuracy assessment of the draft map rather than before image classification. As a result, only associations known to be confused were combined.

Following AA, the mapping team, NatureServe, and PACN staff worked together to develop the map model classes. For each NatureServe association a determination was made regarding if the association was:

- abundant and distinguishable using the imagery and/or ancillary data so as to be mapable using CART modeling coupled with manual editing,
- indistinguishable from the imagery and ancillary data and, therefore, needing to be collapsed upward to the Macrogroup or Group level or into a map class, or
- too rare to be mapped using CART modeling coupled with manual editing, in which case it would appear on the final map only in places where it was field verified during the PACN and KGA field data collection.

Final Map, Reports, and GIS Database (Step 12)

Following AA analysis and development of the mapping model, manual edits were made to the draft map based on AA results and PACN comments on the map.

Final delivery included electronic and hard copy maps. Additionally, a geodatabase of the final maps was delivered in Universal Transverse Mercator (UTM) North American Datum of 1983 (NAD83) High Accuracy Reference Network (HARN) datum. All electronic data, including GIS Data, are metadata compliant with Federal Geographic Data Committee Metadata Standards.

Results

Vegetation Sampling

Vegetation sampling at KALA was completed by PACN and NPS staff. Given the high diversity of habitats and plant communities and the extreme ruggedness of the terrain, it was a challenging landscape to sample. This contributed to a relatively high number of association level communities with only one plot (19) or two plots (9) comprising over half the 51 association level communities in the final vegetation classification. Other factors contributing to the low sampling per type include the rare nature of many of the native communities and varying degrees of degradation by invasive non-native species. When possible, NatureServe recommends 3-5 plots of each type to capture some of the range of variability within each type.

Three plant communities at KALA had abundant samples (>10 each). Two of these plant communities, *Schinus terebinthifolius* Semi-natural Scrub Woodland (14 samples) and *Syzygium cumini* Lowland Mesic Semi-natural Forest (11 samples) are invasive, non-native plant communities. The other well-sampled community, *Metrosideros polymorpha* - *Cheirodendron* spp. / (*Cibotium* spp.) Montane Wet Forest (11 samples) occurs widely. All three of these vegetation communities are abundant in the park and their samples comprise over a quarter of the total number of sites sampled.

Table 9. KALA vegetation classification with national vegetation hierarchy upper units.

Association Name	Common Name	ELCODE	Group Name	Macrogroup Name
Forests and Woodlands				
<i>Erythrina sandwicensis</i> Lowland Dry Woodland**	Wiliwili Lowland Dry Woodland	CEGL008036	Hawaiian Lowland Dry Forest & Woodland	Hawaiian Dry Forest
<i>Thespesia populnea</i> / Sparse Understory Woodland	Milo / Sparse understory Woodland	CEGL005412	Hawaiian Lowland Dry Forest & Woodland	Hawaiian Dry Forest
<i>Prosopis pallida</i> Coastal Dry Semi-natural Woodland	Kiawe Lowland Dry Semi-natural Shrubland	CEGL008118	Polynesian Semi-natural Dry Forest	Polynesian Semi-natural Dry Forest
<i>Cocos nucifera</i> Strand Woodland*	Coconut Palm Strand Woodland	CEGL005402	Hawaiian Dry Scrub & Herb Coastal Strand	Hawaiian Scrub & Herb Coastal Vegetation
<i>Diospyros sandwicensis</i> - (<i>Psidium</i> spp.) Lowland Mesic Woodland	Lama - Guava Lowland Mesic Forest	CEGL008183	Hawaiian Lowland - Coastal Seasonal Rainforest	Hawaiian Lowland Rainforest
<i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest	Lama - 'Ōhi'a Lowland Mesic Forest	CEGL008026	Hawaiian Lowland - Coastal Seasonal Rainforest	Hawaiian Lowland Rainforest

Table 9 (continued). KALA vegetation classification with national vegetation hierarchy upper units.

Association Name	Common Name	ELCODE	Group Name	Macrogroup Name
<i>Pandanus tectorius</i> Coastal Mesic Forest	Hala Coastal Mesic Forest	CEGL008032	Hawaiian Lowland - Coastal Seasonal Rainforest	Hawaiian Lowland Rainforest
<i>Pritchardia hillebrandii</i> Coastal Mesic Forest**	Loulu Lelo Coastal Mesic Forest	CEGL008033	Hawaiian Lowland - Coastal Seasonal Rainforest	Hawaiian Lowland Rainforest
<i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland	‘Ōhi’a - (Guava species, Christmas Berry) Woodland	CEGL008142	Hawaiian Lowland Rainforest	Hawaiian Lowland Rainforest
<i>Metrosideros waialealae</i> var. <i>fauriei</i> Woodland [Park Special]	<i>Metrosideros waialealae</i> var. <i>fauriei</i> Woodland [Park Special]	CEPS009650	Hawaiian Lowland Rainforest	Hawaiian Lowland Rainforest
<i>Acacia confusa</i> - <i>Psidium guajava</i> Semi-natural Forest [Park Special]	Formosa Koa - Common Guava Semi-natural Forest [Park Special]	CEPS009673	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	Common Ironwood Semi-natural/Planted Forest	CEGL008182	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Coffea arabica</i> Semi-natural Forest [Park Special]	Arabian Coffee Semi-Natural Forest [Park Special]	CEPS009696	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation	Swamp Mahogany Semi-natural/Plantation Forest	CEGL008143	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Eucalyptus</i> spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional]	Eucalyptus - Mixed Alien Semi-natural Forest/Plantation [Provisional]	CEGL008144	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Grevillea robusta</i> Lowland Mesic Semi-natural Forest	Silk Oak Lowland Mesic Semi-natural Forest	CEGL008113	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest

Table 9 (continued). KALA vegetation classification with national vegetation hierarchy upper units.

Association Name	Common Name	ELCODE	Group Name	Macrogroup Name
<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Park Special]	Date Palm - Christmas Berry - Java Plum Lowland Mesic Semi-natural Woodland [Park Special]	CEPS009664	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	Strawberry Guava Lowland Wet Semi-natural Forest	CEGL008116	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	Common Guava / Disturbed Understory Semi-natural Forest	CEGL008147	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	Christmas Berry Semi-natural Scrub Woodland	CEGL008148	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	Java Plum Lowland Mesic Semi-natural Forest	CEGL008111	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	Pacific Almond Semi-natural Woodland [Park Special]	CEPS009651	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	Lucky-nut Semi-natural Woodland [Park Special]	CEPS009652	Polynesian Semi-natural Lowland Rainforest	Polynesian Semi-natural Lowland Rainforest
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest	‘Ōhi’a - ‘Ōlapa / (Ha pu’u species) Montane Wet Forest	CEGL008008	Hawaiian Montane Rainforest & Cloud Forest	Hawaiian Montane & Cloud Forest
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> ssp. <i>trigynum</i> / <i>Diplopterygium pinnatum</i> Montane Wet Forest [Park Special]	‘Ōhi’a - ‘Ōlapa / Uluhe lau nui Montane Wet Forest [Park Special]	CEPS009653	Hawaiian Montane Rainforest & Cloud Forest	Hawaiian Montane & Cloud Forest
<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	‘Ōhi’a - Hapu’u species Montane Wet Forest	CEGL008009	Hawaiian Montane Rainforest & Cloud Forest	Hawaiian Montane & Cloud Forest

Table 9 (continued). KALA vegetation classification with national vegetation hierarchy upper units.

Association Name	Common Name	ELCODE	Group Name	Macrogroup Name
<i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland	‘Ōhi’a / Uluhe Montane Wet Woodland	CEGL008041	Hawaiian Montane Rainforest & Cloud Forest	Hawaiian Montane & Cloud Forest
<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	‘Ōhi’a / Mixed Shrub Montane Wet Scrub Forest	CEGL008152	Hawaiian Montane Rainforest & Cloud Forest	Hawaiian Montane & Cloud Forest
<i>Metrosideros polymorpha</i> - <i>Ilex anomala</i> - <i>Myrsine lessertiana</i> Woodland	‘Ōhi’a - Kāwa‘u - Kōlea lau nui Woodland	CEGL008158	Hawaiian Montane-Subalpine Mesic Forest	Hawaiian Montane & Cloud Forest
<i>Aleurites moluccana</i> Lowland Wet Forest	Kukui Lowland Wet Forest	CEGL008115	Hawaiian Riparian & Floodplain Forest & Shrubland	Hawaiian Flooded & Swamp Forest
<i>Coprosma foliosa</i> - <i>Perrottetia sandwicensis</i> - <i>Cibotium</i> spp. Riparian Woodland [Park Special]	Pilo -Olomea - Hāpu‘u species Riparian Woodland [Park Special]	CEPS009675	Hawaiian Riparian & Floodplain Forest & Shrubland	Hawaiian Flooded & Swamp Forest
<i>Hibiscus tiliaceus</i> Lowland Wet Forest [Provisional]	Hau Lowland Wet Forest [Provisional]	CEGL008163	Hawaiian Riparian & Floodplain Forest & Shrubland	Hawaiian Flooded & Swamp Forest
<i>Metrosideros polymorpha</i> / <i>Dicranopteris</i> spp. / <i>Lycopodiella cernua</i> Montane Wet Bog Scrub Woodland [Provisional]	‘Ōhi’a / Uluhe / Wāwae‘iole Montane Wet Bog Scrub Woodland	CEGL008146	Hawaiian Bog	Hawaiian Bog & Fen
Mixed Forest Plantation [Park Special]	Mixed Forest Plantation [Park Special]	CEPS009672	Unclassified	Unclassified
Shrublands				
<i>Euphorbia celastroides</i> Coastal Dry Dwarf-shrubland ^{2**}	‘Akoko Coastal Dry Dwarf-shrubland	CEGL008075	Hawaiian Dry Scrub & Herb Coastal Strand	Hawaiian Scrub & Herb Coastal Vegetation
<i>Scaevola taccada</i> Coastal Dry Shrubland ¹	Naupaka Kahakai Coastal Dry Shrubland	CEGL008054	Hawaiian Dry Scrub & Herb Coastal Strand	Hawaiian Scrub & Herb Coastal Vegetation

Table 9 (continued). KALA vegetation classification with national vegetation hierarchy upper units.

Association Name	Common Name	ELCODE	Group Name	Macrogroup Name
<i>Sida fallax</i> Coastal Dry Shrubland	'Ilima Coastal Dry Shrubland	CEGL008055	Hawaiian Dry Scrub & Herb Coastal Strand	Hawaiian Scrub & Herb Coastal Vegetation
<i>Wikstroemia uva-ursi</i> - <i>Sida fallax</i> Coastal Shrubland	'Akia - 'Ilima Coastal Shrubland	CEGL008175	Hawaiian Dry Scrub & Herb Coastal Strand	Hawaiian Scrub & Herb Coastal Vegetation
<i>Wikstroemia uva-ursi</i> / <i>Fimbristylis cymosa</i> Mixed Grass Coastal Shrubland [Park Special]	'Akia / Mau'u Mixed Grass Coastal Shrubland [Park Special]	CEPS009667	Hawaiian Dry Scrub & Herb Coastal Strand	Hawaiian Scrub & Herb Coastal Vegetation
<i>Agave sisalana</i> Semi-natural Shrubland [Park Special]	Sisal Semi-natural Shrubland [Park Special]	CEPS009661	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna
<i>Heliotropium amplexicaule</i> Semi-natural Shrubland [Park Special]*	Clasping Heliotrope Semi-natural Shrubland [Park Special]	CEPS009711	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna
<i>Lantana camara</i> Semi-natural Shrubland [Provisional]	Lantana Semi-natural Shrubland [Provisional]	CEGL008145	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna
<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	Koa Haole Lowland Dry Semi-natural Shrubland	CEGL008114	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna
<i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	Common Guava - Lantana Semi-natural Shrubland [Park Special]	CEPS009697	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna
Herbaceous Vegetation				
<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	Fimbristylis Coastal Dry Herbaceous Vegetation	CEGL008089	Hawaiian Dry Scrub & Herb Coastal Strand	Hawaiian Scrub & Herb Coastal Vegetation

Table 9 (continued). KALA vegetation classification with national vegetation hierarchy upper units.

Association Name	Common Name	ELCODE	Group Name	Macrogroup Name
<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	'Akulikuli Coastal Dry Herbaceous Vegetation	CEGL008098	Hawaiian Dry Scrub & Herb Coastal Strand	Hawaiian Scrub & Herb Coastal Vegetation
<i>Dicranopteris linearis</i> Wet Herbaceous Mat	Uluhe Lowland Wet Herbaceous Mat	CEGL008048	Hawaiian Lowland Mesic-Wet Shrubland & Grassland	Hawaiian Lowland Shrubland, Grassland & Savanna
<i>Cyclosorus dentatus</i> - <i>Hedychium coronarium</i> - <i>Coix lacryma-jobi</i> Semi-natural Herbaceous Vegetation [Park Special] ²	<i>Cyclosorus dentatus</i> - White Ginger - Kūkaekōlea Herbaceous Vegetation [Park Special]	CEPS009659	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna
<i>Cynodon dactylon</i> - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	Bermuda grass - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	CEGL008167	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna
<i>Melinis minutiflora</i> - (<i>Schizachyrium condensatum</i>) Semi-natural Herbaceous Vegetation	Natal Redtop - (Beardgrass) Semi-natural Herbaceous Vegetation	CEGL008169	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna
<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	Hilo Grass - Glenwood Grass - Carpetgrass Mixed Semi-natural Herbaceous Vegetation [Provisional]	CEGL008170	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna

¹USNVC name *Scaevola sericea* modified to *Scaevola taccada* based on taxonomy of Wagner et al. (2012).

²USNVC name *Christella dentata* modified to *Cyclosorus dentatus* based on taxonomy of Wagner et al. (2012).

³USNVC name *Chamaesyce celastroides* modified to *Euphorbia celastroides* based on taxonomy of Wagner et al. (2012).

* Associations at KALA based on observations during map the calibration/validation process.

** Associations at KALA based on prior research by Fung and SWCA Environmental Consultants (2010) and Wood (2001, 2008).

Vegetation Classification

The final KALA vegetation classification was delivered to PACN December 2013; it follows the FGDC (2008) USNVC Standard. All vegetation types were placed into the current interpretation of the vegetation hierarchy of the 2008 NVC Standard.

The vegetation data collected from KALA were classified into 10 NVC macrogroups, 12 NVC Groups and 52 association level community types (Table 8). Of these community types, 21 were

attributed to existing NVC associations and 16 were considered new NVC associations. Five NVC associations were categorized as “provisional” rather than “standard” NVC. Classification confidence is low in these types because of limited or inaccessible plot data, and/or lack of comprehensive analysis that limits confidence that the type meets requirements of a standard NVC type. Fourteen types were considered park specials (or proposed) due to lack of sufficient information to justify creating new NVC associations. Park Specials occur only in small stands, are tentatively considered unique to the park, and lack sufficient documentation in the literature. When KALA plant communities are summarized by physiognomic class, there are a total of 34 tree dominated communities (scrub forests/woodlands/ rainforests, wooded bogs), 10 shrublands, and 7 herbaceous vegetation types

Each association or park special is represented from zero to 14 full plot samples. Over half of the 51 association level community types are based on only one or two classification plots (19 single plot types and 9 two plots types). Four association level community types lack classification plots. Two types were based on observations (dominant species and location) made during the map the calibration/validation process (*Cocos nucifera* Strand Woodland and *Heliotropium amplexicaule* Semi-natural Shrubland [Park Special]) and two were based on other research conducted at the park such as studies on *Erythrina sandwicensis* Lowland Dry Woodland stands at Kauhakō Crater (Fung & SWCA Environmental Consultants, 2010) and *Pritchardia hillebrandii* Coastal Mesic Forest and *Euphorbia celastroides* Coastal Dry Dwarf-shrubland on Huelo Islet (Wood 2001, 2008). These four associations (three existing NVC associations and one park special) were added to the draft KALA vegetation classification after quantitative analysis was complete. These types may be rare in the park, or were simply under sampled as a result of difficult access or limitations of the sampling design. It is important that the vegetation classification of the park be as comprehensive as possible to improve vegetation mapping accuracy.

Appendix D presents the descriptions of selected Vegetation Communities of KALA and Appendix C contains the Field Key to the Vegetation Associations of KALA. Appendix E is a table of classification plots by association.

Vegetation Mapping

Table 10 relates the KALA vegetation associations to the KALA map classes and presents the number of map hectares and the number of classification plots of each map class. Following the classification work (Step 5), 47 associations were assigned to KALA. During the map calibration and validation field efforts, four additional associations were determined to exist at KALA (*Cocos nucifera* Strand Woodland, *Pritchardia hillebrandii* Coastal Mesic Forest, *Euphorbia celastroides* Coastal Dry Dwarf-Shrubland and *Heliotropium amplexicaule* Semi-natural Shrubland [Park Special]). Following AA, the 51 vegetation associations were collapsed into 38 vegetation map classes as illustrated in Table 10. An additional six non vegetation classes were also added, bringing the total number of map classes to 45.

Six forested associations were combined to create three map classes because their associations were not distinguishable from one another using either the imagery and/or ancillary data:

- *Metrosideros polymorpha* - *Cheirodendron trigynum* / (*Cibotium* spp.) Montane Wet Forest and *Metrosideros polymorpha* / *Dicranopteris linearis* Montane Wet Woodland were collapsed into *Metrosideros polymorpha* Montane Wet Forest,
- *Diospyros sandwicensis* - (*Psidium* spp.) Lowland Mesic Woodland and *Diospyros sandwicensis* - *Metrosideros polymorpha* Lowland Mesic Forest were collapsed into *Diospyros sandwicensis* Lowland Mesic, and
- *Eucalyptus robusta* Semi-natural Forest/Plantation and *Eucalyptus* spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional] associations were combined to create the *Eucalyptus* spp. - Mixed Forest map class.

The confusion within the *Diospyros* and *Eucalyptus* associations occurred because none of the spectral or informational independent variables were able to distinguish the associations from one another. Conversely, the confusion between the *Metrosideros polymorpha* - *Cheirodendron trigynum* / (*Cibotium* spp.) Montane Wet Forest and *Metrosideros polymorpha* / *Dicranopteris linearis* Montane Wet Woodland associations on the draft map was driven by spectral differences in the imagery across Pu‘u Ali‘i NAR. However, AA showed that these spectrally unique areas are not different associations, but part of the *Metrosideros polymorpha* - *Cheirodendron trigynum* / (*Cibotium* spp.) Montane Wet Forest. Following AA, a PC-Ord analysis was performed on the AA samples in this area, but no significant vegetative differences were found to be correlated with the spectral differences apparent on the imagery.

Two coastal associations were also collapsed into one map class: *Wikstroemia uva-ursi* - *Sida fallax* Shrubland and *Wikstroemia uva-ursi* / *Fimbristylis cymosa* Mixed Grass Coastal Shrubland [Park Special] were combined into *Wikstroemia uva-ursi* Coastal Shrubland.

Six associations do not occur on the map because they are relatively rare, occur only below the MMU and are not ecologically or culturally important, and/or are indistinguishable from other associations using the imagery or ancillary data: *Metrosideros waialealae* var. *fauriei* Woodland [Park Special], *Metrosideros polymorpha* - *Cheirodendron trigynum* ssp. *trigynum* / *Diplopterygium pinnatum* Montane Wet Forest [Park Special], *Metrosideros polymorpha* / *Dicranopteris* spp. / *Lycopodiella cernua* Montane Wet Bog Scrub Woodland [Provisional], *Metrosideros polymorpha* - *Ilex anomala* - *Myrsine lessertiana* Woodland, *Coffea arabica* Semi-Natural Forest [Park Special] and *Dicranopteris linearis* Wet Herbaceous Mat. Two additional associations (*Grevillea robusta* Lowland Mesic Semi-natural Forest, and *Coprosma foliosa* - *Perrottetia sandwicensis* - *Cibotium* spp. Riparian Woodland [Park Special]) are represented by one classification plot each, and both plots are outside of the park. Because neither of these two associations was encountered on the calibration or validation trips or during AA, they are assumed to not occur at KALA in areas larger than the MMU.

One map class (*Schinus terebinthifolius* / *Lantana camara* Mosaic Woodland) was added to allow for delineation of the mosaic of *Schinus terebinthifolius* and *Lantana camara* that transitions from the *Schinus terebinthifolius* Semi-natural Scrub Woodland in the south to the *Lantana camara* Semi-natural Shrubland [Provisional] in the north of the peninsula.

Finally, two additional associations are also confused with other associations and occur primarily in areas below the MMU: *Pandanus tectorius* Coastal Mesic Forest and *Agave sisalana* Semi-natural Shrubland [Park Special]. However, because of their ecological or cultural importance, the locations of these associations were retained on the map if the locations had been field verified during classification plot collection, AA site collection, and/or calibration or validation trips. The locations of these two associations on the map are field verified. However, there may be many other locations of these associations at KALA which are not on the map.

Several map classes were also added to make the map a comprehensive depiction of the entire KALA landscape: Built-up and Commercial Services, Built-up Residential, Built-up Transportation, Communications, and Utilities, Unvegetated, Water, Helicopter Landing Zone, and *Schinus terebinthifolius* / *Lantana camara* Mosaic Woodland. Appendix H contains the Map Class descriptions for KALA.

Table 10. Association and map class names and hectares for the vegetation of KALA. Green text indicates that the association was eliminated, collapsed with other associations into a map class, or mapped only where field verified.

Association Name	Map Class Name	Map Hectares	No. of Class.Plots
Forests and Woodlands			
<i>Erythrina sandwicensis</i> Lowland Dry Woodland	<i>Erythrina sandwicensis</i> Lowland Dry Woodland	0.98	0
<i>Thespesia populnea</i> / Sparse Understory Woodland	<i>Thespesia populnea</i> / Sparse Understory Woodland	1.74	0
<i>Prosopis pallida</i> Coastal Dry Semi-natural Woodland	<i>Prosopis pallida</i> Coastal Dry Semi-natural Woodland	3.40	1
<i>Cocos nucifera</i> Strand Woodland	<i>Cocos nucifera</i> Strand Woodland	0.09	0
<i>Diospyros sandwicensis</i> - (<i>Psidium</i> spp.) Lowland Mesic Woodland	<i>Diospyros sandwicensis</i> - (<i>Psidium</i> spp.) Lowland Mesic Woodland and <i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest collapsed to <i>Diospyros sandwicensis</i> Lowland Mesic Woodland map class.	426.05	2
<i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest			3
<i>Pandanus tectorius</i> Coastal Mesic Forest	Rare but culturally significant association. Mapped only where field verified.	2.55	2
<i>Pritchardia hillebrandii</i> Coastal Mesic Forest	<i>Pritchardia hillebrandii</i> Coastal Mesic Forest	0.09	0
<i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland	<i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland	36.68	7
<i>Metrosideros waialealae</i> var. <i>fauriei</i> Woodland [Park Special]	Rare association. Does not occur on the map.		3
<i>Acacia confusa</i> - <i>Psidium guajava</i> Semi-natural Forest [Park Special]	<i>Acacia confusa</i> - <i>Psidium guajava</i> Semi-natural Forest [Park Special]	13.14	1

Table 10 (continued). Association and map class names and hectares for the vegetation of KALA. Green text indicates that the association was eliminated, collapsed with other associations into a map class, or mapped only where field verified.

Association Name	Map Class Name	Map Hectares	No. of Class.Plots
<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	35.20	5
<i>Coffea arabica</i> Semi-natural Forest [Park Special]	Rare association. Does not occur on the map.		1
<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation	<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation and <i>Eucalyptus</i> spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional] associations collapsed into <i>Eucalyptus</i> spp. - Mixed Forest map class.	8.02	6
<i>Eucalyptus</i> spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional]			2
<i>Grevillea robusta</i> Lowland Mesic Semi-natural Forest	Does not occur at KALA. Sole classification plot was outside of the park boundary.		1
<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Park Special]	<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Park Special]	14.28	1
<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	201.73	7
<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	116.04	4
<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	889.87	14
None	<i>Schinus terebinthifolius</i> / <i>Lantana camara</i> Mosaic Woodland	46.28	0
<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	313.08	11
<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	4.65	2
<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	6.12	1
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest	<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest merged with <i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland to become <i>Metrosideros polymorpha</i> Montane Wet	476.48	11
<i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland			5
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> ssp. <i>trigynum</i> / <i>Diplopterygium pinnatum</i> Montane Wet Forest [Park Special]	Rare association. Does not occur on the map.		1
<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	15.95	1
<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	255.31	2

Table 10 (continued). Association and map class names and hectares for the vegetation of KALA. Green text indicates that the association was eliminated, collapsed with other associations into a map class, or mapped only where field verified.

Association Name	Map Class Name	Map Hectares	No. of Class.Plots
<i>Metrosideros polymorpha</i> - <i>Ilex anomala</i> - <i>Myrsine lessertiana</i> Woodland	Rare association. Does not occur on the map.		1
<i>Aleurites moluccana</i> Lowland Wet Forest	<i>Aleurites moluccana</i> Lowland Wet Forest	73.33	3
<i>Coprosma foliosa</i> - <i>Perrottetia sandwicensis</i> - <i>Cibotium</i> spp. Riparian Woodland [Park Special]	Does not occur at KALA. Sole classification plot was outside of the park boundary.		1
<i>Hibiscus tiliaceus</i> Lowland Wet Forest [Provisional]	<i>Hibiscus tiliaceus</i> Lowland Wet Forest [Provisional]	5.17	1
<i>Metrosideros polymorpha</i> / <i>Dicranopteris</i> spp. / <i>Lycopodiella cernua</i> Montane Wet Bog Scrub Woodland [Provisional]	Rare association. Does not occur on the map.		1
Mixed Forest Plantation [Park Special]	Mixed Forest Plantation [Park Special]	2.95	5
Shrublands			
<i>Euphorbia celastroides</i> Coastal Dry Dwarf-Shrubland ³	<i>Euphorbia celastroides</i> Coastal Dry Dwarf-Shrubland	1.07	0
<i>Scaevola taccada</i> Coastal Dry Shrubland ¹	<i>Scaevola taccada</i> Coastal Dry Shrubland	12.11	3
<i>Sida fallax</i> Coastal Dry Shrubland	<i>Sida fallax</i> Coastal Dry Shrubland	9.30	1
<i>Wikstroemia uva-ursi</i> - <i>Sida fallax</i> Coastal Shrubland	<i>Wikstroemia uva-ursi</i> - <i>Sida fallax</i> Shrubland and <i>Wikstroemia uva-ursi</i> / <i>Fimbristylis cymosa</i> Mixed Grass Coastal Shrubland [Park Special] combined into <i>Wikstroemia uva-ursi</i> Coastal Shrubland.	56.56	2
<i>Wikstroemia uva-ursi</i> / <i>Fimbristylis cymosa</i> Mixed Grass Coastal Shrubland [Park Special]			1
<i>Agave sisalana</i> Semi-natural Shrubland [Park Special]	Rare but ecologically significant association. Mapped only where field verified.	1.79	1
<i>Heliotropium amplexicaule</i> Semi-natural Shrubland [Park Special]	<i>Heliotropium amplexicaule</i> Semi-natural Shrubland [Park Special]	0.30	0
<i>Lantana camara</i> Semi-natural Shrubland [Provisional]	<i>Lantana camara</i> Semi-natural Shrubland [Provisional]	145.81	4
<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	28.35	1
<i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	<i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	11.84	2
Herbaceous Vegetation			
<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	29.51	1
<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	1.04	1
<i>Dicranopteris linearis</i> Wet Herbaceous Mat	Does not occur in polygons larger than the MMU. Does not occur on the map.		1

Table 10 (continued). Association and map class names and hectares for the vegetation of KALA. Green text indicates that the association was eliminated, collapsed with other associations into a map class, or mapped only where field verified.

Association Name	Map Class Name	Map Hectares	No. of Class.Plots
<i>Cyclosorus dentatus</i> - <i>Hedychium coronarium</i> - <i>Coix lacryma-jobi</i> Semi-natural Herbaceous Vegetation [Park Special] ²	<i>Cyclosorus dentatus</i> - <i>Hedychium coronarium</i> - <i>Coix lacryma-jobi</i> Semi-natural Herbaceous Vegetation [Park Special]	0.2	1
<i>Cynodon dactylon</i> - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	<i>Cynodon dactylon</i> - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	32.23	3
<i>Melinis minutiflora</i> - (<i>Schizachyrium condensatum</i>) Semi-natural Herbaceous Vegetation	<i>Melinis minutiflora</i> - (<i>Schizachyrium condensatum</i>) Semi-natural Herbaceous Vegetation	73.14	2
<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	23.29	3
Other Map Classes			
None	Built-up Commercial and Services	10.10	0
None	Built-up Residential	21.91	0
None	Built-up Transportation, Communications, and Utilities	20.59	0
None	Helicopter Landing Zone	0.51	0
None	Water	777.45	0
None	Unvegetated	101.73	0

¹USNVC name *Scaevola sericea* modified to *Scaevola taccada* based on taxonomy of Wagner et al. (2012).

²USNVC name *Christella dentata* modified to *Cyclosorus dentatus* based on taxonomy of Wagner et al. (2012).

³USNVC name *Chamaesyce celastroides* modified to *Euphorbia celastroides* based on taxonomy of Wagner et al. (2012).

Figure 18 shows the final KALA vegetation map. The largest class by far is the invasive *Schinus terebinthifolius* Semi-natural Scrub Woodland (with 24% of the park's land base), followed by native dominated *Metrosideros polymorpha* Montane Wet Forest (13%), and *Diospyros sandwicensis* Lowland Mesic Woodlands (12%).

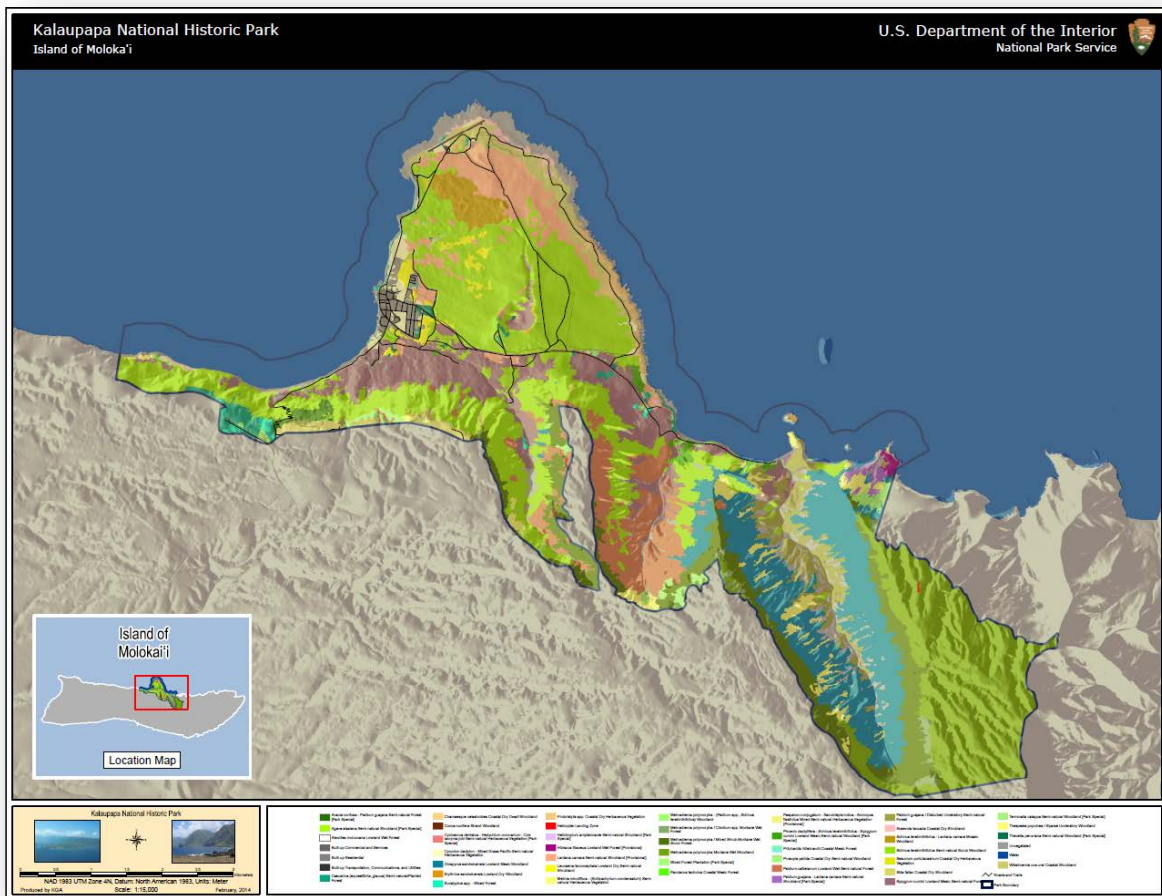


Figure 18. Final vegetation map of KALA.

Figure 19 shows the percentage of KALA's land which is comprised of forests, shrubs, herbaceous, and built up types. Map classes of introduced forest species dominate over 48% of KALA's forestland and 40% of the park. Besides *Schinus terebinthifolius* Semi-natural Scrub Woodland (with 30% of the park's forest), other important invasive forest types include *Syzygium cumini* Lowland Mesic Semi-natural Forest, *Psidium cattleianum* Lowland Wet Semi-natural Forest, and *Psidium guajava* / Disturbed Understory Semi-natural Forest, which respectively occupy 11%, 7%, and 4% of KALA's forests. However, KALA's cliff tops and uplands support large expanses of native forestlands. The four *Metrosideros* map classes comprise 28% of the park's land base and 27% of its forests, and the *Diospyros sandwicensis* Lowland Mesic Woodland makes up 14% of the KALA's forestland.

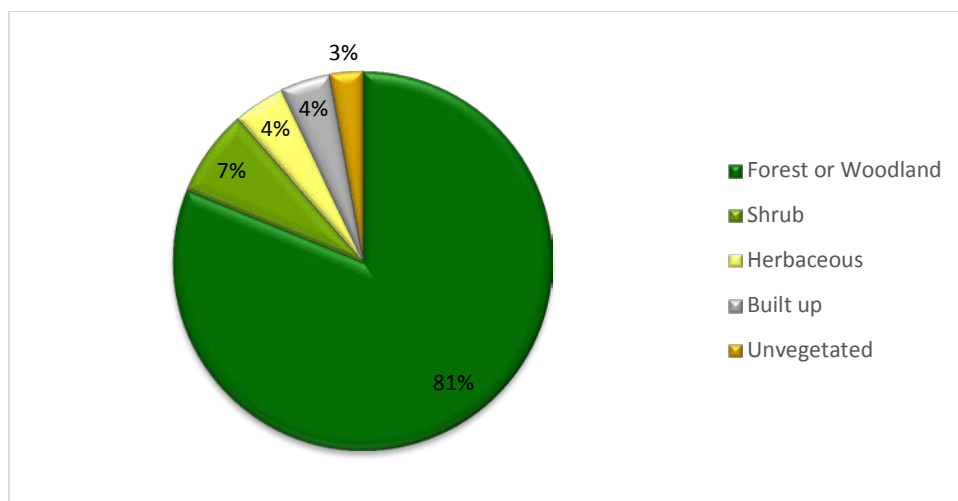


Figure 19. Percentage of KALA vegetation by lifeform.

The largest shrubland class in KALA is the introduced *Lantana camara* Semi-natural Shrubland, which comprises 4% of the park's land base and 54% of its shrublands. Shrublands within the coastal spray zone of the northeast and central east portions of the peninsula are represented primarily by map classes comprised of native species such as *Scaevola taccada*, *Sida fallax* and, *Wikstroemia uva-ursi*.

Similar to other lifeforms, KALA's herbaceous lands are also dominated by invasive species with *Melinis minutiflora* - (*Schizachyrium condensatum*) Semi-natural Herbaceous Vegetation occupying 46% and *Cynodon dactylon* - Mixed Grass Pacific Semi-natural Herbaceous Vegetation occupying 20% of the park's herbaceous lands. However, the southeast coastal spray zone of the peninsula supports a large and fairly contiguous area of the native *Fimbristylis* spp. Coastal Dry Herbaceous Vegetation which comprises 19% of the park's herbaceous land base.

As Figure 20 illustrates, invasive, non-native species have greatly altered the vegetation at KALA with almost half of the park's land base comprised of map classes dominated by species introduced by either the Polynesians or later by Europeans or Americans. Over half of the plant associations identified at KALA are dominated by non-native plant species and are classified as semi-natural or plantations (conversion). In addition, some degraded native plant communities may be co-dominated by non-native species such as *Metrosideros polymorpha* - (*Psidium* spp., *Schinus terebinthifolius*) Woodland. Although formerly a native plant community, this community has been so altered and degraded by non-native species that the former community cannot be determined and the current floristic composition represents a long-lived, widespread novel plant community.

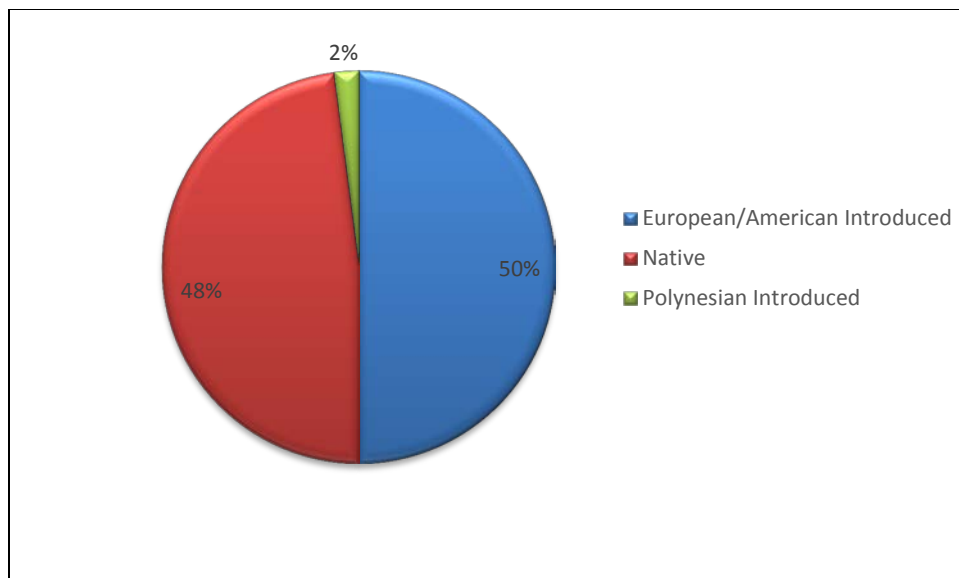


Figure 20. Area of introduced verses native associations at KALA.

Accuracy Assessment

Following creation of the mapping model, AA analysis was performed at the map model level. Figure 21 shows the confusion matrix of the 30 map classes assessed for accuracy. Of the 241 sites, 201 (84%) had matching map and reference labels on the primary label, and 88% matched on the primary labels plus the secondary labels. When weighted for map class area, overall accuracy is 82%. A 90% confidence interval on area weighted overall accuracy ranges from 75% to 89%. The Kappa statistic (Congalton and Green 2009) is 81% with a 90% confidence interval of 77% to 85%.

Table 11 summarizes the producer's and user's accuracies of the draft map. Nine map classes have 100% producer's and user's accuracies, and with the average of user's and producer's accuracies above 80% in 20 classes. Classes occupying large areas of the park (e.g. *Schinus terebinthifolius* Semi-natural Scrub Woodland, *Psidium guajava* / Disturbed Understory Semi-natural Forest, *Metrosideros polymorpha* Montane Wet Forest, *Syzygium cumini* Lowland Mesic Semi-natural Forest, *Diospyros sandwicensis* Lowland Mesic Woodland and *Lantana camara* Semi-natural Shrubland) have high accuracies, with the low accuracies falling to rare classes such as *Agave sisalana* Semi-natural Shrubland and *Pandanus tectorius* Coastal Mesic Forest. As a result, these rare classes were edited to occur on the final map only where field verified and, therefore, have no commission errors. However, they may exist at other locations in the park which were not visited in the field, resulting in omission errors.

Most of the errors on the Draft Map were geographically focused and systematic which made them relatively straight-forward to correct during Final Map editing¹. An example of a geographically focused error was the commission of four geographically correlated samples of *Psidium cattleianum* Lowland Wet Semi-natural Forest to *Syzygium cumini* Lowland Mesic Semi-natural Forest at the mouth of the Wai'ale'ia Valley. This area was edited in the Final Map to reflect the AA reference labels (Figure 22).

Finally, the coastal spray native shrub and herbaceous classes (*Fimbristylis* spp. Coastal Dry Herbaceous Vegetation, *Sida fallax* Coastal Dry Shrubland, and *Wikstroemia uva-ursi* Coastal Shrubland) have medium to low accuracies, but they are, in all but one case, only confused with one another. This is not surprising, considering the high variance and heterogeneity of their composition and occurrence at KALA.

¹ All errors discovered during accuracy assessment and final map review were edited to create the Final Map. However, the accuracy assessment samples cannot be used to assess the Final Map as the samples are no longer independent of the map because they were used to edit the map. The Final Map has been corrected for known Draft Map errors and its overall accuracy is at least 84% which is the overall accuracy of the Draft Map.

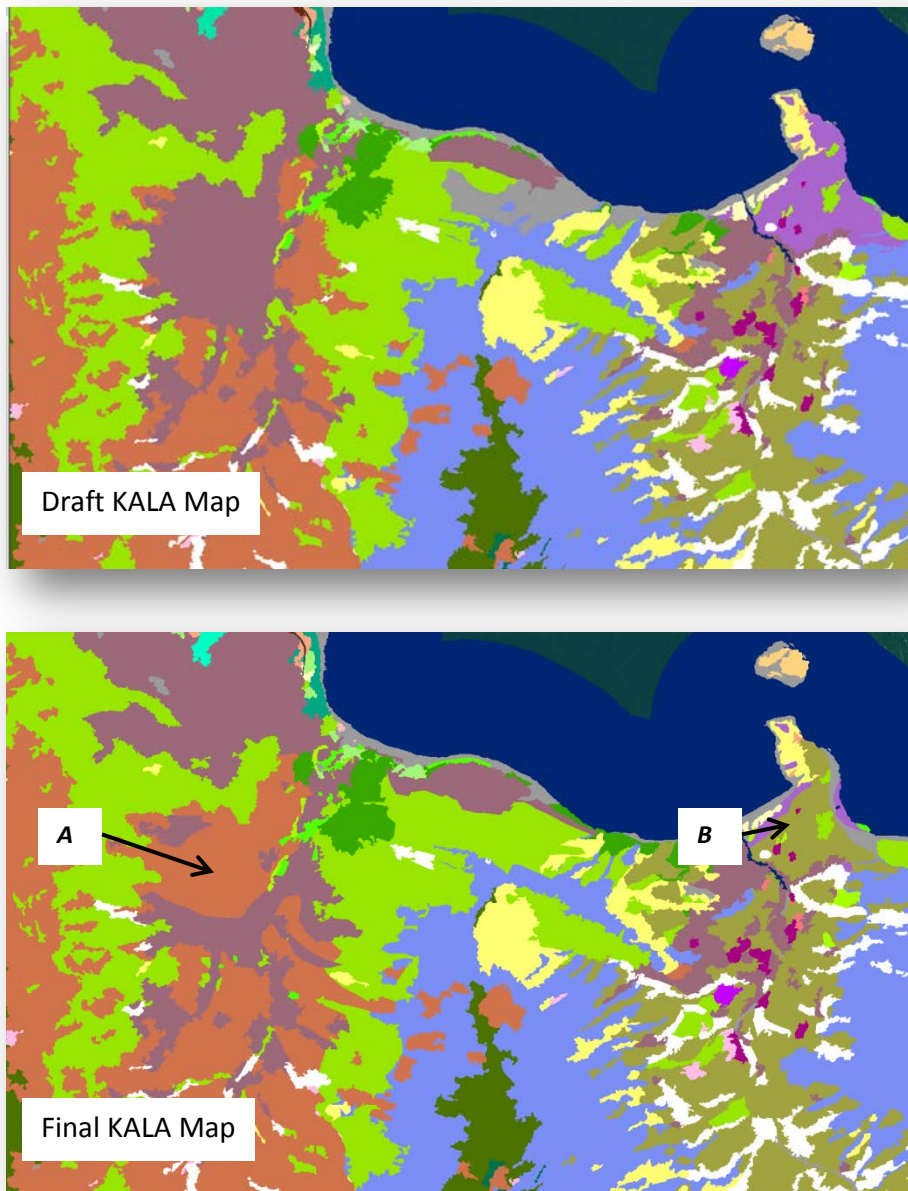


Figure 22. Example of the impact of final editing as a result of incorporating information gained from accuracy assessment into the Final Map. Area A shows the change from *Syzygium cumini* Lowland Mesic Semi-natural Forest to *Psidium cattleianum* Lowland Wet Semi-natural Forest at the mouth of the Wai'ale'ia Valley. Area B shows a change from *Psidium guajava* - *Lantana camara* Semi-natural Shrubland to *Psidium guajava* / Disturbed Understory Semi-natural Forest.

