



# Early Detection of Invasive Plant Species Monitoring Plan

## *Pacific Island Network*

Natural Resource Report NPS/PACN/NRR—2017/1545





**ON THIS PAGE**

*Sonchus oleraceus* and *Euphorbia prostrata* at Kalaupapa National Historical Park  
Photograph by: Jacob Gross NPS

**ON THE COVER**

*Verbascum thapsus* at Hawai'i Volcanoes National Park  
Photograph by: David Benitez NPS

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## Executive Summary

This document describes the plan for early detection of incipient invasive plant species within the national parks in the Pacific Island Network (PACN). Oceanic islands are extremely vulnerable to invasion by non-native plant species from continents because of their evolution in relative isolation and in the absence of some of the forces shaping continental organisms. As a result, ecologically disruptive or invasive species are able to completely displace native vegetation and alter ecosystem processes. Non-native plant invasions can also lead to significant economic and cultural costs.

By targeting invasions at initial stages, significant costs may be reduced or avoided in the long-term. The PACN early detection program involves 1) repeated early detection field surveys along park dispersal corridors (e.g., roads, trails, fence lines) including other high-risk sites (e.g., parking lots), 2) maintaining a database (NPSpecies) consisting of all species documented in each park, and 3) the development of educational materials such as identification cards and calendars designed to increase park staff invasive species awareness and reporting capability.

Field crews knowledgeable of the native flora, will survey sections of corridors and high-risk invasion sites in the parks in order to document non-native plants that are new to the area, or of interest to the park. Documentation will include GPS points, photos of the species encountered, and associated attributes related to the species' age, abundance, and distribution. Field survey effort will also be documented by GPS. Field surveys under this plan emphasize dispersal corridors and other high-risk sites as these are important areas for non-native plant species transport via humans and animals. Additionally, frequent disturbance along these corridors provides sites for non-native plant species establishment. Information on incipient species found during surveys is communicated with park management to facilitate rapid response efforts. This is a long-term program that uses repeated survey efforts to detect and report new invasive or suspect plants before they become widespread. The timeline and budget developed for this plan are assumed to be on a three-year cycle with field surveys conducted by the Pacific Island Inventory and Management Program. Although a three-year cycle is considered ideal, PACN does not currently have the resources to regularly implement this plan and it will require either an increase in base funding or reduction of other monitoring work to implement it as described. Surveys may also be conducted by PACN, park staff, or contractors opportunistically, as done for the four reported pilot studies in this plan. In all four of these studies, new non-native plant species were identified, locations were provided to park managers, and control efforts were instituted, exhibiting the value of any early detection surveys even when conducted on an opportunistic and sporadic basis.

After each field season, the project lead will summarize the information and survey data from that year in a report. Reporting will 1) categorize, map, and describe the incipient species detected during the survey, 2) summarize species attributes (e.g., species richness, life form, reproductive status), 3) explore potential trends related to location of detections (i.e., frequency of detections relative to distance from trailheads and/or populated areas), 4) provide updated status of species identified during previous sampling events (i.e., species now considered widespread and not included in survey), and 5) summarize overall survey effort (e.g., worker hours, distance surveyed, time required

to identify unknown species). When paired with rapid response, early detection of invasive species along corridors is a cost-effective way of addressing plant species before they cause long-term damage to park resources and other areas of conservation value.

For all parks, the NPSpecies database includes all species documented within the park and source evidence identifying who and when new species were included (e.g., research studies, pers. comm.). This database will be updated to include any new species documented within parks during early detection surveys. It is imperative that NPSpecies be kept up to date and reviewed by park staff, local experts, and field crews prior to conducting future early detection corridor surveys. Educational materials (e.g., field plant identification guides, calendars) based on an incipient subset of invasive species are developed for park staff and volunteers to increase the park's early detection capabilities.

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## Acronyms

|      |                                               |
|------|-----------------------------------------------|
| ALKA | Ala Kahakai National Historic Trail           |
| AMME | American Memorial National Park               |
| BRD  | Biological Resources Division                 |
| ED   | Early Detection                               |
| FOIA | Freedom of information Act                    |
| FTE  | Fulltime Employment                           |
| GIS  | Geographic Information System                 |
| GPS  | Global Positioning System                     |
| HALE | Haleakalā National Park                       |
| HAVO | Hawai‘i Volcanoes National Park               |
| I&M  | Inventory & Monitoring Program                |
| KAHO | Kaloko-Honokōhau National Historical Park     |
| KALA | Kalaupapa National Historical Park            |
| NPS  | National Park Service                         |
| NPSA | National Park of American Samoa               |
| PACN | Pacific Island Network                        |
| PUHE | Pu‘ukoholā Heiau National Historic Site       |
| PUHO | Pu‘uhonua o Hōnaunau National Historical Park |
| SOP  | Standard Operating Procedure                  |
| SQL  | Structure Query Language                      |
| USGS | US Geological Survey                          |
| UTM  | Universal Transverse Mercator                 |
| WAPA | War in the Pacific National Historical Park   |



## Background and Objectives

One of the major agents of stress or change to plant communities is non-native species introductions. Non-native species are species capable of propagating in ecosystems where they were absent prior to intentional or accidental introduction through human activity (Richardson et al. 2000). Some widely used synonyms include alien, exotic, and non-indigenous plants. Of the plant species introductions that occur, those that have a high potential to severely impact the integrity of terrestrial plant communities and biological diversity through competition and displacement are labeled invasive (Vitousek et al. 1997). In a Presidential Executive Order (USPEO 1999) addressing this topic, invasive species are defined as non-native species whose introduction does or is likely to cause economic or environmental harm or damage to humans. Richardson et al. (2000) defines invasive species in a biological context as non-native plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants (for taxa spread by seed and other propagules, >100 m in less than 50 years; for taxa spreading by roots, rhizomes, stolons, or creeping stems, >6 m per 3 years), and thus have the potential to spread over a considerable area.

Due to their evolution in relative isolation and in the absence of some of the forces shaping continental organisms, ecological communities on oceanic islands are extremely vulnerable to invasion by non-native plant species from continents (Loope and Mueller-Dombois 1989, Denslow 2003). The catastrophic impacts of plant invaders on native biodiversity and ecosystem processes in subtropical and tropical island ecosystems are well-documented (Huenneke and Vitousek 1989, Walker and Vitousek 1991, Meyer and Florence 1996, Lavergne et al. 1999, Buddenhagen et al. 2004, Asner and Vitousek 2005, Bellingham et al. 2005, Hughes and Denslow 2005). At their very worst, ecologically disruptive species (e.g., non-native grasses, *Morella faya*, *Miconia calvascens*, *Psidium cattleianum*) are able to completely displace native vegetation and alter natural ecosystem processes (Vitousek and Walker 1989, D'Antonio and Vitousek 1992).