Table 11. User's and producer's accuracies and sample numbers per map class.

Map Class	User's Accuracy	Producer's Accuracy	Number of AA Samples by Reference Label
Helicopter Landing Zone	100%	100%	1
<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	100%	100%	4
Mixed Forest Plantation [Park Special]	100%	100%	1
<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	100%	100%	4
<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Provisional]	100%	100%	4
<i>Schinus terebinthifolius</i> / <i>Lantana camara</i> Mosaic Woodland	100%	100%	2
<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	100%	100%	1
<i>Thespesia populnea</i> / Sparse Understory Woodland	100%	100%	3
<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	100%	100%	2
<i>Aleurites moluccana</i> Lowland Wet Forest	95%	100%	20
<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	90%	95%	21
<i>Cynodon dactylon</i> - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	83%	100%	6
<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	83%	100%	23
<i>Metrosideros polymorpha</i> Montane Wet Forest	86%	91%	38
<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	95%	82%	19
<i>Diospyros sandwicensis</i> Lowland Mesic Woodland	88%	88%	7
<i>Lantana camara</i> Semi-natural Shrubland [Provisional]	94%	77%	19
<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	100%	67%	4
<i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	100%	67%	2
<i>Eucalyptus</i> spp. – Mixed Forest	67%	100%	6

Table 11 (continued). User's and producer's accuracies and sample numbers per map class.

Map Class	User's Accuracy	Producer's Accuracy	Number of AA Samples by Reference Label
<i>Scaevola taccada</i> Coastal Dry Shrubland	100%	67%	4
<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	77%	81%	21
<i>Acacia confusa</i> - (<i>Psidium guajava</i>) Semi-natural Forest [Park Special]	100%	50%	1
<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	100%	50%	1
<i>Wikstroemia uva-ursi</i> Coastal Shrubland	67%	44%	4
<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	67%	80%	6
<i>Sida fallax</i> Coastal Dry Shrubland	29%	100%	5
<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	33%	33%	1
<i>Agave sisalana</i> Semi-natural Shrubland (Park Special)	0%	0%	1
<i>Pandanus tectorius</i> Coastal Mesic Forest	0%	0%	1

Vegetation Distribution

The landscape of Kalaupapa National Historical Park is highly diverse and greatly influenced by terrain, non-native vegetation, and human settlements and cultivation. Plant communities at KALA can be described as belonging to 3 elevational zones: coastal, lowland, and montane. Within each of these zones there are three possible moisture regimes: dry, mesic, and wet. Dry sites are limited as this park is located on the wet, windward side of Moloka'i. This section of the report summarizes the vegetative cover of the park by zone, moisture regime and region.

In general, much of the lowland zones are dominated by non-native vegetation, with the less disturbed montane zones composed of vegetation types dominated or co-dominated by native trees. Exceptions to native dominance in the montane zone include the upper elevation semi-natural forests and forest plantations.



Figure 23. *Scaevola taccada* Coastal Dry Shrubland¹ on the northeast portion of the KALA peninsula.

The northeast and east coastal shelves of the peninsula are primarily dominated by native shrub or herbaceous vegetation including *Fimbristylis cymosa*, *Scaevola taccada*, *Sida fallax*, and *Wikstroemia uva-ursi*. The peninsula's eastern coastal spray zone includes a mixture of coastal shrubs with *Fimbristylis* spp. Coastal Dry Herbaceous Vegetation predominant in the southern portions, and *Wikstroemia uva-ursi* associations, *Scaevola taccada* and *Fimbristylis cymosa* Coastal Dry Shrublands in the northern areas (Figures 23 & 24). Much of the remaining coastal zones of the park are composed of non-native species such as the herbaceous species *Cynodon dactylon*, *Digitaria ciliaris*, *Ageratina adenophora*, shrubs *Lantana camara*, and trees such as *Psidium guajava*, *Phoenix dactylifera*, *Schinus terebinthifolius* or *Terminalia catappa* (Figures 25 & 26).



Figure 24. *Fimbristylis* spp. Coastal Dry Herbaceous Vegetation on the southeast portion of the KALA peninsula.



Figure 25. Mouth of Waikolu with non-native grassland *Cynodon dactylon* - Mixed Grass Pacific Semi-natural Herbaceous Vegetation along the coast surrounded by wind-dwarfed *Psidium guajava* - *Lantana camara* Semi-natural Shrubland [Park Special] on slopes.



Figure 26. Non-native *Phoenix dactylifera* - *Schinus terebinthifolius* - *Syzygium cumini* Lowland Mesic Semi-natural Woodland [Park Special] on steep slope above coast.

The central uplands of the Kalaupapa peninsula are characterized by dense stands of *Schinus terebinthifolius* Semi-natural Scrub Woodlands (Figure 27) and *Leucaena leucocephala* Lowland Dry Semi-natural Shrubland. *Lantana camara* Semi-natural Shrubland dominates the northeast portion of the uplands with a mosaic of *Lantana camara* and *Schinus terebinthifolius* between the central and north portions (Figure 28).

Kauhakō Crater and its outlet are heavily covered in *Syzygium cumini* Lowland Mesic Semi-natural Forests with isolated remnant stands of *Erythrina sandwicensis* Lowland Dry Woodland on the crater floor and rim. *Syzygium cumini* Lowland Mesic Semi-natural Forests also dominate the foot of the north facing cliffs, which transition with elevation gains into *Schinus terebinthifolius* Semi-natural Scrub Woodland covered cliff faces, etched with *Psidium cattleianum* Lowland Wet Semi-natural and *Aleurites moluccana* Lowland Wet Forest filled ravines as the cliffs rise sharply above the peninsula.



Figure 27. Looking east from below Kauhakō Crater at dense thickets of *Schinus terebinthifolius* Semi-natural Scrub Woodlands.



Figure 28. Looking north from Kauhakō Crater. Dense thickets of *Schinus terebinthifolius* Semi-natural Scrub Woodland transitioning to a mosaic of *Schinus terebinthifolius* and *Lantana camara* which then transitions into dense *Lantana camara* Semi-natural Shrubland just south of the lighthouse.

Eucalyptus spp. Mixed Forests, *Casuarina (equisetifolia, glauca)* Semi-natural/Planted Forests, and Mixed Forest Plantations occur where planted by humans, most notably in and around Pālā‘au State Park (Figure 29). *Casuarina (equisetifolia, glauca)* Semi-natural/Planted Forests also occur in isolated stands near the airport, at the crater, along the western coastal strand, in patches in the

settlement and along the coastal cliffs from St. Joseph's to the mouth of the Wai'ale'ia Valley. Strands of *Cocos nucifera* Strand Woodlands can be also be found near St. Joseph's and in Kalawao Park.



Figure 29. Non-native, *Eucalyptus* spp. – Mixed Forests growing in montane zone “topside” on Moloka'i.

Other higher elevation semi-natural forests and forest plantations are also common in and adjacent to the park. They are composed of *Acacia confusa*, *Eucalyptus robusta*, *Eucalyptus saligna*, or the Mixed Forest Plantation that includes planted forests dominated by *Melaleuca quinquenervia*, *Pinus radiata*, or *Syncarpia glomulifera*.

Each of the Park's valleys is uniquely vegetated. The northern portions of the Waihānau valley floor are forested in *Syzygium cumini* Lowland Mesic Semi-natural Forests with the southern portions of the valley floor forested primarily in *Aleurites moluccana* Lowland Wet Forest mixed with some stands of *Psidium guajava* / Disturbed Understory Semi-natural Forest. Several *Eucalyptus robusta* Semi-natural Forest/Plantation also dot the central valley floor. The valley cliffs are covered in *Schinus terebinthifolius* Semi-natural Scrub Woodlands with intermittent patches of *Psidium cattleianum* Lowland Wet Semi-natural Forest. Thin stringers of *Diospyros sandwicensis* associations occur on the north valley ridges of west facing cliffs. Waihānau cliff tops are forested with *Metrosideros polymorpha* / Mixed Shrub Montane Wet Scrubs mixed with *Psidium cattleianum* Lowland Wet Semi-natural Forests.

The northern portions of the Wai'ale'ia Valley floor are also forested in *Syzygium cumini* Lowland Mesic Semi-natural Forests, but the southern portions are dominated by *Psidium cattleianum* Lowland Wet Semi-natural Forest with stringers of *Aleurites moluccana* Lowland Wet Forest along

stream beds. The cliffs are draped in *Schinus terebinthifolius* Semi-natural Scrub Woodlands and *Psidium cattleianum* Lowland Wet Semi-natural Forest with *Diospyros sandwicensis* associations on the north valley ridges of west facing cliffs. The valley mouth supports compact stands of *Phoenix dactylifera* - *Schinus terebinthifolius* - *Syzygium cumini* Lowland Mesic Semi-natural, *Pandanus tectorius* Coastal Mesic, and *Terminalia catappa* Semi-natural forests and woodlands on both sides of the stream (Figure 30). The valley cliff tops sustain *Metrosideros polymorpha* / Mixed Shrub Montane Wet Scrubs and *Psidium cattleianum* Lowland Wet Semi-natural Forests.



Figure 30. Mouth of the Wa'ale'ia Valley with *Phoenix dactylifera* - *Schinus terebinthifolius* - *Syzygium cumini* Lowland Mesic Semi-natural Woodlands.

The Waikolu Valley floor is dominated by *Psidium guajava* / Disturbed Understory Semi-natural Forest with stringers of *Aleurites moluccana* Lowland Wet Forest along stream beds mixed with scattered thickets of *Hibiscus tiliaceus* Lowland Wet Forest. The east facing cliffs are striated with bands of *Diospyros sandwicensis* forest associations and *Melinis minutiflora* Semi-natural Herbaceous Vegetation accompanied by thin shelves of *Aleurites moluccana* Lowland Wet Forest in several stream beds. The cliffs are forested with *Diospyros sandwicensis* associations, and the cliff tops are covered by *Metrosideros polymorpha* / Mixed Shrub Montane Wet Scrub Forests (Figure 31). The floor of the valley mouth is wooded with *Syzygium cumini* Lowland Mesic Semi-natural and *Psidium guajava* / Disturbed Understory Semi-natural forests with a large area of *Psidium guajava* - *Lantana camara* Semi-natural Shrubland on the stream's eastern slope above where it enters the sea.



Figure 31. *Diospyros* striated cliffs of Waikolu Valley.

The Pu‘u Ali‘i NAR is overwhelmingly dominated by *Metrosideros polymorpha* Montane Wet Forests composed primarily of the *Metrosideros polymorpha* - *Cheirodendron trigynum*/ (*Cibotium* spp.) Montane Wet Forest association (Figure 32). Wind exposed *Metrosideros polymorpha* / Mixed Shrub Montane Wet Scrub on ridges often have a dwarfed or scrubby structure. Other native trees such as *Cibotium menziesii*, *Kadua axillaris*, *Ilex anomala*, *Melicope clusiifolia*, *Myrsine lessertiana*, *Psychotria Hawaiiensis*, or *Psychotria mauiensis* may be present. These upper elevation rainforests contain the most intact communities with rare species such as *Cyanea* spp. (Figure 33).

Finally the islet of Huelo supports a cap of one of the last remaining stands of *Pritchardia hillebrandii* Coastal Mesic Forest in the Hawaiian Islands and the threatened *Euphorbia celastroides* Coastal Dry Dwarf-shrubland.



Figure 32. Native *Metrosideros polymorpha* - *Cheirodendron trigynum* / (*Cibotium* spp.) Montane Wet Forest is common in the wet montane zone of KALA.



Figure 33. Diverse, native *Metrosideros polymorpha* / Mixed Shrub Montane Wet Scrub Forest growing on upper ridge of Waikolu Valley with *Cyanea* spp. present.

Discussion

This section of the report discusses the results and lessons learned from this project and is organized along the significant steps of the 12 Step Mapping Guidance Document (NPS 2013b).

Field Plot Data Collection

The 135 classification samples were well distributed throughout KALA, capturing the vast majority of variation in KALA's vegetation which is a testament to the KALA vegetation classification sample design and implementation. Unsourced vegetated classes discovered during calibration, validation, and AA field efforts and added to the KALA associations are *Cocos nucifera* Strand Woodland, *Erythrina sandwicensis* Lowland Dry Woodland, *Pritchardia hillebrandii* Coastal Mesic Forest, *Heliotropium amplexicaule* Semi-natural Shrubland [Park Special], *Euphorbia celastroides* Coastal Dry Dwarf-Shrubland¹, *Thespesia populnea* / Sparse Understory Woodland, and Helicopter Landing Zone. These additional associations are rare at KALA (in total occupying less than 1% of KALA's landbase), and often below the MMU.

However, two classification plots were located outside of the park, resulting in the creation of two vegetation associations which do not occur in the park (*Grevillea robusta* Lowland Mesic Semi-natural Forest and *Coprosma foliosa* - *Perrottetia sandwicensis* - *Cibotium* spp. Riparian Woodland [Park Special]). Additionally, three associations were found to occur frequently, but not above the map MMU at KALA.

Future efforts should look to KALA as an example of thorough vegetation classification sampling, but should also be careful to sample only within park boundaries as human impacted vegetative conditions outside of parks can be drastically different than those found within park boundaries. NPS vegetation classification sampling procedures should include consideration of the plots relative to their surroundings and the NPS MMU of 0.5 ha so as to minimize the creation of vegetation associations which exist only below the MMU.

Vegetation Classification

Fifty one vegetation associations were created for KALA. Of these more than half (26) were represented by only one or two classification plots. However, of those 26 low sampled associations, 19 were encountered multiple times during the calibration, validation and AA field work, which showcases both the sample design and NatureServe's ability to use ordination analysis to tease significant vegetation distinctions out of small sample sets. Three of these low sampled associations were *Metrosideros* associations (*Metrosideros polymorpha* - *Cheirodendron trigynum* ssp. *trigynum* / *Diplopterygium pinnatum* Montane Wet Forest [Park Special], *Metrosideros polymorpha* - *Ilex anomala* - *Myrsine lessertiana* Woodland, and *Metrosideros polymorpha* / *Dicranopteris* spp. / *Lycopodiella cernua* Montane Wet Bog Scrub Woodland [Provisional]) which were not encountered again (and do not occur on the map), which suggests that the distinctions were perhaps too fine in the *Metrosideros* forest types.

Ten associations at KALA are ranked by NatureServe and Natural Heritage Programs as globally imperiled (Table 12). The primary criterion for ranking elements is the number of known distinct

localities or populations. Also of importance are the size of the geographic range, the number of individuals, the trends in both population and distribution, identifiable threats, and the number of protected occurrences. These global ranks for Hawaiian vegetation associations have not been updated based on new information from KALA or the other NPS VIP projects in Hawaii, but these ten associations likely have not become more secure since these rankings. The critically imperiled *Pritchardia hillebrandii* Coastal Mesic Forest on Huelo Islet was not visited by vegetation crews from this project, but is known from other research (Wood 2001, 2008).

Table 12. List of G1-G3 Global Ranks for Associations at KALA.

Association Name	ELCODE	Global Rank
<i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest	CEGL008026	G3
<i>Erythrina sandwicensis</i> Lowland Dry Woodland	CEGL008036	G3
<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	CEGL008089	G3
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest	CEGL008008	G3
<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	CEGL008009	G3
<i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland	CEGL008041	G3
<i>Pandanus tectorius</i> Coastal Mesic Forest	CEGL008032	G3
<i>Pritchardia hillebrandii</i> Coastal Mesic Forest	CEGL008033	G1
<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	CEGL008098	G3
<i>Sida fallax</i> Coastal Dry Shrubland	CEGL008055	G3

The Heritage Conservation Status Global Rank which best characterizes the relative rarity or endangerment of the Association worldwide. Values for Global Rank are:

G1 = Critically imperiled globally = Generally 5 or fewer occurrences and/or very few remaining acres or very vulnerable to elimination throughout its range due to other factor(s)

G2 = Imperiled globally = Generally 6-20 occurrences and/or few remaining acres or very vulnerable to elimination throughout its range due to other factor(s)

G3 = Rare or uncommon = Generally 21-100 occurrences; either very rare and local throughout its range or found locally, even abundantly, within a restricted range or vulnerable to elimination throughout its range due to specific factor(s)

G4 = Widespread, abundant, and apparently secure, but with cause for long-term concern = Uncommon but not rare (although it may be quite rare in parts of its range, especially at the periphery); apparently not vulnerable in most of its range

G5 = Demonstrably widespread, abundant and secure = Common, widespread, and abundant (although it may be quite rare in parts of its range, especially at the periphery); not vulnerable in most of its range

Acquire and Prepare Imagery

The Digital Globe satellite imagery used in this project was acquired by USDA's NRCS-National Geospatial Center of Excellence, who worked with Digital Globe to acquire cloud free ortho imagery over the Hawaiian Islands for use by multiple government agencies. The spectral quality and spatial accuracy of the imagery is exceptional. However, its use should be cautioned by the following:

- The imagery products used to make the KALA vegetation map are mosaics of cloud free imagery captured over multiple dates. While cloud free, mosaic lines and sun angle shifts are apparent within the mosaicked products.
- While the spatial accuracy of the imagery meets government requirements, the steep terrain of KALA results in some registration issues and pixel shifts are noticeable between the Quickbird and Worldview2 imagery of KALA, especially along the northeast shoreline of the park.

Imagery Analysis and Classification

Image segmentation, CART analysis, and manual image interpretation were used to classify the imagery. This combination of methods was successful as shown by the overall and per class map accuracies. However, more manual editing was required than anticipated for the following reasons:

- eCognition image segmentation software is not particularly effective at delineating long linear landscape features. Therefore, these features required manual delineation, especially in the Waikolu Valley where there are long strips of *Diospyros sandwicensis* Lowland Mesic Woodland intermixed with long strips of *Melinis minutiflora* - (*Schizachyrium condensatum*) Semi-natural Herbaceous Vegetation.
- The steep slopes of KALA remained deeply shadowed in all image sets available to the project. These heavily shadowed areas required field identification and manual mapping.
- CART methods are most cost effective in large mapping projects where the economies of scale can be readily captured. KALA is a highly diverse, smaller park and each of its 44 map classes required some manual editing no matter how small the area of the class.

Considering these results, it is questionable if CART is cost effective for diverse, smaller national parks of 6050 ha (15,000 ac) or less.

Accuracy Assessment

The KALA vegetation map overall accuracy is 84%, which is high considering the detail of the map (e.g. 45 map classes of which 38 are vegetated classes). However, users need to move beyond the overall and class accuracy percentages and fully understand the error matrix to be aware of which classes are likely to be confused with one another and which are not. For example, from the error matrix the user can learn that within the coastal spray zone, the *Sida fallax* Coastal Dry Shrubland, *Fimbristylis* spp. Coastal Dry Herbaceous Vegetation and *Wikstroemia uva-ursi* Coastal Shrubland are likely to be confused with one another, whereas all three classes are unlikely to be confused with *Scaevola taccada* Coastal Dry Shrubland. The error matrix also shows the number of accuracy samples collected per map class. Producer's and user's accuracies of classes with low sample sizes

have low statistical confidence and those with high sample sizes will have higher statistical confidence.

Some of the most significant changes between the draft and the final map were the result of collapsing some associations into map classes (see below Map Model section) and manual editing of the map to incorporate learnings from the AA field work. While this final editing does not affect the accuracy analysis of the map, it does improve the map appreciably. The AA samples are expensive and valuable field data which should be incorporated into the final map, including adding to the field verified locations of *Pandanus tectorius* Coastal Mesic Forest and *Agave sisalana* Semi-natural Shrubland [Park Special].

Several areas of KALA were inaccessible for all vegetation inventory field efforts (i.e. classification plots, calibration, validation and accuracy assessment samples). The inaccessible areas include the islets of Huelo and Ōkala, the park's steep cliffs, and Kukaiwa'a Point. The vegetation of some of these areas (such as Huelo islet) is well documented (Wood, 2001 & 2008). Others (such as the cliffs of Waikolu and Wai'ale'ia valleys) were viewed through binoculars from both the valley floor and the valley rims during the calibration and validation trip to determine their vegetation associations. Other areas, such as Kukaiwa'a Point and the upper reaches of Waihanau Valley above the falls, were completely inaccessible and were mapped based solely on image interpretation, earlier vegetation reports (e.g. Funk 1991) and KALA staff knowledge. If access is gained to these areas for other NPS projects in the future, information should be collected on the distribution of vegetation, and the map should be updated as appropriate.

Map Model

The map model (i.e. map classes) were determined following AA, rather than prior to image classification which had several advantages:

- Associations were collapsed into map classes only where AA showed the associations to be confused, removing guess work from the Map Model step.
- Determining the map classes following AA on the association level draft map also allowed for more associations to be retained in the final map.
- The map classes were informed by data collected on AA samples in areas such as the Pu'u Ali'i NAR which were inaccessible to the mapping crews.

As a recommendation, the NPS could consider formally moving the map model step from step 6 to between steps 11 and 12 in the 12 Step Guidance. However, this approach requires that the USNVC associations adequately represent the vegetation present and it also probably requires a more expensive AA sampling effort, because the assessment is performed at the association rather than the map class level.

Research Opportunities

Having an accurate and current vegetation classification and map presents many new and exciting research opportunities. The locational information for specific species in the modifiers attribute field can be used to target particular management needs and also can be bolstered to include more species or increase the number of known individuals. Research could include expanding or linking the GIS layer to derive other information including fire models, habitat monitoring locations, guides for rare plant surveys, wildlife habitat structural analyses, and inventorying areas that are likely vectors for invasive species. The map could also be enhanced by overlaying other existing GIS layers including geology, hydrology, elevation, and soils. In this manner complex interactions between these layers could be examined and yield important information about growth rates, regeneration after disturbance, biomass distribution, and stream morphology. Finally, through innovative analyses the vegetation layer could possibly be used as a springboard for other ecological studies including examining how the vegetation interacts with soil chemistry, pollution, paleontological/archeological sites, weather patterns, etc.

Literature Cited

- Breiman, L., J.H. Friedman, R.A. Olsen, and C.J. Stone. 1983. *Classification and Regression Trees*. Chapman & Hall. International Thomson Publishing. 358pp.
- Canfield, J.E. 1990. *Description and Map of the Plant communities of the Northeast Coastal Spray Zone of Kalaupapa National Historical Park*. Cooperative National Park Resources Studies Unit Technical Report No. 71. University of Hawaii at Manoa, Honolulu, Hawaii.
- Cogan, D. 2007. *Vegetation Classification and Mapping Recommendations*. Pacific Island Inventory and Monitoring Network. Pacific Island Inventory and Monitoring Network. Unpublished Report. 76 pp. 172 pp.
- Cogan, D., and G. Kudray. 2009. *Vegetation Classification and Inventory WorkPlan*. Pacific Island Inventory and Monitoring Network. Pacific Island Inventory and Monitoring Network Unpublished Report.
- Congalton, R., and K. Green. 2009. *Assessing the Accuracy of Remotely Sensed Data – Principles and Practices*. 2009. CRC Press. Taylor and Francis Group. 183pp.
- FGDC. 2008. *National Vegetation Classification Standard, Version 2 FGDC-STD-005-2008 (version 2)*. Vegetation Subcommittee, Federal Geographic Data Committee, FGDC Secretariat, U.S. Geological Survey. Reston, Virginia, USA. 55p (+ Appendices).
- Fung Associates, Inc. and SWCA Environmental Consultants. 2010. *Assessment of Natural resources and Watershed Conditions for Kalaupapa National Historical Park*. Natural Resource Report NPS/NPRC/WRD/NRR-210/XXX. National Park Service, Fort Collins, Colorado.
http://www.nature.nps.gov/water/nrca/assets/docs/kala_coastal.pdf
- Funk, E.J. 1991 *Vegetation Map of Kalaupapa National Historical Park, Molokaʻi, Hawaii*. Unpublished Technical Report. Cooperative National Park Resources Studies. University of Hawaii at Manoa. Honolulu, Hawaii. 7pp.
- Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P.S. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. *International Classification of Ecological Communities: terrestrial Vegetation of the United States. Volume I. The national vegetation classification system: development, status, and applications*. The Nature Conservancy, Arlington, Virginia, USA.
- Jacobi, J.D. 1989. *Vegetation maps of the upland plant communities on the islands of Hawaiʻi, Maui, Molokaʻi, and Lanaʻi*. Honolulu, HI: Cooperative National Park Resources Studies Unite Technical Report 68. University of Hawaii at Manoa, Honolulu, Hawaii.
- Jennings, M.D., Faber-Langendoen, D., Loucks, O.L., Peet, R.K., Roberts, D. 2009. *Standards for associations and alliances of the U.S. National Vegetation Classification*. *Ecological Monographs*, 79(2): 173-199.

- Kartesz, J.T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First edition. In: Kartesz, JT and CA Meacham. Synthesis of the North American flora [computer program]. Version 1.0. North Carolina Botanical Garden: Chapel Hill, NC.
- Kelley, D.E. 2000. Historical Collections of the Hawaiian Islands: “Keepers of the Culture”. A study in time of the Hawaiian Islands, Moloka‘i, Kalaupapa, Kalawao County – Part 1. Available at: <http://files.usgwarchives.net/hi/keepers/koc8.txt>. (accessed December 2013).
- McCune, B. and M. J. Mefford. 1999. PC-ORD. Multivariate Analysis of Ecological Data. Version 5.0. MjM Software, Gleneden Beach, Oregon, U.S.A.
- Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York, New York, USA.
- National Park Service. 1994. Final Draft Accuracy Assessment Procedures. USGS/NPS Vegetation Mapping Program. esri, Redlands, CA; National Center for Geographic Information and Analysis, Santa Barbara, CA; The Nature Conservancy, Arlington Virginia.
- National Park Service. 2013a. IM Program Brief. Available at: http://science.nature.nps.gov/im/assets/docs/IM_Program_Brief.pdf (accessed July 2013).
- National Park Service. 2013b. 12-Step Guidance for NPS Vegetation Inventories. Available at: http://science.nature.nps.gov/im/inventory/veg/docs/Veg_Inv_12step_Guidance_v1.1.pdf (accessed July 2013).
- National Park Service. 2013c. Inventory Brief: Vegetation Inventory. Available at: <http://science.nature.nps.gov/im/inventory/FactSheets/InventoryFactSheets.pdf>. (accessed July 2013) .
- National Park Service. 2013d. Focus on Pacific Island National Parks. Available at: <http://science.nature.nps.gov/im/units/pacn/parks/index.cfm#map> (accessed July 2013).
- National Park Service. 2013e. A Brief History of Kalaupapa. Available at: <http://www.nps.gov/kala/historyculture/a-brief-history-of-kalaupapa.htm>. (accessed December 2013).
- National Park Service. 2013f. Inventory & Monitoring, Pacific Island Network. Available at: <http://science.nature.nps.gov/im/units/pacn/>. (accessed July 2013).
- National Oceanic and Atmospheric Administration. 2005. 2005 Hawai‘i Moloka‘i High Res Land Cover. NOAA Coastal Services Center. Available at: <http://www.csc.noaa.gov/digitalcoast/dataregistry/#/ccaphighres>. (accessed September 2013).
- Palmer D. 2003. Hawaii’s ferns and fern allies. University of Hawaii Press, Honolulu, Hawaii.

- RuleQuest. 2013. See5/C5.0 2.10. Available at: <http://www.rulequest.com/see5-info.html>. (accessed July 2013).
- Spurr, S. 1948. Photogrammetry and Photo-Interpretation. The Ronald Press Company. New York. New York. 472pp
- Tart, D., C. Williams, J. DiBenedetto, E. Crowe, M. Girard, H. Gordon, K. Sleavin, M. Manning, J. Haglund, B. Short and D. Wheeler. 2005. Section 2: Existing Vegetation Classification Protocol. In: Brohman, R. and L. Bryant eds. Existing Vegetation Classification and Mapping Technical Guide. Gen. Tech. Rep. WO-67. Washington, DC: U.S. Department of Agriculture Forest Service, Ecosystem Management Coordination Staff.
- The Nature Conservancy and ESRI. 1994a. NBS/NPS Vegetation Mapping Program: Standardized National Vegetation Classification System. Arlington, VA.
- The Nature Conservancy and ESRI. 1994b. Field Methods for Vegetation Mapping. USGS/NPS Vegetation Mapping Program. United States Department of the Interior: United States Geological Survey and National Park Service. Available at: <http://www1.usgs.gov/vip/standards/fieldmethods/rpt.p>
- Trimble. 2013. eCognition. Available at: <http://www.ecognition.com/>. (accessed December 2013).
- Wagner, W. L., D. R. Herbst, N. Kahn, and T. Flynn. 2012. Hawaiian vascular plant updates: A supplement to the *Manual of the flowering plants of Hawaii* and *Hawaii's ferns and fern allies*. University of Hawaii Press and Bishop Museum Press, Honolulu. 126 pp. Available at: <http://botany.si.edu/pacificislandbiodiversity/hawaiianflora> (accessed 12 July 2012)
- Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. Manual of the flowering plants of Hawai'i. Revised edition. Volumes 1 and 2. University of Hawaii Press and Bishop Museum Press, Honolulu. 1919 pp.
- Wood, K.R. 2001. *Pritchardia* Coastal Forest on Huelo Islet, Moloka'i, Hawaii. Biological Report Prepared for Kalaupapa National Historic Park. 16pp.
- Wood, K.R. 2008. Vegetation Descriptions of the Offshore Islets, Kalaupapa, Moloka'i, Hawaii and Kūka'iwa'a Peninsula. Special Report Prepared for Kalaupapa National Historic Historical Park.
- Wood, K.R. and G.O. Hughes. 2003. Regional Checklist of Vascular Plants, Pu'u Ali'i Natural Area Reserve, Moloka'i, Hawaii.
- Wysong, M.I., G. Hughes, and K. Kozar. 2008. Kalaupapa National Historical Park. Vascular Plant Inventory, Voucher Collections, and Electronic Herbarium. Cooperative National Park Resources Studies Unit Technical Report No. 159. University of Hawaii at Manoa. Honolulu, Hawaii.

Appendix A: Classification Plot Form

PACN PLOT SURVEY FORM
2008 VEGETATION MAPPING PROGRAM

SURVEY AND SITE INFORMATION

Plot Code: _____ Descriptive Location _____ Survey Date: _____

Park Site Name _____ Park Name: _____

Surveyors _____

Datum: WGS 84 NAD 83 Other _____ Field Northing _____ (UTM) Field Easting _____ (UTM)

GPS UNIT: Garmin 76 Garmin 5 Other: _____ Error: +/- _____ m

GPS Comments: _____

Directions to Plot: _____

Sq plot (20 x 20) (10m x 10m) Rect Plot: len(m) _____ x wid(m) _____ Circ Plot (100 m², 400 m², 1000m²) Azi _____ deg

Camera ID _____ Camera Ht: _____ m Photopoint coords (if not plot center) Northing _____ (UTM) Easting _____ (UTM)

Description of Photopoint: _____

View#	Time	V or H	Bearing	Photographer	View from Photopoint
1					
2					
3					
4					
a					

Views 1-4 - cardinal directions N,E,S,W; view a - person standing on the photopoint itself to help relocate it in future; additional representative views

Plot representativeness (discuss plot placement and explain non-representativeness): _____

ENVIRONMENTAL DESCRIPTION

Elevation _____ m From: GPS / Map (circle one)	Slope _____ (deg) Aspect _____
Topographic Position: High level High Slope Mid Slope Low Slope Backslope Step in Slope Toe Slope Low Level Interfluvium	
Landform: Alluvial Fan, Colluvium, Rockpile, Drainage Channel, Valley Bottom Fill, Side Slope, Interfluvium, Intermittent Stream, Ridge, Terrace, Butte, Cliff, Talus, Sand Dune, Plateau, Beach, Recent Lava Flow, Other: _____	Geology: A'a lava, Pahoehoe Lava, Limestone, Coral, Pumice, Ash, Other: _____
Environmental Comments (factors controlling community plant distribution, seral stage, fire history etc):	

PACN PLOT SURVEY FORM
2008 VEGETATION MAPPING PROGRAM

PLOT CODE: _____

DATE: _____

ENVIRONMENTAL DESCRIPTION (Continued)

Ground Cover: (please estimate to the nearest percentage. Sum = 100%) ☐ Bare soil (<0.1 mm) ☐ Litter/Duff (dead plant material <3 cm diameter) ☐ Lichen (ground) ☐ Sand (0.1-2 mm) ☐ Coarse woody debris (dead wood 3-10 cm) ☐ Moss (ground) ☐ Gravel (2 mm - 6.4 cm) ☐ Woody debris structure (dead >10 cm deep & wide) ☐ Microbiotic soil crust ☐ Rock (> 6.4 cm) ☐ Live ~~veg~~ (litter / wood) ☐ Water ☐ Bedrock (solid surface) ☐ Other: _____		
Soil Texture (optional - see soil key): modify to fewer classes ☐ sand ☐ loam ☐ silt ☐ clay ☐ peat ☐ muck		
Surface Water: w/in 25m? YES/NO Seep, Spring, Stream, Pothole, River, ~~Archaeological~~ Pond, Ocean, Estuary		Soil Moisture: dry moist saturated standing water
Animal Use Evidence: ☐ Burrows ☐ Animal / Game Trails ☐ Animal Sighting ☐ Scat (Whose? _____) ☐ Vegetation Damage (animal) ☐ Other: _____ ☐ Browsing Evidence ☐ Bedding Sites ☐ Grazing Evidence ☐ Nests (Whose? _____)		
Anthropogenic Disturbances: ☐ Campsite Evidence ☐ Vegetation Damage (human) ☐ Trails ☐ ORV Evidence ☐ Rock Cairns ☐ Historic Feature ☐ Archaeological Feature ☐ Other: _____		Natural disturbances: ☐ Drought (tree & shrub die-back) ☐ Fire ☐ Flood ☐ Mass Wasting ☐ Water gullies ☐ Vegetation Damage (natural) ☐ Other: _____
Other Comments: Describe surrounding communities and how they relate to the plot.		

VEGETATION DESCRIPTION (Only check one within each box)

Phenological notes: For each stratum, note phenological state of dominant species. (Especially note in ~~herbaceous~~ vegetation if annuals or perennials are dominant)	Leaf Type (of dominant stratum) ☐ Broad-leaved ☐ Needle-leaved ☐ Microphyllous ☐ Graminoid ☐ Forb ☐ Eriophyllum ☐ Non-vascular ☐ Mixed (describe)	Physiognomic Class (see cheat sheet) ☐ Forest ☐ Woodland ☐ Shrubland ☐ Wooded Shrubland ☐ Dwarf Shrubland ☐ Shrub Herbaceous ☐ Wooded Herbaceous ☐ Herbaceous ☐ Nonvascular ☐ Sparsely Vegetated
--	---	--

Plot Name: _____

Date: _____

Provisional Community Name:

Species/Strata: Starting with the uppermost stratum list all species with full scientific names, cover class and % cover for each species in the stratum. For each tree species estimate seedling sapling and total cover in appropriate stratum. Once species level information is completed, then complete height class and cover class for each tree (shaded blocks). Indicate with an asterisk (*) diagnostic species for each stratum and check where a specimen has been collected. Additional space is available on the back side of this form. List species outside the plot at the end of the table and designate with a 0 in Cover Class Column.

SPECIES STRATA TABLE / TREES & SHRUBS						SPECIES STRATA TABLE / HERBACEOUS						
State / Species Scientific Name		Cover Class	% Cover	Spec ✓		State / Species Scientific Name		Cover Class	% Cover	Spec ✓		
Whole Plot:		Total Vegetation Cover ____ (%)				Maximum Vegetation Height ____ (m)						
T1	EMERGENT		Strata Height ____	Strata Cover ____		Hr HERBACEOUS		Sum of H1, H2, H3, H4	Strata Height	Strata Cover		
						H1 GRAMINOIDS		Strata Height ____	Strata Cover ____			
T2	CANOPY		Strata Height ____	Strata Cover ____								
T3	SUBCANOPY		Strata Height ____	Strata Cover ____								
						H2 FORBS	Strata Height ____	Strata Cover ____				
S1 TALL SHRUB (>2m)		Strata Height	Strata Cover									
S2 SHORT SHRUB (<2m)		Strata Height	Strata Cover									
						H3 FERNS & ALLIES	Strata Height	Strata Cover				
						H4 TREE SEEDLINGS	Strata Height	Strata Cover				
S3 DWARF SHRUB (<0.5m)		Strata Height	Strata Cover									
						N NON-VASCULAR	Strata Height	Strata Cover				
Cover Scale for Species t = few T = <1% 1a = 5.01 ->10% 2 = 15.01 ->25% 4 = 35.01 ->45% 6 = 55.01 ->65% 8 = 75.01 ->85% 10 = >95% P = 1-5% 1b = 10.01 ->15% 3 = 25.01 ->35% 5 = 45.01 ->55% 7 = 65.01 ->75% 9 = 85.01 ->95%												
Height Scale for Strata 01 = <0.5 m 03 = 1.01 ->2 m 05 = 5.01 ->10 m 07 = 15.01 ->20 m 09 = 35.01 ->50 m 02 = 0.5-1 m 04 = 2.01 ->5 m 06 = 10.01 ->15 m 08 = 20.01 ->35 m 10 = >50 m												

Appendix B: Plant Species Found within Sample Plots at Kalaupapa National Historical Park

Three-hundred and eight plant species were encountered while sampling field plots, observation points, and accuracy assessment plots. Family, genus species, common names and origin are reported. Plant species are indicated that were not present in sample plots at KALA, but are important for community classification. Nomenclature follows that of Wagner et al. (1999) for flowering plants and Palmer (2003) for ferns and Wagner et al. (2012) updates for all. Common names listed were selected primarily from Wagner et al. (1999) and Palmer (2003) by PACN and used throughout the document. Species names that differ from those in the USNVC are identified with footnotes.