Prior to human colonization, very few new species arrived in the Hawaiian Islands and became established. It is estimated that the rate of new species establishment in the Hawaiian Islands prior to human arrival was approximately one new species every 2,500 years (Loope 1998). Today, with the advent of ships, jets, and other forms of long-distance transportation, introductions of new species by the activities of humans are increasing to an estimated 90 new species/year, an approximately 50,000-fold increase over the estimated natural rate during the past 5 million years (Loope 1998, Price and Clague 2002). With globalization, the pressure and influx of introduced species to islands pose a chronic problem with no signs of slowing. This trend is likely to continue without concerted prevention and early detection efforts. In Hawai'i, the number of naturalized (found in the wild) non-native plant species recently surpassed the number of native plant species (Eldredge 2000). Because Hawai'i is a hub of horticultural trade in the Pacific, other Pacific Islands are susceptible to the introduction and spread of invasive plants from Hawai'i.

The impact of invasive species on native island ecosystems is costly, both ecologically and economically (OTA 1993, Leung et al. 2002). For example, some fire-adapted grass species that invade new areas are responsible for increased fire frequency and spread in wildland-suburban

interfaces as well as the loss or alteration of culturally significant species and landscapes (NPS 1990). Prevention programs that seek to prevent the introduction of invasive plants to islands are clearly the most cost effective defense against invasive species. These may involve legislative actions that prevent the importation of plants known to be invasive elsewhere or implementing an effective screening and quarantine program to intercept invasive plants from entering an island. At present, prevention actions in the Hawaiian Islands and other PACN islands are currently inadequate to prevent incursion of most invasive plants although inroads have been made in recent years. Early detection surveys, in the absence of stringent prevention measures, are therefore a valuable tool to detect and ultimately prevent the island-wide spread of invasive plants that are already on the island. Repeated early detection surveys are recommended to identify new invaders while eradication is still possible (McDougall et al. 2011).

Once invasive species become established and naturalized, eradication becomes unlikely, and costly long-term containment, “site-led” control, or biocontrol are then the only options other than simply accepting whatever resultant damage occurs (Hobbs and Humphries 1995, Leung et al. 2002). However, when a species is first introduced, there may be a lag phase where it is not yet escaped or established in the natural environment (Figure 1) (Sakai et al. 2001). By targeting resources at the initial stages of invasion, significant economic and environmental costs may be reduced or avoided in the long-term. Early detection of invasive species when paired with rapid response is a cost-effective way of addressing plant species before they cause long-term damage to park resources and other areas of conservation value (Figure 1). This PACN plan provides the framework for early detection defined as finding and identifying invasive species or suspect species that are incipient or newly established to parks or specific sections of parks.

Roadside or corridor sampling has been used pragmatically and successfully for studying plant populations, including invasion and spread (Crawley and Brown 2004, Johnson 2006, Alexander et al. 2009). Shuster et al. (2005) compared random grid sampling with roadside sampling for detection of an invasive plant species and found that though random sampling was better for avoiding bias, it required at least four times more person hours to complete than the roadside survey for a similar amount of area. Although roadside sampling did not provide a completely reliable assessment of all target plant populations within the landscape, the authors determined that it did provide an adequate approximation. Given that disturbed lands along roadsides are important for invasion and spread of many invasive plant species (Forman et al. 2003), roadside surveys provide a useful, practical method for detecting incipient invasions and to assess spread. Finally, corridors serve as convenient line transects to survey repeatedly.

Loope et al. (2004) and Starr et al. (2005, 2006, 2007) were among the first in the Pacific Islands to conduct roadside surveys for early detection and status of invasive plant species along roads of the islands of Molokai, Maui, and Lanai. Their methodology is relatively simple and has been broadly adopted by all of Hawai‘i’s Invasive Species Committees (Hall 2007, Imada et al. 2007, Kraus and Duffy 2010). Surveys described by this plan build upon previous roadside methods with the addition of multiple corridor types (e.g., trails, fence lines) and developed areas around landscaping and parking lots within parks. Park surveys are conducted by foot as opposed to a slow-moving vehicle

for increased detectability and road safety. Any resulting incipient invasive plant locations are provided to the parks so that they may conduct more thorough searches in the vicinity of the discovered plant(s) and remove the plants before they become widespread. This coordinated effort completes an effective early detection program.

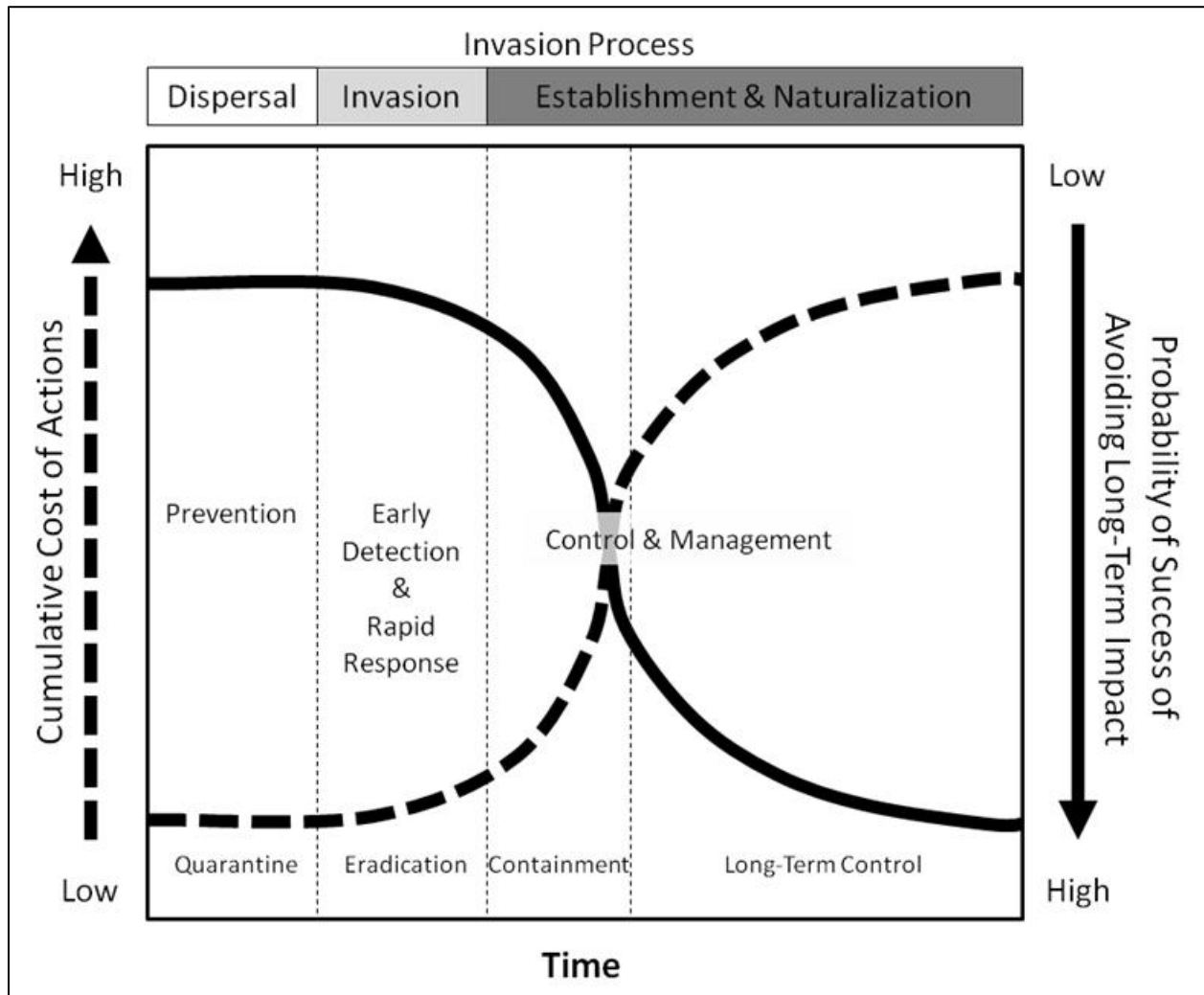


**Figure 1.** Relative societal cost and probability of success for actions designed to avoid negative impacts of invasive plant species in PACN (modified from Hobbs and Humphries 1995).

Unlike other long-term monitoring programs that monitor change over time, the goal of the PACN early detection monitoring plan is to locate potentially invasive populations at early stages of invasion to inform park resource managers so that appropriate action (i.e., eradication, containment, additional monitoring) may be implemented. Field surveys emphasize corridors (e.g., roads, trails, fence lines, power lines) and other high-risk invasion sites as these are important areas for non-native plant species transport via humans and animals, and non-native plant species establishment via ground disturbance and/or increased light availability. The detection of any incipient species found during surveys represents a trigger point for park management. This is a long-term program that uses

repeated survey efforts to detect and report new invasive or suspect plants before they become widespread (Table 1). The logistics, timeline, and budget developed for this plan are assumed to be on a three-year cycle with field surveys conducted by the Pacific Island Inventory and Management Program. Although a three-year cycle is considered ideal, PACN does not currently have the resources to regularly implement this plan and it will require either an increase in base funding or reduction of other monitoring work to implement it as described. Surveys may also be conducted by PACN, park staff, or contractors opportunistically, as done for the four reported pilot studies in this plan. In all four of these studies, new non-native plant species were identified, locations were provided to park managers, and control efforts were instituted, exhibiting the value of any early detection surveys even when conducted on an opportunistic and sporadic basis (Appendix B). This design also allows for more frequent surveying should funding and staffing permit and potentially community participation via citizen science after appropriate technologies such as smart phone applications are developed.

**Table 1.** Portions of Early Detection of Invasive Plant Species Monitoring Plan implemented for 10 PACN parks.

| Park code | Park name                                     | Island        | Corridor surveys | Outreach products |
|-----------|-----------------------------------------------|---------------|------------------|-------------------|
| ALKA      | Ala Kahakai National Historic Trail           | Hawai'i       | No               | Yes               |
| AMME      | American Memorial National Park               | Saipan        | No               | Yes               |
| HALE      | Haleakalā National Park                       | Maui          | Yes              | Yes               |
| HAVO      | Hawai'i Volcanoes National Park               | Hawai'i       | Yes              | Yes               |
| KAHO      | Kaloko-Honokōhau National Historical Park     | Hawai'i       | Yes              | Yes               |
| KALA      | Kalaupapa National Historical Park            | Moloka'i      | Yes              | Yes               |
| NPSA      | National Park of American Samoa               | Tutuila, Ta'ū | Yes              | Yes               |
| PUHE      | Pu'ukoholā Heiau National Historic Site       | Hawai'i       | Yes              | Yes               |
| PUHO      | Pu'uhonua o Hōnaunau National Historical Park | Hawai'i       | Yes              | Yes               |
| WAPA      | War in the Pacific National Historical Park   | Guam          | No               | Yes               |

For all parks, the NPSpecies database includes all species documented within the park and source evidence indicating when new species were included and who identified it (e.g., research studies, pers. comm.). This database will be updated to include any new species documented within parks where early detection surveys are conducted. It is imperative that NPSpecies be kept up to date and reviewed by park staff, local experts, and field crews prior to conducting future early detection corridor surveys. Educational materials (e.g., field plant identification guides, calendars) based on a subset of incipient invasive species are developed for park staff and volunteers to increase the park's early detection capabilities.

### **Relationship to other PACN Terrestrial Plant Monitoring**

Terrestrial plant communities are central to ecosystem function and in recognition of this importance, four PACN terrestrial plant monitoring vital signs were identified: 1) Focal Terrestrial Plant

Communities (FTPC), 2) Established Invasive Plant Species (EIPS), 3) Early Detection of Invasive Plants (ED), and 4) Focal Terrestrial Plant Species (FTPS). Together these vital signs provide parks valuable information on the status and trends of their vegetation resources and the primary threats to those resources. Monitoring will be done by the same personnel for all vegetation vital signs whenever possible to increase botanical identification accuracy and field efficiency. The location and frequency of sampling differ because the primary objectives differ. The FTPC protocol (Ainsworth et al. 2011) involves sampling permanent and temporary plots every five years and provides an overarching picture of plant communities. While invasive species are monitored in these plots, the plots themselves cover less than 5% of the communities and are often far from corridors. By the time an invasive species is detected in a focal community plot, it is likely widely distributed within the community and beyond means of removal. To directly address the severe invasive species threat in island ecosystems, two of the PACN monitoring vital signs focus on invasive plant species. EIPS monitoring (Ainsworth et al. 2012) is conducted concurrently with the focal community plots every five years and provides greater coverage across communities than the community plots alone. These monitoring data inform parks of the relative abundance of non-native species within focal communities (e.g., wet forest, subalpine shrubland, coastal strand). Alternatively, ED surveys should be conducted more frequently (e.g., every three years) along dispersal corridors throughout the parks as opposed to only those within focal communities. More frequent surveys provide park managers critical early detection data that they can respond to before new species become established in a region of the park. Lastly, the FTPS will address the status and aid in identifying some of the limiting factors (e.g., competition with invasive plant species) affecting rare and keystone native plant species (this protocol is on hold indefinitely due to funding and resource limitations at PACN; fortunately this does not negatively impact the ability of PACN to detect and monitor new and existing non-native species).