Family	Scientific Name	Common Name	Origin
Agavaceae	<i>Agave sisalana</i> Perrine	sisal	Non-Native
Aizoaceae	<i>Sesuvium portulacastrum</i> (L.) L.	‘ākulikuli	Native
Amaranthaceae	<i>Amaranthus spinosus</i> L.	spiny amaranth	Non-Native
Amaranthaceae	<i>Chenopodium carinatum</i> R. Br.	Chenopodium carinatum	Non-Native
Anacardiaceae	<i>Mangifera indica</i> L.	mango	Non-Native
Anacardiaceae	<i>Schinus terebinthifolius</i> Raddi	Christmas berry	Non-Native
Annonaceae	<i>Cananga odorata</i> (Lam.) Hook. f. & T. Thomson	ylang-ylang	Non-Native
Apiaceae	<i>Centella asiatica</i> (L.) Urb.	Asiatic pennywort	Non-Native
Apocynaceae	<i>Alyxia stellata</i> (J. R. Forst. & G. Forst.) Roem. & Schult.	maile	Native
Apocynaceae	<i>Asclepias curassavica</i> L. ²	butterfly weed	Non-Native
Apocynaceae	<i>Thevetia peruviana</i> (Pers.) K. Schum	lucky-nut	Non-Native
Aquifoliaceae	<i>Ilex anomala</i> Hook. & Arnott	kāwa‘u	Native
Araliaceae	<i>Cheirodendron trigynum</i> ssp. <i>trigynum</i> (Gaudich) A. Heller	‘ōlapa	Native
Arecaceae	<i>Phoenix dactylifera</i> L.	date palm	Non-Native
Arecaceae	<i>Pritchardia hillebrandi</i> Becc. ¹	loulou lelo	Native
Asclepiadaceae	<i>Cryptostegia</i> spp.	rubber vine	Non-native
Asparagaceae	<i>Cordyline fruticosa</i> (L.) A. Chev	ti	Non-Native
Asparagaceae	<i>Furcraea foetida</i> (L.) Haw.	Mauritius hemp	Non-Native
Aspleniaceae	<i>Asplenium acuminatum</i> Hook. & Arn.	lola	Native
Aspleniaceae	<i>Asplenium contiguum</i>	forest spleenwort	Native
Aspleniaceae	<i>Asplenium insititium</i> Brack.	pi‘ipi‘i lau manamana	Native
Aspleniaceae	<i>Asplenium lobulatum</i> Mett.	pi‘ipi‘i lau manamana	Native
Aspleniaceae	<i>Asplenium nidus</i> L.	‘ēkaha	Native
Aspleniaceae	<i>Asplenium polyodon</i> G. Forst.	pūnana manu	Native
Aspleniaceae	<i>Asplenium sphenotomum</i> Hillebr.	Asplenium sphenotomum	Native
Asteliaceae	<i>Astelia menziesiana</i> Sm.	pa‘iniu	Native
Asteraceae	<i>Ageratina adenophora</i> (Spreng.) R. King & H. Robinson	Maui pamakani	Non-Native
Asteraceae	<i>Ageratina riparia</i> (Regel) R. King & H. Robinson	hamakua pamakani	Non-Native

Family	Scientific Name	Common Name	Origin
Asteraceae	<i>Ageratum conyzoides</i> L.	maile honohono	Non-Native
Asteraceae	<i>Aster</i> spp.	Aster spp.	Non-Native
Asteraceae	<i>Bidens molokaiensis</i> (Hillebr.) Sherff	ko'oko'olau	Native
Asteraceae	<i>Bidens pilosa</i> L.	Spanish needle	Non-Native
Asteraceae	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	Siam weed	Non-Native
Asteraceae	<i>Conyza bonariensis</i> (L.) Cronq.	hairy horseweed	Non-Native
Asteraceae	<i>Dubautia laxa</i> ssp. <i>laxa</i> Hook. & Arnott	na'ena'e pua melemele	Native
Asteraceae	<i>Dubautia linearis</i> ssp. <i>linearis</i> (Gaudich.) D. D. Keck	na'ena'e	Native
Asteraceae	<i>Eclipta prostrata</i> (L.) L.	false daisy	Non-Native
Asteraceae	<i>Emilia fosbergii</i> Nicolson	Emilia fosbergii	Non-Native
Asteraceae	<i>Erechtites valerianifolia</i> (Wolf) DC.	fireweed	Non-Native
Asteraceae	<i>Erigeron belliioides</i> DC.	Erigeron belliioides	Non-Native
Asteraceae	<i>Erigeron karvinskianus</i> DC.	daisy fleabane	Non-Native
Asteraceae	<i>Hypochoeris radicata</i> L.	hairy cat's ear	Non-Native
Asteraceae	<i>Pluchea carolinensis</i> (Jacq.) G. Don	sourbush	Non-Native
Asteraceae	<i>Pluchea indica</i> (L.) Less.	Indian fleabane	Non-Native
Asteraceae	<i>Sonchus oleraceus</i> L.	pualele	Non-Native
Asteraceae	<i>Synedrella nodiflora</i> (L.) Gaertn.	nodeweed	Non-Native
Asteraceae	<i>Taraxacum officinale</i> W. W. Weber ex F. H. Wigg.	common dandelion	Non-Native
Asteraceae	<i>Tridax procumbens</i> L.	coat buttons	Non-Native
Asteraceae	<i>Verbesina encelioides</i> (Cav.) Benth. & Hook.	golden crown-beard	Non-Native
Asteraceae	<i>Xanthium strumarium</i> var. <i>canadense</i> L.; (Mill.) Torr & A. Gray	cocklebur	Non-Native
Asteraceae	<i>Youngia japonica</i> (L.) D. C.	oriental hawksbeard	Non-Native
Blechnaceae	<i>Blechnum appendiculatum</i> Willd.	Blechnum appendiculatum	Non-Native
Blechnaceae	<i>Blechnum orientale</i> L.	Blechnum orientale	Non-Native
Blechnaceae	<i>Sadleria cyatheoides</i> Kaulf.	'ama'u	Native
Blechnaceae	<i>Sadleria pallida</i> Hook. & Arn.	'ama'u	Native
Blechnaceae	<i>Sadleria souleyetiana</i> (Gaudich.) T. Moore	'ama'u	Native
Blechnaceae	<i>Sadleria squarrosa</i> (Gaudich.) T. Moore	'ama'u	Native
Boraginaceae	<i>Heliotropium amplexicaule</i> Vahl	clasping heliotrope	Non-Native
Boraginaceae	<i>Heliotropium anomalum</i> var. <i>argenteum</i> Hook. & Arn.; A. Gray	hinahina	Native
Brassicaceae	<i>Coronopus didymus</i> (L.) Sm.	swinecress	Non-Native
Caricaceae	<i>Carica papaya</i> L.	papaya	Non-Native
Casuarinaceae	<i>Casuarina equisetifolia</i> L.	common ironwood	Non-Native
Cibotiaceae	<i>Cibotium chamissoi</i> Kaulf.	hāpu'u	Native
Cibotiaceae	<i>Cibotium glaucum</i> (Sm.) Hook. & Arn.	hāpu'u pulu	Native
Cibotiaceae	<i>Cibotium menziesii</i> Hook.	hāpu'u i'i	Native
Combretaceae	<i>Terminalia catappa</i> L.	Pacific almond	Non-Native
Commelinaceae	<i>Commelina diffusa</i> Burm. f.	honohono	Non-Native

Family	Scientific Name	Common Name	Origin
Convolvulaceae	<i>Cuscuta sandwichiana</i> Choisy	kauna'oa	Native
Convolvulaceae	<i>Ipomoea pes-caprae</i> (L.) R. Br.	pōhuehue	Native
Convolvulaceae	<i>Ipomoea purpurea</i> (L.) Roth	common morning-glory	Non-Native
Convolvulaceae	<i>Jacquemontia sandwichensis</i> A. Gray	pa'uohi'iaka	Native
Crassulaceae	<i>Kalanchoe pinnata</i> (Lam.) Pers.	air plant	Non-Native
Cucurbitaceae	<i>Momordica charantia</i> L.	balsam pear	Non-Native
Cyperaceae	<i>Bolboschoenus maritimus</i> (L.) Palla		Native
Cyperaceae	<i>Carex alligata</i> Boott	Carex alligata	Native
Cyperaceae	<i>Carex</i> spp.	Carex spp.	Unknown
Cyperaceae	<i>Carex wahuensis</i> C. A. Mey.	Carex wahuensis	Native
Cyperaceae	<i>Cyperaceae</i> spp.	Cyperaceae spp.	Unknown
Cyperaceae	<i>Cyperus gracilis</i> R. Br.	McCoy grass	Non-Native
Cyperaceae	<i>Cyperus haspan</i> L.	Cyperus haspan	Non-Native
Cyperaceae	<i>Cyperus polystachyos</i> Rottb.	Cyperus polystachyos	Native
Cyperaceae	<i>Fimbristylis cymosa</i> R. Br.	mau'u	Native
Cyperaceae	<i>Fimbristylis cymosa</i> ssp. <i>spathacea</i> R. Br.; (Roth) T. Koyama	mau'u	Native
Cyperaceae	<i>Kyllinga brevifolia</i> Rottb.	Kyllinga brevifolia	Non-Native
Cyperaceae	<i>Machaerina angustifolia</i> (Gaudich) T. Koyama	'uki	Native
Cyperaceae	<i>Uncinia uncinata</i> (L. f.) Kük.	Uncinia uncinata	Native
Dennstaedtiaceae	<i>Microlepia strigosa</i> (Thunb.) C. Presl	palapalai	Native
Dipentodontaceae	<i>Perrottetia sandwichensis</i> A. Gray	olomea	Native
Dryopteridaceae	<i>Cyrtomium falcatum</i> (L.f.) C. Presl	Holly fern	Non-Native
Dryopteridaceae	<i>Dryopteris fusco-atra</i> var. <i>fusco-atra</i> (Hillebr.) W. J. Rob.	'i'i	Native
Dryopteridaceae	<i>Dryopteris glabra</i> (Brack.) Kuntze	kīlau	Native
Dryopteridaceae	<i>Dryopteris rubiginosa</i> (Brack.) Kuntze	Dryopteris rubiginosa	Native
Dryopteridaceae	<i>Dryopteris wallichiana</i> (Spreng.) Hyl.	'i'o nui	Native
Ebenaceae	<i>Diospyros sandwichensis</i> (A. DC.) Fosberg	lama	Native
Elaphoglossaceae	<i>Elaphoglossum aemulum</i> (Kaulf.) Brack.	'ēkaha	Native
Elaphoglossaceae	<i>Elaphoglossum crassifolium</i> (Gaudich.) W. R. Anderson & Crosby	hoe a Māui	Native
Elaphoglossaceae	<i>Elaphoglossum paleaceum</i> (Hook. & Grev.) Sledge	māku'e	Native
Elaphoglossaceae	<i>Elaphoglossum parvisquameum</i> Skottsb.	hoe a Māui	Native
Elaphoglossaceae	<i>Elaphoglossum</i> spp.	Māui's paddle	Native
Elaphoglossaceae	<i>Elaphoglossum wawrae</i> (Luer.) C. Chr.	laukahi	Native
Ericaceae	<i>Leptecophylla tameiameia</i> (Cham. & Schltdl.) C. M. Weiller ³	pūkiawe	Native
Ericaceae	<i>Vaccinium calycinum</i> Sm.	'ōhelo	Native
Ericaceae	<i>Vaccinium dentatum</i> Sm.	'ōhelo	Native
Ericaceae	<i>Vaccinium reticulatum</i> Sm.	'ōhelo	Native

Family	Scientific Name	Common Name	Origin
Euphorbiaceae	<i>Aleurites moluccana</i> (L.) Willd. var. <i>katoi</i> O. Deg., I. Deeg. & B. C. Stone	kukui	Non-Native
Euphorbiaceae	<i>Euphorbia celastroides</i> var. <i>amplectens</i> Boiss.; Sherff ⁴	'akoko	Native
Euphorbiaceae	<i>Euphorbia degeneri</i> Sherff ⁴	'akoko	Native
Euphorbiaceae	<i>Euphorbia hirta</i> L. ⁴	hairy spurge	Non-Native
Euphorbiaceae	<i>Euphorbia prostrata</i> Aiton ⁴	prostrate spurge	Non-Native
Euphorbiaceae	<i>Euphorbia</i> spp. ⁴	Euphorbia spp.	Non-Native
Fabaceae	<i>Acacia confusa</i> Merr.	formosa koa	Non-Native
Fabaceae	<i>Acacia melanoxylon</i> R. Br. ex Aiton	Australian blackwood	Non-Native
Fabaceae	<i>Chamaecrista nictitans</i> ssp. <i>patellaria</i> var. <i>glabrata</i> (L.) Moench; (DC. Ex Collad.) H. S. Irwin & Barneby; (Vogel) H. S. Irwin & Barneby	partridge pea	Non-Native
Fabaceae	<i>Desmodium incanum</i> DC.	Spanish clover	Non-Native
Fabaceae	<i>Desmodium sandwicense</i> E. Mey.	Spanish clover	Non-Native
Fabaceae	<i>Desmodium tortuosum</i> (Sw.) DC.	Florida beggarweed	Non-Native
Fabaceae	<i>Desmodium triflorum</i> (L.) DC.	Desmodium triflorum	Non-Native
Fabaceae	<i>Erythrina sandwicensis</i> O. Deg.	wiliwili	Native
Fabaceae	<i>Indigofera suffruticosa</i> Mill.	indigo	Non-Native
Fabaceae	<i>Leucaena leucocephala</i> (Lam.) de Wit	koa haole	Non-Native
Fabaceae	<i>Macroptilium lathyroides</i> (L.) Urb.	wild bean	Non-Native
Fabaceae	<i>Medicago sativa</i> L.	lucerne	Non-Native
Fabaceae	<i>Prosopis pallida</i> (Humb. & Bonpl. ex Willd.) Kunth	kiawe	Non-Native
Fabaceae	<i>Senna alata</i> (L.) Roxb.	candle bush	Non-Native
Fabaceae	<i>Senna gaudichaudii</i> (Hook. & Arn.) H. S. Irwin & Barneby	uhiuhi	Native
Fabaceae	<i>Senna occidentalis</i> (L.) H. S. Irwin & Barneby	coffee senna	Non-Native
Fabaceae	<i>Tamarindus indica</i> L.	tamarind	Non-Native
Gesneriaceae	<i>Cyrtandra grayana</i> Hillebr.	ha'iwale	Native
Gesneriaceae	<i>Cyrtandra procera</i> Hillebr.	ha'iwale	Native
Gleicheniaceae	<i>Dicranopteris linearis</i> (Burm. f.) Underw.	uluhe	Native
Gleicheniaceae	<i>Diplopterygium pinnatum</i> (Kunze) Nakai	uluhe lau nui	Native
Goodeniaceae	<i>Scaevola gaudichaudiana</i> Cham.	naupaka kuahiwi	Native
Goodeniaceae	<i>Scaevola gaudichaudii</i> Hook. & Arn.	naupaka kuahiwi	Native
Goodeniaceae	<i>Scaevola taccada</i> (Gaertn.) Roxb. ⁵	naupaka kahakai	Native
Hydrangeaceae	<i>Broussaisia arguta</i> Gaudich.	kanawao	Native
Hymenophyllaceae	<i>Vandenboschia davallioides</i> (Gaudich.) Copel.	palai hihi	Native
Juncaceae	<i>Juncus effusus</i> L.	Japanese mat rush	Non-Native
Juncaceae	<i>Juncus planifolius</i> R. Br.	rush	Non-Native
Juncaceae	<i>Luzula hawaiiensis</i> var. <i>glabrata</i> Buchenau; (Hillebr.) O. Deg. & I. Deg.	Luzula hawaiiensis var. <i>glabrata</i>	Native
Lamiaceae	<i>Leonotis nepetifolia</i> (L.) R. Br.	lion's ear	Non-Native
Lamiaceae	<i>Plectranthus parviflorus</i> Willd.	'ala'ala wai nui wahine	Native

Family	Scientific Name	Common Name	Origin
Lamiaceae	<i>Stenogyne kamehamehae</i> Wawra	Stenogyne kamehamehae	Native
Lindsaeaceae	<i>Sphenomeris chinensis</i> (L.) Maxon	pala'ā	Native
Loganiaceae	<i>Labordia hedyosmifolia</i> Baill.	kāmakahala	Native
Loganiaceae	<i>Labordia waiolani</i> Wawra	kāmakahala	Native
Lomariopsidaceae	<i>Nephrolepis brownii</i> (Desv.) Hovenkamp & Miyam.	sword fern	Non-Native
Lomariopsidaceae	<i>Nephrolepis cordifolia</i> (L.) C. Presl	kupukupu	Native
Lomariopsidaceae	<i>Nephrolepis exaltata</i> ssp. <i>hawaiiensis</i> (L.) Schott	kupukupu	Native
Lycopodiaceae	<i>Lycopodiella cernua</i> (L.) Pic. Serm.	wāwae'iole	Native
Lycopodiaceae	<i>Lycopodium venustulum</i> Gaudich.	Lycopodium venustulum	Native
Lythraceae	<i>Cuphea carthagenensis</i> (Jacq.) J. F. Macbr.	tarweed	Non-Native
Lythraceae	<i>Lythrum maritimum</i> Kunth	pūkāmole	Non-Native
Malvaceae	<i>Abutilon grandifolium</i> (Willd.) Sweet	hairy abutilon	Non-Native
Malvaceae	<i>Hibiscus tiliaceus</i> L.	hau	Native
Malvaceae	<i>Malvastrum coromandelianum</i> (L.) Garcke	false mallow	Unknown
Malvaceae	<i>Sida fallax</i> Walp.	'ilima	Native
Malvaceae	<i>Sida rhombifolia</i> L.	arrowleaf sida	Non-Native
Malvaceae	<i>Waltheria indica</i> L.	'uhaloa	Native
Melastomataceae	<i>Clidemia hirta</i> (L.) D. Don	Koster's curse	Non-Native
Melastomataceae	<i>Tibouchina herbacea</i> (DC) Cogn.	cane tibouchina	Non-Native
Meliaceae	<i>Melia azedarach</i> L.	Chinaberry	Non-Native
Menispermaceae	<i>Cocculus orbiculatus</i> (L.) DC.	huehue	Native
Moraceae	<i>Ficus benjamina</i> L.	weeping fig	Non-Native
Moraceae	<i>Ficus microcarpa</i> L. f.	Chinese banyan	Non-Native
Myrtaceae	<i>Eucalyptus globulus</i> Labill.	blue gum	Non-Native
Myrtaceae	<i>Eucalyptus robusta</i> Sm.	swamp mahogany	Non-Native
Myrtaceae	<i>Eucalyptus saligna</i> Sm.	Sydney blue gum	Non-Native
Myrtaceae	<i>Eugenia uniflora</i> L.	Surinam cherry	Non-Native
Myrtaceae	<i>Melaleuca quinquenervia</i> (Cav.) S. T. Blake	paperbark	Non-Native
Myrtaceae	<i>Metrosideros polymorpha</i> Gaudich.	'ōhi'a	Native
Myrtaceae	<i>Metrosideros polymorpha</i> var. <i>polymorpha</i> Gaudich.	'ōhi'a	Native
Myrtaceae	<i>Metrosideros waialealae</i> var. <i>fauriei</i> (Rock) Rock; (H. Lév.) J.W. Dawson & Stemmerm.	Metrosideros waialealae var. fauriei	Native
Myrtaceae	<i>Psidium cattleianum</i> Sabine	strawberry guava	Non-Native
Myrtaceae	<i>Psidium guajava</i> L.	common guava	Non-Native
Myrtaceae	<i>Syncarpia glomulifera</i> (Sm.) Nied	turpentine tree	Non-Native
Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels	java plum	Non-Native
Nyctaginaceae	<i>Boerhavia coccinea</i> Mill.	scarlet spiderling	Non-Native
Nyctaginaceae	<i>Boerhavia repens</i> L.	alena	Native
Nyctaginaceae	<i>Boerhavia</i> spp.	Boerhavia spp.	Unknown

Family	Scientific Name	Common Name	Origin
Orchidaceae	<i>Liparis hawaiiensis</i> H. Mann	'awapuhiakanaloa	Native
Orchidaceae	<i>Nervilia aragoana</i> Guadich.	tall shield orchid	Non-Native
Orchidaceae	<i>Spathoglottis plicata</i> Blume	Philippine ground orchid	Non-Native
Oxalidaceae	<i>Oxalis corniculata</i> L.	yellow wood sorrel	Non-Native
Pandanaceae	<i>Freycinetia arborea</i> Gaudich.	'ie'ie	Native
Pandanaceae	<i>Pandanus tectorius</i> Parkinson ex Z	hala	Native
Passifloraceae	<i>Passiflora</i> spp.	passion flower	Non-Native
Passifloraceae	<i>Turnera ulmifolia</i> L.	yellow alder	Non-Native
Phyllanthaceae	<i>Antidesma platyphyllum</i> H. Mann	hame	Native
Phyllanthaceae	<i>Phyllanthus debilis</i> Klein ex Willd.	niruri	Non-Native
Phytolaccaceae	<i>Phytolacca octandra</i> L.	pokeberry	Non-Native
Pinaceae	<i>Pinus</i> spp.	pine	Non-Native
Piperaceae	<i>Peperomia cookiana</i> C. DC.	'ala'ala wai nui	Native
Piperaceae	<i>Peperomia macraeana</i> C. DC.	'ala'ala wai nui	Native
Piperaceae	<i>Peperomia membranacea</i> Hook. & Arnott	'ala'ala wai nui	Native
Piperaceae	<i>Peperomia sandwicensis</i> Miq.	'ala'ala wai nui	Native
Piperaceae	<i>Peperomia</i> spp.	'ala'ala wai nui	Native
Piperaceae	<i>Peperomia tetraphylla</i> (G. Forst.) Hook. & Arn.	'ala'ala wai nui	Native
Pittosporaceae	<i>Pittosporum glabrum</i> Hook. & Arn.	hō'awa	Native
Plantaginaceae	<i>Plantago lanceolata</i> L.	English plantain	Non-Native
Plantaginaceae	<i>Plantago major</i> L.	broad-leaved plantain	Non-Native
Poaceae	alien grass	alien grass	Non-native
Poaceae	<i>Andropogon virginicus</i> L.	broomsedge	Non-Native
Poaceae	<i>Anthoxanthum odoratum</i> L.	sweet vernalgrass	Non-Native
Poaceae	<i>Axonopus fissifolius</i> (Raddi) Kuhlm.	carpetgrass	Non-Native
Poaceae	<i>Cenchrus clandestinus</i> Hochst. Ex Chiov. ⁶	kikuyu grass	Non-Native
Poaceae	<i>Coix lacryma-jobi</i> L.	kūkaekōlea	Non-Native
Poaceae	<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	Non-Native
Poaceae	<i>Digitaria ciliaris</i> (Retz.) Koeler	Henry's crabgrass	Non-Native
Poaceae	<i>Digitaria insularis</i> (L.) Fedde	sourgrass	Non-Native
Poaceae	<i>Digitaria</i> spp.	crabgrass	Non-Native
Poaceae	<i>Ehrharta stipoides</i> Labill.	meadow ricegrass	Non-Native
Poaceae	<i>Melinis minutiflora</i> P. Beauv.	molasses grass	Non-Native
Poaceae	<i>Oplismenus hirtellus</i> (L.) P. Beauv.	basketgrass	Non-Native
Poaceae	<i>Panicum fauriei</i> var. <i>fauriei</i> Hitchc.	<i>Panicum fauriei</i> var. <i>fauriei</i>	Native
Poaceae	<i>Paspalum conjugatum</i> P. J. Bergius	Hilo grass	Non-Native
Poaceae	<i>Paspalum scrobiculatum</i> L.	mau'u laiki	Native
Poaceae	<i>Paspalum</i> spp.	<i>Paspalum</i> spp.	Unknown
Poaceae	<i>Sacciolepis indica</i> (L.) Chase	glenwood grass	Non-Native
Poaceae	<i>Setaria parviflora</i> (Poir.) Kerguélen	foxtail	Non-Native

Family	Scientific Name	Common Name	Origin
Poaceae	<i>Sporobolus africanus</i> (Poir.) Robyns & Tournay	rattail grass	Non-Native
Poaceae	<i>Sporobolus indicus</i>	Indian dropseed	Non-Native
Poaceae	<i>Sporobolus</i> spp.	dropseed	Non-Native
Polygonaceae	<i>Persicaria punctata</i> (Elliot) Small	water smartweed	Non-Native
Polypodiaceae	<i>Adenophorus hymenophylloides</i> (Kaulf.) Hook. & Grev.	pai	Native
Polypodiaceae	<i>Adenophorus periens</i> L. E. Bishop	palai lā'au	Native
Polypodiaceae	<i>Adenophorus pinnatifidus</i> var. <i>pinnatifidus</i> Gaudich.	Adenophorus pinnatifidus var. pinnatifidus	Native
Polypodiaceae	<i>Adenophorus pinnatifidus</i> var. <i>rockii</i> Gaudich.; (Copel.) D. D. Palmer	Adenophorus pinnatifidus var. rockii	Native
Polypodiaceae	<i>Adenophorus tamariscinus</i> (Kaulf.) Hook. & Grev.	wahine noho mauna	Native
Polypodiaceae	<i>Adenophorus tenellus</i> (Kaulf.) Ranker	kolokolo	Native
Polypodiaceae	<i>Adenophorus tripinnatifidus</i> Gaudich.	Adenophorus tripinnatifidus	Native
Polypodiaceae	<i>Grammitis hookeri</i> (Brack.) Copel.	māku'e lau li'i	Native
Polypodiaceae	<i>Lepisorus thunbergianus</i> (Kaulf.) Ching	pākahakaha	Native
Polypodiaceae	<i>Phlebodium aureum</i> (L.) J. Sm.	rabbit's-foot fern	Non-Native
Polypodiaceae	<i>Phymatosorus grossus</i> (Langsd. & Fisch.) Brownlie	naturalized laua'e	Non-Native
Polypodiaceae	<i>Polypodium pellucidum</i> Kaulf.	'ae	Native
Portulacaceae	<i>Portulaca lutea</i> Sol. ex G. Forst.	'ihi	Native
Portulacaceae	<i>Portulaca oleracea</i> L.	pigweed	Non-Native
Portulacaceae	<i>Portulaca pilosa</i> L.	Portulaca pilosa	Non-Native
Portulacaceae	<i>Portulaca</i> spp.	purslane	Unknown
Primulaceae	<i>Anagallis arvensis</i> L.	scarlet pimpernel	Non-Native
Primulaceae	<i>Lysimachia hillebrandii</i> Hook.f. ex A. Gray	kolokolo kuahiwi	Native
Primulaceae	<i>Myrsine lessertiana</i> A. DC.	kōlea lau nui	Native
Proteaceae	<i>Grevillea robusta</i> A. Cunn. ex R. Br.	silk oak	Non-Native
Proteaceae	<i>Macadamia integrifolia</i> Maiden & Betcher	macadamia nut	Non-Native
Psilotaceae	<i>Psilotum complanatum</i> Sw.	moa	Native
Psilotaceae	<i>Psilotum nudum</i> (L.) P. Beauv.	moa	Native
Pteridaceae	<i>Adiantum capillus-veneris</i> L.	'iwa'iwa	Native
Pteridaceae	<i>Adiantum hispidulum</i> Sw.	rough maidenhair fern	Non-Native
Pteridaceae	<i>Adiantum raddianum</i> C. Presl	Adiantum raddianum	Non-Native
Pteridaceae	<i>Pityrogramma austroamericana</i> Domin	gold fern	Non-Native
Pteridaceae	<i>Pityrogramma calomelanos</i> (L.) Link	silver fern	Non-Native
Pteridaceae	<i>Pteris excelsa</i> Gaudich.	waimakanui	Native
Rosaceae	<i>Osteomeles anthyllidifolia</i> (Sm.) Lindl.	'ūlei	Native
Rosaceae	<i>Rubus argutus</i> Link	prickly Florida blackberry	Non-Native
Rosaceae	<i>Rubus hawaiiensis</i> A. Gray	'ākala	Native
Rosaceae	<i>Rubus rosifolius</i> Sm.	thimbleberry	Non-Native
Rubiaceae	<i>Coffea arabica</i> L.	Arabian coffee	Non-Native

Family	Scientific Name	Common Name	Origin
Rubiaceae	<i>Coprosma foliosa</i> A. Gray	pilo	Native
Rubiaceae	<i>Coprosma ochracea</i> W. R. B. Oliv.	pilo	Native
Rubiaceae	<i>Coprosma</i> spp.	pilo	Native
Rubiaceae	<i>Kadua affinis</i> DC. ⁷	manono	Native
Rubiaceae	<i>Kadua axillaris</i> (Wawra) W. L. Wagner & Lorence ⁸	manono	Native
Rubiaceae	<i>Kadua</i> spp. ⁹	Kadua spp.	Non-Native
Rubiaceae	<i>Morinda citrifolia</i> L.	noni	Non-Native
Rubiaceae	<i>Nertera granadensis</i> (Mutis ex L. f.) Druce	mākole	Native
Rubiaceae	<i>Psychotria hawaiiensis</i> (A. Gray) Fosb.	kōpiko 'ula	Native
Rubiaceae	<i>Psychotria hawaiiensis</i> var. <i>hawaiiensis</i> (A. Gray) Fosb.	kōpiko 'ula	Native
Rubiaceae	<i>Psychotria mariniana</i> (Cham. & Schltdl.) Fosberg	kōpiko	Native
Rubiaceae	<i>Psychotria mauiensis</i> Fosberg	kōpiko	Native
Rubiaceae	<i>Psydrax odorata</i> (G. Forst.) A. C. Sm. & S.P. Darwin	alahe'e	Native
Rubiaceae	<i>Spermacoce</i> spp.	buttonweed	Non-Native
Rutaceae	<i>Melicope clusiifolia</i> (A. Gray) T. G. Hartley & B. C. Stone	kolokolo mokihana	Native
Rutaceae	<i>Melicope molokaiensis</i> (Hillebr.) T.G. Hartley & B.C. Stone	alani	Native
Rutaceae	<i>Melicope sessilis</i> (H. Lév.) T. G. Hartley and B.C. Stone	alani	Native
Rutaceae	<i>Melicope</i> spp.	alani	Native
Sapindaceae	<i>Dodonaea viscosa</i> Jacq.	a'ali'i	Native
Schizaeaceae	<i>Schizaea robusta</i> Baker	'oāli'i makali'i	Native
Scrophulariaceae	<i>Buddleja asiatica</i> Lour.	dog tail	Non-Native
Selaginellaceae	<i>Selaginella arbuscula</i> (Kaulf.) Spring	lepelepe a moa	Native
Smilacaceae	<i>Smilax melastomifolia</i> Sm.	hoi kuahiwi	Native
Solanaceae	<i>Nicotiana glauca</i> Graham	tree tobacco	Non-Native
Solanaceae	<i>Petunia</i> spp.	nightshade	Unknown
Solanaceae	<i>Solanum capsicoides</i> All.	cockroach berry	Non-Native
Solanaceae	<i>Solanum seaforthianum</i> Andrews	Brazilian nightshade	Non-Native
Taxodiaceae	<i>Cryptomeria japonica</i> (Thunb. ex L. f.) D. Don	Japanese cedar	Non-Native
Thelypteridaceae	<i>Cyclosorus dentatus</i> (Forssk.) Ching ¹⁰	Cyclosorus dentatus	Non-Native
Thelypteridaceae	<i>Cyclosorus parasiticus</i> (L.) Farw. ¹¹	Cyclosorus parasiticus	Non-Native
Thelypteridaceae	<i>Cyclosorus sandwicensis</i> (Brack.) Copel. ¹²	hō'i'o kula	Native
Thelypteridaceae	<i>Cyclosorus</i> spp. ¹³	Cyclosorus spp.	Unknown
Thymelaeaceae	<i>Wikstroemia oahuensis</i> var. <i>oahuensis</i> (A. Gray) Rock	'ākia	Native
Thymelaeaceae	<i>Wikstroemia</i> spp.	'ākia	Native
Thymelaeaceae	<i>Wikstroemia uva-ursi</i>	akia	Unknown
Urticaceae	<i>Touchardia latifolia</i> Gaudich.	olonā	Native
Verbenaceae	<i>Lantana camara</i> L.	lantana	Non-Native

Family	Scientific Name	Common Name	Origin
Verbenaceae	<i>Stachytarpheta cayennensis</i> (Rich.) Vahl	Stachytarpheta cayennensis	Non-Native
Verbenaceae	<i>Stachytarpheta jamaicensis</i> (L.) Vahl	Jamaica vervain	Non-Native
Verbenaceae	<i>Stachytarpheta urticifolia</i>	nettleleaf velvetberry	Unknown
Verbenaceae	<i>Verbena hybrida</i> Groenland & Rümpler	garden vervain	Non-Native
Verbenaceae	<i>Verbena litoralis</i> Kunth	ha'uowi	Non-Native
Violaceae	<i>Viola chamissoniana</i> ssp. <i>robusta</i> (Hillebr.) W. L. Wagner; D. R. Herbst & Sohmer	pāmakani	Native
Violaceae	<i>Viola chamissoniana</i> ssp. <i>tracheliifolia</i> Ging; (Ging) W. L. Wagner, D. R. Herbst & Sohmer	pāmakani	Native
Viscaceae	<i>Korthalsella cylindrica</i> (Tiegh.) Engl.	hulumoa	Native
Woodsiaceae	<i>Athyrium microphyllum</i> (Sm.) Alston	'ākōlea	Native
Woodsiaceae	<i>Deparia petersenii</i> (Kunze) M. Kato	false spleenwort	Non-Native
Woodsiaceae	<i>Diplazium sandwichianum</i> (C. Presl) Diels	hō'i'o	Native
Xanthorrhoeaceae	<i>Dianella sandwicensis</i> Hook. & Arn.	'uki'uki	Native
Zingiberaceae	<i>Hedychium coronarium</i> J. König	white ginger	Non-Native
Zingiberaceae	<i>Zingiber zerumbet</i> (L.) Sm.	'awapuhi	Non-Native

¹ Species important for community types, but not sampled in vegetation plots at KALA.

² Listed in USNVC as *Alyxia oliviformis*.

³ Listed in USNVC as *Styphelia tameiameia*.

⁴ Listed in USNVC as *Chamaesyce*.

⁵ Listed in USNVC as *Scaevola sericea* var. *taccada*.

⁶ Listed in USNVC as *Pennisetum clandestinum*.

⁷ Listed in USNVC as *Hedyotis terminalis*.

⁸ Listed in USNVC as *Hedyotis hillebrandii*.

⁹ Listed in USNVC as *Hedyotis* spp.

¹⁰ Listed in USNVC as *Christella dentata*.

¹¹ Listed in USNVC as *Christella parasitica*.

¹² Listed in USNVC as *Pneumatopteris sandwicensis*.

¹³ Listed in USNVC as *Christella* spp.

Literature Cited

- Integrated Taxonomic Information System (ITIS) on-line database, <http://www.itis.gov>. (accessed June 2010).
- Palmer D. 2003. Hawaii's ferns and fern allies. University of Hawaii Press, Honolulu, Hawaii.
- The Taxonomic Name Resolution Service, versions 3. Online, <http://tnrs.iplantcollaborative.org>. (accessed February 2012).
- Wagner, W. L., D. R. Herbst, N. Kahn, and T. Flynn. 2012. Hawaiian vascular plant updates: A supplement to the *Manual of the flowering plants of Hawaii* and *Hawaii's ferns and fern allies*. University of Hawai'i Press and Bishop Museum Press, Honolulu. 126 pp. Available from <http://botany.si.edu/pacificislandbiodiversity/hawaiianflora>
- Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. Manual of the flowering plants of Hawai'i. Revised edition. Volumes 1 and 2. University of Hawaii Press and Bishop Museum Press, Honolulu. 1919 pp.
- U.S. Department of Agriculture, Natural Resources Conservation Service. 2007. The PLANTS Database. Online, <http://plants.usda.gov>. (accessed June 2010).

Appendix C: Vegetation Association Key

FIELD KEY TO THE VEGETATION TYPES OF

Kalaupapa National Historical Park, Hawaii



The vegetation of Kalaupapa National Historical Park, Hawaii (KALA) was characterized using field plot data collected in 2009-2011 as a part of the National Park Service Vegetation Mapping Program. To assist in the accurate field identification of the 51 plant associations this dichotomous key has been developed from plot and observation point data.

This key is structured to facilitate identification of vegetation types with one or a combination of “diagnostic species”- species or group of species whose relative constancy or abundance differentiates one vegetation type from another. Most of these diagnostic species are “dominant species” - species which occur constantly in the plots with high percent cover in a vegetation type or a canopy layer, usually in the tallest (upper most) layer. Several species may also co-dominate with the greatest absolute cover. Other diagnostic species include “differential species” – species with high constancy that because of its fidelity are clearly associated with a particular vegetation type and “indicator species”- species with known fidelity to certain habitat conditions such as soil moisture, soil nutrients, flooding regime, and disturbance history. During AA, crews may go to randomly selected points that fall within ecotones - boundary or transition zones between vegetation types where diagnostic species intermix, and it may be difficult to determine a definitive type. Be aware that a map polygon may have small inclusions of other vegetation types.

Special instructions for AA Crews

1. The key relies on the absolute percent cover of individual species by major lifeform layers (tree, shrub and herbaceous). Stands with an “overwhelming dominance” (highest absolute cover is more than double any other species in that layer) of a single species are usually keyed by that dominant species. Sometimes key species co-dominate a layer.
2. Dominance is defined as having >50% relative cover in a layer and refers to a species or group of species such as (natives). Co-dominance is generally defined as two (or more) of the most abundant species in a layer usually with nearly equal cover. Some couplets have specific criteria for co-dominance such as both species have at least 10% cover.
3. At KALA there are several ubiquitous species that define most associations and have broad ecological amplitudes. These associations are distinguished by their life zones based on elevation and moisture availability. We relied on species that occurred consistently (high fidelity) in most or all stands classified as a single type (referred to as the “differential” or “indicator” species) to validate the classification. These diagnostic species often do not have the highest absolute cover in the stand.
4. Scrub forests and woodlands are included with taller forest and woodlands in the key. Scrub forests and woodlands typically occur because of harsh environmental conditions that limit tree growth such as high winds or saturated soils.
5. In this classification ~1000 m threshold is used to separate “lowland” from “montane” and “subalpine” vegetation types in addition to floristic composition and vegetation structure.

6. Herbaceous types typically have less than 10% cover of woody vegetation, but may include up to 10-15% cover of scattered trees or shrubs if herbaceous cover is very high (>75% cover) and no woody species clearly dominant/diagnostic or no discernible tree or shrub layer is formed.
7. If vegetation does not key, assume it is a new vegetation type and collect as much data as possible. At a minimum fill out an observation point form, ideally a full plot form if possible-- so the data and field notes can be reviewed and the stand classified at a later date.

Physiognomic Group Key

- 1a. Canopy of vascular plant species exceeds 10%. Diagnostic species are present to characterize stand as a woodland, shrubland or herbaceous vegetation type **2**
- 1b. Cover of vascular plant species usually less than 10%, but may include up to 15% total vegetation cover when vegetation is mixed with no diagnostic species. **Sparse Vegetation Types (None Classified at KALA)**

- 2a. Trees form a canopy layer with at least 10% cover. Note that early successional forests and woodlands with short trees key here and not in the shrubland key **Go to Forest and Woodland Key**
- 2b. Tree cover, if present has less than 10% canopy cover. Occasionally clumps of mixed trees might slightly exceed 10% cover (to 15% cover) when total vegetation is strongly characterized as a grassland or shrubland with scattered trees that do not form a distinct layer as an open woodland. These mixed sites are often disturbed or transitional..... **3**

- 3a. Shrub species comprise at least 10% cover, individually or in the aggregate; if the stand has reduced total vegetation cover (< 20%), then the shrub component exceeds herbaceous cover. Many shrub stands are heavily invaded by exotic grass species **Go to Shrubland Key**
- 3b. Shrub species comprise less than 10% canopy cover, and herbaceous species typically constitute more than 10% cover. If stand has reduced total vegetation cover (< 20%); then the herbaceous component exceeds the shrub cover. Occasionally clumps of mixed shrubs or mixed trees might slightly exceed 10% cover (but < 20% cover) when total vegetation has a dense herbaceous layer with > 75% cover. The scattered mixed shrub or mixed tree species do not form a distinct layer..... **Go to Herbaceous Key**

Forest and Woodland Key

- 1a. Forests, woodlands and scrub (dwarf woodland) dominated by native tree species and tree species thought to be early Polynesian introductions such as *Aleurites moluccana*, *Cocos nucifera*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Thespesia populnea* **2**
- 1b. Forests, woodlands and scrub (dwarf woodland) dominated non-native species **21**

- 2a. Forests and woodlands with canopies dominated or co-dominated by *Aleurites moluccana*, *Cocos nucifera*, *Coprosma foliosa*, *Diospyros sandwicensis*, *Erythrina sandwicensis*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Perrottetia sandwicensis*, *Pritchardia hillebrandii*, or *Thespesia populnea*. **3**
- 2b. Forests, woodlands and scrub (dwarf woodland) dominated or co-dominated by *Metrosideros* or other tree species..... **12**

- 3a. Forests and woodlands with canopies dominated or co-dominated by *Pritchardia hillebrandii*. This association is known from Huelo Islet.....***Pritchardia hillebrandii* Coastal Mesic Forest (F_PRHI)**
- 3b. Forests and woodlands with canopies dominated *Aleurites moluccana*, *Cocos nucifera*, *Coprosma foliosa*, *Diospyros sandwicensis*, *Erythrina sandwicensis*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Perrottetia sandwicensis*, or *Thespesia populnea***4**
- 4a. Forests and woodlands with canopies dominated by *Cocos nucifera*.....***Cocos nucifera* Strand Woodland (W_CONU)**
- 4b. Forests and woodlands with canopies dominated *Aleurites moluccana*, *Coprosma foliosa*, *Diospyros sandwicensis*, *Erythrina sandwicensis*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Perrottetia sandwicensis*, or *Thespesia populnea***5**
- 5a. Woodlands with canopies dominated or co-dominated by deciduous native tree *Erythrina sandwicensis*, often with non-native invasive trees *Schinus terebinthifolius* or *Syzygium cumini* present to co-dominant. This uncommon type is mostly found within and near the Kauhakō Crater. If sampling at time when leaves are not present, estimate likely canopy cover of this deciduous tree.....***Erythrina sandwicensis* Lowland Dry Woodland (W_ERSA)**
- 5b. Forests and woodlands with canopies dominated *Aleurites moluccana*, *Coprosma foliosa*, *Diospyros sandwicensis*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Perrottetia sandwicensis*, or *Thespesia populnea*. If *Erythrina sandwicensis* is present then it occurs at low cover**6**
- 6a. Forests and woodlands with canopies dominated or co-dominated by *Aleurites moluccana* often with *Syzygium cumini* or species of *Psidium*. This type is abundant in Waikolu Valley.....***Aleurites moluccana* Lowland Wet Forest (F_ALMO_L)**
- 6b. Forests and woodlands with canopies dominated *Coprosma foliosa*, *Diospyros sandwicensis*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Perrottetia sandwicensis*, or *Thespesia populnea*.**7**
- 7a. Forests and woodlands with canopies dominated or co-dominated by *Pandanus tectorius* often with *Syzygium cumini* or species of *Psidium*..... ***Pandanus tectorius* Coastal Mesic Forest (F_PATE_C)**
- 7b. Forests and woodlands with canopies dominated by *Coprosma foliosa*, *Diospyros sandwicensis*, *Hibiscus tiliaceus*, *Perrottetia sandwicensis*, or *Thespesia populnea***8**
- 8a. Forests and woodlands with tree canopy dominated by *Thespesia populnea*. Stands tend to be small and occur on coastal sites.....***Thespesia populnea* / Sparse Understory Woodland (W_THPO)**
- 8b. Forests and woodlands with canopies dominated by *Coprosma foliosa*, *Diospyros sandwicensis*, *Hibiscus tiliaceus*, or *Perrottetia sandwicensis*.**9**
- 9a. Forests and woodlands with canopies dominated by *Hibiscus tiliaceus*. *Aleurites moluccana* and other wet and riparian tree species may be present in canopy. Stands are found Waikolu Valley.....
.....***Hibiscus tiliaceus* Lowland Wet Forest [Provisional] (F_HITI_L)**
- 9b. Forests and woodlands with canopies dominated *Coprosma foliosa*, *Diospyros sandwicensis*, *Perrottetia sandwicensis***10**

- 10a. Highly diverse riparian forest and woodlands with canopies co-dominated by *Coprosma foliosa*, *Perrottetia sandwicensis* and *Cibotium* spp. *Kadua axillaris* or *Psychotria mauiensis* present to co-dominant. *Metrosideros polymorpha* may be present, but not co-dominant
.....***Coprosma foliosa* - *Perrottetia sandwicensis* - *Cibotium* spp. Riparian Woodland [Park Special] (W_COPECI)**
- 10b. Forests and woodlands with canopies dominated or co-dominated by *Diospyros sandwicensis***11**
- 11a. Forests and woodlands with canopies co-dominated by *Diospyros sandwicensis* and *Metrosideros polymorpha* both species have at least 10% cover. *Psidium* spp. may be present to co-dominant.....
.....***Diospyros sandwicensis* - *Metrosideros polymorpha* Lowland Mesic Forest (F_DIME)**
- 11b. Forests and woodlands with canopies dominated or co-dominated by *Diospyros sandwicensis* often with *Psidium* spp. present to co-dominant. *Metrosideros polymorpha* may be present with less than 10% cover.....
.....***Diospyros sandwicensis* - (*Psidium* spp.) Lowland Mesic Woodland (W_DIPS)**
- 12a. Forests and woodlands with canopies dominated by *Metrosideros waialealae* var. *fauriei*. *Metrosideros polymorpha* may be present with low cover (not co-dominant). Non-native trees such as *Psidium cattleianum* may be present to co-dominant in degraded stands.....***Metrosideros waialealae* var. *fauriei* Woodland [Park Special] (W_MEWA)**
- 12b. Forests and woodlands with canopies dominated or co-dominated by *Metrosideros polymorpha* and other tree species. *Metrosideros waialealae* var. *fauriei* may be present to co-dominant.....**13**
- 13a. Scrub forest dominated by dwarfed *Metrosideros polymorpha* and mixed shrubs such as *Dodonaea viscosa*, *Leptecophylla tameiameia*, *Vaccinium reticulatum*, and *Wikstroemia oahuensis* var. *oahuensis*. *Metrosideros waialealae* var. *fauriei* may be present to co-dominant in some stands. Stands occur on exposed upper slopes and ridges.....***Metrosideros polymorpha* / Mixed Shrub Montane Wet Scrub Forest (F_MEPO_M)**
- 13b. Forests and woodlands with canopies dominated or co-dominated by *Metrosideros polymorpha* and other tree species ...**14**
- 14a. Forests and woodlands with canopies co-dominated by *Metrosideros polymorpha* and *Diospyros sandwicensis* with both species having at least 10% cover....***Diospyros sandwicensis* - *Metrosideros polymorpha* Lowland Mesic Forest (F_DIME)**
- 14b. Forests and woodlands with canopies dominated by *Metrosideros polymorpha* with *Diospyros sandwicensis* absent or with low cover (< 10% cover) **15**
- 15a. Forests and woodlands with canopies dominated or co-dominated by *Metrosideros polymorpha* with *Ilex anomala* and/or *Myrsine lessertiana* co-dominant. If *Cheirodendron trigynum* ssp. *trigynum* or *Cibotium* species are present, then combined cover of *Ilex anomala* and/or *Myrsine lessertiana* is greater.....
.....***Metrosideros polymorpha* - *Ilex anomala* - *Myrsine lessertiana* Woodland (W_MEILMY)**
- 15b. Forests and woodlands with canopies dominated or co-dominated by *Metrosideros polymorpha*, with *Ilex anomala* and *Myrsine lessertiana* absent or with low cover (typically<10% total) **16**
- 16a. Forests and woodlands with canopies co-dominated by *Metrosideros polymorpha* and *Cheirodendron* spp. with both species having at least 10% tree cover. If *Ilex anomala* or *Myrsine lessertiana* is present then cover of *Cheirodendron* spp. is greater than cover of *Ilex anomala* and/or *Myrsine lessertiana***17**

- 16b. Forests and woodlands dominated or co-dominated by *Metrosideros polymorpha*. *Cheirodendron* spp. is absent or if present the with low cover<10% cover **18**
- 17a. Understory dominated by *Diplopterygium pinnatum*. Short (~5 m tall) wooded bog sampled from one location on plateau near Pu'u Ali'i cabin ***Metrosideros polymorpha* - *Cheirodendron trigynum* ssp. *trigynum* / *Diplopterygium pinnatum* Montane Wet Forest [Park Special] (F_MECHDI)**
- 17b. Understory not dominated by *Diplopterygium pinnatum*, if present cover of *Diplopterygium pinnatum* is low. *Cibotium* spp. is often present to dominant in tree subcanopy and understory. Widespread montane rainforest type ***Metrosideros polymorpha* – *Cheirodendron trigynum* / (*Cibotium* spp.) Montane Wet Forest (F_MECHCI)**
- 18a. Forests and woodlands with canopies co-dominated by *Metrosideros polymorpha* and introduced species *Psidium cattleianum*, *Psidium guajava* and/or *Schinus terebinthifolius* ***Metrosideros polymorpha* - (*Psidium* spp., *Schinus terebinthifolius*) Woodland (W_MEPSSC)**
- 18b. Forests and woodlands with canopies dominated or co-dominated by *Metrosideros polymorpha* with low cover of introduced species, *Psidium cattleianum*, *Psidium guajava* and/or *Schinus terebinthifolius* **19**
- 19a. Forest and woodlands with canopies dominated or co-dominated by *Metrosideros polymorpha* and subcanopy and understory dominated by *Cibotium* spp. *Cheirodendron trigynum* is typically absent or has low cover (<10%) and is not co-dominant. ***Metrosideros polymorpha* / *Cibotium* spp. Montane Wet Forest (F_MECI)**
- 19b. Subcanopy and understory not dominated by *Cibotium* spp. *Cheirodendron* spp. is absent or has low cover (<5%). Understory is strongly dominated by *Dicranopteris* spp. **20**
- 20a. Montane forests and woodlands found in boggy areas with substrates typically saturated year-round. The dominant over story species; *Metrosideros polymorpha* is often low and scrubby. The understory is dominated by ferns *Dicranopteris linearis* and *Lycopodiella cernua* ***Metrosideros polymorpha* / *Dicranopteris* spp. / *Lycopodiella cernua* Montane Wet Bog Scrub Woodland [Provisional] (W_MEDI_LY)**
- 20b. Montane forests and woodlands found in wet areas, but not perennially saturated boggy areas. The fern *Dicranopteris linearis* strongly dominates the understory with high cover (50% or more). ***Metrosideros polymorpha* / *Dicranopteris linearis* Montane Wet Woodland (W_MEDI_M)**
- 21a. Forests and woodlands with canopies dominated by *Prosopis pallida* often with a tall shrub layer dominated by *Leucaena leucocephala*. Understory typically dominated by introduced grasses or sparse. ***Prosopis pallida* Coastal Dry Semi-natural Woodland (W_PRPA)**
- 21b. Forests and woodlands not as above **22**
- 22a. Forests and woodlands with canopies dominated by *Casuarina equisetifolia* and/or *Casuarina glauca*. Stands typically originated as plantations, but have naturalized and invade surrounding areas. ***Casuarina (equisetifolia, glauca)* Semi-natural/Planted Forest (F_CASU)**
- 22b. Forests and woodlands not as above **23**