### **PACN Parks Included**

Outreach materials will be developed for the ten PACN parks (Table 1) with adequate terrestrial resources (excluding WWII Valor in the Pacific NM). During ED plan development, Honouliuli National Monument was not yet a designated PACN monument and ALKA acquired their first pieces of property. The I&M program has specifically directed that new monitoring should not begin in new park lands until networks acquire additional resources to do such work. Thus, these areas are not referenced here; however, these methodologies may be applied in the future. Field corridor surveys are recommended for seven of these ten parks. Two parks are not recommended for field surveys at this time because other I&M monitoring adequately captures incipient invaders (AMME, WAPA).

### **Objectives**

Most successful monitoring programs were developed around specific questions and objectives (NPS 2006). These objectives are statements that provide additional focus about the purpose or desired outcome of the monitoring program and should be consistent and justifiable with current scientific knowledge. The remainder of this plan documents the steps toward meeting the primary objective of identifying and finding non-native species that should be rapidly responded to and eradicated if possible.

- 1) Survey dispersal corridors and other high-risk sites for incipient populations of potentially invasive plants.
- 2) Provide timely information to park managers regarding the presence of new and potentially invasive plant species in order to facilitate a rapid management response.
- 3) Update and maintain NPSpecies (<https://irma.nps.gov/NPSpecies/>), the plant species database for each park, including new species detected during field surveys.
- 4) Develop and distribute invasive plant outreach materials to park staff to increase awareness and reporting capability.

## Sampling Design

The more area covered by the early detection survey, the more effective the plan would be at detecting, and preventing, new species from establishing in the Pacific islands. Given unlimited resources, surveys could be conducted across all corridors (e.g. paved and unpaved roads, trails, fence lines, and power lines) both within and outside of park boundaries, and even include known points of entry such as ports and plant nurseries. However, logistical limitations require that efforts be focused within parks at this time. Early detection surveys will be limited to the seven aforementioned parks on five islands: Ta'ū and Tutuila in American Samoa and Moloka'i, Maui, and Hawai'i Island in Hawai'i (Tables 2, 3). However, the methodology described here may be applied more widely as funding, staffing, and time permits and may be adopted by other agencies to complement this effort. Detailed step-by-step methods are provided in the accompanying SOPs.

**Table 2.** Survey frequency for corridors in PACN parks assuming a three-year cycle with no field work in the third year.

| Park code | Park name                                     | Island        | Survey cycle year |  |
|-----------|-----------------------------------------------|---------------|-------------------|--|
| HALE      | Haleakalā National Park                       | Maui          | 2                 |  |
| HAVO      | Hawai'i Volcanoes National Park               | Hawai'i       | 1                 |  |
| KAHO      | Kaloko-Honokōhau National Historical Park     | Hawai'i       | 1                 |  |
| KALA      | Kalaupapa National Historical Park            | Moloka'i      | 2                 |  |
| NPSA      | National Park of American Samoa               | Tutuila, Ta'ū | 2                 |  |
| PUHE      | Pu'ukoholā Heiau National Historic Site       | Hawai'i       | 1                 |  |
| PUHO      | Pu'uho'ou o Hōnaunau National Historical Park | Hawai'i       | 1                 |  |

**Table 3.** Recommended survey time periods for corridors on PACN Islands.

| Island        | Recommended Months for Survey |
|---------------|-------------------------------|
| Tutuila, Ta'ū | March through September       |
| Moloka'i      | January through March         |
| Maui          | January through March         |
| Hawai'i       | January through December      |

### Incipient Species Detections

Early detection surveys focus on invasive species that pose a significant threat to areas of conservation value and have the potential for eradication within these areas. It is extremely challenging to develop a concise list of all potentially incipient invasive species in the Pacific Island Parks and therefore it is critical that field staff have a proficient knowledge of the native flora and the ability to recognize unknown or new invaders per park or region of interest. PACN staff will work directly with park managers prior to each field season to ensure that any known plant threats are cataloged on a target species list and familiar to the field crew (See SOP #5 Creating Target Species

Lists). These “target species” will be recorded in addition to any unknown or undocumented species in the region. To determine if a species is undocumented, crew members will reference plant checklists for the study area. Checklists may be simply the NPSpecies list for the park, or a more specific ecoregion plant checklist if one is available. For example at HAVO, resources management maintains a park plant species list indicating which regions of the park species are found in. In our summit area pilot study, we recorded non-native species that were not listed as present within this region of the park and were relatively uncommon (Appendix B “Pilot Studies 2014-2016”). Depending on the park, resource management may not have a target species list available. If this is the case, PACN staff can use the following examples of types of species park resource managers may want to consider including in a target list:

- Species with the potential to severely impact areas of conservation value within parks (e.g., special ecological areas or portions of parks identified by management that are relatively intact with high native species diversity)
- Species for which control programs already exist
- Species that are not yet naturalized or are very limited in distribution
- Species that are invasive elsewhere in similar habitats and are not yet present on an island or in a region of a park

New non-native species can establish at any time, and those already present may call for inclusion or exclusion from the manager’s target species lists. As such, target species lists and checklists need to be updated prior to each sampling event or early detection will lose its efficacy in providing data to protect PACN park resources. These lists will be provided to field crews as a starting point prior to conducting field corridor surveys, but it is essential that field crews have an excellent foundational knowledge of the native flora. Early detection of incipient invasive plant species will be the most successful if those monitoring are able to identify all new, uncommon non-native species.

### **Corridor Selection (Spatial Design)**

Survey corridors within the parks include all accessible roads, trails, fence lines, power lines and developed areas which largely serve as line transects that can be surveyed repeatedly. Access to the survey sites will be obtained by foot, vehicle, or helicopter. Inference for this plan is limited to the survey corridors themselves; however, the detection of incipient invaders along a corridor may lead to additional park-based random sampling off the corridors. For larger parks (i.e., HAVO) or when limited resources are available for a survey, corridors may be prioritized based on the quality of the surrounding community or area, the risk of invasion related to intensity of human use or disturbance, and existence of other park sampling efforts along the corridor.