23a. Forests and woodlands with canopies dominated by <i>Terminalia catappa</i> . Other common tree species may include <i>Aleurites moluccana</i> , <i>Melia azedarach</i> , or <i>Syzygium cumini</i> . Common along coast line, where stands tend to be small.....	
..... <i>Terminalia catappa</i> Semi-natural Woodland [Park Special] (W_TECA)	
23b. Forests and woodlands not as above	24
24a. Forests and woodlands with tree canopy dominated by <i>Thevetia peruviana</i>	
..... <i>Thevetia peruviana</i> Semi-natural Woodland [Park Special] (W_THPE)	
24b. Forests and woodlands not as above	25
25a. Former plantation areas dominated by <i>Eucalyptus</i> spp.	26
25b. Forests and woodlands not as above	27
26a. Former plantation areas strongly dominated by <i>Eucalyptus robusta</i> . Other common tree species may include <i>Aleurites moluccana</i> , <i>Psidium cattleianum</i> , <i>Acacia melanoxylon</i> or <i>Syzygium cumini</i> . Naturalized stands may have significant cover of native trees. This type is common topside.....	
..... <i>Eucalyptus robusta</i> Semi-natural Forest/Plantation (F_EURO)	
26b. Former plantation areas dominated or co-dominated by <i>Eucalyptus globulus</i> and/or <i>Eucalyptus saligna</i> . Other common tree species may include <i>Acacia melanoxylon</i> or <i>Psidium cattleianum</i>	
..... <i>Eucalyptus</i> spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional] (F_EUMS)	
27a. Canopy ranges from moderately dense tall woodland to dense scrub woodland strongly dominated by <i>Schinus terebinthifolius</i> (usually 2x cover or more of other tree species). <i>Syzygium cumini</i> is often present, but not co-dominant...	
..... <i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland (W_SCTE_S)	
27b. Forests and woodlands not as above	28
28a. Forests and woodlands with tree canopy strongly dominated by <i>Syzygium cumini</i> (usually 2x cover or more of other tree species). Other introduced trees are commonly present, but not co-dominant except for <i>Schinus terebinthifolius</i> . Occasional, emergent <i>Samanea saman</i> or <i>Phoenix dactylifera</i> trees may be present locally.....	
..... <i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest (F_SYCU)	
28b. Forests and woodlands not as above	29
29a. Forests and woodlands with canopies dominated by <i>Psidium cattleianum</i> . <i>Psidium guajava</i> , <i>Schinus terebinthifolius</i> , and <i>Syzygium cumini</i> are often present to co-dominant.....	
..... <i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest (F_PSCA)	
29b. Forests and woodlands not as above	30
30a. Forests and woodlands with canopies dominated by <i>Acacia confusa</i> with <i>Psidium guajava</i> co-dominant. The stand was naturalized, not a plantation.....	
..... <i>Acacia confusa</i> – <i>Psidium guajava</i> Semi-natural Forest [Park Special] (F_ACPS)	
30b. Forests and woodlands not as above	31

31a. Forests and woodlands with canopies dominated by <i>Psidium guajava</i> . Other introduced trees are common. Understory is often disturbed and dominated by introduced species of <i>Ageratina</i> , <i>Andropogon</i> , <i>Cenchrus</i> , <i>Cyclosorus</i> , <i>Digitaria</i> , or <i>Erigeron</i>	<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest (F_PSGU)
31b. Forests and woodlands not as above	32
32a. Open woodlands (10-25 % cover) with tree canopies co-dominated by <i>Phoenix dactylifera</i> , <i>Schinus terebinthifolius</i> , and <i>Syzygium cumini</i> . Stands are found on open slopes near mouth of Waikolu Valley. <i>Phoenix dactylifera</i> is the indicator species and may co-dominate with low cover (2-5% cover) in the very open stands. The single plot had high cover of <i>Ageratina riparia</i> , <i>Erigeron karvinskianus</i> , and other introduced species.....	<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Park Special] (W_PHSCSY)
32b. Forests and woodlands not as above	33
33a. Forests and woodlands with canopies dominated by <i>Grevillea robusta</i> . Type occurs topside, often in mixed stands with <i>Acacia confusa</i> , <i>Eucalyptus robusta</i> , or <i>Psidium cattleianum</i>	<i>Grevillea robusta</i> Lowland Mesic Semi-natural Forest (F_GRRO)
33b. Forests and woodlands not as above	34
34a. Forests and woodlands with canopies dominated by <i>Coffea Arabica</i> . Stands in Waikolu Valley appear semi-natural (not planted), but other stands might be planted and be better classified as Mixed Forest Plantation.....	<i>Coffea arabica</i> Semi-Natural Forest [Park Special] (F_COAR)
34b. Forests and woodlands not as above	35
35a. Plantation forests and woodlands with canopies dominated by <i>Cryptomeria japonica</i> , <i>Melaleuca quinquenervia</i> , <i>Pinus elliottii</i> , <i>P. radiata</i> or <i>Syncarpia glomulifera</i> . Other introduced trees are common.....	Mixed Forest Plantation [Park Special] (F_MIXED)
35b. Forests and woodlands not as above	Unclassified Forest or Woodland at KALA

Key to Shrubland

- 1a. Shrublands dominated by *Agave sisalana*, *Heliotropium amplexicaule*, *Lantana camara*, *Leucaena leucocephala*, *Senna occidentalis*, *Turnera ulmifolia*, wind-dwarfed *Psidium guajava*, or other non-native shrubs 2
- 1b. Shrublands dominated by thicket forming fern *Dicranopteris linearis*, *Euphorbia celastroides*, *Scaevola taccada*, *Sida fallax* and/or *Wikstroemia uva-ursi*, or other native shrub 7

- 2a. Shrublands characterized by moderately dense to dense shrub layer of *Agave sisalana*. Scattered trees may be present up to 10% cover. Common near mouth of Waikolu Valley.....***Agave sisalana* Semi-natural Shrubland [Park Special] (S_AGSI)**
- 2b. Shrublands dominated by *Heliotropium amplexicaule*, *Lantana camara*, *Leucaena leucocephala*, *Senna occidentalis*, *Turnera ulmifolia*, shrubby *Psidium guajava*, or other non-native shrubs.....3

- 3a. Shrublands characterized by an open to moderately dense shrub layer of *Heliotropium amplexicaule*.....***Heliotropium amplexicaule* Semi-natural Shrubland [Park Special] (S_HEAM)**
- 3b. Shrublands dominated by *Lantana camara*, *Leucaena leucocephala*, *Senna occidentalis*, *Turnera ulmifolia*, shrubby *Psidium guajava*, or other non-native shrubs 4

- 4a. Shrublands dominated by wind-dwarfed (mostly <1 m tall), *Psidium guajava* growing on exposed slopes at the mouth of Waikolu Valley. *Lantana camara* typically co-dominates the short shrub layer.....***Psidium guajava* - *Lantana camara* Semi-natural Shrubland [Park Special] (S_PSLA)**
- 4b. Shrublands dominated by *Lantana camara*, *Leucaena leucocephala*, or other non-native shrubs. *Psidium guajava* is absent or has low cover.....5

- 5a. Shrublands dominated by *Lantana camara*. *Senna occidentalis* may be co-dominant. Understories of non-native grasses may be common.....***Lantana camara* Semi-natural Shrubland [Provisional] (S_LACA)**
- 5b. Shrublands dominated by *Leucaena leucocephala* or other non-native shrubs.....6

- 6a. Shrublands dominated by *Leucaena leucocephala*.....***Leucaena leucocephala* Lowland Dry Semi-natural Shrubland (S_LELE)**
- 6b. Shrublands dominated by other non-native shrubs **Unclassified Semi-natural Shrubland at KALA**

- 7a. Shrublands dominated by dense cover of or thicket forming fern *Dicranopteris linearis*.....***Dicranopteris linearis* Wet Herbaceous Mat (H_DILL_W)**
- 7b. Shrublands dominated by *Euphorbia celastroides*, *Scaevola taccada*, *Sida fallax* and/or *Wikstroemia uva-ursi* or other native shrubs 8

- 8a. Shrublands dominated by *Euphorbia celastroides*.....
..... ***Euphorbia celastroides* Coastal Dry Dwarf-shrubland³ (S_EUCE)**
- 8b. Shrublands dominated by *Scaevola taccada*, *Sida fallax* and/or *Wikstroemia uva-ursi* or other native shrubs.....**9**
- 9a. Shrublands typically strongly dominated by *Scaevola taccada*, but sometimes co-dominated by *Sida fallax* or *Wikstroemia uva-ursi* var. *uva-ursi*.....***Scaevola taccada* Coastal Dry Shrubland¹ (S_SCTA)**
- 9b. Shrublands dominated by *Sida fallax* and/or *Wikstroemia uva-ursi*. *Scaevola taccada* absent or has less cover than *Sida fallax* or *Wikstroemia uva-ursi* **10**
- 10a. Shrublands dominated by *Sida fallax*. *Wikstroemia uva-ursi* is absent or is present with low cover.....
.....***Sida fallax* Coastal Dry Shrubland (S_SIFA)**
- 10b. Shrublands not dominated by *Sida fallax*..... **11**
- 11a. Shrublands dominated by *Wikstroemia uva-ursi*.....**12**
- 11b. Shrublands dominated by other native shrubs. If *Wikstroemia uva-ursi* is present, then it has low cover
.....**Unclassified Native Shrubland at KALA**
- 12a. Open shrublands dominated by *Wikstroemia uva-ursi* with *Sida fallax* co-dominant.....
.....***Wikstroemia uva-ursi* - *Sida fallax* Coastal Shrubland (S_WISI)**
- 12b. Open shrublands dominated by *Wikstroemia uva-ursi* with *Sida fallax* absent or with low cover. *Fimbristylis cymosa* is present to dominant in herbaceous layer and diagnostic. Other grasses may be more common such as *Cynodon dactylon* and *Digitaria ciliaris*.....
.....***Wikstroemia uva-ursi* / *Fimbristylis cymosa* Mixed Grass Coastal Shrubland [Park Special] (S_WIFI)**

Herbaceous Key

- 1a. Vegetation dominated by dense cover of thicket forming fern *Dicranopteris linearis*, often on wet steep slopes.....
.....***Dicranopteris linearis* Wet Herbaceous Mat (H_DILI_W)**
- 1b. Vegetation dominated by other species.....2
- 2a. Herbaceous vegetation co-dominated by native *Cyclosorus dentatus* and introduced species *Hedychium coronarium* and *Coix lacryma-jobi*. A single stand was sampled near a waterfall, but other stands were observed in saturated valley bottom areas. This represents wet, mixed non-native species dominated herbaceous vegetation.....***Cyclosorus dentatus* - *Hedychium coronarium* - *Coix lacryma-jobi* Semi-natural Herbaceous Vegetation [Park Special]² (H_CYHECO)**
- 2b. Herbaceous vegetation dominated by *Sesuvium portulacastrum* and/or various other herbaceous species 3
- 3a. Native coastal vegetation dominated by *Sesuvium portulacastrum*.....
.....***Sesuvium portulacastrum* Coastal Dry Herbaceous Vegetation (H_SEPO)**
- 3b. Herbaceous vegetation dominated by other species.....4
- 4a. Native coastal vegetation dominated or co-dominated by *Fimbristylis cymosa*. This type is often degraded with non-native species present to co-dominant such as *Cynodon*.
.....***Fimbristylis* spp. Coastal Dry Herbaceous Vegetation (H_FIMB)**
- 4b. Grasslands dominated by other species.....5
- 5a. Grasslands dominated by non-native species such as *Andropogon virginicus*, *Axonopus fissifolius*, *Cynodon dactylon*, *Digitaria ciliaris*, *Melinis minutiflora*, *Paspalum conjugatum*, or *Sacciolepis indica*.....6
- 5b. Grasslands dominated by other native species**Unclassified Native Herbaceous Vegetation KALA**
- 6a. Grasslands strongly dominated by *Melinis minutiflora* with *Schizachyrium condensatum* absent to co-dominant. *Andropogon virginicus* and *Digitaria ciliaris* may be present, but are not co-dominant. Scattered trees may be present. If tree cover is 10-15% cover then grass cover is very high (>75%).....
.....***Melinis minutiflora*- (*Schizachyrium condensatum*) Semi-natural Herbaceous Vegetation (H_MESC)**
- 6b. Grasslands co-dominated by other non-native species such as *Axonopus fissifolius*, *Cynodon dactylon*, *Paspalum conjugatum*, or *Sacciolepis indica*.....7
- 7a. Grasslands dominated or co-dominated by *Paspalum conjugatum*, *Sacciolepis indica*, *Axonopus fissifolius* and/or *Andropogon virginicus*.....***Paspalum conjugatum* - *Sacciolepis indica* - *Axonopus fissifolius* Mixed Semi-natural Herbaceous Vegetation [Provisional] (H_PASAAX)**
- 7b. Grasslands dominated or co-dominated by other non-native species such as *Cynodon dactylon* and *Digitaria ciliaris*. Native species such as *Fimbristylis cymosa* are typically absent or have low cover.....8

- 8a. Grasslands dominated or co-dominated by *Cynodon dactylon* and *Digitaria ciliaris*. Native species such as *Fimbristylis cymosa* are typically absent or have low cover.....
.....***Cynodon dactylon* - Mixed Grass Pacific Semi-natural Herbaceous Vegetation (H_CYMI)**
- 8b. Grasslands dominated or co-dominated by other non-native species.....
.....**Unclassified Non-native Herbaceous Vegetation KALA**

¹USNVC name *Scaevola sericea* modified to *Scaevola taccada* based on taxonomy of Wagner et al. (2012).

²USNVC name *Christella dentata* modified to *Cyclosorus dentatus* based on taxonomy of Wagner et al. (2012).

³USNVC name *Chamaesyce celastroides* modified to *Euphorbia celastroides* based on taxonomy of Wagner et al. (2012).

Appendix D: Vegetation Association Descriptions

NATIONAL VEGETATION CLASSIFICATION

Vegetation Communities of Kalaupapa National Historical Park

15 February 2013

by

NatureServe

4600 North Fairfax Drive, 7th Floor

Arlington, VA 22203

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This subset of the International Ecological Classification Standard covers vegetation communities of Kalaupapa National Historical Park. This classification has been developed in consultation with many individuals and agencies and incorporates information from a variety of publications and other classifications. Comments and suggestions regarding the contents of this subset should be directed to Mary J. Russo, Central Ecology Data Manager, Durham, NC mary_russo@natureserve.org, and/or Keith Schulz, Vegetation Ecologist, Boulder, CO <keith_schulz@natureserve.org>.



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¹ NatureServe is an international organization including NatureServe regional offices, a NatureServe central office, U.S. State Natural Heritage Programs, and Conservation Data Centres (CDC) in Canada and Latin America and the Caribbean. Ecologists from the following organizations have contributed the development of the ecological systems classification:

United States

Central NatureServe Office, Arlington, VA; Eastern Regional Office, Boston, MA; Midwestern Regional Office, Minneapolis, MN; Southeastern Regional Office, Durham, NC; Western Regional Office, Boulder, CO; Alabama Natural Heritage Program, Montgomery AL; Alaska Natural Heritage Program, Anchorage, AK; Arizona Heritage Data Management Center, Phoenix AZ; Arkansas Natural Heritage Commission Little Rock, AR; Blue Ridge Parkway, Asheville, NC; California Natural Heritage Program, Sacramento, CA; Colorado Natural Heritage Program, Fort Collins, CO; Connecticut Natural Diversity Database, Hartford, CT; Delaware Natural Heritage Program, Smyrna, DE; District of Columbia Natural Heritage Program/National Capital Region Conservation Data Center, Washington DC; Florida Natural Areas Inventory, Tallahassee, FL; Georgia Natural Heritage Program, Social Circle, GA; Great Smoky Mountains National Park, Gatlinburg, TN; Gulf Islands National Seashore, Gulf Breeze, FL; Hawaii Natural Heritage Program, Honolulu, Hawaii; Idaho Conservation Data Center, Boise, ID; Illinois Natural Heritage Division/Illinois Natural Heritage Database Program, Springfield, IL; Indiana Natural Heritage Data Center, Indianapolis, IN; Iowa Natural Areas Inventory, Des Moines, IA; Kansas Natural Heritage Inventory, Lawrence, KS; Kentucky Natural Heritage Program, Frankfort, KY; Louisiana Natural Heritage Program, Baton Rouge, LA; Maine Natural Areas Program, Augusta, ME; Mammoth Cave National Park, Mammoth Cave, KY; Maryland Wildlife & Heritage Division, Annapolis, MD; Massachusetts Natural Heritage & Endangered Species Program, Westborough, MA; Michigan Natural Features Inventory, Lansing, MI; Minnesota Natural Heritage & Nongame Research and Minnesota County Biological Survey, St. Paul, MN; Mississippi Natural Heritage Program, Jackson, MI; Missouri Natural Heritage Database, Jefferson City, MO; Montana Natural Heritage Program, Helena, MT; National Forest in North Carolina, Asheville, NC; National Forests in Florida, Tallahassee, FL; National Park Service, Southeastern Regional Office, Atlanta, GA; Navajo Natural Heritage Program, Window Rock, AZ; Nebraska Natural Heritage Program, Lincoln, NE; Nevada Natural Heritage Program, Carson City, NV; New Hampshire Natural Heritage Inventory, Concord, NH; New Jersey Natural Heritage Program, Trenton, NJ; New Mexico Natural Heritage Program, Albuquerque, NM; New York Natural Heritage Program, Latham, NY; North Carolina Natural Heritage Program, Raleigh, NC; North Dakota Natural Heritage Inventory, Bismarck, ND; Ohio Natural Heritage Database, Columbus, OH; Oklahoma Natural Heritage Inventory, Norman, OK; Oregon Natural Heritage Program, Portland, OR; Pennsylvania Natural Diversity Inventory, PA; Rhode Island Natural Heritage Program, Providence, RI; South Carolina Heritage Trust, Columbia, SC; South Dakota Natural Heritage Data Base, Pierre, SD; Tennessee Division of Natural Heritage, Nashville, TN; Tennessee Valley Authority Heritage Program, Norris, TN; Texas Conservation Data Center, San Antonio, TX; Utah Natural Heritage Program, Salt Lake City, UT; Vermont Nongame & Natural Heritage Program, Waterbury, VT; Virginia Division of Natural Heritage, Richmond, VA; Washington Natural Heritage Program, Olympia, WA; West Virginia Natural Heritage Program, Elkins, WV; Wisconsin Natural Heritage Program, Madison, WI; Wyoming Natural Diversity Database, Laramie, WY

Canada

Alberta Natural Heritage Information Centre, Edmonton, AB, Canada; Atlantic Canada Conservation Data Centre, Sackville, New Brunswick, Canada; British Columbia Conservation Data Centre, Victoria, BC, Canada; Manitoba Conservation Data Centre, Winnipeg, MB, Canada; Ontario Natural Heritage Information Centre, Peterborough, ON, Canada; Quebec Conservation Data Centre, Quebec, QC, Canada; Saskatchewan Conservation Data Centre, Regina, SK, Canada; Yukon Conservation Data Centre, Yukon, Canada

Latin American and Caribbean

Centro de Datos para la Conservacion de Bolivia, La Paz, Bolivia; Centro de Datos para la Conservacion de Colombia, Cali, Valle, Columbia; Centro de Datos para la Conservacion de Ecuador, Quito, Ecuador; Centro de Datos para la Conservacion de Guatemala, Ciudad de Guatemala, Guatemala; Centro de Datos para la Conservacion de Panama, Querry Heights, Panama; Centro de Datos para la Conservacion de Paraguay, San Lorenzo, Paraguay; Centro de Datos para la Conservacion de Peru, Lima, Peru; Centro de Datos para la Conservacion de Sonora, Hermosillo, Sonora, Mexico; Netherlands Antilles Natural Heritage Program, Curacao, Netherlands Antilles; Puerto Rico-Departamento De Recursos Naturales Y Ambientales, Puerto Rico; Virgin Islands Conservation Data Center, St. Thomas, Virgin Islands.

NatureServe also has partnered with many International and United States Federal and State organizations, which have also contributed significantly to the development of the International Classification. Partners include the following The Nature Conservancy; Provincial Forest Ecosystem Classification Groups in Canada; Canadian Forest Service; Parks Canada; United States Forest Service; National GAP Analysis Program; United States National Park Service; United States Fish and Wildlife Service; United States Geological Survey; United States Department of Defense; Ecological Society of America; Environmental Protection Agency; Natural Resource Conservation Services; United States Department of Energy; and the Tennessee Valley Authority. Many individual state organizations and people from academic institutions have also contributed to the development of this classification.

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1. Forest to Open Woodland

1.A.2. Tropical Lowland Humid Forest

1.A.2.Oa. Polynesian Lowland Rainforest

M187. Hawaiian Lowland Rainforest

G388. Hawaiian Lowland - Coastal Seasonal Rainforest

Diospyros sandwicensis - *Metrosideros polymorpha* Lowland Mesic Forest

Lama - 'Ōhi'a Lowland Mesic Forest

Identifier: CEG008026

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Hawaiian Lowland Rainforest (M187)
Group	Hawaiian Lowland - Coastal Seasonal Rainforest (G388)
Association	<i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This lowland mesic forest occurs at elevations between 140 and 270 m on steep slopes on all aspects. Landforms are variable and include sideslopes, cliffs and ridges.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This forest association is characterized by a moderate to closed canopy co-dominated by *Diospyros sandwicensis* and *Metrosideros polymorpha*. The non-native tree *Psidium guajava* may codominate some stands. There are no clear dominant shrub species, but taxa may include *Clidemia hirta*, *Pluchea carolinensis*, and *Euphorbia celastroides* var. *amplectens*. The herbaceous layer may be forb- or graminoid-dominated by *Melinis minutiflora*, *Andropogon virginicus*, *Ageratina riparia*, *Erigeron karvinskianus*, or *Kalanchoe pinnata*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Diospyros sandwicensis</i> , <i>Metrosideros polymorpha</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Diospyros sandwicensis*, *Metrosideros polymorpha*

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Ageratina riparia* (non-native\exotic), *Andropogon virginicus* (non-native\exotic), *Erigeron karvinskianus* (non-native\exotic), *Kalanchoe pinnata* (non-native\exotic, Medium/Low), *Melinis minutiflora* (non-native\exotic), *Pluchea carolinensis* (non-native\exotic)

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Waikolu Valley.

Nations: US

States/Provinces: HI:S3

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (3 plots): KALA.0411, KALA.9116, KALA.9118.

Local Description Authors: M. Hall

Global Description Authors:

References: Gagne and Cuddihy 1990, Gon 2008, Western Ecology Working Group n.d.

***Diospyros sandwicensis* - (*Psidium* spp.) Lowland Mesic Woodland**

Lama - (Guava species) Lowland Mesic Woodland

Identifier: CEGL008183

USNVC CLASSIFICATION

Division Polynesian Lowland Rainforest (1.A.2.Oa)

Macrogroup Hawaiian Lowland Rainforest (M187)

Group Hawaiian Lowland - Coastal Seasonal Rainforest (G388)

Association *Diospyros sandwicensis* - (*Psidium* spp.) Lowland Mesic Woodland

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is known from two disturbed sites at 171-279 m in elevation on steep sideslopes near the mouth of a river and above an aqueduct.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This site is characterized by a mixed native and non-native open canopy co-dominated by *Diospyros sandwicensis* and *Psidium cattleianum* and/or *Psidium guajava*. *Metrosideros polymorpha* is absent or has low cover. *Syzygium cumini* may be present as an emergent tree. Shrub cover is sparse to moderate and mostly composed of introduced species such as *Clidemia hirta*, *Lantana camara*, or *Pluchea carolinensis*. The herbaceous layer is dominated by introduced species *Ageratina riparia*, *Erigeron karvinskianus*, *Melinis minutiflora*, and *Nephrolepis brownii*, and native species *Sphenomeris chinensis*. Although significantly degraded by alien species, the dominance or codominance of the characteristic species *Diospyros sandwicensis* is diagnostic of this woodland association.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

Stratum

Tree canopy

Lifeform

Broad-leaved evergreen tree

Species

Diospyros sandwicensis, *Psidium cattleianum*,
Psidium guajava

Herb (field)

Fern or fern ally

Nephrolepis brownii, *Sphenomeris chinensis*

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Diospyros sandwicensis*

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Ageratina riparia* (non-native\exotic), *Clidemia hirta* (non-native\exotic), *Erigeron karvinskianus* (non-native\exotic), *Lantana camara* (non-native\exotic, Medium), *Melinis minutiflora* (non-native\exotic), *Nephrolepis brownii* (non-native\exotic), *Sphenomeris chinensis* (non-native\exotic), *Pluchea carolinensis* (non-native\exotic), *Psidium cattleianum* (non-native\exotic), *Psidium guajava* (non-native\exotic)

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is only sampled from Waikolu Valley, 100 m upstream of aqueduct and west and near river mouth, but it occurs on steep, well-drained walls and ridges directly above valley floors in all major valleys in park.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (2 plots): KALA.0407, KALA.0413.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

***Pandanus tectorius* Coastal Mesic Forest**

Hala Coastal Mesic Forest

Identifier: CEGLO08032

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Hawaiian Lowland Rainforest (M187)
Group	Hawaiian Lowland - Coastal Seasonal Rainforest (G388)
Association	<i>Pandanus tectorius</i> Coastal Mesic Forest

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This forest association is known from elevations below 200 m on gentle to steep slopes. Landforms include ridges and cliffs at low- and high-slope positions.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This uncommon association is characterized by a moderate to dense tree canopy dominated by *Pandanus tectorius*, an early Polynesian introduced species. Canopy associates include Polynesian introduced *Morinda citrifolia* and recently introduced trees *Syzygium cumini* and *Psidium cattleianum*. Shrub diversity is low, and *Pluchea carolinensis* may dominate some stands. Herbaceous cover is low and may be fern-dominated by *Nephrolepis brownii* or by seedlings of canopy trees.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved deciduous tree	<i>Pandanus tectorius</i>
Tall shrub/sapling	Broad-leaved deciduous shrub	<i>Pluchea carolinensis</i>
Herb (field)	Fern or fern ally	<i>Nephrolepis brownii</i>

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Morinda citrifolia* (non-native\exotic), *Nephrolepis brownii* (non-native\exotic), *Psidium cattleianum* (non-native\exotic), *Syzygium cumini* (non-native\exotic)

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Waileia Valley.

Nations: US

States/Provinces: HI:S3

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (2 plots): KALA.0016, KALA.9120.

Local Description Authors: M. Hall

Global Description Authors:

References: Gagne and Cuddihy 1990, Gon 2008, Western Ecology Working Group n.d.

G389. Hawaiian Lowland Rainforest

Metrosideros polymorpha - (*Psidium* spp., *Schinus terebinthifolius*) Woodland

‘Ōhi‘a - (Guava species, Christmas Berry) Woodland

Identifier: CEG008142

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Hawaiian Lowland Rainforest (M187)
Group	Hawaiian Lowland Rainforest (G389)
Association	<i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This lowland rainforest is known from elevations ranging from 500-1000 m. Slopes are moderate to steep and aspects are typically western. Landforms include sideslopes and ridges on mid- to high-slope positions.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by a mixed native and non-native canopy co-dominated by *Metrosideros polymorpha* and introduced trees *Psidium cattleianum*, *Psidium guajava*, and/or *Schinus terebinthifolius*. Other canopy associates may include *Aleurites moluccana*, *Antidesma platyphyllum*, and *Psychotria mariniana*. Constancy in the shrub stratum is low, including a mixture of introduced and native species such as *Clidemia hirta*, *Dicranopteris linearis*, *Dodonaea viscosa*, *Kadua affinis*, *Leptecophylla tameiameia*, *Pluchea carolinensis*, *Rubus rosifolius*, *Scaevola gaudichaudiana*, and *Wikstroemia oahuensis* var. *oahuensis*. The herbaceous layer may be forb- or graminoid-dominated by introduced species *Ageratina riparia*, *Erigeron karvinskianus*, or *Melinis minutiflora*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Metrosideros polymorpha</i> , <i>Psidium cattleianum</i> , <i>Schinus terebinthifolius</i>
Herb (field)	Forb	<i>Ageratina riparia</i> , <i>Erigeron karvinskianus</i>
Herb (field)	Graminoid	<i>Melinis minutiflora</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Metrosideros polymorpha*, *Psidium cattleianum*, *Schinus terebinthifolius*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Kalaupapa Trail, Pu‘u Kauwā Road, Upper Waimanu and Waikolu Valley.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (7 plots): KALA.0205, KALA.0209, KALA.0218, KALA.0220, KALA.0403, KALA.9101, KALA.9110.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

***Metrosideros waialealae* var. *fauriei* Woodland [Park Special]**

***Metrosideros waialealae* var. *fauriei* Woodland¹**

Identifier: CEPS009650

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Hawaiian Lowland Rainforest (M187)
Group	Hawaiian Lowland Rainforest (G389)
Association	<i>Metrosideros waialealae</i> var. <i>fauriei</i> Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This mesic woodland is known from moderate to steep sites on mid- and high-slope positions on ridges at 110-735 m elevation. Aspect is variable with two sites on south slopes and one north-facing.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This Park Special plant community is dominated by the native, sometimes shrubby small tree *Metrosideros waialealae* var. *fauriei*. The canopy is a relatively diverse mixture of native and introduced tree species. Introduced species include *Psidium cattleianum*, *Psidium guajava*, and *Syzygium cumini*, and scattered natives include *Cibotium menziesii*, *Dodonaea viscosa*, *Freycinetia arborea* (liana), *Kadua axillaris*, *Metrosideros polymorpha*, *Psychotria maritima*, and *Wikstroemia oahuensis*. The native fern *Dicranopteris linearis* dominates the understory of two of three plots. Diverse introduced herbaceous species may be present with the grass *Melinis minutiflora*, and ferns *Blechnum appendiculatum*, *Cyclosorus dentatus*, and *Cyclosorus parasiticus* are most abundant.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved deciduous tree	<i>Metrosideros waialealae</i> var. <i>fauriei</i>

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Psidium cattleianum* (non-native\exotic), *Psidium guajava* (non-native\exotic), *Syzygium cumini* (non-native\exotic)

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (2-Dec-2011).

CLASSIFICATION

Status: Nonstandard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This plant community was sampled near lower Pu‘u Kuawa road and on well-drained northeast-facing walls in Waikolu Valley.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (3 plots): KALA.0203, KALA.9100, KALA.9119.

Local Description Authors: M. Hall and K. Schulz

Global Description Authors:

References: Western Ecology Working Group n.d.

M190. Polynesian Ruderal Lowland Rainforest

G390. Polynesian Ruderal Lowland Rainforest

***Casuarina (equisetifolia, glauca)* Semi-natural/Planted Forest**

Common Ironwood Semi-natural/Planted Forest¹

Identifier: CEGLO08182

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Polynesian Semi-natural Lowland Rainforest (M190)
Group	Polynesian Semi-natural Lowland Rainforest (G390)
Association	<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This non-native plantation association is known from lower elevations from 150-550 m on gentle to moderate slopes at all aspects. The competitive nature of the nominal species allows for a broad ecological amplitude, and it may occupy a variety of landforms and positions including sideslopes, ridges, and plateaus.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by near monotypic stands of *Casuarina equisetifolia* which was planted in the 1930s in an effort to stabilize degraded areas as a result of overgrazing. No other canopy trees were documented nor are there any understory species which appear associated to warrant inclusion in the description or association name.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Casuarina equisetifolia</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Casuarina equisetifolia*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (modified/managed) (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Pālā‘au State Park, Ironwood Plantation, along the western coastline of the peninsula, and in Crater Management Unit.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (5 plots): KALA.0202, KALA.0211, KALA.0212, KALA.9003, KALA.9107.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

Eucalyptus robusta Semi-natural Forest/Plantation

Swamp Mahogany Semi-natural Forest/Plantation

Identifier: CEG008143

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Polynesian Ruderal Lowland Rainforest (M190)
Group	Polynesian Ruderal Lowland Rainforest (G390)
Association	<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This semi-natural forest association may occur from near sea level to 1100 m elevation and was planted originally on sites too steep for agriculture, although the community has colonized more level areas. Soils tend towards basaltic parent material and are strongly acidic.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by a mixed non-native and native species composition. Canopies are clearly dominated by *Eucalyptus robusta* as some stands were planted. There are lesser amounts of *Psidium cattleianum*, *Cheirodendron trigynum* ssp. *trigynum*, and *Metrosideros polymorpha*. Shrubs contribute little cover and have low species constancy, but may include *Coprosma foliosa*, *Coprosma ochracea*, *Dodonaea viscosa*, *Kadua affinis*, *Leptecophylla tameiameia*, *Rubus argutus*, *Vaccinium reticulatum*, and *Wikstroemia oahuensis* var. *oahuensis*. The herbaceous layer may have a variety of forbs, ferns, and grasses, occurring in low cover and constancy.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

Stratum

Tree canopy

Lifeform

Broad-leaved evergreen tree

Species

Eucalyptus robusta

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Eucalyptus robusta*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (ruderal) (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Pālā‘au State Park, Kamakou Preserve, and Waikolu Valley Rim Eucalyptus plantations (Kahanui).

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (6 plots): KALA.0213, KALA.0214, KALA.0226, KALA.0229, KALA.0230, KALA.0242.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

Eucalyptus spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional]

Eucalyptus - Mixed Alien Semi-natural Forest/Plantation

Identifier: CEG008144

USNVC CLASSIFICATION

Division Polynesian Lowland Rainforest (1.A.2.Oa)

Macrogroup Polynesian Semi-natural Lowland Rainforest (M190)

Group Polynesian Semi-natural Lowland Rainforest (G390)

Association *Eucalyptus* spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional]

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This non-native association is known from two locations ranging from 470-1015 m in elevation on gentle to nearly flat slopes on a plateau and high-level ridge. This is a broadly defined forest type composed of various combinations of non-native tree species; it that needs more plot data and further analysis to determine types with confidence. However it is not dominated by *E. robusta* as that is separate type.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: The composition of this association is largely non-native and characterized by an open canopy dominated or co-dominated by *Eucalyptus globulus* and/or *Eucalyptus saligna*. *Acacia melanoxylon* or *Psidium cattleianum* may codominate at some

sites. Native trees *Psydrax odorata* and *Metrosideros polymorpha* may be present but do not dominate. Shrubs are nearly absent and the herbaceous layer is very sparse.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved deciduous tree	<i>Eucalyptus saligna</i>
Tree canopy	Broad-leaved evergreen tree	<i>Eucalyptus globulus</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Eucalyptus globulus*, *Eucalyptus saligna*

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Acacia melanoxylon* (non-native\exotic, Medium/Insignificant), *Psidium cattleianum* (non-native\exotic)

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (modified/managed) (5-Dec-2011).

CLASSIFICATION

Status: Provisional

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from two locations: lower Pālā‘au State Park and lower Kahanui in Waimanu.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (2 plots): KALA.9104, KALA.9106.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

Grevillea robusta Lowland Mesic Semi-natural Forest

Silk Oak Lowland Mesic Semi-natural Forest¹

Identifier: CEGl008113

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Polynesian Semi-natural Lowland Rainforest (M190)
Group	Polynesian Semi-natural Lowland Rainforest (G390)
Association	<i>Grevillea robusta</i> Lowland Mesic Semi-natural Forest

ELEMENT CONCEPT

Global Summary: A forest type dominated by *Grevillea robusta* occupying disturbed mesic forest areas.

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is known from only one location on a plantation at 516 m in elevation. The plantation is on a plateau with a gentle slope.

Global Environment: Typically found in well-developed soils between about 300-1200 m (1000-4000 feet) elevation, dry to mesic moisture conditions.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This site is characterized by an open canopy dominated by *Grevillea robusta*. Other canopy species present include *Acacia confusa*, *Eucalyptus robusta*, *Psidium cattleianum*, and *Psidium guajava*. The shrub and herbaceous layers are generally sparse with a few scattered trees seedlings and ferns such as *Microlepia strigosa*.

Global Vegetation: Typically open-canopy forest dominated by *Grevillea robusta*, commonly 10 to >15 m height. Allelopathic leaf litter suppresses understory growth. Understory often sparse, but may include a variable set of native and alien shrub and grass species.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Grevillea robusta</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Grevillea robusta*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (invasive) (24-Jan-2003).

CLASSIFICATION

Status: Provisional

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association was only sampled from lower Pālā‘au State Park.

Global Range: In Hawaii, escaped from silvicultural plantings and forming dominant stands on the islands of Kaua‘i, O‘ahu, Maui and Hawai‘i. Also found in French Polynesia and Micronesia, Lord Howe Island, Niue, Norfolk Island, Tonga, and Christmas Island.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (1 plot): KALA.0215.

Local Description Authors: M. Hall

Global Description Authors: S. Gon and L. Durand

References: Gagne and Cuddihy 1990, Wagner et al. 1999, Wagner et al. 2012. Western Ecology Working Group n.d.

***Psidium cattleianum* Lowland Wet Semi-natural Forest**

Strawberry Guava Lowland Wet Semi-natural Forest

Identifier: CEGLO08116

USNVC CLASSIFICATION

Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Polynesian Semi-natural Lowland Rainforest (M190)
Group Polynesian Semi-natural Lowland Rainforest (G390)
Association *Psidium cattleianum* Lowland Wet Semi-natural Forest

ELEMENT CONCEPT

Global Summary: Alien forest invading and displacing lowland wet settings in the Hawaiian Islands.

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This semi-natural association is found typically below 300 m in elevation on disturbed slopes and broad ridges. Slopes may be nearly flat to very steep on all aspects.

Global Environment: Wet to mesic settings, steep to flat slopes, all aspects, typically below 1200 m (4000 feet) elevation.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: The composition of this association is largely non-native with dense canopies dominated by *Psidium cattleianum* with lesser amounts of *Schinus terebinthifolius* and *Syzygium cumini*. *Aleurites moluccana*, *Diospyros sandwicensis*, *Pandanus tectorius*, and *Psydrax odorata* may also be present with low cover. The understory is composed of a variety of non-native shrubs and herbs, none of which appear to have an affinity to this semi-natural community.

Global Vegetation: Very dense canopy, 2-5 m, occasionally 5-10 m tall. It forms dense thickets of slender-stemmed individuals and is often monotypic.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Psidium cattleianum</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Psidium cattleianum*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (invasive) (24-Jan-2003).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association occurs in Wai‘ale‘ia Valley and on the west bank south of the pumphouse in Waihānau and in Kalawao below pali on lower plateau.

Global Range: *Psidium cattleianum* is one of the worst invasive species in forests of Hawaii, Tahiti, La Réunion and Mauritius.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (7 plots): KALA.0014, KALA.0015, KALA.0237, KALA.0244, KALA.0246, KALA.9005, KALA.9112.

Local Description Authors: M. Hall

Global Description Authors: S. Gon and L. Durand

References: Gagne and Cuddihy 1990, Wagner et al. 1999, Wagner et al. 2012 Western Ecology Working Group n.d.

***Psidium guajava* / Disturbed Understory Semi-natural Forest**

Common Guava / Disturbed Understory Semi-natural Forest¹

Identifier: CEGLO08147

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Polynesian Semi-natural Lowland Rainforest (M190)
Group	Polynesian Semi-natural Lowland Rainforest (G390)
Association	<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This non-native association occurs at elevations below 600 m on mostly disturbed sites. Occurrences can be found on cliffs, sideslopes and plateaus on high-level, midslope, low-level and low-slope positions. Sites are steep to nearly flat on mostly northerly aspects.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: The composition of this association is diverse but largely non-native with canopies dominated by *Psidium guajava* and lesser amounts of *Acacia confusa*, *Aleurites moluccana*, *Phytolacca octandra*, *Pluchea carolinensis*, *Schinus terebinthifolius*, and *Syzygium cumini*. The understory is composed of a variety of non-native shrubs and herbs, none of which appear to have an affinity to this semi-natural community.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved deciduous tree	<i>Acacia confusa</i>
Tree canopy	Broad-leaved evergreen tree	<i>Psidium guajava</i> , <i>Schinus terebinthifolius</i> , <i>Syzygium cumini</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Psidium guajava*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (ruderal) (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from near Kalaupapa trailhead Pālā‘au State Park, the valley floor and lower slopes in Waikolu Valley and Upper Rim in upper Kalaupapa Trail.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (4 plots): KALA.0216, KALA.0219, KALA.0404, KALA.9115.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

Schinus terebinthifolius Semi-natural Scrub Woodland

Christmas Berry Semi-natural Scrub Woodland¹

Identifier: CEG008148

USNVC CLASSIFICATION

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Polynesian Semi-natural Lowland Rainforest (M190)
Group	Polynesian Semi-natural Lowland Rainforest (G390)
Association	<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This scrub woodland association is known from a range of elevations from coastal areas to slopes as high as 1000 m often on former agricultural sites and pasturelands, but may also occupy recent lava flows. Topographic positions include low slopes, low-level areas, middle and high slopes. Substrates may be extremely rocky and vary from dry to moist.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by an open to closed canopy dominated by the introduced species *Schinus terebinthifolius*, which occurs both as a small tree or shrub (scrub) forms. Other non-native species may share the canopy, including *Acacia confusa*, *Psidium cattleianum*, and *Syzygium cumini*, but they do not codominate. Occasional, emergent *Samanea saman* or *Phoenix dactylifera* trees may be present locally. However, where *Schinus terebinthifolius* forms dense canopies, few others may coexist. The understory varies from sparse to densely dominated by non-native tree saplings and shrubs, especially *Indigofera suffruticosa*, *Senna alata*, and *Senna occidentalis*. A variety of herbaceous species may occur, but none dominate consistently across stands. Species may include *Ageratina riparia*, *Chamaecrista nictitans* ssp. *patellaria* var. *glabrata*, *Cyperus gracilis*, *Kalanchoe pinnata*, *Nephrolepis brownii*, *Oxalis corniculata*, and *Turnera ulmifolia*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

Stratum

Tree canopy

Lifeform

Broad-leaved evergreen tree

Species*Psidium cattleianum*, *Schinus terebinthifolius*,
*Syzygium cumini***CHARACTERISTIC SPECIES****Kalaupapa National Historical Park:** *Schinus terebinthifolius***CONSERVATION STATUS RANK****Global Rank & Reasons:** GNA (ruderal) (5-Dec-2011).**CLASSIFICATION****Status:** Standard**ELEMENT DISTRIBUTION****Kalaupapa National Historical Park Range:** This association is known from Waikolu Valley northwest of pump station, Waihānau lower West Pali and northwest of water station, East and West Makana lua Peninsula, East Crater and Pu‘u ‘Uao, Kalaupapa north of ‘Īlio pi‘i and Upper Kalaupapa Trail, Kalawao upper pali, and Kauhakō Crater.**Nations:** US**States/Provinces:** HI**Federal Lands:** NPS (Kalaupapa)**ELEMENT SOURCES****Kalaupapa National Historical Park Plots and Observation Points:** (14 plots): KALA.0008, KALA.0020, KALA.0036, KALA.0037, KALA.0038, KALA.0039, KALA.0040, KALA.0239, KALA.0240, KALA.0243, KALA.0430, KALA.9002, KALA.9108, KALA.9111.**Local Description Authors:** M. Hall, mod. K. Schulz**Global Description Authors:****References:** Western Ecology Working Group n.d.***Syzygium cumini* Lowland Mesic Semi-natural Forest****Java Plum Lowland Mesic Semi-natural Forest****Identifier:** CEGLO08111**USNVC CLASSIFICATION**

Division	Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup	Polynesian Semi-natural Lowland Rainforest (M190)
Group	Polynesian Semi-natural Rainforest (G390)
Association	<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest

ELEMENT CONCEPT**Global Summary:** Riparian forest type dominated by the fast-growing invasive tree *Syzygium cumini*.**ENVIRONMENTAL DESCRIPTION****Kalaupapa National Historical Park Environment:** This lowland mesic forest is known from elevations ranging from 50-200 m on gentle to steep slopes with variable aspects. Occurrences are typically on riparian zones and low slopes, but may occasionally be found on ridgetops and talus.