The procedure for identifying corridors follows two steps: 1) gather or update GIS transportation, utility, and facility layers of potential corridors, and 2) define the corridors and assign them a priority based on park-specific preferences (e.g., highest priority assigned to the highest trafficked areas, corridors missed during previous surveys). Communication with park staff is very important to accurately prioritize. Details regarding corridor identification and prioritization may be found in SOP

#6 “Selecting Survey Locations.” The maps with the location of potential survey corridors and an example of prioritization for HAVO corridors are available in Appendix A “Target Corridors.”

### **Survey Frequency and Timing (Temporal Design)**

Corridor monitoring can occur in seven PACN parks and is assumed for the rest of this plan to follow a three-year rotational cycle with the parks on Hawai‘i Island surveyed in the first year, and Maui, Moloka‘i, Tutuila, and Ta‘ū island parks surveyed in year two (Table 2). Note the potential survey length in HAVO during year one is nearly twice that of year two, leading to a prioritization list for this park in year one (SOP #6). This plan is an opportunistic, management-focused plan and any survey completed within a year is beneficial as our pilot studies demonstrated (Appendix B). With limited resources available, prioritization is determined before each survey event in collaboration with park natural resource staff. This ensures that I&M does not repeat park efforts and that our data will be as useful as possible for rapid response. All methods are provided and local park staff are encouraged to conduct surveys whenever time permits. Using a three-year survey cycle, field work is conducted within a six month season for the first two years with no field work completed in the third year. This schedule maximizes efficiency and reduces cost over time because it requires less hiring and training. The timing of corridor surveys within a year is influenced by weather patterns on each of the PACN islands. In the Hawaiian Islands (Hawai‘i, Maui, Moloka‘i), vegetation surveys are generally conducted year round, with the preference to exclude the summer months when annual plants die back or perennials become dormant. In American Samoa, it is important to conduct vegetation surveys during the spring and summer months when plants are flowering and fruiting and before the late fall tropical storm or cyclone season (Table 3).



## Field Methods

### Field Season Preparations

Before beginning the field season, the project lead, field leader, and field crew members will review this plan including all appendices and SOPs. The field leader should pay particular attention to the tasks described in SOP #1 “Before the Field Season” and SOP #2 “Training Observers” as these SOPs lay out the tasks and scheduling necessary to prepare for the season. Prior to conducting field work in each PACN park, all observers must read and be familiar with SOP #3 “Safety” and SOP #4 “Biological Sanitation.”

Technical training is imperative before beginning field work in each PACN park because the field crew will likely consist of a combination of permanent and seasonal I&M staff, park staff, cooperators, or volunteers with varying levels of experience and skills. Observers based in parks may be very familiar with the vegetation but may lack experience with the proposed surveying methodology described in SOP #8 “Conducting Corridor Surveys.” Alternatively, traveling I&M staff may know the methodology, but lack site-specific plant identification skills. Because the proposed sampling frequency is three years, it is likely that personnel turnover will occur, requiring new observers to be trained. It is essential that I&M coordinates with resource management staff from each park, as they will most likely be overseeing or guiding the surveys.

Plant identification skills are essential for this plan. Field crews will consist of individuals with existing native and non-native flora identification skills, in order to recognize any non-native plants that are not considered widely established already. Crews will also be familiar with flora local to the parks where they will be working as well as within ecological zones when appropriate. Plant identification training prior to the field season will emphasize skills in identifying species with and without reproductive structures.

Prior to each field season, the field leader will work with local park staff during the permitting process to ensure that access routes are safe (i.e., do not cross areas with >70% slopes) and efficient to minimize disturbance impacts. This permitting procedure facilitates communication and allows for collaboration between the field crew and existing park resource management or trails staff. Shared resources between I&M staff and park staff can reduce overhead costs (e.g., helicopter ferry time) and increase efficiency. Access will typically be through a combination of vehicle and helicopter use and hiking.

### Species Lists

Prior to the field season, the field leader will collaborate with park resource management to identify the most current species reference list for plants in the park. It is important for park resource management to understand that any species encountered that is *not* on the park species list will be recorded and reported to park resource management. Current and complete species lists are essential because this plan focuses on new or undocumented species to PACN parks and/or specific ecological zones within the parks surveyed. In addition to supplying parks with information on potentially invasive species, documenting new species (non-native or native) will also help parks create a more complete and robust species reference list. Crews will utilize NPSpecies

(<https://irma.nps.gov/NPSpecies/>) for reference species lists for each park. When available, crews will use lists provided by park resource management if they are more current and/or include more detailed information such as ecological zones. In the event the park wishes to gather additional early detection information on a species already documented in the park, a separate list of target species will need to be drafted and approved. The list of target species needs to be restricted to uncommon species as frequent stops to record common species will reduce the time available to survey additional corridors.

## **Field Operations**

Corridors will be accessed using established roads, trails, fence lines and landing zones in the backcountry in order to minimize disturbance impacts on the plant communities. Crews will work in teams of two so that both sides of the corridor can be surveyed simultaneously and so that surveyors can assist one another with plant identification. Pilot studies indicated that travel time when conducting road surveys can be greatly decreased by utilizing two teams of two and a vehicle (Appendix B). The road is still surveyed by foot, but each team alternates moving the vehicle past the other team. This method keeps team members connected and access to a vehicle provides added flexibility and mobility to the survey. Furthermore, it eliminates the need to walk long distances back to the vehicle at the end of the day.

Each team will record the location of the corridor, or section of a corridor, they survey each day. Tracking logs, available in many GPS enabled devices, should be used whenever possible to automatically record locations traversed each day. Instructions on creating track logs are detailed in SOP #7A “Using Global Positioning System (GPS) Units” and SOP #7B “Using ArcCollector.” In addition to the track log, crew members will manually collect GPS points corresponding to where surveying starts and stops along the corridor. If tracklogs are not available on the GPS, it may be necessary to also mark waypoints directly after an intersection to indicate which path was actually traversed. Area covered by the surveys will extend from the edge of the corridor to as far as visibility permits. No permanent markers will be installed along corridors.