Global Environment: Dry to mesic settings, along riparian corridors, typically on substrates of weathered basalt, largely below 600 m (2000 feet) elevation.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This semi-natural forest association has open to dense canopies dominated by *Syzygium cumini*. Numerous other trees species may occur. *Psidium cattleianum* often dominates the subcanopy. *Schinus terebinthifolius* trees may be present to codominant, but not dominant in this type. Occasional, emergent *Samanea saman* or *Phoenix dactylifera* trees may be present locally. The shrub layer is very sparse, but herbaceous cover varies from sparse to very dense.

Global Vegetation: Canopy dominated by *Syzygium cumini*, typically 5-10 m height, often with alien shrub and grass understory. Allelopathic litter leaves understory sparse.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Psidium cattleianum</i> , <i>Syzygium cumini</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Syzygium cumini*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (invasive) (24-Jan-2003).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from near Wai‘ale‘ia Stream, Makana lua, Kalaupapa peninsula above and below pumphouse in Waihānau, in Waikolu Valley, near Judd Park and Saint Philomena in Kalawao, and at base of pali, above Kalaupapa Trail.

Global Range: In the Hawaiian Islands, along riparian corridors in the lowlands of both windward and leeward slopes on Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i, especially on substrates of weathered basalt. Also found in Micronesia, the Cook Islands, Fiji, French Polynesia, New Caledonia, Tonga and Christmas Island.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (11 plots): KALA.0004, KALA.0005, KALA.0007, KALA.0012, KALA.0013, KALA.0018, KALA.0235, KALA.0236, KALA.0401, KALA.0408, KALA.9117.

Local Description Authors: M. Hall

Global Description Authors: S. Gon and L. Durand

References: Wagner et al. 1999, Wagner et al. (2012). Western Ecology Working Group n.d.

***Terminalia catappa* Semi-natural Woodland [Park Special]**

Pacific Almond Semi-natural Woodland

Identifier: CEPS009651

USNVC CLASSIFICATION

Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Polynesian Semi-natural Lowland Rainforest (M190)
Group Polynesian Semi-natural Lowland Rainforest (G390)
Association *Terminalia catappa* Semi-natural Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This woodland association occurs near the coast on a ridge and colluvium deposit on dry, moderately sloping sites with northerly aspects. Elevation ranges from 21-57 m. Ground surface has high cover of rock or litter.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This semi-natural woodland association is characterized by a moderate tree canopy dominated by the non-native tree *Terminalia catappa*. Other trees present may include *Aleurites moluccana*, *Melia azedarach*, and *Syzygium cumini*. There is little understory present.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Terminalia catappa</i>

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (ruderal) (2-Dec-2011).

CLASSIFICATION

Status: Nonstandard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association was sampled on the Kalaupapa Peninsula near the rock crusher and the lower Kalaupapa Trail.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (2 plots): KALA.0017, KALA.0238.

Local Description Authors: K. Schulz

Global Description Authors:

References: Western Ecology Working Group n.d.

1.A.3. Tropical Montane Humid Forest

1.A.3.Oa. Polynesian Montane & Cloud Forest

M194. Hawaiian Montane & Cloud Forest

G393. Hawaiian Montane Rainforest & Cloud Forest

***Metrosideros polymorpha* - *Cheirodendron trigynum* / (*Cibotium* spp.) Montane Wet Forest**
 ‘Ōhi‘a - ‘Ōlapa / (Hapu‘u species) Montane Wet Forest
 Identifier: CEG008008

USNVC CLASSIFICATION

Division	Polynesian Montane & Cloud Forest (1.A.3.Oa)
Macrogroup	Hawaiian Montane & Cloud Forest (M194)
Group	Hawaiian Montane Rainforest & Cloud Forest (G393)
Association	<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This montane rainforest association occurs at elevations ranging from 1000-1300 m on all aspects and nearly flat to moderately steep slopes. Landforms include ridges, plateaus, recent lava flows and draws at high-slope and high-level positions.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by an open to dense native tree canopy co-dominated by *Metrosideros polymorpha* and *Cheirodendron trigynum*. The subcanopy is dominated by *Cibotium menziesii* and is diverse with associate species including *Coprosma foliosa*, *Coprosma ochracea*, *Kadua axillaris*, *Kadua affinis*, *Ilex anomala*, *Melicope clusiifolia*, *Myrsine lessertiana*, and *Psychotria mauiensis*. The liana *Freycinetia arborea* is often present. Shrub cover is variable and may be sparse to about 50% cover without any clear consistent dominant species. Common species include *Broussaisia arguta*, *Cyrtandra procera*, *Kadua affinis*, *Melicope clusiifolia*, *Rubus rosifolius*, *Vaccinium calycinum*, and *Vaccinium dentatum*. The herbaceous layer is diverse with a mix of grasses, ferns and forbs. The most consistent dominant herbaceous species are *Astelia menziesiana* and the ferns *Elaphoglossum crassifolium* and *Athyrium microphyllum* which may be terrestrial or epiphytic. Other common herbaceous associates include *Adenophorus pinnatifidus* (= var. *pinnatifidus*), *Adenophorus tamariscinus*, *Adenophorus tripinnatifidus*, *Nertera granadensis*, *Dicranopteris linearis*, *Diplazium sandwichianum*, *Diplopterygium pinnatum*, *Elaphoglossum aemulum*, *Grammitis hookeri*, *Peperomia cookiana*, *Peperomia macraeana*, *Peperomia membranacea*, *Sadleria pallida*, and *Vandenboschia davallioides*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Cheirodendron trigynum</i> , <i>Metrosideros polymorpha</i>
Tree canopy	Tree fern	<i>Cibotium menziesii</i>
Herb (field)	Forb	<i>Astelia menziesiana</i>

Herb (field)

Fern or fern ally

Athyrium microphyllum, *Elaphoglossum crassifolium*

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Astelia menziesiana*, *Cheirodendron trigynum*, *Cibotium glaucum*, *Cibotium menziesii*, *Elaphoglossum crassifolium*, *Metrosideros polymorpha*.

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Pu‘u Ali‘i and Waikolu Falls.

Nations: US

States/Provinces: HI:S3

Federal Lands: NPS (Hawai‘i Volcanoes, Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (11 plots): KALA.0024, KALA.0025, KALA.0026, KALA.0029, KALA.0030, KALA.0033, KALA.0034, KALA.0035, KALA.0234, KALA.9021, KALA.9022.

Local Description Authors: M. Hall

Global Description Authors:

References: Gon 2008, Western Ecology Working Group n.d.

Metrosideros polymorpha / *Dicranopteris linearis* Montane Wet Woodland

‘Ōhi‘a / Uluhe Montane Wet Woodland

Identifier: CEG008041

USNVC CLASSIFICATION

Division Polynesian Montane & Cloud Forest (1.A.3.Oa)

Macrogroup Hawaiian Montane & Cloud Forest (M194)

Group Hawaiian Montane Rainforest & Cloud Forest (G393)

Association *Metrosideros polymorpha* / *Dicranopteris* spp. Montane Wet Woodland

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is known from elevations ranging from 950-1300 m on gentle slopes not exceeding 10% with variable aspects. It occurs mostly on flatter areas such as plateaus and ridgetops at high-level positions. Substrates are moist to saturated with an unvegetated surface composed mostly of litter and duff.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This diverse woodland association is characterized by an open canopy dominated by *Metrosideros polymorpha* with the understory heavily dominated by a dense layer of the mat-forming fern *Dicranopteris linearis*, which often forms thickets over a meter deep. Other trees include *Cheirodendron trigynum* ssp. *trigynum* and/or

introduced trees *Psidium cattleianum* or *Eucalyptus saligna*. The understory is largely herbaceous with a few shrubs such as *Coprosma foliosa*, *Dubautia laxa* ssp. *laxa*, *Melicope sessilis*, and *Scaevola gaudichaudiana*. The herbaceous layer is diverse with many species contributing substantial cover collectively, but few species exceeding 1% cover individually. Other important herbaceous species include *Carex alligata*, *Juncus effusus*, *Juncus planifolius*, *Liparis hawaiiensis*, *Machaerina angustifolia*, *Peperomia macraeana*, *Psilotum complanatum*, and *Verbena litoralis*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Metrosideros polymorpha</i>
Herb (field)	Fern or fern ally	<i>Dicranopteris linearis</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Metrosideros polymorpha*

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Eucalyptus saligna* (non-native\exotic), *Psidium cattleianum* (non-native\exotic).

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Lower Kahanui, Upper Waimanu, Pu'u Ali'i, Waikolu Falls and Lower Pu'u Kauwa Road.

Nations: US

States/Provinces: HI:S3

Federal Lands: NPS (Hawai'i Volcanoes, Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (5 plots): KALA.0027, KALA.0206, KALA.0208, KALA.9103, KALA.9109.

Local Description Authors: M. Hall

Global Description Authors:

References: Gagne and Cuddihy 1990, Gon 2008, Western Ecology Working Group n.d.

Metrosideros polymorpha / Mixed Shrub Montane Wet Scrub Forest

‘Ōhi‘a / Mixed Shrub Montane Wet Scrub Forest

Identifier: CEG008152

USNVC CLASSIFICATION

Division	Polynesian Montane & Cloud Forest (1.A.3.Oa)
Macrogroup	Hawaiian Montane & Cloud Forest (M194)
Group	Hawaiian Montane Rainforest & Cloud Forest (G393)
Association	<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This wet scrub forest association occurs on steep, exposed high slopes and buttes with northeastern aspects. Elevation for the two sample sites is approximately 1100 m elevation. Substrates include weathered pāhoehoe. These sites are very wet and windy, often in clouds.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This scrub forest association is characterized by wind-dwarfed trees, shrubs, diverse ferns and high cover of mosses and lichens. *Metrosideros polymorpha* is the dominant tree species with *Metrosideros waialealae* var. *fauriei* often codominant. *Dodonaea viscosa*, *Leptecophylla tameiameia*, and the widespread non-native *Psidium cattleianum* may be present in the tree canopy. A mixture of shrubs is usually present, including *Alyxia stellata*, *Broussaisia arguta*, *Dubautia linearis* ssp. *linearis*, *Kadua affinis*, *Lysimachia hillebrandii*, *Lythrum maritimum*, *Wikstroemia oahuensis* var. *oahuensis*, *Vaccinium reticulatum*, and widespread non-natives *Rubus argutus*, *Rubus rosifolius*, and *Lythrum maritimum*. Ferns are especially diverse and largely native, occurring terrestrially and epiphytically in this association. Species include *Dicranopteris linearis*, *Dryopteris fusco-atra*, *Dryopteris glabra*, *Elaphoglossum parvisquamaeum*, *Elaphoglossum wawrae*, *Lepisorus thunbergianus*, *Lycopodiella cernua*, *Lycopodium venustum*, *Nephrolepis exaltata* ssp. *hawaiiensis*, *Polypodium pellucidum*, *Cyclosorus sandwicensis*, *Psilotum complanatum*, *Psilotum nudum*, *Sadleria cyatheoides*, and *Sadleria pallida*. The high diversity of ferns and high cover of mosses and lichens are diagnostic of this association. Graminoid and forb species are relatively sparse or have low cover.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved deciduous tree	<i>Metrosideros waialealae</i> var. <i>fauriei</i>
Tree canopy	Broad-leaved evergreen tree	<i>Metrosideros polymorpha</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Alyxia stellata*, *Broussaisia arguta*, *Dodonaea viscosa*, *Dubautia linearis* ssp. *linearis*, *Kadua affinis*, *Lysimachia hillebrandii*, *Metrosideros polymorpha*, *Metrosideros waialealae* var. *fauriei*, *Leptecophylla tameiameia*, *Vaccinium reticulatum*, *Wikstroemia oahuensis* var. *oahuensis*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association was sampled on two sites near Waikolu lookout to the northeast 20 m down pali face and on the east side.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (2 plots): KALA.0227, KALA.0228.

Local Description Authors: M. Hall and K. Schulz

References: Western Ecology Working Group n.d.

1.A.4. Tropical Flooded & Swamp Forest

1.A.4.Ob. Polynesian Flooded & Swamp Forest

M201. Hawaiian Flooded & Swamp Forest

G398. Hawaiian Riparian & Floodplain Forest & Shrubland

Aleurites moluccana Lowland Wet Forest

Kukui Lowland Wet Forest

Identifier: CEGLO08115

USNVC CLASSIFICATION

Division Polynesian Flooded & Swamp Forest (1.A.4.Ob)
Macrogroup Hawaiian Flooded & Swamp Forest (M201)
Group Hawaiian Riparian & Floodplain Forest & Shrubland (G398)
Association *Aleurites moluccana* Lowland Wet Forest

ELEMENT CONCEPT

Global Summary: Alien forest naturalized in riparian, mesic to wet settings in the Hawaiian Islands. Not considered an invasive species (state tree of Hawaii, because of its significance to Hawaiian culture).

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This lowland forest association is known from low elevations ranging from 50-400 m on gentle sideslopes and low-level areas often along gulches and streams.

Global Environment: Lowland, typically riparian settings, well-drained soils.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by a largely non-native species composition. Canopies are open to closed and dominated by *Aleurites moluccana*, an early Polynesian introduced species. *Syzygium cumini* may codominate in some stands. *Aleurites moluccana* forms a spreading canopy and therefore the understory is typically sparse and composed of shade-tolerant species. The shrub layer is often dominated by introduced species and includes *Lantana camara*, *Pluchea carolinensis*, *Psidium cattleianum*, *Psidium guajava*, and *Rubus rosifolius*. Herbaceous species may include *Adiantum hispidulum*, *Adiantum raddianum*, *Ageratina riparia*, *Ageratum conyzoides*, *Cyclosorus dentatus*, *Cyclosorus parasiticus*, *Kalanchoe pinnata*, *Nephrolepis brownii*, *Oxalis corniculata*, *Phymatosorus grossus*, *Polypodium pellucidum*, *Solanum capsicoides*, and *Youngia japonica*.

Global Vegetation: Typically with a closed canopy 5-10 m in height. Often *Aleurites moluccana* is the sole dominant in canopy, but with several tree and shrub species in secondary layers including native and alien taxa.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

Stratum

Tree canopy

Lifeform

Broad-leaved evergreen tree

Species

Aleurites moluccana

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Aleurites moluccana*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (invasive) (26-May-2006).

CLASSIFICATION

Status: Provisional

Global Comments: The concept of "Polynesian Introductions" is a special class of alien species of importance to the indigenous Hawaiian people. Of the approximately 50 plant species considered Polynesian introductions, few have naturalized at all, and only *Aleurites* has naturalized widely enough to establish a dominant canopy and thus an association.

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Waikolu Valley, Waihānau and Wai‘ale‘ia.

Global Range: In Hawaiian Islands, in lowland riparian settings on the islands of Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i. Outside of Hawaii: in Malaysia and western Polynesia; early introduction throughout Polynesia.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (3 plots): KALA.0418, KALA.0241, KALA.0245.

Local Description Authors: M. Hall

Global Description Authors: S. Gon and L. Durand

References: Wagner et al. 1999, Wagner et al. (2012). Western Ecology Working Group n.d.

Hibiscus tiliaceus Lowland Wet Forest [Provisional]

Hau Lowland Wet Forest

Identifier: CEG008163

USNVC CLASSIFICATION

Division	Polynesian Flooded & Swamp Forest (1.A.4.Ob)
Macrogroup	Hawaiian Flooded & Swamp Forest (M201)
Group	Hawaiian Riparian & Floodplain Forest & Shrubland (G398)
Association	<i>Hibiscus tiliaceus</i> Lowland Wet Forest [Provisional]

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is only known from one location at 235 m in elevation on a sideslope with a 15% slope 40 m above an aqueduct. *Hibiscus tiliaceus* forms a dense thicket in wet areas. It is not clear if it should be treated as a community or population.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This site is characterized by an open canopy dominated by *Hibiscus tiliaceus* with a dense shrub understory dominated by *Coffea arabica*, *Clidemia hirta*, and *Aleurites moluccana*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Hibiscus tiliaceus</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Hibiscus tiliaceus*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (5-Dec-2011).

CLASSIFICATION

Status: Provisional

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from one location in Waikolu Valley.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (1 plot): KALA.0405.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

2. SHRUBLAND TO GRASSLAND

2.A.1. Tropical Lowland Grassland, Savanna & Shrubland

2.A.1.OI. Polynesian Lowland Shrubland, Grassland & Savanna

M217. Hawaiian Lowland Shrubland, Grassland & Savanna

G411. Hawaiian Lowland Mesic-Wet Shrubland & Grassland

Dicranopteris linearis Wet Herbaceous Mat

Uluhe Lowland Wet Herbaceous Mat

Identifier: CEGL008048

USNVC CLASSIFICATION

Division	Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup	Hawaiian Lowland Shrubland, Grassland & Savanna (M217)
Group	Hawaiian Lowland Mesic-Wet Shrubland & Grassland (G411)
Association	<i>Dicranopteris linearis</i> Wet Herbaceous Mat

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is only known from one location at 146 m in elevation on a gentle sideslope, but is common vegetation on disturbed areas, including steep slopes and cliffs from low to mid elevations extending into the montane zone.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This site is characterized by a nearly homogenous and very dense layer of the large fern *Dicranopteris linearis* that forms an intertwining mat a meter deep. Individuals of *Metrosideros polymorpha* and *Psidium guajava* are present with low cover.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

Stratum

Herb (field)

Lifeform

Fern or fern ally

Species

Dicranopteris linearis

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Dicranopteris linearis*

CONSERVATION STATUS RANK

Global Rank & Reasons: G4 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association was only sampled from Waikolu Valley.

Nations: US

States/Provinces: HI:S4

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (1 plot): KALA.9113.

Local Description Authors: M. Hall

Global Description Authors:

References: Gon 2008, Western Ecology Working Group n.d.

M220. Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna

G413. Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna

***Cynodon dactylon* - Mixed Grass Pacific Semi-natural Herbaceous Vegetation**

Bermuda Grass - Mixed Grass Pacific Semi-natural Herbaceous Vegetation

Identifier: CEG008167

USNVC CLASSIFICATION

Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.O1)

Macrogroup Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (M220)

Group Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (G413)
Association *Cynodon dactylon* - Mixed Grass Pacific Semi-natural Herbaceous Vegetation

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This semi-natural grassland occurs on coastal areas below 35 m elevation on a low-level shallow drainage channel, an alluvial fan and a sideslope. One plot is close enough to shoreline to get salt spray. Pāhoehoe is exposed on one site. Other sites have mixed alluvium or colluvium. This plant association might also occur away from the coast as *Cynodon dactylon* is a widespread species.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This grassland association is dominated by the introduced perennial grass *Cynodon dactylon*. Other graminoids include *Digitaria ciliaris*, which codominates one stand, and *Kyllinga brevifolia* is frequently present. *Fimbristylis cymosa* is absent or has very low cover. Other herbaceous species, such as *Ageratum conyzoides*, *Ageratina riparia*, *Centella asiatica*, *Conyza bonariensis*, *Desmodium sandwicense*, *Hypochaeris radicata*, *Oxalis corniculata*, and *Xanthium strumarium*, may be present, generally with low cover. Scattered woody species may also be present such as *Lantana camara*, *Pluchea carolinensis*, or *Psidium guajava*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

Stratum

Herb (field)

Lifeform

Graminoid

Species

Cynodon dactylon, *Digitaria ciliaris*

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Cynodon dactylon*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (ruderal) (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This semi-natural grassland occurs on coastal sites at Kalawao, 150 m west of the landing; and on the east and west banks at the river mouth, Waikolu Valley.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (3 plots): KALA.0011, KALA.0402, KALA.0415.

Local Description Authors: M. Hall and K. Schulz

Global Description Authors:

References: Western Ecology Working Group n.d.

***Lantana camara* Semi-natural Shrubland [Provisional]**

Lantana Semi-natural Shrubland¹

Identifier: CEGLO08145

USNVC CLASSIFICATION

Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (M220)
Group Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (G413)
Association *Lantana camara* Semi-natural Shrubland [Provisional]

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This lowland shrub association is known from elevations generally below 50 m on flat to gentle slopes on low-level positions in dry and mesic pastures and forests.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by an open to dense short-shrub layer dominated by *Lantana camara*. A variety of other shrubs may occur, but none codominate. Other shrub associates may include *Amaranthus spinosus*, *Asclepias curassavica*, *Indigofera suffruticosa*, *Phyllanthus debilis*, *Prosopis pallida*, *Senna occidentalis*, and natives *Sida fallax* and *Wikstroemia uva-ursi*. The understory is dominated by introduced forbs or graminoids such as *Digitaria insularis*, *Chamaecrista nictitans* ssp. *patellaria* var. *glabrata*, or *Ageratum conyzoides*. Although there are 4 plots sampled at KALA, they occur in different environments than other *Lantana camara* dominated plots (dry vs wet sites). It is not clear if they represent a new coastal type or variation within the existing NVC provisional type. This type will likely be refined as addition plots are available and analyzed.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Short shrub/sapling	Broad-leaved deciduous shrub	<i>Lantana camara</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Lantana camara*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (invasive) (14-Dec-2011).

CLASSIFICATION

Status: Provisional

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from east of lighthouse on the Makana lua Peninsula, and east pali, top.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (4 plots): KALA.0001, KALA.0023, KALA.0425, KALA.0429.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

***Leucaena leucocephala* Lowland Dry Semi-natural Shrubland**

Koa Haole Lowland Dry Semi-natural Shrubland

Identifier: CEGLO08114

USNVC CLASSIFICATION

Division	Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (M220)
Group	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (G413)
Association	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland

ELEMENT CONCEPT

Global Summary: This shrubland community is found in dry to mesic settings, typically below 457 m (1500 feet) elevation and on leeward settings. It is a disclimax shrubland maintained by fire, but strongly dominant due to allelopathic litter. The vegetation is characterized by a moderately dense, closed-canopy tall-shrub layer (2-5 m tall) that is dominated by nearly monotypic *Leucaena leucocephala*. There is often a sparse low-shrub stratum, though no single taxon is dominant; shrubs include *Sida cordifolia*, *Sida fallax*, *Waltheria indica*, and *Indigofera suffruticosa*. The sparse herbaceous stratum is dominated by *Talinum triangulare* with some *Urochloa maxima* and scattered seedlings of canopy trees, *Kalanchoe pinnata*, *Passiflora foetida*, *Catharanthus roseus*, and *Commelina benghalensis*.

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is known from only one location at a former plantation 30 m in elevation on a low-level plateau.

Global Environment: This shrubland is found in dry to mesic settings, typically below 457 m elevation and on leeward settings.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This site is characterized by a near monoculture of *Leucaena leucocephala* with only a few woody seedlings at trace cover.

Global Vegetation: The vegetation is characterized by a moderately dense, closed-canopy tall-shrub layer (2-5 m tall) that is dominated by nearly monotypic *Leucaena leucocephala*. There is often a sparse low-shrub stratum, though no single taxon is dominant; shrubs may include *Sida cordifolia*, *Sida fallax*, *Waltheria indica*, and *Indigofera suffruticosa*. The sparse herbaceous stratum is dominated by *Talinum triangulare* with some *Urochloa maxima* and scattered seedlings of canopy trees, *Kalanchoe pinnata*, *Passiflora foetida*, *Catharanthus roseus*, and *Commelina benghalensis*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

Stratum

Tree canopy

Lifeform

Broad-leaved deciduous tree

Species*Leucaena leucocephala***CHARACTERISTIC SPECIES****Kalaupapa National Historical Park:** *Leucaena leucocephala***CONSERVATION STATUS RANK****Global Rank & Reasons:** GNA (invasive) (26-May-2006).**CLASSIFICATION****Status:** Standard**Global Comments:** In Hawaii, *Leucaena leucocephala* shrublands are marked by distinct understory grasses and herbs.

This community is found in several Pacific parks including Hawai'i Volcanoes National Park, Pu'uuhonua o Honaunau National Historical Park, Pu'ukoholā Heiau National Historic Site, Haleakelā National Park, American Memorial Park, and War in the Pacific National Historical Park.

Global Similar Associations:

- *Leucaena leucocephala* Shrubland [Provisional] (CEGL004872)

ELEMENT DISTRIBUTION**Kalaupapa National Historical Park Range:** This association is only known from a field behind McVeigh Hall.**Global Range:** This type is dominated by a new-world tropical species that is invasive throughout Polynesia, and has been documented to occur in Hawaii and Guam. In Hawaii, this association covers large portions of leeward dry to mesic regions. Through introductions, it is now virtually pantropical.**Nations:** GU, MP, US**States/Provinces:** HI**Federal Lands:** NPS (American Memorial, Hawai'i Volcanoes, Kalaupapa, Pu'uuhonua o Hōnaunau, War in the Pacific)**ELEMENT SOURCES****Kalaupapa National Historical Park Plots and Observation Points:** (1 plot): KALA.0422.**Local Description Authors:** M. Hall**Global Description Authors:** S. Gon and L. Durand, mod. M.J. Russo**References:** Cogan et al. 2011c, Gagne and Cuddihy 1990, Wagner et al. 1999, Wagner et al. (2012), Western Ecology Working Group n.d.***Melinis minutiflora* - (*Schizachyrium condensatum*) Semi-natural Herbaceous Vegetation****Molasses Grass - (Beardgrass) Semi-natural Herbaceous Vegetation****Identifier:** CEGL008169**USNVC CLASSIFICATION**

Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.O1)

Macrogroup Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (M220)

Group Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (G413)

Association *Melinis minutiflora* - (*Schizachyrium condensatum*) Semi-natural Herbaceous
Vegetation

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This semi-natural association is known from the southwestern lowlands of the park at elevations ranging from 137-245 m. Positions are moderately steep midslopes with northeast and southeast aspects. Ground cover is mostly litter, moss and bedrock.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by dense herbaceous vegetation strongly dominated (40-75% cover) by the non-native grass *Melinis minutiflora* often with *Andropogon virginicus* prominent (5-20% cover). Various non-native trees and shrub species may be present with low cover, and occasionally exceed 10% total cover (up to 20%) when species are mixed and do not form distinct layers. Common non-native trees include *Psidium guajava*, *Phoenix dactylifera*, *Schinus terebinthifolius*, and *Syzygium cumini*. Shrub species *Leptecophylla tameiameia* and non-native *Pluchea carolinensis* are common. Other non-native herbaceous species are prevalent and include *Ageratina riparia*, *Desmodium incanum*, *Digitaria ciliaris*, *Erigeron karvinskianus*, *Nephrolepis brownii*, *Oxalis corniculata*, *Sacciolepis indica*, *Setaria parviflora*. Moss and lichen cover may be abundant. Native vascular species are generally few with low cover.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

Stratum

Herb (field)

Lifeform

Graminoid

Species

Andropogon virginicus, *Digitaria ciliaris*,
Melinis minutiflora

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Melinis minutiflora*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (ruderal) (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This semi-natural association was sampled from Waikolu Valley near the river mouth and midslope on the west side.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Hawai'i Volcanoes, Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (2 plots): KALA.0409, KALA.0412.

Local Description Authors: K.A. Schulz

Global Description Authors:

References: Western Ecology Working Group n.d.

***Paspalum conjugatum* - *Sacciolepis indica* - *Axonopus fissifolius* Mixed Semi-natural Herbaceous Vegetation [Provisional]**

Hilo Grass - Glenwood Grass - Carpetgrass Mixed Semi-natural Herbaceous Vegetation

Identifier: CEG008170

USNVC CLASSIFICATION

Division	Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.O1)
Macrogroup	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (M220)
Group	Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (G413)
Association	<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This semi-natural mixed grassland association occurs on moist to dry sites on moderately high-elevation plateaus (550-970 m). Sites were nearly flat with two of three samples having high cover of bare soil (55-70%).

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This grassland association is composed of a lush mixture of introduced perennial grasses with a few usually codominating. Scattered trees and shrubs are often present, but do not form a distinct tree or shrub canopy (generally <10% cover). One or more of the following grasses dominate or codominate the herbaceous layer: *Paspalum conjugatum*, *Sacciolepis indica*, or *Axonopus fissifolius*. Many other introduced graminoid species may be present such as *Anthoxanthum odoratum*, *Cyperus polystachyos*, *Digitaria ciliaris*, *Kyllinga brevifolia*, *Melinis minutiflora*, *Cenchrus clandestinus*, and *Setaria parviflora* with low cover. However, *Andropogon virginicus* is codominant on one site. Forb cover is variable and relatively sparse. This association is represented by three different plots) dominated by one of several non-native species. This broadly defined association needs further review as more information on the many different non-native dominant grasses becomes available.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Herb (field)	Graminoid	<i>Axonopus fissifolius</i> , <i>Paspalum conjugatum</i> , <i>Sacciolepis indica</i>

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (ruderal) (5-Dec-2011).

CLASSIFICATION

Status: Provisional

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association was sampled in Kalaupapa near Lower Kahanui / Waikolu Rim, near Lower Pu'u Kauwa Road, and in pasture near upper Kalaupapa Trail outside of the park boundaries.

Nations: US
States/Provinces: HI
Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (3 plots): KALA.0204, KALA.0221, KALA.9102.

Local Description Authors: K. Schulz

Global Description Authors:

References: Western Ecology Working Group n.d.

2.A.3. Tropical Scrub & Herb Coastal Vegetation

2.A.3.Ob. Polynesian Scrub & Herb Coastal Vegetation

M231. Hawaiian Scrub & Herb Coastal Vegetation

G421. Hawaiian Dry Scrub & Herb Coastal Strand

Fimbristylis spp. Coastal Dry Herbaceous Vegetation

Fimbristylis species Coastal Dry Herbaceous Vegetation

Identifier: CEGL008089

USNVC CLASSIFICATION

Division	Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup	Hawaiian Scrub & Herb Coastal Vegetation (M231)
Group	Hawaiian Dry Scrub & Herb Coastal Strand (G421)
Association	<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation

ELEMENT CONCEPT

Global Summary: This coastal dry herbaceous vegetation is currently sampled from a single national historical park in Hawaii, and this description is based on occurrences there. Additional global information will be added as it becomes available. This community is found on low slopes near the ocean. Nearly all the ground surface is bedrock (recent lava). This association has sparse cover of monotypic *Fimbristylis cymosa*.

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is known from one location at 50 m in elevation on a recent lava flow bounded to the north and east by the ocean. Soils are shallow and derived of basalt.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This site is characterized mixed native and non-native open herbaceous layer dominated by *Fimbristylis cymosa* with lesser amounts of introduced *Cynodon dactylon*. The dwarf-shrub *Sida fallax* is present with sparse cover.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Herb (field)	Graminoid	<i>Cynodon dactylon</i> , <i>Fimbristylis cymosa</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Cynodon dactylon*, *Fimbristylis cymosa*

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known only from Kalawao near Old Ladies Cave.

Global Range: This community is currently sampled from one national historical park in Hawaii; additional global distribution will be added as it becomes available.

Nations: US

States/Provinces: HI:S3

Federal Lands: NPS (Kalaupapa, Pu‘uhonua o Hōnaunau)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (1 plot): KALA.0006.

Local Description Authors: M. Hall

Global Description Authors: M.J. Russo

References: Cogan et al. 2011c, Gon 2008, Warshauer et al. 2008, Western Ecology Working Group n.d.

Scaevola taccada Coastal Dry Shrubland¹

Naupaka Kahakai Coastal Dry Shrubland

Identifier: CEG008054

USNVC CLASSIFICATION

Division	Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup	Hawaiian Scrub & Herb Coastal Vegetation (M231)
Group	Hawaiian Dry Scrub & Herb Coastal Strand (G421)
Association	<i>Scaevola taccada</i> Coastal Dry Shrubland ¹

ELEMENT CONCEPT

Global Summary: This dry shrubland is currently sampled from two national historical parks in Hawaii, and this description is based on occurrences there. Additional global information will be added as it becomes available. These shrublands are found near the ocean and may be affected by sea spray. The substrate is lava with some coral/beach sand. This is a low, open-canopied shrubland dominated by scattered *Scaevola taccada*, occasionally with *Pluchea carolinensis*. There is often a very sparse tree canopy comprised of *Tournefortia argentea* and a similarly sparse herbaceous layer comprised of trace amounts of *Euphorbia prostrata*, *Passiflora foetida*, *Portulaca pilosa*, *Cynodon dactylon*, *Fimbristylis cymosa*, and *Cenchrus setaceus*.

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This coastal dwarf-shrubland is known from three locations at low elevations of about 30 m or less on low-slope or low-level positions with gentle or flat slopes. Sampled occurrences on the island have a mixture of sandy and basaltic substrates with lava rock strewn throughout, but may also occur on dunes, coral, talus and alluvium.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This dwarf-shrub community is variable and may be sparsely vegetated or have a closed shrub layer dominated by *Scaevola taccada*. Other shrub associates may include *Euphorbia degeneri*, *Sida fallax*, and *Wikstroemia uva-ursi*. The most constant herbaceous associate is the graminoid *Fimbristylis cymosa* which occurs at low cover typically less than 5%. The non-native species *Lantana camara* and *Cynodon dactylon* are known to invade some sites. Forb diversity is low. Species may include *Boerhavia coccinea*, *Euphorbia hirta*, *Heliotropium anomalum* var. *argenteum*, *Ipomoea pes-caprae*, and *Jacquemontia ovalifolia* ssp. *sandwicensis*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Short shrub/sapling	Dwarf-shrub	<i>Scaevola taccada</i>
Herb (field)	Graminoid	<i>Fimbristylis cymosa</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Fimbristylis cymosa*, *Scaevola taccada*

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Cynodon dactylon* (non-native/exotic, Medium/Low)

CONSERVATION STATUS RANK

Global Rank & Reasons: G4 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from the lighthouse, east end of runway, Makana lua North and Ho'olehua northeast of lighthouse.

Global Range: This community is currently sampled from two national historical parks in Hawaii; additional global distribution will be added as it becomes available.

Nations: US

States/Provinces: HI:S3

Federal Lands: NPS (Kalaupapa, Kaloko-Honokohau, Pu'uho'ona o Hōnaunau)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (3 plots): KALA.0002, KALA.0010, KALA.0022.

Local Description Authors: M. Hall

Global Description Authors: M.J. Russo

References: Canfield 1990, Cogan et al. 2011a, Cogan et al. 2011c, Gagne and Cuddihy 1990, Gon 2008, Warshauer et al. 2008, Western Ecology Working Group n.d.

***Sesuvium portulacastrum* Coastal Dry Herbaceous Vegetation**

'Akulikuli Coastal Dry Herbaceous Vegetation

Identifier: CEGL008098

USNVC CLASSIFICATION

Division	Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup	Hawaiian Scrub & Herb Coastal Vegetation (M231)
Group	Hawaiian Dry Scrub & Herb Coastal Strand (G421)
Association	<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is known from one location in a low-level seasonal wetland at 18 m in elevation. The area was used as a fishpond in the early 1990s.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This site is characterized by an open herbaceous layer co-dominated by *Sesuvium portulacastrum* and *Bolboschoenus maritimus*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Herb (field)	Forb	<i>Sesuvium portulacastrum</i>
Herb (field)	Graminoid	<i>Bolboschoenus maritimus</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Sesuvium portulacastrum*

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association was sampled on Kalaupapa Peninsula, above the pumphouse.

Nations: US

States/Provinces: HI:S3

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Inventory Notes: Seasonal wetland. Geology: hard pan (lava boulders embedded). Seasonal wetland used historically as fish pond.

Kalaupapa National Historical Park Plots and Observation Points: (1 plot): KALA.0009.

Local Description Authors: M. Hall

Global Description Authors:

References: Gagne and Cuddihy 1990, Gon 2008, Warshauer et al. 2008, Western Ecology Working Group n.d.

***Sida fallax* Coastal Dry Shrubland**

'Ilima Coastal Dry Shrubland

Identifier: CEGL008055

USNVC CLASSIFICATION

Division	Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup	Hawaiian Scrub & Herb Coastal Vegetation (M231)
Group	Hawaiian Dry Scrub & Herb Coastal Strand (G421)
Association	<i>Sida fallax</i> Coastal Dry Shrubland

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This coastal shrubland occurs at near-shore environments often with high exposure to salt-laden winds on sand dunes and volcanic soils derived of basalt. Elevations are generally less than 30 m and slopes are gentle.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by an open short-shrub layer dominated by *Sida fallax* which typically forms prostrate mats, although on more sheltered sites, a more erect ecotype may occur. Other shrubs are present but contribute little cover. Species may include *Euphorbia degeneri*, *Waltheria indica*, and *Wikstroemia uva-ursi*. Herbaceous cover is low with no clear dominant species. Graminoids present at sample sites include *Cyperus gracilis* and introduced *Digitaria insularis* or *Cynodon dactylon*. A variety of forbs may occur and include *Ageratum conyzoides*, *Anagallis arvensis*, *Chamaecrista nictitans* var. *glabrata*, *Euphorbia hirta*, *Coronopus didymus*, *Cuscuta sandwichiana*, *Desmodium triflorum*, *Emilia fosbergii*, *Erigeron karvinskianus*, and *Portulaca pilosa*. The non-native species *Lantana camara* and *Plantago lanceolata* have invaded some sites.

MOST ABUNDANT SPECIES**Kalaupapa National Historical Park**

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Short shrub/sapling	Dwarf-shrub	<i>Sida fallax</i>
Herb (field)	Forb	<i>Portulaca pilosa</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Ageratum conyzoides*, *Anagallis arvensis*, *Sida fallax*

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Cynodon dactylon* (non-native\exotic, Medium/Low), *Plantago lanceolata* (non-native\exotic, High/Low)

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (1-Dec-1997).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from near the airport and lighthouse.

Nations: US

States/Provinces: HI:S3

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (2 plots): KALA.0019, KALA.0426.

Local Description Authors: M. Hall

Global Description Authors:

References: Gagne and Cuddihy 1990, Gon 2008, Warshauer et al. 2008, Western Ecology Working Group n.d.

Wikstroemia uva-ursi - *Sida fallax* Coastal Shrubland

‘Ākia - ‘Īlima Coastal Shrubland

Identifier: CEGLO08175

USNVC CLASSIFICATION

Division	Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup	Hawaiian Scrub & Herb Coastal Vegetation (M231)
Group	Hawaiian Dry Scrub & Herb Coastal Strand (G421)
Association	<i>Wikstroemia uva-ursi</i> - <i>Sida fallax</i> Coastal Shrubland

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This shrubland is known from two locations along a peninsular beach on low-level positions.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This association is characterized by an open shrub layer co-dominated by *Wikstroemia uva-ursi* and *Sida fallax*. Other shrubs may contribute significant cover but are never codominant. Shrub species include native *Waltheria indica* and aliens *Lantana camara*, *Phyllanthus debilis*, and *Schinus terebinthifolius*. Herbaceous cover may exceed that of the shrub stratum and is usually a mixture of native and introduced species. Graminoids include *Cyperus gracilis*, *Digitaria ciliaris*, and native *Fimbristylis cymosa*. The non-native grasses *Cynodon dactylon* or *Digitaria ciliaris* may dominate some stands. A variety of native and introduced forbs may occur. Introduced species *Anagallis arvensis* contributes the highest cover. Other forbs may include native *Boerhavia repens* and *Jacquemontia ovalifolia* ssp. *sandwicensis*, and introduced *Ageratum conyzoides*, *Euphorbia hirta*, *Desmodium triflorum*, *Emilia fosbergii*, *Heliotropium amplexicaule*, *Ipomoea purpurea*, *Oxalis corniculata*, *Plantago lanceolata*, *Sonchus oleraceus*, and *Turnera ulmifolia*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Short shrub/sapling	Broad-leaved deciduous shrub	<i>Sida fallax</i> , <i>Wikstroemia uva-ursi</i>

Herb (field)
Herb (field)

Forb
Graminoid

Anagallis arvensis
Fimbristylis cymosa

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Boerhavia repens*, *Fimbristylis cymosa*, *Jacquemontia ovalifolia* ssp. *sandwicensis*, *Sida fallax*, *Wikstroemia uva-ursi*

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Cynodon dactylon* (non-native\exotic, Medium/Low), *Plantago lanceolata* (non-native\exotic, High/Low)

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (5-Dec-2011).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This is known from two locations, both several hundred meters from the lighthouse on Kalaupapa Peninsula.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (2 plots): KALA.0427, KALA.428.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

2.A.4. Tropical Bog & Fen

2.A.4.Oa. Polynesian Bog & Fen

M238. Hawaiian Bog & Fen

G426. Hawaiian Bog

Metrosideros polymorpha / *Dicranopteris* spp. / *Lycopodiella cernua* Montane Wet Bog Scrub Woodland [Provisional]

‘Ōhi‘a / Uluhe species / Wāwae‘iole Montane Wet Bog Scrub Woodland

Identifier: CEGLO08146

USNVC CLASSIFICATION

Division Polynesian Bog & Fen (2.A.4.Oa)

Macrogroup Hawaiian Bog & Fen (M238)

Group Hawaiian Bog (G426)

Association *Metrosideros polymorpha* / *Dicranopteris* spp. / *Lycopodiella cernua* Montane Wet Bog Scrub Woodland [Provisional]

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This association is only known from one location at 1176 m in elevation on a nearly level boggy area on a plateau.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This site is characterized by an open canopy exclusively dominated by *Metrosideros polymorpha* with a dense understory of the fern *Dicranopteris linearis* and the clubmoss *Lycopodiella cernua*.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Metrosideros polymorpha</i>
Herb (field)	Fern or fern ally	<i>Dicranopteris linearis</i> , <i>Lycopodiella cernua</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Dicranopteris linearis*, *Lycopodiella cernua*, *Metrosideros polymorpha*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (5-Dec-2011).

CLASSIFICATION

Status: Provisional

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is only known from Pu‘u Ali‘i cabin.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (1 plot): KALA.0032.

Local Description Authors: M. Hall

Global Description Authors:

References: Western Ecology Working Group n.d.

X. Not in hierarchy

Mixed Forest Plantation [Park Special]

Mixed Forest Plantation

Identifier: CEPS009672

AssociationMixed Forest Plantation [Park Special]

ENVIRONMENTAL DESCRIPTION

Kalaupapa National Historical Park Environment: This plantation type can be found as localized occurrences where planted. Sampled stands range from 500-1000 m in elevation, but likely can be

found from sea level to over 1400 m, thriving most vigorously on soils developed from volcanic ash or lava rock of moderate acidity.

VEGETATION DESCRIPTION

Kalaupapa National Historical Park Vegetation: This park special plant community is composed of several plantation types and can be dominated by one or more plantation species including *Cryptomeria japonica*, *Melaleuca quinquenervia*, *Pinus elliottii* or *Pinus radiata*, and *Syncarpia glomulifera*, often with other widespread naturalized introduced trees species such as *Casuarina equisetifolia*, *Psidium cattleianum*, or *Psidium guajava*. *Eucalyptus* spp. are absent or have low cover. Understories are generally sparse and composed mainly of woody seedlings of canopy trees. Native species are rarely present in plantations in significant amounts, except for species such as *Dicranopteris linearis* that colonize after disturbance.

MOST ABUNDANT SPECIES

Kalaupapa National Historical Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tree canopy	Broad-leaved evergreen tree	<i>Melaleuca quinquenervia</i>

CHARACTERISTIC SPECIES

Kalaupapa National Historical Park: *Cryptomeria japonica*, *Melaleuca quinquenervia*, *Pinus elliottii*, *Syncarpia glomulifera*

OTHER NOTEWORTHY SPECIES

Kalaupapa National Historical Park: Invasive/Exotic: *Coffea arabica* (non-native\exotic), *Cryptomeria japonica* (non-native\exotic), *Melaleuca quinquenervia* (non-native\exotic), *Pinus elliottii* (non-native\exotic), *Syncarpia glomulifera* (non-native\exotic)

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (2-Dec-2011).

CLASSIFICATION

Status: Nonstandard

ELEMENT DISTRIBUTION

Kalaupapa National Historical Park Range: This association is known from Waikolu Rim, Pu‘u Kauwa, near the A-frame Pavilion in Pālā‘au State Park, lower Pālā‘au State Park and lower Pu‘u Kuawa road.

Nations: US

States/Provinces: HI

Federal Lands: NPS (Kalaupapa)

ELEMENT SOURCES

Kalaupapa National Historical Park Plots and Observation Points: (5 plots): KALA.0200, KALA.0207, KALA.0210, KALA.0217, KALA.9105.

Local Description Authors: M. Hall and K. Schulz

Global Description Authors:

References: Western Ecology Working Group n.d.

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¹USNVC name *Scaevola sericea* modified to *Scaevola taccada* based on taxonomy of Wagner et al. (2012).

Appendix E: Classification Plots by Vegetation Association

Association Name	ELCODE	Supporting Plots/Observation	Number of Samples
<i>Acacia confusa</i> - <i>Psidium guajava</i> Semi-natural Forest [Park Special]	CEPS009673	KALA.0201	1
<i>Agave sisalana</i> Semi-natural Shrubland [Park Special]	CEPS009661	KALA.9114	1
<i>Aleurites moluccana</i> Lowland Wet Forest	CEGL008115	KALA.0241, KALA.0245, KALA.0245	3
<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	CEGL008182	KALA.0202, KALA.0211, KALA.0212, KALA.9003, KALA.9107	5
<i>Cocos nucifera</i> Strand Woodland*	CEGL005402	KALA.3006	
<i>Coffea arabica</i> Semi-Natural Forest [Park Special]	CEPS009696	KALA.0406	1
<i>Coprosma foliosa</i> - <i>Perrottetia</i> <i>sandwicensis</i> - <i>Cibotium</i> spp. Riparian Woodland [Park Special]	CEPS009675	KALA.0233	1
<i>Cyclosorus dentatus</i> - <i>Hedychium</i> <i>coronarum</i> - <i>Coix lacryma-jobi</i> Semi- natural Herbaceous Vegetation [Park Special] ²	CEPS009659	KALA.0419	1
<i>Cynodon dactylon</i> - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	CEGL008167	KALA.0011, KALA.0402, KALA.0415	3
<i>Dicranopteris linearis</i> Wet Herbaceous Mat	CEGL008048	KALA.9113	1
<i>Diospyros sandwicensis</i> - (<i>Psidium</i> spp.) Lowland Mesic Woodland	CEGL008183	KALA.0407, KALA.0413	2
<i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest	CEGL008026	KALA.0411, KALA.9116, KALA.9118	3
<i>Erythrina sandwicensis</i> Lowland Dry Woodland*	CEGL008036	KALA.3005	
<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation	CEGL008143	KALA.0213, KALA.0214, KALA.0226, KALA.0229, KALA.0230, KALA.0242	6
<i>Eucalyptus</i> spp. - Mixed Alien Semi- natural Forest/Plantation [Provisional]	CEGL008144	KALA.9104, KALA.9106	2
<i>Euphorbia celastroides</i> Coastal Dry Dwarf-Shrubland ³	CEGL008075		
<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	CEGL008089	KALA.0006	1
<i>Grevillea robusta</i> Lowland Mesic Semi-natural Forest [Provisional]	CEGL008113	KALA.0215	1
<i>Heliotropium amplexicaule</i> Semi- natural Shrubland [Park Special]*	CEPS009711	KALA.3007	
<i>Hibiscus tiliaceus</i> Lowland Wet Forest [Provisional]	CEGL008163	KALA.0405	1
<i>Lantana camara</i> Semi-natural Shrubland [Provisional]	CEGL008145	KALA.0001, KALA.0023, KALA.0425, KALA.0429	4

Association Name	ELCODE	Supporting Plots/Observation	Number of Samples
<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	CEGL008114	KALA.0422	1
<i>Melinis minutiflora</i> - (<i>Schizachyrium condensatum</i>) Semi-natural Herbaceous Vegetation	CEGL008169	KALA.0409, KALA.0412	2
<i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland	CEGL008142	KALA.0205, KALA.0209, KALA.0218, KALA.0220, KALA.0403, KALA.9101, KALA.9110	7
<i>Metrosideros polymorpha</i> - <i>Cheirodendron</i> spp. / (<i>Cibotium</i> spp.) Montane Wet Forest	CEGL008008	KALA.0024, KALA.0025, KALA.0026, KALA.0029, KALA.0030, KALA.0033, KALA.0034, KALA.0035, KALA.0234, KALA.9021, KALA.9022	11
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> ssp. <i>trigynum</i> / <i>Diplopterygium pinnatum</i> Montane Wet Forest [Park Special]	CEPS009653	KALA.0028	1
<i>Metrosideros polymorpha</i> - <i>Ilex anomala</i> - <i>Myrsine lessertiana</i> Woodland	CEGL008158	KALA.0031	1
<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	CEGL008009	KALA.0231	1
<i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland	CEGL008041	KALA.0027, KALA.0206, KALA.0208, KALA.9103, KALA.9109	5
<i>Metrosideros polymorpha</i> / <i>Dicranopteris</i> spp. / <i>Lycopodiella cernua</i> Montane Wet Bog Scrub Woodland [Provisional]	CEGL008146	KALA.0032	1
<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	CEGL008152	KALA.0227, KALA.0228	2
<i>Metrosideros waialealae</i> var. <i>fauriei</i> Woodland [Park Special]	CEPS009650	KALA.0203, KALA.9100, KALA.9119	3
Mixed Forest Plantation [Park Special]	CEPS009672	KALA.0200, KALA.0207, KALA.0210, KALA.0217, KALA.9105	5
<i>Pandanus tectorius</i> Coastal Mesic Forest	CEGL008032	KALA.0016, KALA.9120	2
<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	CEGL008170	KALA.0204, KALA.0221, KALA.9102	3
<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Provisional]	CEPS009694	KALA.0410	1
<i>Pritchardia hillebrandii</i> Coastal Mesic Forest**	CEGL008033	KALA.3003	
<i>Prosopis pallida</i> Coastal Dry Semi-natural Woodland	CEGL008118	KALA.0424	1

Association Name	ELCODE	Supporting Plots/Observation	Number of Samples
<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	CEGL008116	KALA.0014, KALA.0015, KALA.0237, KALA.0244, KALA.0246, KALA.9005, KALA.9112	7
<i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	CEPS009697	KALA.0416, KALA.0417	2
<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	CEGL008147	KALA.0216, KALA.0219, KALA.0404, KALA.9115	4
<i>Scaevola taccada</i> Coastal Dry Shrubland ¹	CEGL008054	KALA.002, KALA.010, KALA.022	3
<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	CEGL008148	KALA.0008, KALA.0020, KALA.0036, KALA.0037, KALA.0038, KALA.0039, KALA.0040, KALA.0239, KALA.0240, KALA.0243, KALA.0430, KALA.9002, KALA.9108, KALA.9111	14
<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	CEGL008098	KALA.0009	1
<i>Sida fallax</i> Coastal Dry Shrubland	CEGL008055	KALA.0019, KALA.0426	1
<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	CEGL008111	KALA.0004, KALA.0005, KALA.0007, KALA.0012, KALA.0013, KALA.0018, KALA.0235, KALA.0236, KALA.0401, KALA.0408, KALA.9117	11
<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	CEPS009651	KALA.0017, KALA.0238	2
<i>Thespesia populnea</i> / Sparse Understory Woodland*	CEGL005412	KALA.3001	1
<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	CEPS009652	KALA.0423	1
<i>Wikstroemia uva-ursi</i> - <i>Sida fallax</i> Coastal Shrubland	CEGL008175	KALA.0427, KALA.0428	2
<i>Wikstroemia uva-ursi</i> / <i>Fimbristylis cymosa</i> Mixed Grass Coastal Shrubland [Park Special]	CEPS009667	KALA.0021	1

¹USNVC name *Scaevola sericea* modified to *Scaevola taccada* based on taxonomy of Wagner et al. (2012).

²USNVC name *Christella dentata* modified to *Cyclosorus dentatus* based on taxonomy of Wagner et al. (2012).

³USNVC name *Chamaesyce celastroides* modified to *Euphorbia celastroides* based on taxonomy of Wagner et al. (2012).

* Associations at KALA based on observations during map the calibration/validation process.

** Associations at KALA based on prior research by Fung and SWCA Environmental Consultants, (2010) and Wood (2001, 2008).

Appendix F: Accuracy Assessment Form

Entered by ____

Checked by ____

PACN VEGETATION MAPPING ACCURACY ASSESSMENT FORM

**IDENTIFIERS/LOCATORS

AA Target No. _____ Park Site Name: _____			
Survey Date _____ Surveyors _____			
Datum: WGS 84 NAD 83 Field UTM X _____ m (E) Field UTM Y _____ m (N)			
GPS Unit: Garmin 76 / 5 / 60CSX Trimble Other _____ Error +/- _____ m			
GPS Notes: _____			
Relocated/Reshaped Plot? No ____ Yes ____ Notes: _____			
Radio Reception? No ____ Yes ____ Notes: _____			
Cell phone reception (Verizon)? No ____ Yes ____ Notes: _____			
Camera: Ricoh-GPS Other: _____			
View#	Bearing	Photographer	Comments
1			
2			
3			
4			
Canopy			
Ground			
Data			

**ASSOCIATION INFORMATION

Primary Name Veg Association: _____	Corresponding Assc. Code: _____
Secondary Name Veg Association: _____	Corresponding Assc. Code: _____
Tertiary Name Veg Association: _____	Corresponding Assc. Code: _____
Representativeness of point within polygon/surrounding area (within 1 ha) <u>Good</u> <u>Fair</u> <u>Poor</u> ...of association to description: <u>Good</u> <u>Fair</u> <u>Poor</u> <u>N/A</u>	
Classification Comments: (complications, uncertainties, explanation of poor representativeness)	
Does the key work? Yes ____ No ____ N/A ____ Comments:	
Is the corresponding description accurate? Yes ____ No ____ N/A ____ Comments:	

Date: _____

Height Class Scale	Cover Class Scale			MMU=0.5 ha
01 <0.5 m	T <1%			Circle: r=40m
02 0.5-1 m	P 1-5%			*Rectangle: 50m x 100m
03 1-2 m	1a 5.01-10%			*Square: 71m x71m
04 2-5 m	1b 10.01-15%			
05 5-10 m	02 15.01-25%			
06 10-15 m	03 25.01-35%			
07 15-20 m	04 35.01-45%			
08 20-35 m	05 45.01-55%			
09 35-50 m	06 55.01-65%			
10 > 50 m	07 65.01-75%			
	08 75.01-85%			
	09 85.01-95%			
	10 > 95%			*Only sample if cannot sample a circular plot

If other: **Size:** **Shape:**

Stratum Code	Height Class	Cover Class	Dominant species in stratum (mark diagnostic species with a *)	%Cover
_____	_____	_____	_____ _____ _____ _____ _____	_____
_____	_____	_____	_____ _____ _____ _____ _____	_____
_____	_____	_____	_____ _____ _____ _____ _____	_____
_____	_____	_____	_____ _____ _____ _____ _____	_____

T1 Emergent (above canopy)	S1 Tall shrub (>2 m)	H1 Graminoids	H4 Tree Seedlings
T2 Canopy	S2 Short Shrub (>0.5 m- 2 m)	H2 Forbs	N Nonvascular
T3 Sub-canopy	S3 Dwarf-shrub (< 0.5 m)	H3 Ferns & Allies	V Vine/Liana

Target Number _____

Date: _____

ENVIRONMENTAL DESCRIPTION (Only complete if association is difficult to key or if it is a new type)

Elevation _____ From: <u>GPS / Map</u> (circle one) Slope _____ Aspect _____		
Topographic Position: High level High Slope Mid Slope Low Slope Backslope Step in Slope Toe Slope Low Level Interfluv		
Landform: Alluvial Fan, Colluvium, Rockpile, Drainage Channel, Valley Bottom Fill, Side Slope, Interfluv, Intermittent Stream, Ridge, Terrace, Butte, Cliff, Talus, Sand Dune, Plateau, Beach, Recent Lava Flow, Other: _____		Geology: A 'a lava, Pahoehoe Lava, Ash, Cinder, Coral, Limestone, Pumice, Obscured by soil, Other: _____
Ground Cover: (please estimate to the nearest percentage. Sum = 100%)		
☐ Bare soil (<0.1 mm) ☐ Sand (0.1-2 mm) ☐ Small Rock (2mm-6.4cm) ☐ Rock (> 6.4 cm) ☐ Bedrock (solid surface)	☐ Litter/Duff (dead plant material <3 cm diameter) ☐ Coarse woody debris (dead wood 3-10 cm) ☐ Woody debris structure (dead >10 cm deep & wide) ☐ Live veg (litter / wood)	☐ Lichen (ground) ☐ Moss (ground) ☐ Microbiotic soil crust ☐ Water ☐ Other: _____
Surface Water w/in 25m? YES/NO Seep, Spring, Stream, Pothole, River, Anchialine Pond, Ocean, Estuary		
Environmental Comments:		

Appendix G: Special Notes on Accuracy Assessment and Final Map

The following plots received *post-hoc* changes to the reference labels as proposed by KGA and PACN. In each situation, field forms, plot photos, crew notes, NVC key and descriptions were evaluated to determine if reference label is best-fit.

Table 1. AA plots with a primary field call of “unclassified forest”, when the secondary field call was accepted as the correct reference label.

Plot	Secondary/Tertiary Field Call	Reason for Accepting Secondary Label	Notes
KALA.AA.0210	<i>Metrosideros polymorpha</i> / <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest	<i>Metrosideros waialealae</i> co-dominate in plot and is not spectrally distinguishable from <i>M. polymorpha</i> . This site is an example of variation within the larger vegetation landscape.	<i>Metrosideros waialealae</i> may co-dominate some stands in the <i>Metrosideros polymorpha</i> / <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest
KALA.AA.0159	<i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland	Field notes mention site is on a ridge and seems to be transitional vegetation. Photos support secondary field call.	<i>Cheirodendron trigynum</i> may co-dominate some stands of <i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland.
KALA.AA.0297	<i>Metrosideros polymorpha</i> / <i>Cheirodendron trigynum</i> (<i>Cibotium</i> spp.)	Notes mention transitional vegetation between secondary type and a <i>M. polymorpha</i> type over <i>Leptecophylla tameiameia</i> understory.	Site within the variation of <i>Metrosideros polymorpha</i> / <i>Cheirodendron trigynum</i> (<i>Cibotium</i> spp.) Montane Wet Forest.
KALA.AA.0178	<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	KGA ran PcOrd to see if new type fell out as a new type, but had no significance. Accepted tertiary field label. Imagery suggests that the secondary field call is incorrect.	

Table 2. Plots with no secondary field calls, but a different reference label was accepted for AA site.

Plot	Modified Reference Label	Reason for Modification	Notes
KALA.AA.0144	<i>Psidium guajava</i> – <i>Lantana camara</i> Semi-natural Shrubland	Life form in NVC classification is incorrect and thus lifeform was recorded improperly and resulted in a forested primary field call when it is shrubland type.	Field label did not have a secondary field call.
KALA.AA.0243	<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	<i>Post-hoc</i> evaluation of field forms, photos, notes and NVC descriptions support changing label.	Field label did not have a secondary field call.

Table 2 (continued). Plots with no secondary field calls, but a different reference label was accepted for AA site.

Plot	Modified Reference Label	Reason for Modification	Notes
KALA.AA.0030	<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland	Ambiguous language in the field key led to an incorrect field call.	Future efforts could better define the rules for this type.
KALA.AA.0007	Helicopter Landing Zone	The vegetation within this site did not fit any NVC classification as it was a helicopter landing zone being invaded by various herbs, each species with low cover.	Future efforts could better define the vegetation around landing zones in Pu'u Ali'i.

Table 3. Plots where the reference label was changed to a new vegetation map class developed from AA data.

Plot	Modified Reference Label	Reason for Modification	Notes
KALA.AA.0200	<i>Schinus terebinthifolius</i> / <i>Lantana camara</i> Mosaic Woodland	Primary reference label and field crew notes support development of map class.	The mosaic map class was developed to capture vegetation mixing based on field calls and imagery.
KALA.AA.0233	<i>Schinus terebinthifolius</i> / <i>Lantana camara</i> Mosaic Woodland	Primary and secondary reference labels support development of map class.	The mosaic map class was developed to capture vegetation mixing based on field calls and imagery.

Table 4. Vegetation associations that were merged into larger map classes.

NVC Vegetation Association	Map class	Reason
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest	<i>Metrosideros polymorpha</i> Montane Wet Forest map class	<i>Dicranopteris linearis</i> is a disturbance regime species and only occurs in small patches on the landscape (e.g. <MMU). <i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland is part of the mosaic of the larger <i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest.
<i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland		
<i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest	<i>Diospyros sandwicensis</i> Lowland Mesic Woodland map class	Although these two vegetation types exist on the landscape there is much overlap and defined polygon boundaries are difficult to define. Additionally, access is difficult as <i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest seems restricted to areas less impacted by ungulates (e.g. high ridges) in Waikolu valley. Future sampling in these types could focus on
<i>Diospyros sandwicensis</i> - (<i>Psidium</i> spp.) Lowland Mesic Woodland		

Table 4 (continued). Vegetation associations that were merged into larger map classes.

NVC Vegetation Association	Map class	Reason
<i>Wikstroemia uva-ursi</i> / <i>Fimbristylis cymosa</i> Mixed Grass Coastal Shrubland [Park Special]	<i>Wikstromia uva-ursi</i> Coastal Shrubland	Rules in the classification to distinguish between these types are poor. No correlation with the imagery.
<i>Wikstroemia uva-ursi</i> – <i>Sida fallax</i> Coastal Shrubland		
<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation	<i>Eucalyptus</i> spp. – Mixed Forest	No correlation with the imagery or ancillary data.
<i>Eucalyptus</i> spp. – Mixed Alien Semi-natural Forest/Plantation [Provisional]		

Table 5. Vegetation types that are only mapped where field verified (i.e. all polygons are <MMU), but were retained due to special park interest. All mapped polygons for these vegetation types have been field verified (during classification plot, and/or calibration and validation field sampling); however the distribution across the landscape is unknown as these types are rare and occur in small areas. Future sampling of these types may provide insight to their full range.

NVC Vegetation Association	Reason for Inclusion	Mapped Range
<i>Cocos nucifera</i> Coastal Strand Woodland	Historic and cultural importance, some stands in decline.	In settlement on the west coast of Kalaupapa Peninsula and Kalawao.
<i>Erythrina sandwicensis</i> Lowland Dry Woodland	Species of concern, ongoing monitoring and restoration of habitat in Kauhakō crater.	Isolated to Kauhakō Crater, with additional individual trees occurring along the base of the cliffs (e.g. along pali trail).
<i>Agave sisalina</i> Semi-natural Shrubland	Invasive nature of plant.	Invading the eastern slopes near the river mouth of Waikolu Valley, within the crater, and on the cliffs & valley floor at the mouth of the Waihanau drainage
<i>Heliotropium amplexicaule</i> Semi-natural Shrubland	Invasive nature of plant on peninsula and in coastal regions.	Invading herbaceous areas in the eastern coastal region.
<i>Cyclosorus dentatus</i> - <i>Hedychium coronarium</i> - <i>Coix lacryma-jobi</i> Semi-natural Herbaceous Vegetation ²	Riparian affinity of this vegetation type has important implications for river fauna.	Near the river mouth of Waikolu Valley.

²USNVC name *Christella dentata* modified to *Cyclosorus dentatus* based on taxonomy of Wagner et al. (2012).

Table 6. NVC vegetation associations that occur both above and below the MMU, but were retained due to special Park interest.

NVC Vegetation Association	Reason for Inclusion	% Accuracy (user's/producer's)
<i>Aleurites moluccana</i> Lowland Wet Forest	Polynesian introduced tree that flourishes in riverine environments.	95/100
<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	Native coastal sedge/graminoid, may include non-native grasses.	67/80
Mixed Forest Plantation [Park Special]	Invasive trees with low understory cover due to deer browsing and pig rooting activities	100/100
<i>Pandanus tectorius</i> Coastal Mesic Forest	Ecologically and culturally important. The remnants of goat impacted low-elevation forest.	0/0
<i>Prosopis pallida</i> Coastal Dry Semi-natural Woodland	Invasive nature, historically introduced for fodder, firewood or honey production.	n/a
<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	Culturally significant.	0/0
<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	Likely Introduced as an ornamental and is naturalizing within the settlement.	100/100

Table 7. Two vegetation types were mapped based on previous literature based on Fung and SWCA Environmental Consultants (2010), and Wood (2001, 2008). These rare types only occur on the Islets of the eastern shores of the Park and were retained at the small level due to their conservation implications.

NVC Vegetation Association	Reason for inclusion	Mapped Range
<i>Euphorbia celastroides</i> Coastal Dry Dwarf-shrubland ³	Endangered species	‘Ōkala Islet
<i>Pritchardia hillebrandii</i> Coastal Mesic Forest	Endangered species, one of two populations in Hawaii.	Huelo Islet.

³USNVC name *Chamaesyce celastroides* modified to *Euphorbia celastroides* based on taxonomy of Wagner et al. (2012).

Appendix H: Map Class Descriptions

This appendix describes the vegetated map classes for Kalaupapa National Historical Park. Unvegetated map classes are not described. The purpose of the descriptions is to provide the map user with a comprehensive portrayal of each map class. For each vegetated map class the following is provided:

- Latin name
- Common name
- Map code
- ELCODE
- A representative ground photograph of the map class. Photographs were selected from the classification, accuracy assessment, calibration, and validation photos captured over the life of the vegetation inventory project.
- A representative portion of the WorldView-2 infrared imagery of the map class. The polygons of the map class are delineated in yellow and the map code label of the map class has been inserted into a representative number of the map class polygons.
- The USNVC Association(s) that comprise the map class.
- A description of the map class and how it was mapped. Where available and appropriate, NatureServe local vegetation association descriptions for KALA were used as the map class description. When two associations comprise one map class, the NatureServe association descriptions are combined. NatureServe descriptions were sometimes edited for brevity to keep the map class descriptions to one page each. If a NatureServe description does not exist for the map class, the accuracy assessment and classification data were used to create a simple map class description. The description also discusses how accuracy assessment sites were employed to correct draft map errors and produce the final map.
- The most abundant species found in the map class.
- A description of the map class's distribution and location at KALA.
- For each map class, a table is also provided which presents the map class's hectares, number of classification plots, user's accuracy, producer's accuracy, number of accuracy assessment map samples, and number of accuracy assessment reference samples.

The map classes at KALA are based on the KALA USNVC plant associations and additional vegetation types discovered during the calibration and validation trips. Some of the USNVC associations do not exist at KALA (they are outside of the park) or exist only in rare, below minimum mapping unit (MMU) areas, and, therefore, do not occur on the map and do not have map class descriptions. Other USNVC associations were combined into one map class because they were impossible to distinguish from one another using remote sensing methods and prioritized field reconnaissance. Table 1 of this appendix (which is a repeat of Table 10 of the main body of the report) provides information about how map classes and USNVC associations relate to one another.

Table 1. Association and map class names and hectares for the vegetation of KALA. Green text indicates that the association was eliminated, collapsed with other associations into a map class, or mapped only where field verified.

Association Name	Map Class Name	Map Hectares	Percent of KALA landscape	No. of Class. Plots
Forests and Woodlands				
<i>Erythrina sandwicensis</i> Lowland Dry Woodland	<i>Erythrina sandwicensis</i> Lowland Dry Woodland	0.98	0%	0
<i>Thespesia populnea</i> / Sparse Understory Woodland	<i>Thespesia populnea</i> / Sparse Understory Woodland	1.74	0%	0
<i>Prosopis pallida</i> Coastal Dry Semi-natural Woodland	<i>Prosopis pallida</i> Coastal Dry Semi-natural Woodland	3.40	0%	1
<i>Cocos nucifera</i> Strand Woodland	<i>Cocos nucifera</i> Strand Woodland	0.09	0%	0
<i>Diospyros sandwicensis</i> - (<i>Psidium</i> spp.) Lowland Mesic Woodland	<i>Diospyros sandwicensis</i> - (<i>Psidium</i> spp.) Lowland Mesic Woodland and <i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest collapsed to <i>Diospyros sandwicensis</i> Lowland Mesic Woodland map class.	426.05	12%	2
<i>Diospyros sandwicensis</i> - <i>Metrosideros polymorpha</i> Lowland Mesic Forest				3
<i>Pandanus tectorius</i> Coastal Mesic Forest	Rare but culturally significant association. Mapped only where field verified.	2.55	0%	2
<i>Pritchardia hillebrandii</i> Coastal Mesic Forest	<i>Pritchardia hillebrandii</i> Coastal Mesic Forest	0.09	0%	0
<i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland	<i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland	36.68	1%	7
<i>Metrosideros waialealae</i> var. <i>fauriei</i> Woodland [Park Special]	Rare association. Does not occur on the map.			3
<i>Acacia confusa</i> - <i>Psidium guajava</i> Semi-natural Forest [Park Special]	<i>Acacia confusa</i> - <i>Psidium guajava</i> Semi-natural Forest [Park Special]	13.14	0%	1
<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	35.20	1%	5
<i>Coffea arabica</i> Semi-natural Forest [Park Special]	Rare association. Does not occur on the map.			1
<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation	<i>Eucalyptus robusta</i> Semi-natural Forest/Plantation and <i>Eucalyptus</i> spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional] associations collapsed into <i>Eucalyptus</i> spp. - Mixed Forest map class.	8.52	0%	6
<i>Eucalyptus</i> spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional]				2
<i>Grevillea robusta</i> Lowland Mesic Semi-natural Forest	Does not occur at KALA. Sole classification plot was outside of the park boundary.			1
<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Park Special]	<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Park Special]	14.28	0%	1
<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	201.73	6%	7

Table 1 (continued). Association and map class names and hectares for the vegetation of KALA. Green text indicates that the association was eliminated, collapsed with other associations into a map class, or mapped only where field verified.

Association Name	Map Class Name	Map Hectares	Percent of KALA landscape	No. of Class. Plots
<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	116.04	3%	4
<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	889.85	24%	14
None	<i>Schinus terebinthifolius</i> / <i>Lantana camara</i> Mosaic Woodland	46.28	1%	0
<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	312.58	9%	11
<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	4.65	0%	2
<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	6.47	0%	1
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest	<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> / (<i>Cibotium</i> spp.) Montane Wet Forest merged with <i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland to become <i>Metrosideros polymorpha</i> Montane Wet	476.48	16%	11
<i>Metrosideros polymorpha</i> / <i>Dicranopteris linearis</i> Montane Wet Woodland				5
<i>Metrosideros polymorpha</i> - <i>Cheirodendron trigynum</i> ssp. <i>trigynum</i> / <i>Diplopterygium pinnatum</i> Montane Wet Forest [Park Special]	Rare association. Does not occur on the map.			1
<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	15.95	1%	1
<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	<i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	255.31	9%	2
<i>Metrosideros polymorpha</i> - <i>Ilex anomala</i> - <i>Myrsine lessertiana</i> Woodland	Rare association. Does not occur on the map.			1
<i>Aleurites moluccana</i> Lowland Wet Forest	<i>Aleurites moluccana</i> Lowland Wet Forest	73.33	2%	3
<i>Coprosma foliosa</i> - <i>Perrottetia sandwicensis</i> - <i>Cibotium</i> spp. Riparian Woodland [Park Special]	Does not occur at KALA. Sole classification plot was outside of the park boundary.			1
<i>Hibiscus tiliaceus</i> Lowland Wet Forest [Provisional]	<i>Hibiscus tiliaceus</i> Lowland Wet Forest [Provisional]	5.17	0%	1
<i>Metrosideros polymorpha</i> / <i>Dicranopteris</i> spp. / <i>Lycopodiella cernua</i> Montane Wet Bog Scrub Woodland [Provisional]	Rare association. Does not occur on the map.			1
Mixed Forest Plantation [Park Special]	Mixed Forest Plantation [Park Special]	2.95	0%	5

Table 1 (continued). Association and map class names and hectares for the vegetation of KALA. Green text indicates that the association was eliminated, collapsed with other associations into a map class, or mapped only where field verified.

Association Name	Map Class Name	Map Hectares	Percent of KALA landscape	No. of Class. Plots
Shrublands				
<i>Euphorbia celastroides</i> Coastal Dry Dwarf-Shrubland ³	<i>Euphorbia celastroides</i> Coastal Dry Dwarf-Shrubland	1.07	0%	0
<i>Scaevola taccada</i> Coastal Dry Shrubland ¹	<i>Scaevola taccada</i> Coastal Dry Shrubland	12.11	0%	3
<i>Sida fallax</i> Coastal Dry Shrubland	<i>Sida fallax</i> Coastal Dry Shrubland	9.42	0%	1
<i>Wikstroemia uva-ursi</i> - <i>Sida fallax</i> Coastal Shrubland	<i>Wikstroemia uva-ursi</i> - <i>Sida fallax</i> Shrubland and <i>Wikstroemia uva-ursi</i> / <i>Fimbristylis cymosa</i> Mixed Grass Coastal Shrubland [Park Special] combined into <i>Wikstroemia uva-ursi</i> Coastal Shrubland.	56.56	2%	2
<i>Wikstroemia uva-ursi</i> / <i>Fimbristylis cymosa</i> Mixed Grass Coastal Shrubland [Park Special]				1
<i>Agave sisalana</i> Semi-natural Shrubland [Park Special]	Rare but ecologically significant association. Mapped only where field verified.	1.79	0%	1
<i>Heliotropium amplexicaule</i> Semi-natural Shrubland [Park Special]	<i>Heliotropium amplexicaule</i> Semi-natural Shrubland [Park Special]	0.30	0%	0
<i>Lantana camara</i> Semi-natural Shrubland [Provisional]	<i>Lantana camara</i> Semi-natural Shrubland [Provisional]	145.81	4%	4
<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	28.93	1%	1
<i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	<i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	11.84	0%	2
Herbaceous Vegetation				
<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	28.80	1%	1
<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	1.09	0%	1
<i>Dicranopteris linearis</i> Wet Herbaceous Mat	Does not occur in polygons larger than the MMU. Does not occur on the map.			1
<i>Cyclosorus dentatus</i> - <i>Hedychium coronarium</i> - <i>Coix lacryma-jobi</i> Semi-natural Herbaceous Vegetation [Park Special] ²	<i>Cyclosorus dentatus</i> - <i>Hedychium coronarium</i> - <i>Coix lacryma-jobi</i> Semi-natural Herbaceous Vegetation [Park Special]	0.23	0%	1
<i>Cynodon dactylon</i> - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	<i>Cynodon dactylon</i> - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	32.23	1%	3
<i>Melinis minutiflora</i> - (<i>Schizachyrium condensatum</i>) Semi-natural Herbaceous Vegetation	<i>Melinis minutiflora</i> - (<i>Schizachyrium condensatum</i>) Semi-natural Herbaceous Vegetation	73.14	2%	2
<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	23.29	1%	3

Table 1 (continued). Association and map class names and hectares for the vegetation of KALA. Green text indicates that the association was eliminated, collapsed with other associations into a map class, or mapped only where field verified.

Association Name	Map Class Name	Map Hectares	Percent of KALA landscape	No. of Class. Plots
Other Map Classes				
None	Built-up Commercial and Services	10.10	0%	0
None	Built-up Residential	21.91	1%	0
None	Built-up Transportation, Communications, and Utilities	20.59	1%	0
None	Helicopter Landing Zone	0.51	0%	0
None	Water	777.45		0
None	Unvegetated	101.73	3%	0

¹USNVC name *Scaevola sericea* modified to *Scaevola taccada* based on taxonomy of Wagner et al. (2012).

²USNVC name *Christella dentata* modified to *Cyclosorus dentatus* based on taxonomy of Wagner et al. (2012).

²USNVC name *Chamaesyce celastroides* modified to *Euphorbia celastroides* based on taxonomy of Wagner et al. (2012).

Table 2. Lists the map classes assessed for accuracy in order of their user's and producer's accuracies (copy of Table 11 in main report).

Map Class	User's Accuracy	Producer's Accuracy	Number of AA Samples by Reference Label
Helicopter Landing Zone	100%	100%	1
<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	100%	100%	4
Mixed Forest Plantation [Park Special]	100%	100%	1
<i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	100%	100%	4
<i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Provisional]	100%	100%	4
<i>Schinus terebinthifolius</i> / <i>Lantana camara</i> Mosaic Woodland	100%	100%	2
<i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	100%	100%	1
<i>Thespesia populnea</i> / Sparse Understory Woodland	100%	100%	3
<i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	100%	100%	2
<i>Aleurites moluccana</i> Lowland Wet Forest	95%	100%	20
<i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	90%	95%	21
<i>Cynodon dactylon</i> - Mixed Grass Pacific Semi-natural Herbaceous Vegetation	83%	100%	6
<i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	83%	100%	23
<i>Metrosideros polymorpha</i> Montane Wet Forest	86%	91%	38
<i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	95%	82%	19
<i>Diospyros sandwicensis</i> Lowland Mesic Woodland	88%	88%	7
<i>Lantana camara</i> Semi-natural Shrubland [Provisional]	94%	77%	19
<i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	100%	67%	4

Table 2 (continued). Users and producer's accuracies and sample numbers per map class.

Map Class	User's Accuracy	Producer's Accuracy	Number of AA Samples by Reference Label
<i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	100%	67%	2
<i>Eucalyptus</i> spp. – Mixed Forest	67%	100%	6
<i>Scaevola taccada</i> Coastal Dry Shrubland	100%	67%	4
<i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	77%	81%	21
<i>Acacia confusa</i> - (<i>Psidium guajava</i>) Semi-natural Forest [Park Special]	100%	50%	1
<i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	100%	50%	1
<i>Wikstroemia uva-ursi</i> Coastal Shrubland	67%	44%	4
<i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	67%	80%	6
<i>Sida fallax</i> Coastal Dry Shrubland	29%	100%	5
<i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	33%	33%	1
<i>Agave sisalana</i> Semi-natural Shrubland (Park Special)	0%	0%	1
<i>Pandanus tectorius</i> Coastal Mesic Forest	0%	0%	1

The following map class descriptions are listed first by life form (e.g. forests and woodlands, shrubland, herbaceous), then by joint user's and producer's accuracy from higher to lower accuracy. If several map classes have identical user's and producer's accuracy within a life form, map classes are listed in the order of percent of KALA's landscape covered by the map class, from larger to smaller percentages.

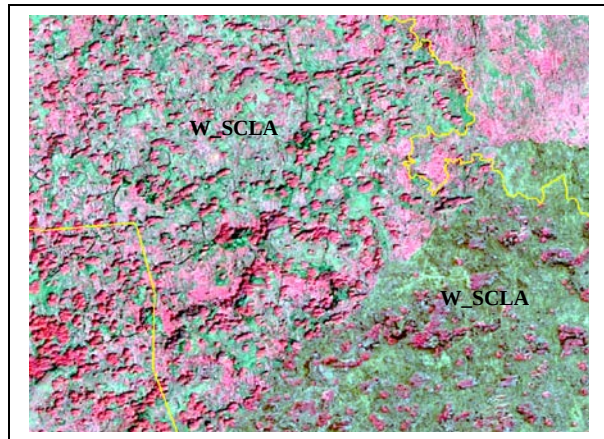
Forests and Woodlands

Map Class Name: <i>Schinus terebinthifolius</i> / <i>Lantana camara</i> Mosaic Woodland	Common Name: Christmas berry / Lantana Mosaic Woodland
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MAP CODE: W_SCLA

Ground View



ELCODE: none

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: None

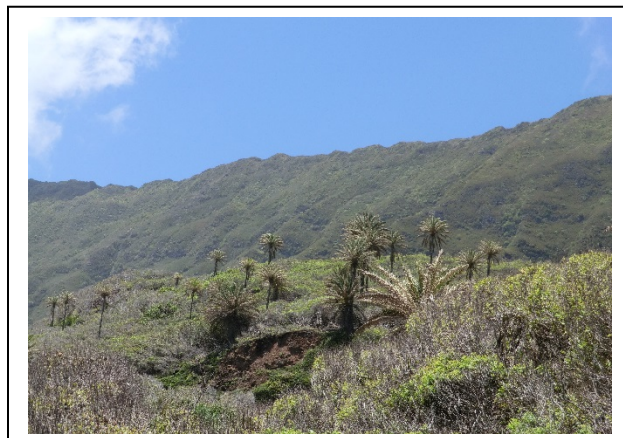
Description: This association was created to accommodate the patchy mosaic of *Schinus terebinthifolius* and *Lantana camara* which occurs in the northern portion of the peninsula and forms a transition zone between the relatively closed canopy *Schinus terebinthifolius* Semi-natural Scrub Woodlands to the south and the *Lantana camara* Semi-natural Shrublands to the west and north. It has no classification samples and, therefore, no NatureServe description. Data from this class's accuracy assessment sample indicate that it has sparse canopy of *Schinus terebinthifolius* with a more substantial canopy of *Lantana camara* (40-60%). Few other species exist in the mosaic. This class was mapped using manual image interpretation.

Most Abundant Species: *Lantana camara*, *Schinus terebinthifolius*

Distribution/Location: This map class occurs in one large polygon in the northwest portion of the peninsula.

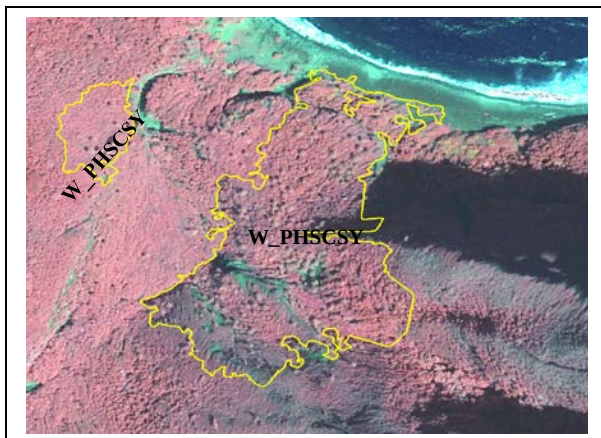
Classification Samples: 0	Hectares: 46.28
Producer's Accuracy: 100%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 2	Accuracy Assessment Reference Samples: 2

Map Class Name: <i>Phoenix dactylifera</i> - <i>Schinus terebinthifolius</i> - <i>Syzygium cumini</i> Lowland Mesic Semi-natural Woodland [Park Special]	Common Name: Date Palm - Christmas Berry - Java Plum Lowland Mesic Semi-natural Woodland [Park Special]
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MAP CODE: W_PHSCSY

Ground View



ELCODE: CEPS009664

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Phoenix dactylifera* - *Schinus terebinthifolius* - *Syzygium cumini* Lowland Mesic Semi-natural Woodland [Park Special]

Description: This class has only one classification sample, but four accuracy assessment samples. It is not described by NatureServe, but accuracy assessment samples show that this class is dominated by a mix of *Schinus terebinthifolius* (23-45%) and *Syzygium cumini* (3-35%) with an emergent layer of *Phoenix dactylifera* (5-12%). *Terminalia catappa* is often present at low covers (0-5%). The shrub and herbaceous layers are sparse to non-existent, with *Cynodon dactylon* sometimes present at low cover (0-5%). This class was mapped using a combination of CART analysis and manual image interpretation.

Most Abundant Species: *Phoenix dactylifera*, *Schinus terebinthifolius*, *Syzygium cumini*

Distribution/Location: This class can be found on the east and west slopes above the mouth of the Wai'ale'ia Valley, just north and slightly inland from the coast at Kalawao, and along the coast between the Waihānau and Wai'ale'ia Valleys.

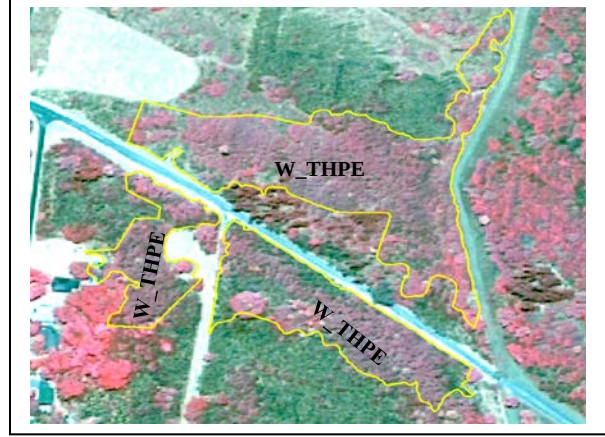
Classification Samples: 1	Hectares: 14.28
Producer's Accuracy: 100%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 4	Accuracy Assessment Reference Samples: 4

Map Class Name: <i>Thevetia peruviana</i> Semi-natural Woodland [Park Special]	Common Name: Lucky-nut Semi-natural Woodland [Park Special]
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MAP CODE: W_THPE

Ground View



ELCODE: CEPS009652

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Thevetia peruviana* Semi-natural Woodland [Park Special]

Description: This map class was discovered during the calibration trip. It has no classification samples, and, therefore no NatureServe description. It has two accuracy assessment samples which show the class to be highly dominated by *Thevetia peruviana* (85-90%) with few or no canopy associates and no understory. This class was mapped using manual image interpretation.

Most Abundant Species: *Thevetia peruviana*

Distribution/Location: This rare class is found in isolated stands on the southern outskirts of Kalaupapa Settlement and in a small stand which spans the road northwest of Kalawao.

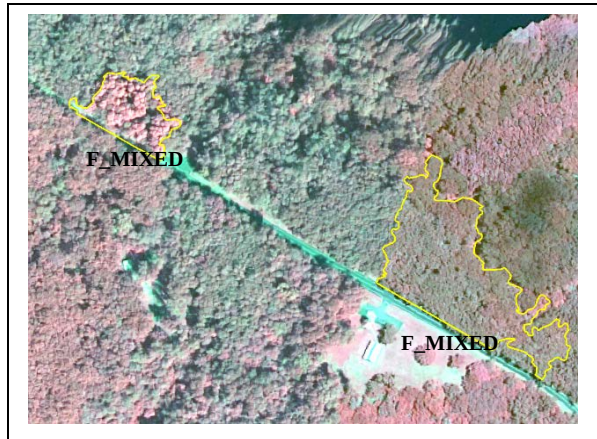
Classification Samples: 0	Hectares: 6.47
Producer's Accuracy: 100%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 2	Accuracy Assessment Reference Samples: 2

Map Class Name: Mixed Forest Plantation [Park Special]	Common Name: Mixed Forest Plantation [Park Special]
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MAP CODE: F_MIXED

Ground View



ELCODE: CEPS009672

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: Mixed Forest Plantation [Park Special]

Description: This map class has two classification plots and one accuracy assessment samples. It does not have a NatureServe description. The classification and accuracy assessment data show that the map class is dominated by *Melaleuca quinquenervia*.

Most Abundant Species: *Melaleuca quinquenervia*

Distribution/Location: This map class occurs in two polygons at the edge of the park near Pala'au State Park.