For high-risk sites that are nonlinear corridors, such as parking lots or campgrounds, crew members will survey the perimeter of the area along with a systematic survey of the core area, which may be adjusted based on the site characteristics. For example, a rectangular parking lot may require only a brief core inspection with concentration focused on areas that plants can establish, while a campground might require visual inspection of each campsite or possibly walking adjacent transects spaced evenly across the area. Field crews will need to ensure that the track log or descriptions associated with the start/stop GPS points adequately represent how the perimeter and core area of the nonlinear feature was surveyed.

Field quality assurance and control measures will be conducted during the field season. Specifically, select transect sections will be surveyed and if observations among observers do not meet with acceptable variability, data will be flagged as suspect and the site will be re-surveyed. It is important that inconsistencies among staff are detected early to increase field efficiency and prevent false management alerts.

### **Collecting Observation Waypoints**

A GPS waypoint is created for any plant that 1) is *not* documented on the park's master plant species list or specific ecological zone, 2) is specifically targeted by the park or by I&M outreach products, or 3) is unknown to the observers. Field crew members must be familiar with both the common species and the uncommon species at the survey site and knowledgeable about the target species identified by park NRM and outreach identification cards.

A number of attributes associated with the observation waypoint will be recorded. These attributes include the species (if known), its reproductive status, the abundance class of the plant, and reference photos. If the species name of the plant is unknown to the surveyors, an unknown ID# is generated and additional information is required including an alias used to refer to the unknown plant, the life form of the plant (e.g. shrub, grass, herb), and a short description of the unknown species' unique characteristics (for example, "pubescent pinnatifid leaves, yellow disc and ray florets"). The unknown ID#, date of collection, and the identifier for the GPS unit used to collect the waypoint will uniquely identify the unknown species until the proper taxonomic name is determined. The unknown ID# will help maintain distinct groupings of unknown species so that repeated encounters with the same unknown species, or encounters with new unknown species, can be classified accordingly. Additionally, the alias and short description are designed to help crews remember the distinct groupings of unknown species as more and more unknowns are encountered. The reproductive status of the plant is important to many invasive species control programs in evaluating a timeline for treatment and understanding population trends. Crews will record whether or not the plant is fruiting or flowering and if no reproductive material are observed whether the plant is a juvenile or adult. Abundance data also help resource management develop appropriate control strategies. Depending on the habit of the plant, abundance may be recorded by either the number of individuals (<10, 11-50, >50), or by an area estimate of the plant cover (<1m<sup>2</sup>, 1-5m<sup>2</sup>, >5m<sup>2</sup>) and whether the population is contiguous or scattered. Photographs are taken for all new or unknown species, or when a photo will aid resource management in their rapid response (e.g., invasive plants are difficult to see if they are high up in the canopy). A minimum of three photographs are recommended for new or unknown species to provide valuable reference for species identification and confirmation. Voucher specimens of unknown species or new park records may be collected as described in SOP #9 "Collecting and Vouchering." Typically, the entire plant is collected unless the population is small (<20 individuals) and potentially native, in which case only the parts of the plant required for keying are collected (e.g., a flower and stem without roots) or only photos are taken. If a voucher specimen is collected for the observation waypoint, this detail will be noted with the waypoint and the specimen itself will be labeled with the unknown ID#, alias, life form, and short description. Finally, surveyors are encouraged to include additional notes with the waypoint explaining other important plant characteristics and measurements of the plant's morphological features whenever possible.

### **Post-collection Processing**

A large part of the post-collection processing involves plant identification. Records of unknown plant species will need to be updated in the database whenever unknown species become identified. Crews will utilize the internet and plant keys to identify unknown species. Plants that are unidentifiable by the I&M crew or botanist will be reported to NRM (see Notifications section below) in addition to

new plant species. If there are a large number of specimens to identify, botanists from the Bishop Museum on O‘ahu and/or other trained botanists may be able to provide assistance.

### **Notifications**

Following the completion of each survey, established contacts within park staff will be informed of all new and targeted species detected. NRM contacts for each park can be found in Appendix E “Early Detection Plant Species Outreach Products.” Email correspondence and, if necessary, phone correspondence is recommended in order to document communication efforts and ensure park inquiries are addressed in a timely manner. Accompanying data indicating the species, location, GPS UTM, population abundance and distribution type, phenology, age class, photos if necessary, and other relevant notes are provided to aid the park’s rapid response.

### **After the Field Season**

General post-season logistics and tasks are detailed in SOP #10 “After the Field Season.” Following the field season, the field leader is responsible for collecting all field gear and data books if used. The list of completed corridors and species are updated to reflect changes encountered during the season. All field data must be compiled in the project database and maps submitted as outlined in the below section “Data Handling, Analysis and Reporting”. In addition, the project lead and field leader are responsible for conducting summary analyses and generating the summary report for that field effort.

During non-survey years, the project lead and park staff may review and update the list of species used for outreach products. As surveys will be conducted intermittently, new threats may arrive in the interim or new data on non-native species already present may call for inclusion or exclusion from a park’s target list. NPSpecies lists will also need to be updated for all parks prior to each field surveying cycle. Without regular updates to NPSpecies, early detection will lose its efficacy in providing data to protect PACN park resources.

## Data Handling, Analysis, and Reporting

Data handling, analysis, and reporting are treated as three interrelated steps in managing early detection of invasive plant species information. An accompanying data quality standards report highlights and summarizes the importance of establishing and maintaining data quality standards for all plan activities related to the collection, processing, storage, analysis, and publication of early detection data (Kozar et al. 2017). Additional detailed implementation SOPs are available and will be updated as needed over time for each section listed below with a corresponding title (see SOPs #11-20).

### Project Information Management Overview

Project information management may be best understood as an ongoing or cyclic process (Figure 2). Specific yearly information management tasks for this project and their timing are described in Appendix D “Yearly Project Task List.” The stages of this cycle are briefly summarized below with greater detail following:

- *Preparation* – Plan logistics, train staff, and prepare field data forms, species lists, and maps
- *Data acquisition* – Collect data in the field and identify all unknown species
- *Data entry, processing, and verification* – Enter and upload data into the working copy of the database, process GPS data and photographic images, and verify data
- *Data quality review* – Review data for quality and logical consistency
- *Metadata Preparation* – Prepare documentation of data collection and the results of the quality review for the year
- *Data certification* – Certify data as complete for the period of record
- *Data delivery* – Deliver certified data and metadata for archival and upload to the master project database
- *Data analysis* – Summarize and analyze data
- *Product development* – Develop reports, maps, and other products
- *Product delivery* – Deliver reports and other products for posting and archiving
- *Posting & distribution* – Distribute products as planned and/or post to NPS clearinghouses
- *Archival & records management* – Review analog and digital files for retention (or destruction) according to NPS Director’s Order 1. Retained files are renamed and stored as needed
- *Season close-out* – Review and document needed improvements to project procedures or infrastructure, complete administrative reports, and develop work plans for the coming season

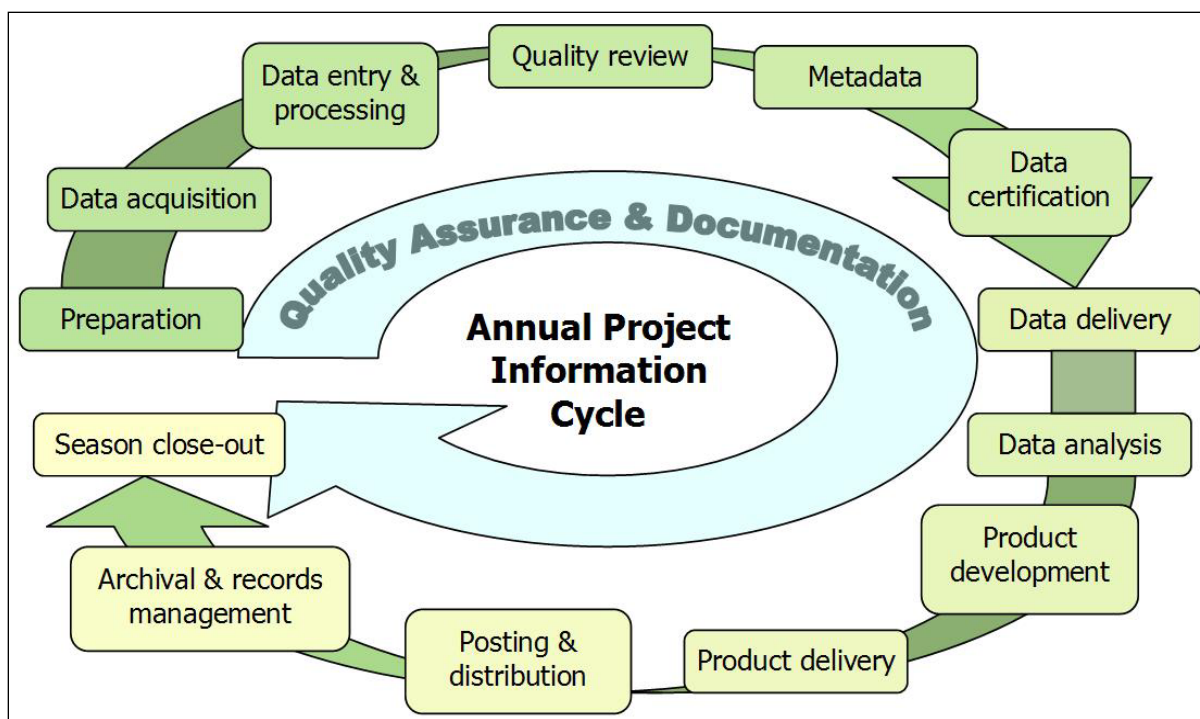


**Figure 2.** Idealized flow diagram of the cyclical stages of project information management from pre-season preparation to season close-out. Note that quality assurance and documentation are thematic and not limited to any particular stage of the information life cycle.

### ***Pre-season Preparations for Information Management***

Set Up Project Workspace: A section of the networked PACN server is reserved for this project, and access permissions are established so that project staff members have access to needed files within this workspace. Prior to each season, the project lead should make sure that network accounts are established for each new staff member, and that the data manager is notified to ensure access to the project workspace and databases. If network connections are too slow for efficient data entry and processing, individual staff members may set up a workspace on their own workstation, with periodic data transfer to the PACN server. Daily backups of the workstation to an external hard drive will ensure that no data are lost.

GPS Loading and Preparation: The GIS specialist and field leader will work together to ensure that target corridors and data dictionaries are loaded into the GPS units and data loggers (if used) prior to the onset of field work, and that GPS download software is available and ready for use.

Implement Working Database Copy: Prior to the field season, the data manager will implement a blank copy of the working database and ensure proper access on the part of the project staff. Refer to Overview for Database Design for additional information about the database design and implementation strategy.

### ***Overview of Database Design***

PACN data management staff designed customized relational database applications to enter, store, and manipulate the corridor survey data associated with this project. The design of the ED database

follows the hierarchical data table organization of the Natural Resource Database Template (NPS 2007) which is the standard for the NPS I&M Program. For additional details see the table relationships diagram, data dictionary, and other documentation in Appendix C “Early Detection Database Documentation.” The PACN data management staff is responsible for development and maintenance of the database including customization of data summarization and export routines.

The database is divided into two components: (1) one for entering, editing, and error-checking data for the current season (i.e., the “working database copy”), and (2) one that contains the complete set of certified data for the project (i.e., the “master project database”). A functional comparison of these two components is provided in Table 4.

**Table 4.** Functional comparison of master project database and working database.

| <b>Project database functions and capabilities</b> | <b>Working database</b> | <b>Master database</b>     |
|----------------------------------------------------|-------------------------|----------------------------|
| Contains full list of sampling locations and taxa  | MS Access               | MS SQL Server or MS Access |
| Portable for remote data entry                     | Yes                     | Yes                        |
| Forms for entering and editing current year data   | Yes                     | –                          |
| Quality assurance and data validation tools        | Yes                     | –                          |
| Preliminary data summarization capabilities        | Yes                     | Yes                        |
| Full analysis, summarization and export tools      | –                       | Yes                        |
| Pre-formatted report output                        | –                       | Yes                        |
| Contains certified data for all observation years  | –                       | Yes                        |
| Limited editing capabilities, edits are logged     | –                       | Yes                        |
| Full automated backups and transaction logging     | –                       | Yes                        |

Each of these components is based on an identical underlying data structure (tables, fields and relationships, as documented in Appendix C). The working database is implemented in Microsoft (MS) Access to permit greater flexibility when implementing on computers with limited or unreliable network access. Eventually, the master database may be implemented in MS Structured Query Language (SQL) Server in order to take advantage of the backup and transaction logging capabilities of this enterprise database software.