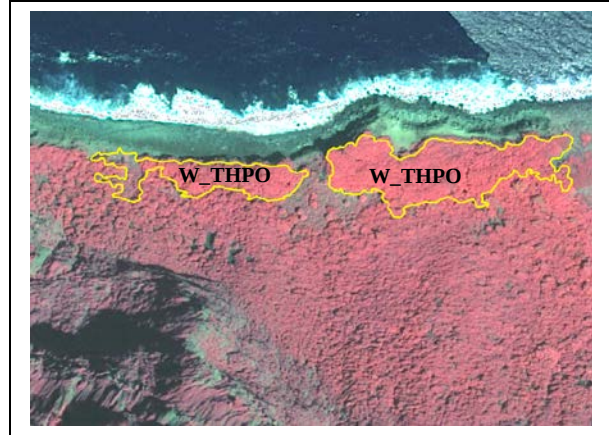
Classification Samples: 2	Hectares: 2.95
Producer's Accuracy: 100%	User's Accuracy: 100%
Accuracy Assessment Reference Samples: 1	Accuracy Assessment Reference Samples: 1

Map Class Name: <i>Thespesia populnea</i> / Sparse Understory Woodland	Common Name: Milo / Sparse Understory Woodland
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MAP CODE: W_THPO

Ground View



ELCODE: CEGLO05412

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Thespesia populnea* / Sparse Understory Woodland

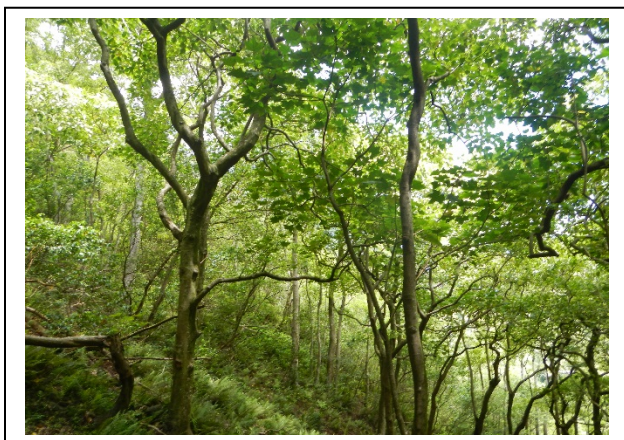
Description: This map class was not sampled during the vegetation classification sampling effort and has no NatureServe description. However, three samples were collected for accuracy assessment which indicate that the map class is characterized by dense thickets of *Thespesia populnea* (78-95%) with few other species occurring. This class was mapped using field identification and manual image interpretation.

Common Species: *Thespesia populnea*

Distribution/Location: The largest stands of *Thespesia populnea* / Sparse Understory Woodland in KALA occur at Kaluanui on the very western edge of the park. Other smaller isolated stands occur along the coast between Kapuahiapele and Puwahi.

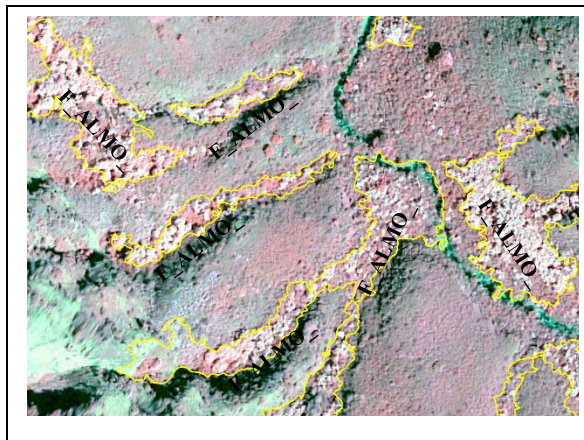
Classification Samples: 0	Hectares: 1.74
Producer's Accuracy: 100%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 3	Accuracy Assessment Reference Samples: 3

Map Class Name: <i>Aleurites moluccana</i> Lowland Wet Forest	Common Name: Kukui Lowland Wet Forest
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MAP CODE: F_ALMO_L

Ground View



ELCODE: CEGLO08115

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Aleurites moluccana* Lowland Wet Forest

Description: This association is characterized by a largely non-native species composition. Canopies are open to closed and dominated by *Aleurites moluccana*, an early Polynesian introduced species. *Syzygium cumini* may codominate in some stands. *Aleurites moluccana* forms a spreading canopy and therefore the understory is typically sparse and composed of shade-tolerant species. The shrub layer is often dominated by introduced species and includes *Lantana camara*, *Pluchea carolinensis*, *Psidium cattleianum*, *Psidium guajava*, and *Rubus rosifolius*. Herbaceous species may include *Adiantum hispidulum*, *Adiantum raddianum*, *Ageratina riparia*, *Ageratum conyzoides*, *Cyclosorus dentatus*, *Cyclosorus parasiticus*, *Kalanchoe pinnata*, *Nephrolepis multiflora*, *Oxalis corniculata*, *Phymatosorus grossus*, *Polypodium pellucidum*, *Solanum capsicoides*, and *Youngia japonica*. This class was mapped using a combination of CART modelling and manual image interpretation.

Most Abundant Species: *Aleurites moluccana*

Distribution/Location: This map class occupies the floors of all three of KALA's valleys and in small hanging stringers on the north facing cliffs. Large continuous stands are found in the Waihānau Valley floor, whereas in the Wai'ale'ia and Waikolu Valleys the class is found close in along stream banks and in narrow hanging shelves on cliff walls. It can also be found on the floor of Kauhako Crater and its outlet and on the small peninsula south of Kuka'wa'e point.

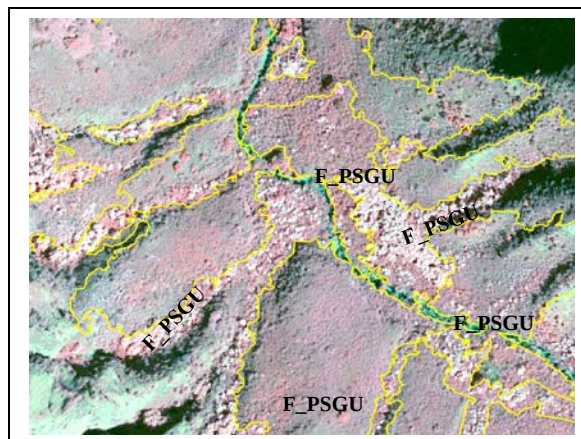
Classification Samples: 3	Hectares: 73.33
Producer's Accuracy: 100%	User's Accuracy: 95%
Accuracy Assessment Map Samples: 19	Accuracy Assessment Reference Samples: 20

Map Class Name: <i>Psidium guajava</i> / Disturbed Understory Semi-natural Forest	Common Name: Common Guava / Disturbed Understory Semi-natural Forest
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MAP CODE: F_PSGU

Ground View



ELCODE: CEGLO08147

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Psidium guajava* / Disturbed Understory Semi-natural Forest

Description: The composition of this association is diverse but composed largely of non-native trees with canopies dominated by *Psidium guajava* and lesser amounts of *Acacia confusa*, *Aleurites moluccana*, *Phytolacca octandra*, *Pluchea carolinensis*, *Schinus terebinthifolius*, and *Syzygium cumini*. The understory is composed of a variety of non-native shrubs and herbs, none of which appear to have an affinity to this semi-natural community. This class was mapped using a combination of CART and manual image interpretation. Two accuracy assessment sites were labeled *Psidium guajava* / Disturbed Understory Semi-natural Forest by accuracy assessment personnel, but mapped as *Acacia confusa* - (*Psidium guajava*) Semi-natural Forest [Park Special] or *Psidium guajava* - *Lantana Camara* Semi-natural Shrubland in the draft map. The areas of both samples were corrected in the final map.

Most Abundant Species: *Psidium guajava*, *Schinus terebinthifolius*, *Syzygium cumini*, *Acacia confusa*

Distribution/Location: This class dominates most of the entire Waikolu Valley floor. Topside of the north facing cliffs and the southern portions of the Waihānau Valley also include some stands of this map class.

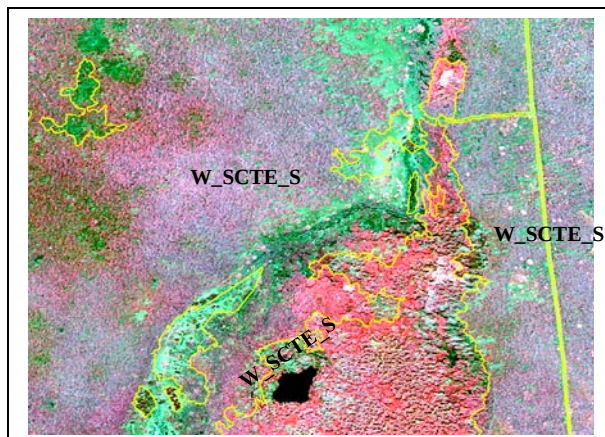
Classification Samples: 4	Hectares: 116.04
Producer's Accuracy: 95%	User's Accuracy: 90%
Accuracy Assessment Map Samples: 20	Accuracy Assessment Reference Samples: 21

Map Class Name: <i>Schinus terebinthifolius</i> Semi-natural Scrub Woodland	Common Name: Christmas berry Semi-natural Scrub Woodland
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MAP CODE: W_SCTE_S

Ground View



ELCODE: CEGLO08148

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Schinus terebinthifolius* Semi-natural Scrub Woodland

Description: This association is characterized by an open to closed canopy dominated by *Schinus terebinthifolius*, which occurs both as small tree or shrub forms. Other non-native species may share the canopy, including *Acacia confusa*, *Psidium cattleianum*, and *Syzygium cumini*, but they do not codominate. Occasional, emergent *Samanea saman* or *Phoenix dactylifera* trees may be present locally. However, where *Schinus terebinthifolius* forms dense canopies, few others may coexist. The understory varies from sparse to densely dominated non-native tree saplings and shrubs, especially *Indigofera suffruticosa*, *Senna alata*, and *Senna occidentalis*. A variety of herbaceous species may occur, but none dominate consistently across stands. This class was mapped using CART and manual image interpretation. Four accuracy assessment sites were labeled *Schinus terebinthifolius* Semi-natural Scrub Woodland by accuracy assessment personnel, but received other map classes in the draft map. The area around all of the four sites were edited to their correct label in the final map.

Most Abundant Species: *Psidium cattleianum*, *Schinus terebinthifolius*, *Syzygium cumini*

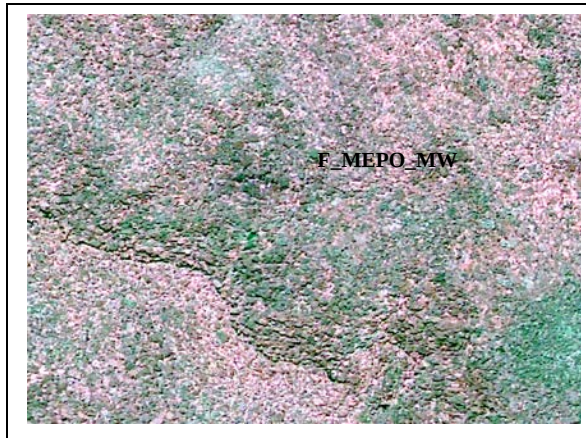
Distribution/Location: This is the largest map class at KALA and it occurs in a variety of landscapes. *Schinus terebinthifolius* Semi-natural Scrub Woodlands dominate the central uplands of the Kalaupapa peninsula and cover the cliff walls of the Waihānau Valley, the north facing cliffs, and the northern portions of the Wai'ale'ia Valley.

Classification Samples: 14	Hectares: 889.85
Producer's Accuracy: 100%	User's Accuracy: 83%
Accuracy Assessment Map Samples: 19	Accuracy Assessment Reference Samples: 23

Map Class Name: <i>Metrosideros polymorpha</i> Montane Wet Forest	Common Name: 'Ōhi'a Montane Wet Forest
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MAP CODE: F_MEPO_MW
Ground View



ELCODES: CEGLO08008 and CEGLO08041
Aerial View (WorldView-2 Infrared Imagery)

USNVC Associations: *Metrosideros polymorpha* - *Cheirodendron trigynum* / (*Cibotium* spp.) Montane Wet Forest and *Metrosideros polymorpha* / *Dicranopteris linearis* Montane Wet Woodland

Description: This diverse map class is characterized by open to dense native tree canopies dominated by *Metrosideros polymorpha* with *Cheirodendron trigynum* often codominant. The subcanopy is dominated either by *Cibotium menziesii* and associate species, or by a dense layer of the mat-forming fern *Dicranopteris linearis* that often forms thickets over a meter deep. Shrub cover is variable and may be sparse to about 50% cover without any clear consistent dominant species. The herbaceous layer is diverse with a mix of grasses, ferns and forbs. This class was mapped using a combination of CART modeling and manual image interpretation.

Most Abundant Species: *Cheirodendron trigynum*, *Metrosideros polymorpha*, *Cibotium menziesii*, *Astelia menziesiana*, *Athyrium microphyllum*, *Elaphoglossum crassifolium*, *Dicranopteris linearis*

Distribution/Location: This large map class primarily occupies one large polygon which encompasses most of the Pu'u Ali'i Natural Area Reserve. It also occurs in smaller areas on the east facing ridge tops of the Waikolu Valley. As seen in the Worldview-2 image above, the map class exhibits high spectral variability which does not appear to be related to map class variability.

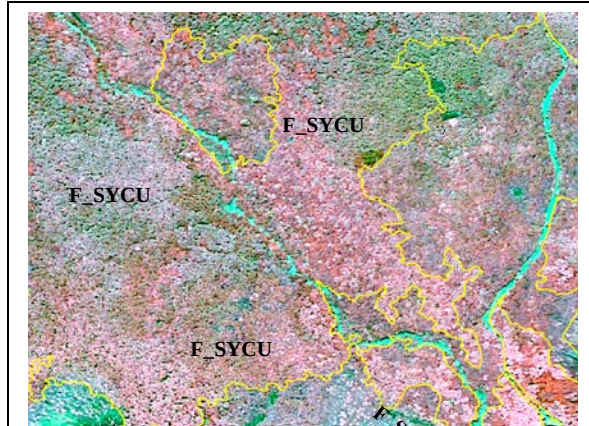
Classification Samples: 16	Hectares: 476.48
Producer's Accuracy: 94%	User's Accuracy: 87%
Accuracy Assessment Map Samples: 35	Accuracy Assessment Reference Samples: 38

Map Class Name: <i>Syzygium cumini</i> Lowland Mesic Semi-natural Forest	Common Name: Java Plum Lowland Mesic Semi-natural Forest
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MAP CODE: F_SYCU

Ground View



ELCODE: CEGLO08111

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Syzygium cumini* Lowland Mesic Semi-natural Forest

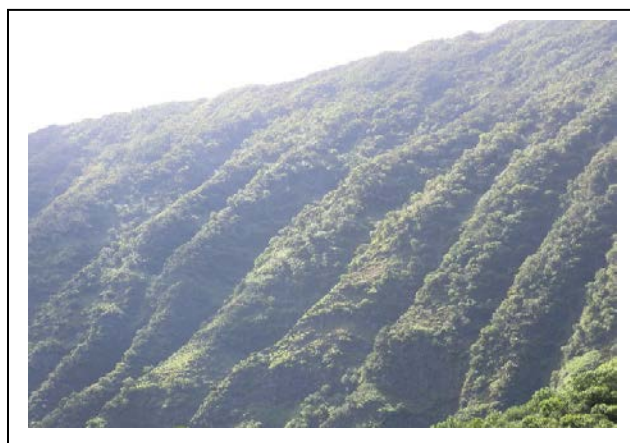
Description: This semi-natural forest association has open to dense canopies dominated by *Syzygium cumini*. Numerous other trees species may occur. *Psidium cattleianum* often dominates the subcanopy. *Schinus terebinthifolius* trees may be present to codominant, but not dominant in this type. Occasional, emergent *Samanea saman* or *Phoenix dactylifera* trees may be present locally. The shrub layer is very sparse, but herbaceous cover varies from sparse to very dense. This map class was mapped using CART analysis and manual image interpretation. Four accuracy assessment sites were mapped as *Syzygium cumini* Lowland Mesic Semi-natural Forest in the draft map, but labeled *Psidium cattleianum* Lowland Wet Semi-natural Forest by accuracy assessment personnel. The area surrounding all 4 sites were edited to *Psidium cattleianum* Lowland Wet Semi-natural Forest in the final map.

Most Abundant Species: *Psidium cattleianum*, *Syzygium cumini*

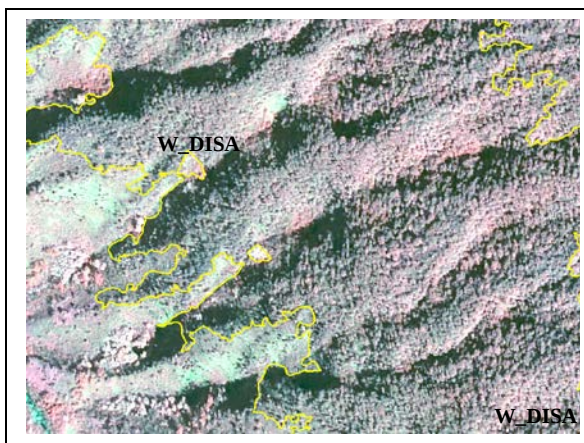
Distribution/Location: This class covers much of the foot of the north facing cliffs as well as portions of the northern Waihānau and Wai'ale'ia Valley floors.

Classification Samples: 11	Hectares: 312.58
Producer's Accuracy: 82%	User's Accuracy: 95%
Accuracy Assessment Map Samples: 22	Accuracy Assessment Reference Samples: 23

Map Class Name: <i>Diospyros sandwicensis</i> Lowland Mesic Woodland	Common Name: Lama Lowland Mesic Woodland
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MAP CODE: W_DISA
Ground View



ELCODES: CEGLO08183 & CEGLO08026
Aerial View (WorldView-2 Infrared Imagery)

USNVC Associations: *Diospyros sandwicensis* - (*Psidium* spp.) Lowland Mesic Woodland and *Diospyros sandwicensis* - *Metrosideros polymorpha* Lowland Mesic Forest.

Description: This map class is a combination of two associations and is characterized by a mixed native and non-native open to closed canopy dominated by *Diospyros sandwicensis* with *Metrosideros polymorpha*, *Psidium cattleianum* and/or *Psidium guajava* co-dominant. *Syzygium cumini* may be present as an emergent tree. Shrub cover is sparse to moderate and mostly composed of species such as *Clidemia hirta*, *Lantana camara*, *Euphorbia celastroides* var. *amplectens*, or *Pluchea carolinensis*. The herbaceous layer may be forb- or graminoid-dominated. This map class was mapped using a combination of CART modeling and manual image interpretation. On the draft map it was confused only with *Psidium cattleianum* Lowland Wet Semi-natural Forest with which there was one error of commission and one error of omission. In both samples, accuracy assessment personnel noted that a *Diospyros sandwicensis* association would have been an acceptable label for the sample.

Most Abundant Species: *Diospyros sandwicensis*, *Metrosideros polymorpha*, *Psidium cattleianum*, *Psidium guajava*, *Nephrolepis brownii*, *Sphenomeris chinensis*

Distribution/Location: This map class occurs on all three of KALA's valley cliff walls. In the Waihānau and Wai'ale'ia Valleys, thin stingers of *Diospyros sandwicensis* Lowland Mesic Woodland occur on the north valley ridges of west facing cliffs. In the Waikolu Valley the east facing cliffs are striated with bands of *Diospyros sandwicensis* Lowland Mesic Woodland alternated with *Melinis minutiflora* - (*Schizachyrium condensatum*) Semi-natural Herbaceous Vegetation. The west facing cliffs are predominantly forested with *Diospyros sandwicensis* Lowland Mesic Woodland.

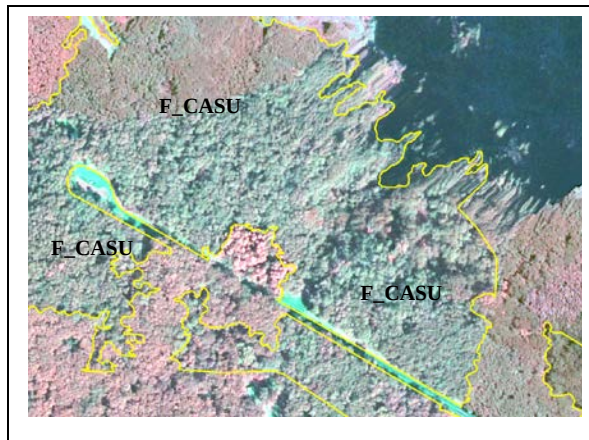
Classification Samples: 5	Hectares: 426.05
Producer's Accuracy: 88%	User's Accuracy: 88%
Accuracy Assessment Map Samples: 8	Accuracy Assessment Reference Samples: 7

Map Class Name: <i>Casuarina (equisetifolia, glauca)</i> Semi-natural/Planted Forest	Common Name: Common Ironwood Semi-natural/Planted Forest
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MAP CODE: F_CASU

Ground View



ELCODE: CEG008182

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Casuarina (equisetifolia, glauca)* Semi-natural/Planted Forest

Description: This association is characterized by near monotypic stands of *Casuarina equisetifolia* which were planted in the 1930s primarily to stabilize degraded areas resulting from overgrazing. No other canopy trees were documented nor are there any understory species which appear associated to warrant inclusion in the description or association name. This class was mapped using a combination of CART modeling and image interpretation. Two accuracy assessment sites were labeled *Casuarina (equisetifolia, glauca)* Semi-natural/Planted Forest on the draft map, but were identified by the accuracy assessment crews to be *Eucalyptus* spp. - Mixed Forest. The areas of both samples were edited to *Eucalyptus* spp. - Mixed Forest in the final map.

Most Abundant Species: *Casuarina equisetifolia*, *Casuarina glauca*

Distribution/Location: This map class occurs where planted by humans, most notably in and around Pala'au State Park. It also occurs in isolated stands near the airport, at the crater, along the western coastal strand, in patches in the settlement and along the coastal cliffs from St. Philomena's to the mouth of the Wai'ale'ia Valley.

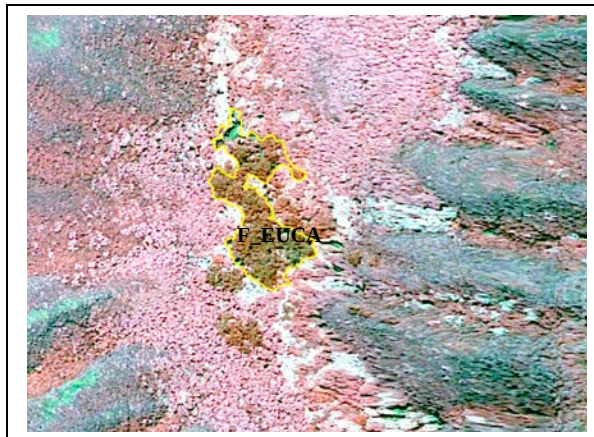
Classification Samples: 5	Hectares: 35.20
Producer's Accuracy: 100%	User's Accuracy: 67%
Accuracy Assessment Map Samples: 6	Accuracy Assessment Reference Samples: 4

Map Class Name: <i>Eucalyptus</i> spp. - Mixed Forest	Common Name: Eucalyptus - Mixed Forest
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MAP CODE: F_EUCA

Ground View



ELCODES: CEGLO08144 and CEGLO08143

Aerial View (WorldView-2 Infrared Imagery)

USNVC Associations: *Eucalyptus robusta* Semi-natural Forest/Plantation and *Eucalyptus* spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional]

Description: This map class is the result of combining two associations: *Eucalyptus robusta* Semi-natural Forest/Plantation and *Eucalyptus* spp. - Mixed Alien Semi-natural Forest/Plantation [Provisional]. Canopies of this class are clearly dominated by *Eucalyptus robusta*, *Eucalyptus globulus*, and/or *Eucalyptus saligna*. *Acacia melanoxylon* or *Psidium cattleianum* may co-dominate (but not dominate) at some sites, and *Cheirodendron trigynum* ssp. *trigynum*, *Psydrax odorata*, and *Metrosideros polymorpha* may be present. The shrub and herbaceous layers are nearly absent or sparse and have low species constancy. This class was mapped using a combination of CART analysis and manual image interpretation. Two accuracy assessment samples of *Eucalyptus* spp. Mixed Forests were mistakenly mapped as *Casuarina (equisetifolia, glauca)* Semi-natural/Planted Forests in the draft map. Both areas were edited in the final map to *Eucalyptus* spp. Mixed Forests.

Most Abundant Species: *Eucalyptus salign*, *Eucalyptus robusta*, *Eucalyptus globulus*

Distribution/Location: This class occurs where planted by humans, most notably in and around Pala'au State Park. Several *Eucalyptus* spp. - Mixed Alien Semi-natural Forest/Plantation stands (including some below the MMU) occur near Kalawao and also dot the Waihānau Valley floor.

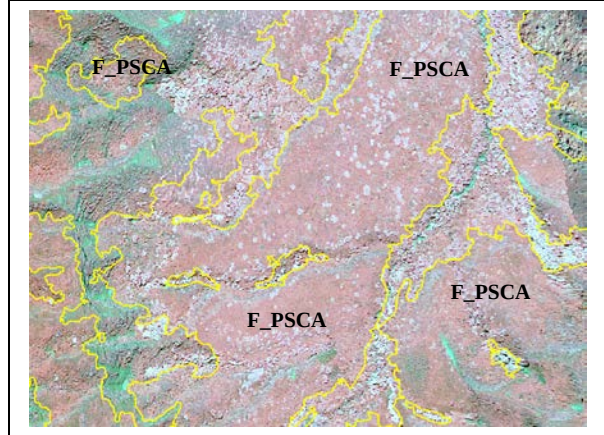
Classification Samples: 8	Hectares: 8.52
Producer's Accuracy: 100%	User's Accuracy: 67%
Accuracy Assessment Map Samples: 4	Accuracy Assessment Reference Samples: 6

Map Class Name: <i>Psidium cattleianum</i> Lowland Wet Semi-natural Forest	Common Name: Strawberry Guava Lowland Wet Semi-natural Forest
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MAP CODE: F_PSCA

Ground View



ELCODE: CEGLO08116

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Psidium cattleianum* Lowland Wet Semi-natural Forest

Description: This association is largely non-native with dense canopies dominated by *Psidium cattleianum* with lesser amounts of *Schinus terebinthifolius* and *Syzygium cumini*. *Aleurites moluccana*, *Diospyros sandwicensis*, *Pandanus tectorius*, and *Psydrax odorata* may also be present with low cover. The understory is composed of a variety of non-native shrubs and herbs, none of which appear to have an affinity to this semi-natural community. This class was mapped using CART analysis and manual image interpretation. Four spatially associated accuracy assessment sites were labeled *Psidium cattleianum* Lowland Wet Semi-natural Forest by accuracy assessment personnel, but *Syzygium cumini* Lowland Mesic Semi-natural Forest on the draft map. The area surrounding all 4 sites was edited to *Psidium cattleianum* Lowland Wet Semi-natural Forest in the final map.

Most Abundant Species: *Psidium cattleianum*

Distribution/Location: This is one of the largest map classes at KALA. It dominates much of the Wai'ale'ia Valley floor and slopes and the southern portions of the Waihānau Valley cliff slopes. It also forms stringers along the north facing cliffs and stingers and patches on the northern Waihānau Valley cliffs.

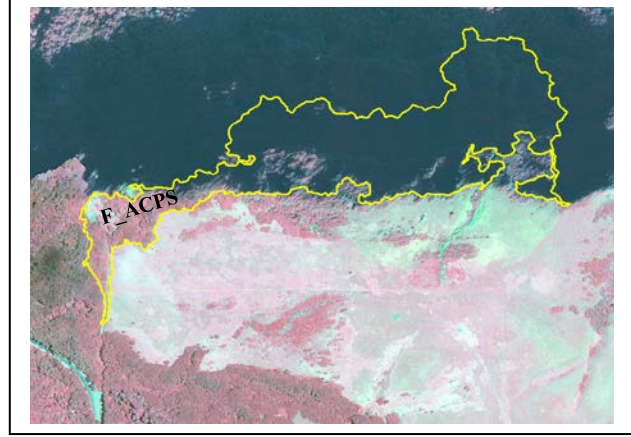
Classification Samples: 7	Hectares: 201.73
User's Accuracy: 81%	Producer's Accuracy: 81%
Accuracy Assessment Reference Samples: 21	Accuracy Assessment Map Samples: 21

Map Class Name: <i>Acacia confusa</i> - <i>Psidium guajava</i> Semi-natural Forest [Park Special]	Common Name: Formosa Koa - Common Guava Semi-natural Forest [Park Special]
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MAP CODE: F_ACPS

Ground View



ELCODE: CEPS009673

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Acacia confusa* - *Psidium guajava* Semi-natural Forest [Park Special]

Description: The *Acacia confusa* - *Psidium guajava* Semi-natural Forest [Park Special] map class has one classification sample (which is outside of the park) and one accuracy assessment reference sample. The association was not described by NatureServe. Both the classification plot and the accuracy assessment sample are heavily dominated by *Acacia confusa* (25-87% cover) with *Psidium guajava* also in the canopy (6-35%). This class was mapped through manual interpretation of the imagery. One accuracy assessment site is labeled *Acacia confusa* - *Psidium guajava* Semi-natural Forest on the draft map, but *Psidium guajava* Disturbed Understory Semi-Natural Forest by the accuracy assessment personnel. This area of the final map has been edited to *Psidium guajava* Disturbed Understory Semi-Natural Forest.

Most Abundant Species: *Acacia confusa*, *Psidium guajava*

Distribution/Location: The map has one very large polygon of *Acacia confusa* - *Psidium guajava* Semi-natural Forest which starts close to the cliff trail head and spills down over the face of one of the north facing cliffs. While the trail portion of this polygon was field verified and contains a correct accuracy assessment sample site, the steep cliff facing portion was identified through binoculars. *Acacia confusa* - *Psidium guajava* Semi-natural Forest also occurs under the telephone line in KALA, but not in polygons larger than the MMU.

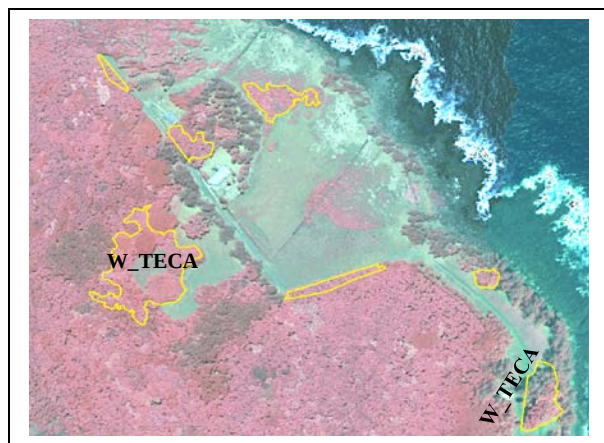
Classification Samples: 1	Hectares: 13.14
Producer's Accuracy: 50%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 2	Accuracy Assessment Reference Samples: 1

Map Class Name: <i>Terminalia catappa</i> Semi-natural Woodland [Park Special]	Common Name: Pacific Almond Semi-natural Woodland [Park Special]
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MAP CODE: W_TECA

Ground View



ELCODE: CEPS009651

Aerial View (WorldView-2 Infrared Imagery)

USNVC Associations: *Terminalia catappa* Semi-natural Woodland [Park Special]

Description: This semi-natural woodland association is characterized by a moderate tree canopy dominated by the non-native tree *Terminalia catappa*. Other trees present may include *Aleurites moluccana*, *Melia azedarach*, and *Syzygium cumini*. There is little understory present. This class was mapped using manual image interpretation.

Most Abundant Species: *Terminalia catappa*

Distribution/Location: This map class occurs only in small patches near both the south-eastern and south-western coasts of KALA and near the mouth of the Wai'ale'ia Valley.

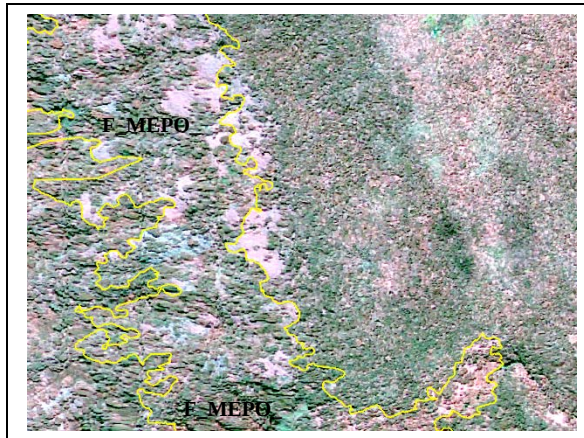
Classification Samples: 2	Hectares: 4.65
Producer's Accuracy: 50%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 2	Accuracy Assessment Reference Samples: 1

Map Class Name: <i>Metrosideros polymorpha</i> / Mixed Shrub Montane Wet Scrub Forest	Common Name: ‘Ōhi’a / Mixed Shrub Montane Wet Scrub Forest
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MAP CODE: F_MEPO_M

Ground View



ELCODE: CEGLO08152

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Metrosideros polymorpha* / Mixed Shrub Montane Wet Scrub Forest

Description: This scrub map class is characterized by wind-dwarfed trees, shrubs, diverse ferns and high cover of mosses and lichens. *Metrosideros polymorpha* is the dominant tree species with *Metrosideros waialealae* var. *fauriei* often codominant. *Dodonaea viscosa*, *Leptecophylla tameiameia*, and the widespread non-native *Psidium cattleianum* may be present in the tree canopy. A mixture of shrubs is usually present. Ferns are especially diverse and largely native, occurring terrestrially and epiphytically in this association. The high diversity of ferns and high cover of mosses and lichens are diagnostic of this association. Graminoid and forb species are relatively sparse or have low cover. This class was mapped using a combination of CART modeling and manual image interpretation. The class was most commonly confused with the *Metrosideros polymorpha* Montane Wet Forest map class in the draft map (4 samples). All confused sample areas were edited to the correct map class in the final map.

Most Abundant Species: *Metrosideros waialealae* var. *fauriei*, *Metrosideros polymorpha*

Distribution/Location: This map class occupies the steep higher reaches of KALA’s valleys’ cliff walls.

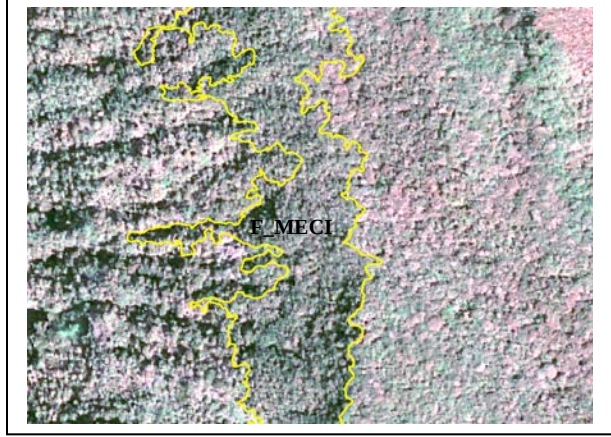
Classification Samples: 2	Hectares: 255.31
Producer’s Accuracy: 33%	User’s Accuracy: 67%
Accuracy Assessment Reference Samples: 6	Accuracy Assessment Reference Samples: 3

Map Class Name: <i>Metrosideros polymorpha</i> / <i>Cibotium</i> spp. Montane Wet Forest	Common Name: 'Ōhi'a - Hapu'u species Montane Wet Forest
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MAP CODE: F_MECI

Ground View



ELCODE: CEGLO08009

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Metrosideros polymorpha* / *Cibotium* spp. Montane Wet Forest

Description: There is no NatureServe description for this map class. Data from the one classification site and three accuracy assessment samples show that this densely forested class is dominated by *Metrosideros polymorpha* (70-75%) with low cover of *Cheiodendron trigynum* (5-7%). The subcanopy is characterized by a cover of *Cibotium* spp. (3-19%). This class was mapped using a combination of CART analysis and manual image interpretation. The accuracy of this class is low. However, it is confused only with other *Metrosideros polymorpha* map classes.

Most Abundant Species: *Metrosideros polymorpha*

Distribution/Location: This map class occurs on steep slopes within the Pu'ali'i Natural Area Reserve.

Classification Samples: 1	Hectares: 15.95
Producer's Accuracy: 33%	User's Accuracy: 33%
Accuracy Assessment Map Samples: 3	Accuracy Assessment Reference Samples: 1

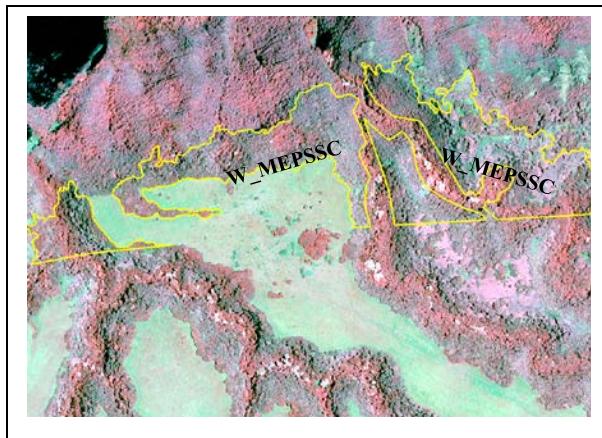
Map Class Name: <i>Metrosideros polymorpha</i> - (<i>Psidium</i> spp., <i>Schinus terebinthifolius</i>) Woodland	Common Name: ‘Ōhi’a (Guava species, Christmas berry) Woodland
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MAP CODE: W_MEPSSC

ELCODE: CEGL008142



Ground View



Aerial View (WorldView 2 Infrared Imagery)

USNVC Association: *Metrosideros polymorpha* - (*Psidium* spp., *Schinus terebinthifolius*) Woodland

Description: This map class is characterized by a mixed native and non-native canopy co-dominated by *Metrosideros polymorpha* and introduced trees *Psidium cattleianum*, *Psidium guajava*, and/or *Schinus terebinthifolius*. Other canopy associates may include *Aleurites moluccana*, *Antidesma platyphyllum*, and *Psychotria mariniana*. Constancy in the shrub stratum is low, including a mixture of species such as *Clidemia hirta*, *Dicranopteris linearis*, *Dodonaea viscosa*, *Kadua affinis*, *Leptecophylla tameiameia*, *Pluchea carolinensis*, *Rubus rosifolius*, *Scaevola gaudichaudiana*, and *Wikstroemia oahuensis* var. *oahuensis*. The herbaceous layer may be forb- or graminoid-dominated by species *Ageratina riparia*, *Erigeron karvinskianus*, or *Melinis minutiflora*. This map class was mapped using CART modeling and image interpretation.

Most Abundant Species: *Metrosideros polymorpha*, *Psidium cattleianum*, *Schinus terebinthifolius*, *Ageratina riparia*, *Erigeron karvinskianus*, *Melinis minutiflora*

Distribution/Location: The *Metrosideros polymorpha* - (*Psidium* spp., *Schinus terebinthifolius*) Woodland map class occurs primarily on KALA ridge tops adjacent to privately managed land.

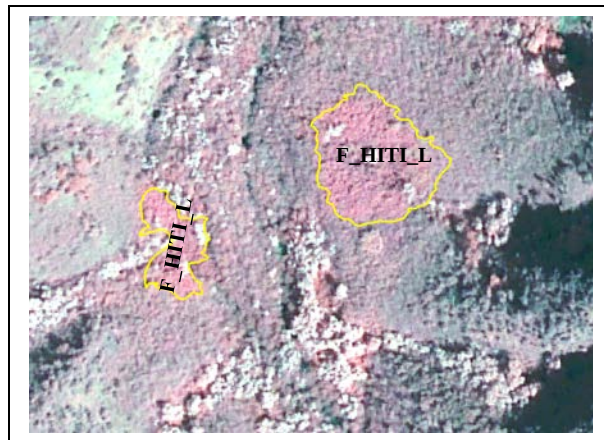
Classification samples: 7	Hectares: 36.68
User’s Accuracy: Not sampled for accuracy	Producer’s Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

Map Class Name: <i>Hibiscus tiliaceus</i> Lowland Wet Forest [Provisional]	Common Name: Hau Lowland Wet Forest [Provisional]
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MAP CODE: F_HITI_L

Ground View



ELCODE: CEGLO08163

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Hibiscus tiliaceus* Lowland Wet Forest [Provisional]

Description: This site is characterized by an open canopy dominated by *Hibiscus tiliaceus* with a dense understory dominated by *Coffea arabica*, *Clidemia hirta*, and *Aleurites moluccana*.

Most Abundant Species: *Hibiscus tiliaceus*

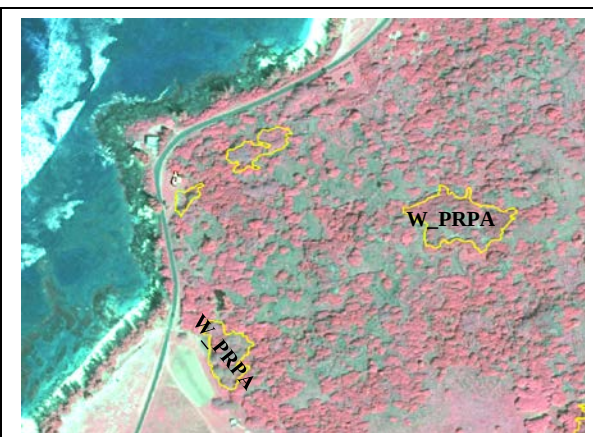
Distribution/Location: This map class is found in small scattered stands at the mouth and farther inland in the Waikolu Valley. It occupies one large coastal polygon on the small peninsula south of Kukaiwa'a point.

Classification Samples: 1	Hectares: 5.17
Producer's Accuracy: Not sampled for accuracy	User's Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

Map Class Name: <i>Prosopis pallida</i> Coastal Dry Semi-natural Woodland	Common Name: Kiawe Coastal Dry Semi-natural Woodland
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MAP CODE: W_PRPA
Ground View



ELCODE: CEGLO08118
Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Prosopis pallida* Coastal Dry Semi-natural Woodland

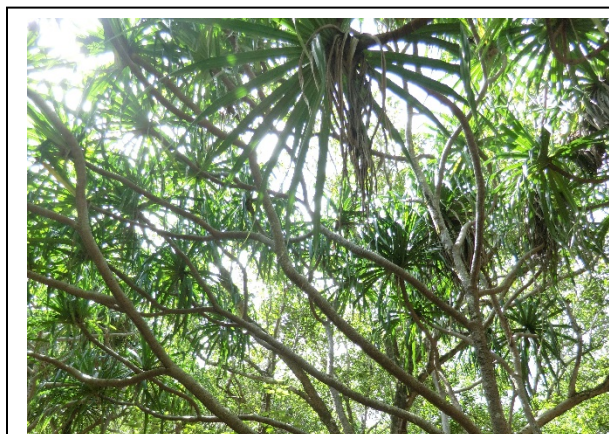
Description: This map class was discovered during the calibration field trip. It was not sampled for classification or accuracy and has no KALA NatureServe description. However, it was described at Haleakala National Park and Pu'ukoholā Heiau, Pu'u honua o Hōnaunau and Kaloko-Honokōhau National Historical Parks. In general, the class is dominated by open to moderately dense *Prosopis pallida* trees from 2-10 m in height. Occasional other trees species such as *Morinda citrifolia*, *Schinus terebinthifolius*, and *Thespesia populnea* may be present with low cover. Subcanopy vegetation may be entirely lacking (bare lava substrates) or sparse to dense mixtures of alien and native grasses and shrubs such as *Leucaena leucocephala*, *Passiflora foetida*, *Waltheria indica*, *Cenchrus ciliaris*, *Cenchrus setaceus*, *Urochloa maxima* (= *Panicum maximum*) (in more mesic settings), *Sida fallax*, and *Acacia farnesiana*. The class was mapped using field verification and manual image interpretation.

Most Abundant Species: *Prosopis pallida*, *Schinus terebinthifolius*

Distribution/Location: *Prosopis pallida* Coastal Dry Semi-natural Woodland map class occurs as isolated islands on the northwest portion of the peninsula. It is commonly surrounded by either *Schinus terebinthifolius* Semi-natural Scrub Woodland or *Leucaena leucocephala* Lowland Dry Semi-natural Shrubland.

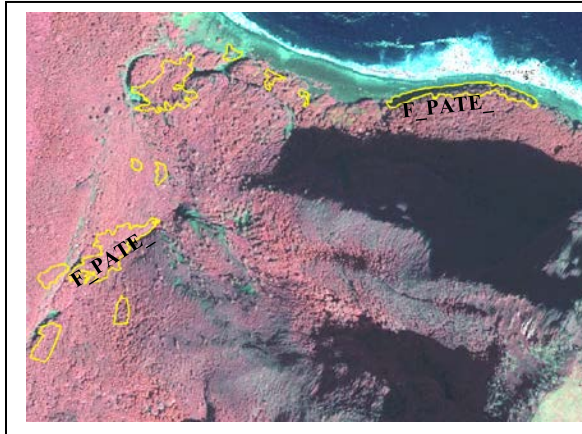
Classification Samples: 0	Hectares: 3.40
User's Accuracy: Not sampled for accuracy	Producer's Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

Map Class Name: <i>Pandanus tectorius</i> Coastal Mesic Forest	Common Name: Hala Coastal Mesic Forest
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MAP CODE: F_PATE_C

Ground View



ELCODE: CEGLO08032

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Pandanus tectorius* Coastal Mesic Forest

Description: This uncommon map class is characterized by a moderate to dense tree canopy dominated by *Pandanus tectorius*, an early Polynesian introduced species. Canopy associates include the Polynesian introduced *Morinda citrifolia*, and recently introduced species such as *Syzygium cumini* and *Psidium cattleianum*. Shrub diversity is low, and *Pluchea carolinensis* may dominate some stands. Herbaceous cover is low and may be fern-dominated by *Nephrolepis brownii* or by seedlings of canopy trees.

Most Abundant Species: *Pandanus tectorius*, *Pluchea carolinensis*, *Nephrolepis brownii*

Distribution/Location: This map class was mapped only where field verified during classification, calibration, validation, or accuracy assessment field efforts because the class is culturally important but impossible to distinguish using remote sensing methods. All but two of this classes 17 polygons are found in the Wai'ale'ia Valley or close to its mouth. While the accuracy assessment of this class is poor, its locations on the map are all field verified and are, therefore, accurate. One accuracy assessment sample had a reference label of *Pandanus tectorius* Coastal Mesic Forest which was erroneously mapped as *Psidium cattleianum* Lowland Wet Semi-natural Forest in the draft map. The site was corrected in the final map. However, there are probably other sites of *Pandanus tectorius* Coastal Mesic Forest in KALA that were not captured in the field efforts, and thus not depicted on the map.

Classification Samples: 2	Hectares: 2.55
Producer's Accuracy: 0%	User's Accuracy: 0%
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 1

Map Class Name: <i>Erythrina sandwicensis</i> Lowland Dry Woodland	Common Name: Wiliwili Lowland Dry Woodland
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MAP CODE: W_ERSA

Ground View

ELCODE: CEGLO08036

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Erythrina sandwicensis* Lowland Dry Woodland

Description: This map class was not sampled during the vegetation classification sampling effort and therefore, has no NatureServe description. Due to small polygon size, it was not sampled during accuracy assessment. Small, below MMU stands were identified during the validation and calibration field work and their locations were verified with earlier research in Kauhakō Crater (Fung & SWCA Environmental Consultants, 2010; Paul Hosten personal communication, 2013). At Haleakalā National Park this association is characterized by an open tree canopy dominated by *Erythrina sandwicensis*. Widespread, dry non-native tree *Prosopis pallida* is often present to codominant with a subcanopy or tall-shrub layer dominated by *Leucaena leucocephala*. The understory is characterized by a moderate to dense herbaceous layer dominated by non-native grasses *Urochloa maxima* (= *Panicum maximum*) and *Cenchrus ciliaris*.

Most Abundant Species: *Erythrina sandwicensis* and *Reynoldsia sandwicensis*

Distribution/Location: This map class is rare and only found in three field verified polygons in or on the edge of Kauhakō Crater. Other locations of *Erythrina sandwicensis* trees occur within KALA, but not in stands larger than the MMU.

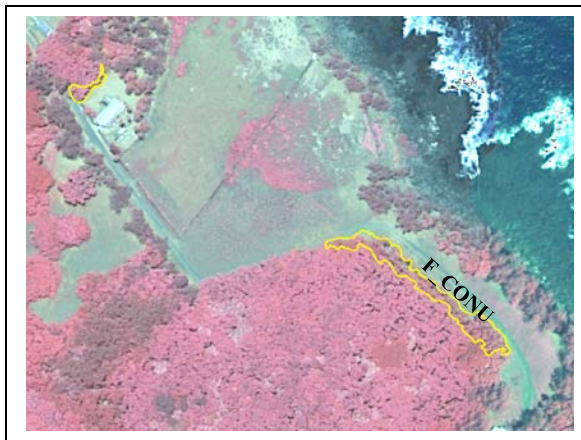
Classification Samples: 0	Hectares: 0.98
User's Accuracy: Not sampled for accuracy	Producer's Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

Map Class Name: <i>Cocos nucifera</i> Strand Woodland	Common Name: Coconut Palm Strand Woodland
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MAP CODE: W_CONU

Ground View



ELCODE: CEGLO05402

Aerial View (WorldView-2 Infrared Imagery)

USNVC Associations: *Cocos nucifera* Strand Woodland

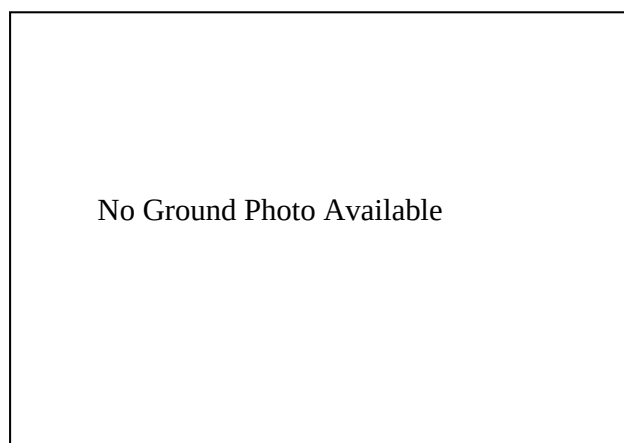
Description: The *Cocos nucifera* Strand Woodland map class was discovered during the calibration field trip. It was not sampled for classification or accuracy and does not have a KALA NatureServe description. However it was described at Kaloko-Honokōhau and Pu‘uhonua o Hōnaunau National Historical Parks where it was found to have an open tree canopy (20-30%) dominated by *Cocos nucifera* 5-10m tall. Trees found in the subcanopy may include *Thespesia populnea*, *Tournefortia argentea*, *Pandanus tectorius*, and *Morinda citrifolia*. At those parks, the shrub layer is absent to moderate and may include *Scaevola taccada* and *Passiflora suberosa*. The class was mapped using manual image interpretation.

Most Abundant Species *Cocos nucifera*

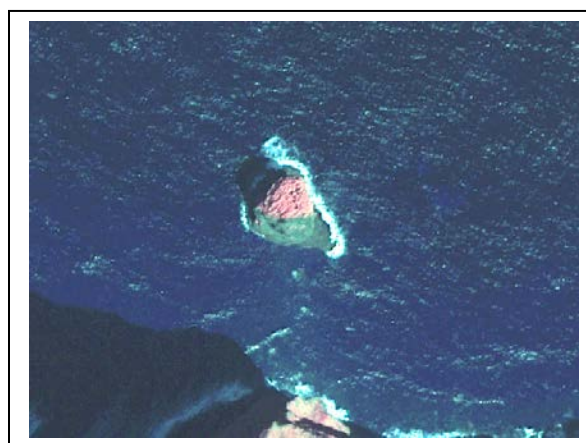
Distribution/Location: *Cocos nucifera* Strand Woodland, is mapped in three locations in KALA; one long thin stand adjacent to the last portions of the road before the mouth of the Wai‘ale‘ia Valley; one cluster of trees northwest of St. Philomena’s, and another cluster near the pier at Kalaupapa Settlement. Other groups of scattered *Cocos nucifera* trees can be found in isolated clusters in the park.

Classification Samples: 0	Hectares: 0.09
User’s Accuracy: Not sampled for accuracy	Producer’s Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

Map Class Name: <i>Pritchardia hillebrandii</i> Coastal Mesic Forest	Common Name: Loulu Lelo Coastal Mesic Forest
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MAP CODE: F_PRHI
Ground View



ELCODE: CEGLO08033
Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Pritchardia hillebrandii* Coastal Mesic Forest

Description: The *Pritchardia hillebrandii* Coastal Mesic Forest was not sampled for classification and, therefore, has no NatureServe description. Due to the remote location there were no accuracy assessment samples. However, the class has been studied extensively (Wood 2001, Wood and LeGrande, 2002; Wood 2008). The class was mapped using manual image interpretation, verified by earlier research.

Most Abundant Species: *Pritchardia hillebrandii*

Distribution/Location: The islet of Huelo supports a cap of one of the last remaining stands of *Pritchardia hillebrandii* Coastal Mesic Forest in the Hawaiian Islands.

Classification Samples: 0	Hectares: 0.09
User's Accuracy: Not sampled for accuracy	Producer's Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

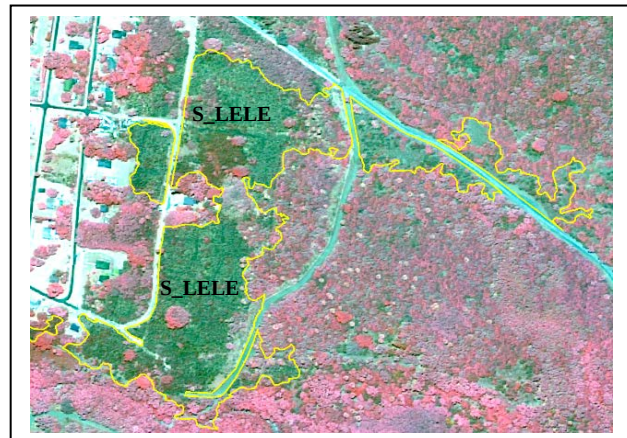
Shrublands

Map Class Name: <i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	Common Name: Koa Haole Lowland Dry Semi-natural Shrubland
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MAP CODE: S_LELE

Ground View



ELCODE: CEGLO08114

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Leucaena leucocephala* Lowland Dry Semi-natural Shrubland

Description: This association is found in dry to mesic settings, typically below 457 m elevation and on leeward settings. It is a disclimax shrubland maintained by fire, but strongly dominant due to allelopathic litter. The vegetation is characterized by a moderately dense, closed-canopy tall-shrub layer (2-5 m tall) that is dominated by nearly monotypic *Leucaena leucocephala*. There is often a sparse low-shrub stratum, though no single taxon is dominant; shrubs include *Sida cordifolia*, *Sida fallax*, *Waltheria indica*, and *Indigofera suffruticosa*. The sparse herbaceous stratum is dominated by *Talinum triangulare* with some *Urochloa maxima* and scattered seedlings of canopy trees, *Kalanchoe pinnata*, *Passiflora foetida*, *Catharanthus roseus*, and *Commelina benghalensis*. This class was mapped using CART modeling and manual image interpretation.

Most Abundant Species: *Leucaena leucocephala*

Distribution/Location: This map class occurs in small to large polygons in the middle western portions of the peninsula and in the north, east, and south outskirts of Kalaupapa Settlement.

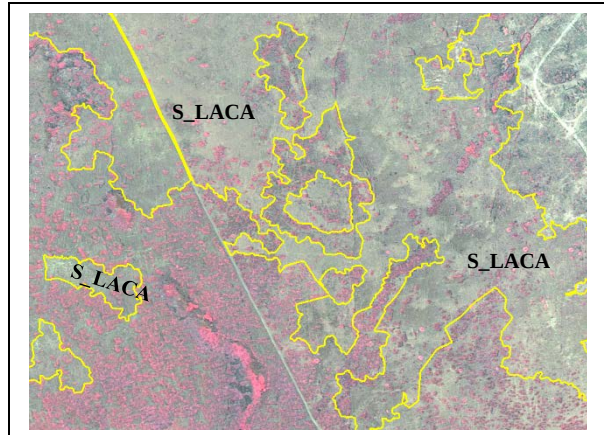
Classification Samples: 1	Hectares: 28.93
Producer's Accuracy: 100%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 4	Accuracy Assessment Reference Samples: 4

Map Class Name: <i>Lantana camara</i> Semi-natural Shrubland [Provisional]	Common Name: Lantana Semi-natural Shrubland [Provisional]
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MAP CODE: S_LACA

Ground View



ELCODE: CEGLO08145

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Lantana camara* Semi-natural Shrubland [Provisional]

Description: This association is characterized by an open to dense short-shrub layer dominated by *Lantana camara*. A variety of other shrubs may occur, but none codominate. Other shrub associates may include *Amaranthus spinosus*, *Asclepias curassavica*, *Indigofera suffruticosa*, *Phyllanthus debilis*, *Prosopis pallida*, *Senna occidentalis*, and natives *Sida fallax* and *Wikstroemia uva-ursi*. Wind-stunted *Psidium guajava* may codominate on exposed ridges. The understory is dominated by introduced forbs or graminoids such as *Digitaria insularis*, *Chamaecrista nictitans* ssp. *patellaria* var. *glabrata*, or *Ageratum conyzoides*. This class was mapped using a combination of CART modeling and manual image interpretation. The only map classes confused with *Lantana camara* Semi-natural Shrubland on the draft map were *Schinus terebinthifolius* Semi-natural Scrub Woodland and *Wikstroemia uva-ursi* - *Sida fallax* - *Fimbristylis cymosa* Coastal Shrubland. These areas are corrected on the final map.

Most Abundant Species: *Lantana camara*

Distribution/Location: This map class occurs in large polygons on the north, northeast and northwest portions of the peninsula, in thin strips along roadsides, and in large patches surrounding St. Philomena's.

Classification Samples: 4	Hectares: 145.81
Producer's Accuracy: 78%	User's Accuracy: 95%
Accuracy Assessment Map Samples: 23	Accuracy Assessment Reference Samples: 19

Map Class Name: <i>Psidium guajava</i> - <i>Lantana camara</i> Semi-natural Shrubland [Park Special]	Common Name: Common Guava - Lantana Semi-natural Shrubland [Park Special]
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MAP CODE: S_PSLA

Ground View



ELCODE: CEPS009697

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Psidium guajava* - *Lantana camara* Semi-natural Shrubland [Park Special]

Description: This map class was discovered during calibration field work. It has no classification samples, and, therefore, no NatureServe description. Data from its two accuracy assessment sites indicate that the class is co-dominated by *Psidium guajava* (45-70%) and *Lantana camara* (25-45%) which form an impenetrable mat of scrub vegetation. Few other species are present. This class was mapped manual image interpretation. The only map class confused with *Psidium guajava* - *Lantana camara* Semi-natural Shrubland on the draft map was *Psidium guajava* / Disturbed Understory Semi-natural Forest. The area around the one mis-classified sample was edited to the correct label in the final map.

Most Abundant Species: *Psidium guajava* and *Lantana camara*

Distribution/Location: This map class occurs east of the mouth of Waikolu Valley and on the peninsula south of Kuka'wa'a Point.

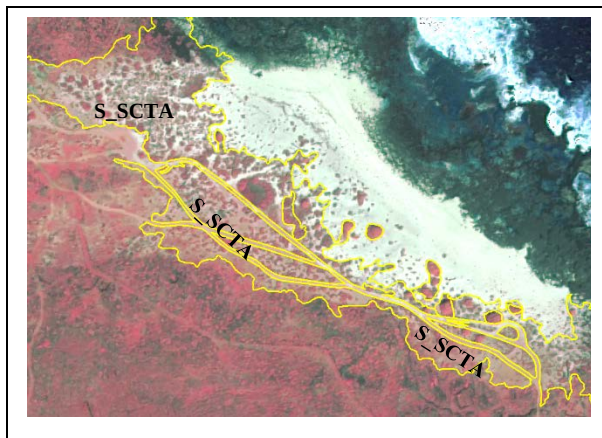
Classification Samples: 0	Hectares: 11.84
Producer's Accuracy: 67%	User's Accuracy: 100%
Accuracy Assessment Reference Samples: 3	Accuracy Assessment Reference Samples: 2

Map Class Name: <i>Scaevola taccada</i> Coastal Dry Shrubland	Common Name: Naupaka Kahakai Coastal Dry Shrubland
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MAP CODE: S_SCTA

Ground View



ELCODE: CEGLO08054

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Scaevola taccada* Coastal Dry Shrubland¹

Description: This dwarf-shrub community is variable and may be sparsely vegetated or have a closed shrub layer dominated by *Scaevola taccada*. Other shrub associates may include *Euphorbia degeneri*, *Sida fallax*, and *Wikstroemia uva-ursi*. The most constant herbaceous associate is the graminoid *Fimbristylis cymosa* which occurs at low cover typically less than 5%. The non-native species *Lantana camara* and *Cynodon dactylon* are known to invade some sites. Forb diversity is low. Species may include *Boerhavia coccinea*, *Euphorbia hirta*, *Heliotropium anomalum* var. *argenteum*, *Ipomoea pes-caprae*, and *Jacquemontia ovalifolia* ssp. *sandwicensis*.

Most Abundant Species: *Scaevola taccada* and *Fimbristylis cymosa*

Distribution/Location: This map class is located primarily on the northern tip of the Kalaupapa Peninsula. Two small polygons of it also can be found at the mouth of the Wai'ale'ia Valley.

Classification Samples: 3	Hectares: 12.11
Producer's Accuracy: 67%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 6	Accuracy Assessment Reference Samples: 4

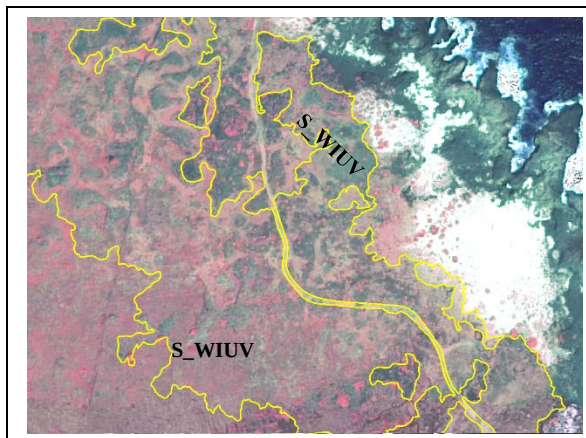
¹USNVC name *Scaevola sericea* modified to *Scaevola taccada* based on taxonomy of Wagner et al. (2012).

Map Class Name: <i>Wikstroemia uva-ursi</i> Coastal Shrubland	Common Name: 'Akia Coastal Shrubland
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MAP CODE: S_WIUV

Ground View



ELCODE: CEGLO08175 and CEP009667

Aerial View (WorldView-2 Infrared Imagery)

USNVC Associations: *Wikstroemia uva-ursi* - *Sida fallax* Coastal Shrubland and *Wikstroemia uva-ursi* / *Fimbristylis cymosa* Mixed Grass Coastal Shrubland [Park Special]

Description: This map class is a combination of two associations one which has a NatureServe description (*Wikstroemia uva-ursi* - *Sida fallax* Coastal Shrubland) and one which does not (*Wikstroemia uva-ursi* / *Fimbristylis cymosa* Mixed Grass Coastal Shrubland). It is characterized by an open shrub layer codominated by *Wikstroemia uva-ursi* with *Sida fallax* or *Fimbristylis cymosa*. Other shrubs may contribute significant cover but are never codominant. Herbaceous cover may exceed that of the shrub stratum and is usually a mixture of native and introduced species. The non-native grass *Cynodon dactylon* may dominate some stands and a variety of native and introduced forbs may occur. This class was mapped using a combination of CART modeling and manual image interpretation. The accuracy of this map class is low because it is frequently confused with similar map classes such as *Fimbristylis* spp. Coastal Dry Herbaceous Vegetation and *Sida fallax* Coastal Dry Shrubland.

Most Abundant Species: *Sida fallax*, *Wikstroemia uva ursi*, *Anagallis arvensis*, *Fimbristylis cymosa*

Distribution/Location: This map class extends along the coast from the north tip of the Kalaupapa Peninsula along its east side to Kalawao.

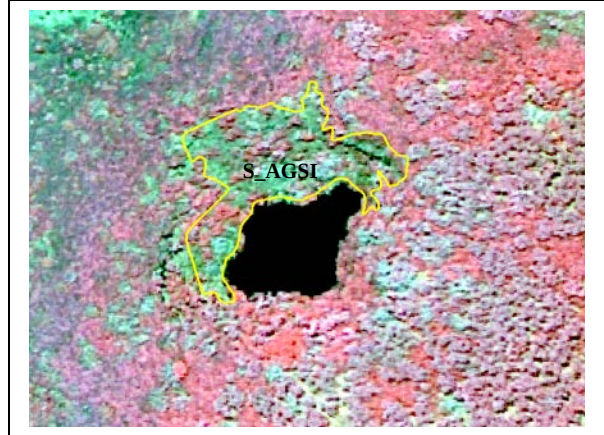
Classification Samples: 3	Hectares: 56.56
Producer's Accuracy: 44%	User's Accuracy: 67%
Accuracy Assessment Map Samples: 9	Accuracy Assessment Reference Samples: 4

Map Class Name: <i>Agave sisalana</i> Semi-natural Shrubland [Park Special]	Common Name: Sisal Semi-natural Shrubland [Park Special]
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MAP CODE: S_AGSI

Ground View



ELCODE: CEPS009661

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Agave sisalana* Semi-natural Shrubland [Park Special]

Description: There is no NatureServe description of this class. The class is ecologically important but impossible to distinguish using remote sensing methods. Therefore, it is mapped only where field verified during classification, calibration, validation, or accuracy assessment field efforts. The class's one accuracy assessment sample was incorrectly mapped on the draft map. The error was corrected in the final map. Because of this class's ecological importance it is included on the map where field verified, even though it usually occurs in areas below the MMU. There may be other occurrences of this map class at KALA. The one observation site for this map class shows it to be dominated by *Agave sisalana* (60%) with *Pluchea carolinensis*, *Schinus terebinthifolius*, *Erigeron karvinskianus*, and *Melinis minutiflora* also present at low cover (5-15%).

Most Abundant Species: *Agave sisalana*

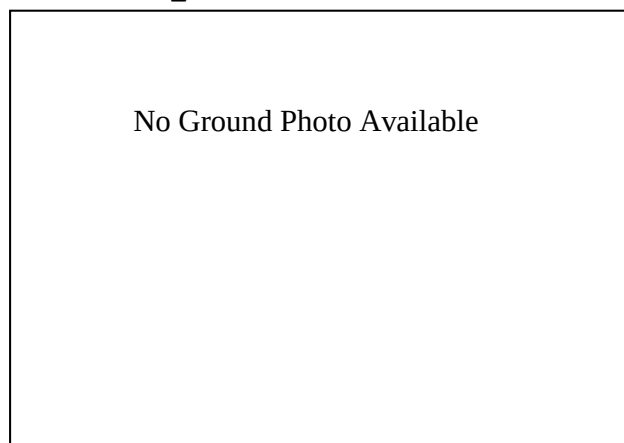
Distribution/Location: This class occurs in isolated locations in KALA at Kauhako Crater, along the first 700 meters of Wai'ale'ia Stream, and on ridges above the mouths of both Wai'ale'ia and Waikolu steams. It typically occurs in areas below the MMU.

Classification Samples: 1	Hectares: 1.79
Producer's Accuracy: 0%	User's Accuracy: 0%
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 1

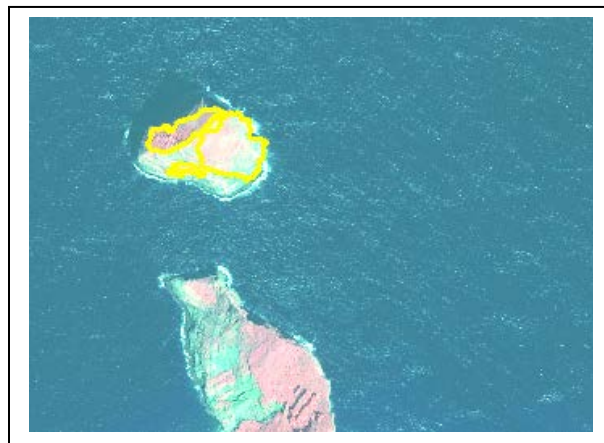
Map Class Name: <i>Euphorbia celastroides</i> Coastal Dry Dwarf-shrubland	Common Name: ‘Akoko Coastal Dry Dwarf-shrubland
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MAP CODE: S_EUCE

ELCODE: CEGLO08075



Ground View



Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Euphorbia celastroides* Coastal Dry Dwarf-shrubland²

Description: The *Euphorbia celastroides* Coastal Dry Dwarf-shrubland Forest was not sampled for classification and, therefore, has no NatureServe description. Due to the remote location there were no accuracy assessment samples. However, the class has been studied extensively (Wood 2001, Wood and LeGrande, 2002; Wood 2008). The class was mapped using manual image interpretation, verified by earlier research.

Most Abundant Species: *Euphorbia celastroides*

Distribution/Location: The islet of ‘Okale supports several small polygons of *Euphorbia celastroides* Coastal Dry Dwarf-shrubland.

Classification Samples: 0	Hectares: 1.07
User’s Accuracy: Not sampled for accuracy	Producer’s Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

²USNVC name *Chamaesyce celastroides* modified to *Euphorbia celastroides* based on taxonomy of Wagner et al. (2012).

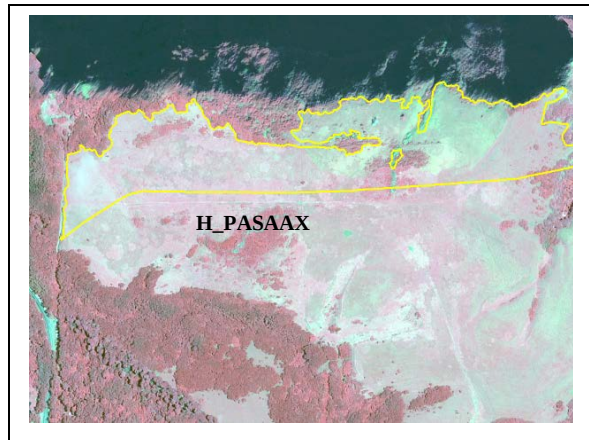
Herbaceous

Map Class Name: <i>Paspalum conjugatum</i> - <i>Sacciolepis indica</i> - <i>Axonopus fissifolius</i> Mixed Semi-natural Herbaceous Vegetation [Provisional]	Common Name: Hilo Grass - Glenwood Grass - Carpetgrass Mixed Semi-natural Herbaceous Vegetation [Provisional]
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MAP CODE: H_PASAAX

Ground View



ELCODE: CEGLO08170

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Paspalum conjugatum* - *Sacciolepis indica* - *Axonopus fissifolius* Mixed Semi-natural Herbaceous Vegetation [Provisional]

Description: This grassland association is composed of a lush mixture of introduced perennial grasses with a few usually codominating. Scattered trees and shrubs are often present, but do not form a distinct tree or shrub canopy (generally <10% cover). One or more of the following grasses dominate or codominate the herbaceous layer: *Paspalum conjugatum*, *Sacciolepis indica*, or *Axonopus fissifolius*. Many other introduced graminoid species may be present such as *Anthoxanthum odoratum*, *Cyperus polystachyos*, *Digitaria ciliaris*, *Kyllinga brevifolia*, *Machaerina angustifolia*, *Melinis minutiflora*, *Cenchrus clandestinus*, and *Setaria parviflora* with low cover. Forb cover is variable and relatively sparse. This class was mapped using CART modeling and manual image interpretation.

Most Abundant Species: *Axonopus fissifolius*, *Paspalum conjugatum*, *Sacciolepis indica*

Distribution/Location: This map class occurs in one small and three large polygons at the southwestern boundary of KALA on the plateau above the north facing cliffs.

Classification Samples: 3	Hectares: 23.29
Producer's Accuracy: 100%	User's Accuracy: 100%
Accuracy Assessment Map Samples: 4	Accuracy Assessment Reference Samples: 4

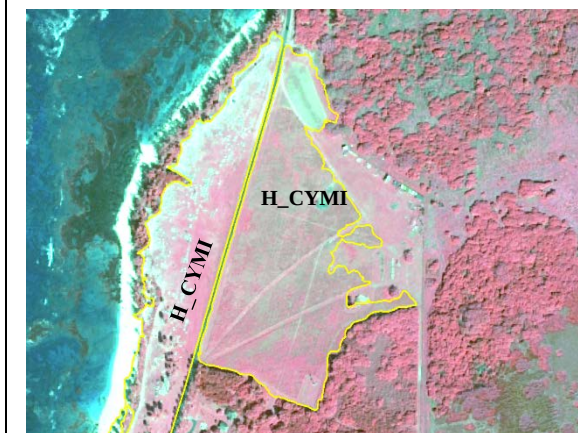
Map Class Name: *Cynodon dactylon* - Mixed Grass Pacific Semi-natural Herbaceous Vegetation

Common Name: Bermuda grass - Mixed Grass Pacific Semi-natural Herbaceous Vegetation



MAP CODE: H_CYMI

Ground View



ELCODE: CEGLO08167

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Cynodon dactylon* - Mixed Grass Pacific Semi-natural Herbaceous Vegetation

Description: This grassland association is dominated by the introduced perennial grass *Cynodon dactylon*. Other graminoids include *Digitaria ciliaris*, which codominates one stand, and *Kyllinga brevifolia* is frequently present. *Fimbristylis cymosa* is absent or has very low cover. Other herbaceous species, such as *Ageratum conyzoides*, *Ageratina riparia*, *Centella asiatica*, *Conyza bonariensis*, *Desmodium sandwicense*, *Hypochoeris radicata*, *Oxalis corniculata*, and *Xanthium strumarium*, may be present, generally with low cover. Scattered woody species may also be present such as *Lantana camara*, *Pluchea carolinensis*, or *Psidium guajava*. This class was mapped using CART modeling and manual image interpretation. The map class was confused only with one sample of *Fimbristylis* spp. Coastal Dry Herbaceous Vegetation on the draft map.

Most Abundant Species: *Cynodon dactylon*, *Digitaria ciliaris* and *Kyllinga brevifolia*

Distribution/Location: This map class occurs in coastal areas throughout KALA.

Classification Samples: 3	Hectares: 32.23
Producer's Accuracy: 100%	User's Accuracy: 83%
Accuracy Assessment Map Samples: 5	Accuracy Assessment Reference Samples: 6

Map Class Name: <i>Sesuvium portulacastrum</i> Coastal Dry Herbaceous Vegetation	Common Name: 'Akulikuli Coastal Dry Herbaceous Vegetation
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MAP CODE: H_SEPO

Ground View



ELCODE: CEGLO08098

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Sesuvium portulacastrum* Coastal Dry Herbaceous Vegetation

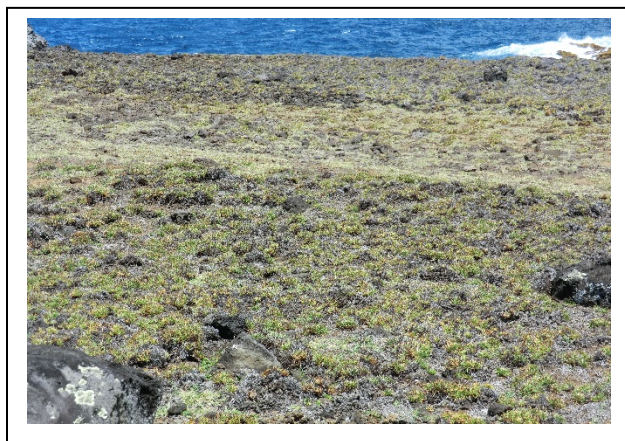
Description: This association is known from one location in a low-level seasonal wetland formerly used as a fishpond. The map class is characterized by an open herbaceous layer co-dominated by *Sesuvium portulacastrum* and *Bolboschoenus maritimus*. This class was mapped using CART modeling and manual image interpretation.

Most Abundant Species: *Sesuvium portulacastrum* and *Bolboschoenus maritimus*

Distribution/Location: This map class occurs at one location on the northwestern portion of the peninsula.

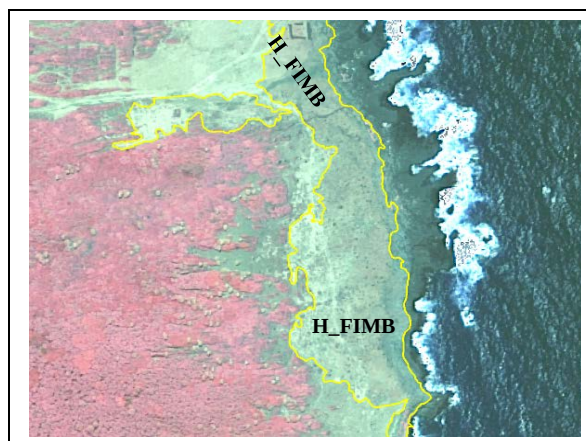
Classification Samples: 1	Hectares: 1.09
User's Accuracy: 100%	Producer's Accuracy: 100%
Accuracy Assessment Map Samples: 1	Accuracy Assessment Reference Samples: 1

Map Class Name: <i>Fimbristylis</i> spp. Coastal Dry Herbaceous Vegetation	Common Name: Fimbristylis Coastal Dry Herbaceous Vegetation
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MAP CODE: H_FIMB

Ground View



ELCODE: CEGLO08089

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Fimbristylis* spp. Coastal Dry Herbaceous Vegetation

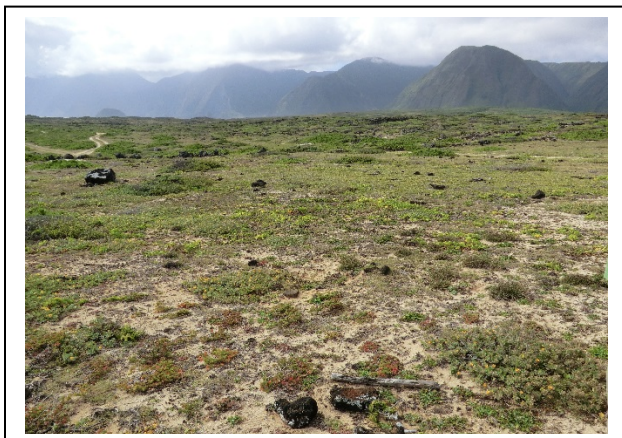
Description: This association is characterized by mixed native and non-native open herbaceous layer dominated by *Fimbristylis cymosa* with lesser amounts of introduced *Cynodon dactylon*. The dwarf-shrub *Sida fallax* is present with sparse cover. This class was mapped using CART modeling and manual image interpretation. The class was confused with the *Cynodon dactylon* - Mixed Grass Pacific Semi-natural Herbaceous Vegetation and *Wikstroemia uva-ursi* Coastal Shrubland map classes on the draft map.

Most Abundant Species: *Fimbristylis cymosa*, *Cynodon dactylon*

Distribution/Location: This map class occurs on the southern two thirds of the peninsula's east coast.

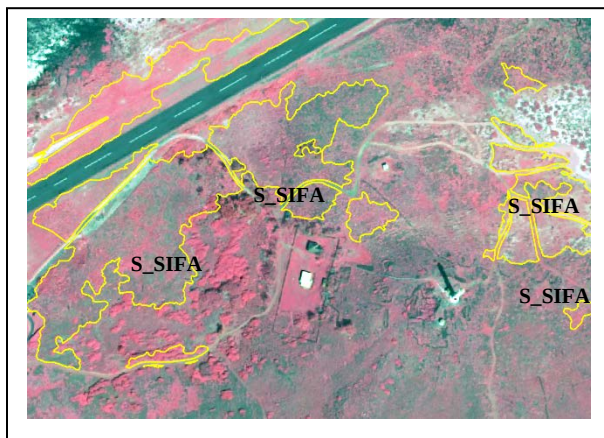
Classification Samples: 1	Hectares: 28.80
Producer's Accuracy: 80%	User's Accuracy: 67%
Accuracy Assessment Map Samples: 5	Accuracy Assessment Reference Samples: 6

Map Class Name: <i>Sida fallax</i> Coastal Dry Shrubland	Common Name: 'Ilima Coastal Dry Shrubland
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MAP CODE: S_SIFA

Ground View



ELCODE: CEGLO08055

Aerial View (WorldView-2 Infrared Imagery)

USNVC Associations: *Sida fallax* Coastal Dry Shrubland

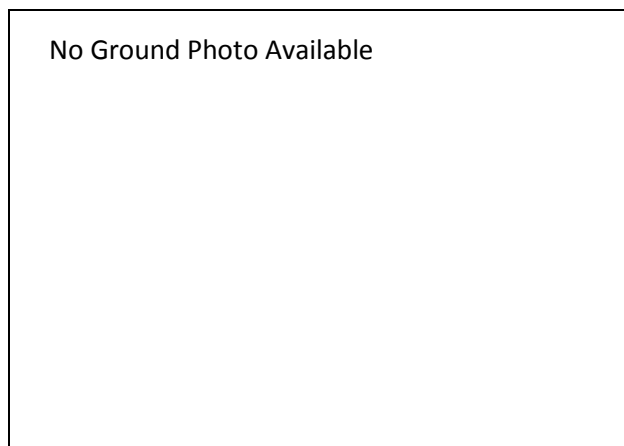
Description: This association is characterized by an open short-shrub layer dominated by *Sida fallax* which typically forms prostrate mats, although on more sheltered sites, a more erect ecotype may occur. Other shrubs are present but contribute little cover. Species may include *Euphorbia degeneri*, *Waltheria indica*, and *Wikstroemia uva-ursi*. Herbaceous cover is low with no clear dominant species. A variety of forbs may occur and include *Ageratum conyzoides*, *Anagallis arvensis*, *Chamaecrista nictitans* var. *glabrata*, *Euphorbia hirta*, *Coronopus didymus*, *Cuscuta sandwichiana*, *Desmodium triflorum*, *Emilia fosbergii*, *Erigeron karvinskianus*, and *Portulaca pilosa*. The non-native species *Lantana camara* and *Plantago lanceolata* have invaded some sites. This map class was mapped with a combination of CART modeling and manual image interpretation. Three of the five accuracy assessment reference sites were mapped as either *Lantana camara* Semi-natural Shrubland (2) or *Scaevola taccada* Coastal Dry Shrubland (1) in the draft map. However, accuracy assessment personnel indicated that the two *Lantana* sites could also have an acceptable map label of *Sida fallax* Coastal Dry Shrubland. Thus, only the *Scaevola taccada* Coastal Dry Shrubland sample site area was edited in the final map.

Most Abundant Species: *Sida fallax* and *Portulaca pilosa*

Distribution/Location: This map class occurs primarily on the north tip of the peninsula near the airport.

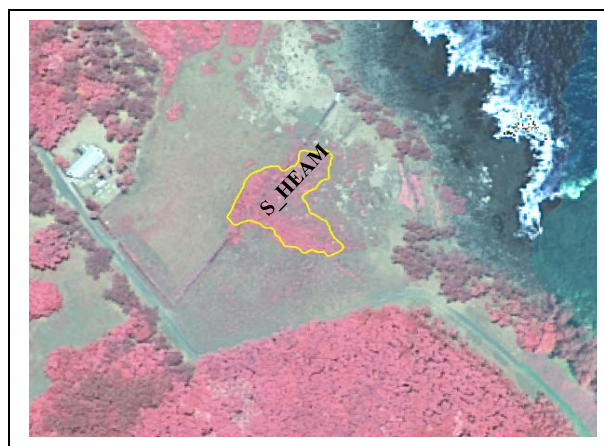
Classification Samples: 1	Hectares: 9.42
Producer's Accuracy: 100%	User's Accuracy: 29%
Accuracy Assessment Map Samples: 2	Accuracy Assessment Reference Samples: 5

Map Class Name: <i>Heliotropium amplexicaule</i> Semi-natural Shrubland [Park Special]	Common Name: Claspig Heliotrope Semi-natural Shrubland [Park Special]
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MAP CODE: S_HEAM

Ground View



ELCODE: CEPS009711

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Heliotropium amplexicaule* Semi-natural Shrubland [Park Special]

Description: This map class was discovered during the calibration trip and mapped in the field. It has no classification samples and, therefore, no NatureServe description. It was also not sampled for accuracy assessment. Insufficient data exists to describe the class in more detail.

Most Abundant Species: *Heliotropium amplexicaule*

Distribution/Location: This map class occurs as one field verified polygon located near St. Philomena's.

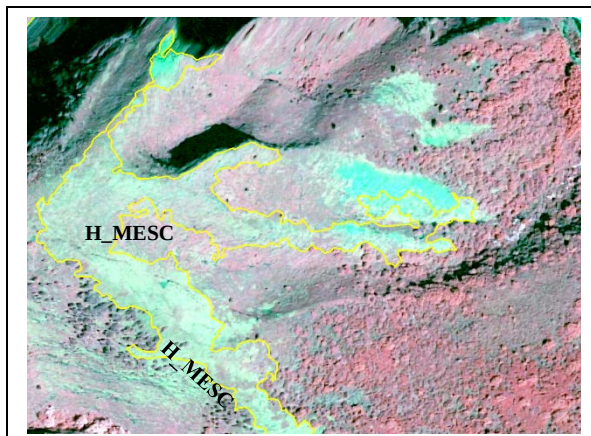
Classification Samples: 0	Hectares: 0.30
Producer's Accuracy: Not sampled for accuracy	User's Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

Map Class Name: <i>Melinis minutiflora</i> - (<i>Schizachyrium condensatum</i>) Semi-natural Herbaceous Vegetation	Common Name: Molasses grass (Beardgrass) Semi-natural Herbaceous Vegetation
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MAP CODE: H_MESC

Ground View



ELCODE: CEGLO08169

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Melinis minutiflora* - (*Schizachyrium condensatum*) Semi-natural Herbaceous Vegetation

Description: This association is characterized by dense herbaceous vegetation strongly dominated (40-75% cover) by the non-native grass *Melinis minutiflora* often with *Andropogon virginicus* prominent (5-20% cover). Various non-native trees and shrub species may be present with low cover, and occasionally exceed 10% total cover (to 20%) when species are mixed and do not form distinct layers. Common non-native trees include *Psidium guajava*, *Phoenix dactylifera*, *Schinus terebinthifolius*, and *Syzygium cumini*. Shrub species *Leptecophylla tameiameia* and non-native *Pluchea carolinensis* are common. Other non-native herbaceous species are prevalent and include *Ageratina riparia*, *Desmodium incanum*, *Digitaria ciliaris*, *Erigeron karvinskianus*, *Nephrolepis multiflora*, *Oxalis corniculata*, *Sacciolepis indica*, *Setaria parviflora*, and *Odontosoria chinensis*. Native vascular species are generally few with low cover. This class was mapped using CART modeling and manual image interpretation.

Most Abundant Species: *Andropogon virginicus*, *Digitaria ciliaris*, *Melinis minutiflora*

Distribution/Location: This map class occurs primarily along the west side of the Waikolu Valley where it alternates with stringers of *Diospyros sandwicensis* Lowland Mesic Woodland.

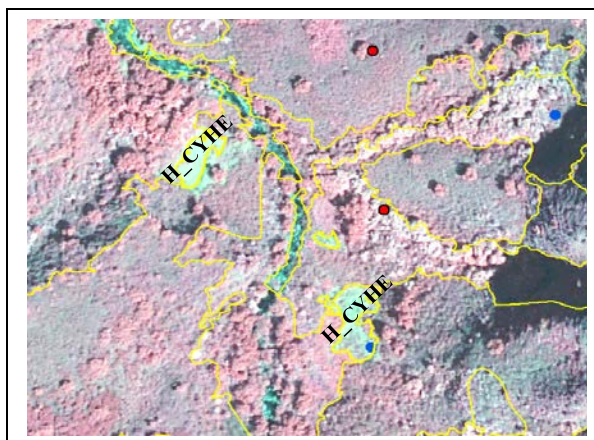
Classification Samples: 2	Hectares: 73.14
User's Accuracy: Not sampled for accuracy	Producer's Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

Map Class Name: <i>Cyclosorus dentatus</i> - <i>Hedychium coronarium</i> - <i>Coix lacryma-jobi</i> Semi-natural Herbaceous Vegetation [Park Special]	Common Name: <i>Cyclosorus dentatus</i> - White Ginger- Kūkaekōlea Semi-natural Herbaceous Vegetation [Park Special]
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MAP CODE: H_CYHECO

Ground View



ELCODE: CEPS009659

Aerial View (WorldView-2 Infrared Imagery)

USNVC Association: *Cyclosorus dentatus* - *Hedychium coronarium* - *Coix lacryma-jobi* Semi-natural Herbaceous Vegetation [Park Special]²

Description: There is no NatureServe description of this class. The class has one classification site, but was not assessed for accuracy. The classification site data shows the class to be codominated by a mix of *Cyclosorus dentatus* (30%), *Coix lacryma-jobi* (30%), and *Hedychium coronarium* (15%). This class was mapped using manual image interpretation. While all of its polygons are below the MMU, they were retained on the map because the class is ecologically significant.

Most Abundant Species: *Cyclosorus dentatus*, *Hedychium coronarium*, *Coix lacryma-jobi*

Distribution/Location: This rare class encompasses three small polygons at KALA, which all occur just south of the mouth of Waikolu Valley.

Classification Samples: 1	Hectares: 0.23
Producer's Accuracy: Not sampled for accuracy	User's Accuracy: Not sampled for accuracy
Accuracy Assessment Map Samples: 0	Accuracy Assessment Reference Samples: 0

²USNVC name *Christella dentata* modified to *Cyclosorus dentatus* based on taxonomy of Wagner et al. (2012).

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