Both components have an associated front-end database application (“user interface” with forms and queries) implemented in MS Access. The working database application has separate screens for data entry, data review, and data quality review tools. The master database application contains the analysis and summarization tools, including pre-formatted report output and exports to other software (e.g., for analysis and graphics production). This front-end application arrangement allows for modification and update of the user interface with no disruption to data entry continuity. The improved front-end file can be distributed to data entry staff, who link it to the back-end file, discard the out-dated front-end file, and proceed with their data entry work. Under this arrangement, data entry staff have no need to open the back-end file, thereby reducing the risk of improper deletions or other inadvertent data loss occurring within the plan-specific data tables. In addition, a multi-user

environment can be accommodated by storing the back-end file on a server available to all users via a computer network.

During the field season, each project crew will be provided with their own copy of a working database into which they enter, process, and quality-check data for the current season. Once data for the field season have been certified they will be uploaded into the master database, which is then used to inform all reporting and analysis. This upload process is performed by the data manager, using a series of pre-built append queries.

### ***Data Entry, Processing, and Verification***

After each field trip, technicians will examine digital or paper data forms to correct obvious errors and incomplete information as soon after data collection as is practical, and enter or download data in order to keep current with data entry tasks. The working database application will be found in the project workspace. If the project workspace is located on the network server, it is recommended that users copy the front-end database onto their workstation hard drives and open it there. This front-end copy may be considered “disposable” because it does not contain any data but rather acts as a pointer to the data that reside in the back-end working database. Whenever updates to the front-end application are made available by the data manager, a fresh copy should be made from the project workspace to the workstation hard drive.

Each data entry form is patterned after the structure of the field form, and has built-in quality assurance components such as pick lists and rules to test for missing data or illogical combinations. Although the database permits users to view the raw data tables and other database objects, users are strongly encouraged only to use these pre-built forms as a way of ensuring the maximum level of quality assurance.

Regular Data Backups: Upon opening the working database, the user will be prompted to make a backup of the underlying data. It is recommended that this be done on a regular basis – at least once per day when new records are being entered – to save time in case of file corruption or mistakes. These periodic backup files should be compressed to save drive space and may be deleted once enough subsequent backups are made. All such backups may be deleted after the data have passed the quality review and been certified.

Data Verification: Effective rapid response requires field detection data that are recorded properly and have acceptable precision and minimal bias. Poor quality data can limit detections or result in poor management control effort estimates. Quality assurance/quality control QA/QC procedures applied to ecological data includes five procedural areas (or activities), ranging from simple to sophisticated and inexpensive to costly:

- defining and enforcing standards for electronic formats, locally defined codes, measurement units, and metadata
- visually reviewing or proofing all data after data entry for transcription errors
- checking for unusual or unreasonable patterns in data
- checking for comparability of values between data sets

- assessing overall data quality

To the greatest extent possible, the early detection database application incorporates quality assurance/quality control strategies involving the first activity (defining and enforcing standards). The database design and the allowable value ranges assigned to individual fields within the data tables help to minimize the potential for data entry errors and/or the transcription of erroneously recorded data. The other activities are integrated in the data quality review phase.

Additionally, as data are being entered, the person doing the data entry will visually review them to make sure that the data on screen match the field forms. This should be done for each record prior to moving to the next form for data entry. At regular intervals and at the end of the field season, the field leader should inspect the data being entered to check for completeness and perhaps catch avoidable errors. The field leader may also periodically run the Quality Assurance Tools that are built into the front-end working database application to check for logical inconsistencies and data outliers.

Field Form Handling Procedures: As the field data forms are part of the permanent record for project data, they should be handled in a way that preserves their future interpretability and information content. To minimize the possibility of data loss, hardcopy data forms and field notebooks should be stored in a well-organized fashion in a secure location with scanned data forms stored in a separate location (e.g., on the PACN data server).

If laptops or other digital devices are used to collect data, then the field crew should back up data in the field at least once a day on an extra memory card. Data files should then be uploaded to a computer and backed up as soon as practical after leaving the field. A hard-copy of the digital dataset should be printed and stored following the procedures developed for field data forms.

Image Handling Procedures: Photographic images should also be handled and processed with care.

GPS Data Procedures: The following general procedures should be followed for GPS data:

- 1) GPS data should be downloaded by the field crew from the units at the end of each field trip (or daily if possible) and stored in the project workspace.
- 2) Raw files should be sent to the GIS specialist for processing (e.g., creating shape files for data points, access routes, opportunistic plant sightings) and differential correction if applicable (e.g., Trimble).
- 3) The GIS specialist will process the raw GPS data and store the processed data in the project workspace.
- 4) The GIS specialist will upload corrected coordinate information into the database and create any GIS data sets.

The field lead should periodically review the processed GPS data to make sure that any problems are identified early on in the data collection process.

### ***Data Quality Review***

After the data have been entered and processed, the project lead reviews the data for quality, completeness, and logical consistency. The working database application facilitates this process by showing the results of pre-built queries that check for data integrity, data outliers and missing values, and illogical values. The user may then fix these problems and document the fixes. Not all errors and inconsistencies can be fixed, in which case a description of the resulting errors and why edits were not made is then documented and included in the metadata and certification report.

Data Edits after Certification: Due to the high volume of data changes and/or corrections during data entry, it is not efficient to log all changes until after data are certified and uploaded into the master database. Prior to certification, daily backups of the working database provide a crude means of restoring data to the state of the previous day. After certification, all data edits in the master database are tracked in an edit log (refer to Appendix C) so that future data users will be aware of changes made after certification. In case future users need to restore data to the certified version, we also retain a separate, read-only copy of the original, certified data for each year in the PACN Digital Library.

Geospatial Data: The project lead and GIS specialist will work together to review the surveyed detection waypoints and surveyed track log geospatial data for accuracy. The purpose of this joint review is to make sure that geospatial data are complete and reasonably accurate.

### ***Metadata Procedures***

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, condition, and other characteristics of a given data set, both tabular and spatial. Additionally, metadata provide the means to catalog and search among datasets, thus making them available to a broad range of potential data users. Metadata for all PACN data will conform to Federal Geographic Data Committee guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized.

At the conclusion of the field season the project lead will be responsible for providing a completed, up-to-date metadata interview form to the data manager. The data manager and GIS specialist will facilitate metadata development by consulting on the use of the metadata interview form, by creating and parsing metadata records from the information in the interview form and by posting such records to national clearinghouses.

### ***Data Certification and Delivery***

Data certification is a benchmark in the project information management process that indicates that: 1) data are complete for the period of record; 2) have undergone and passed the quality assurance checks (Quality Review); and 3) are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may or may not have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The project lead is primarily responsible for completing a PACN Project Data Certification Form, available from the data manager or on the PACN website.

### ***Data Analysis***

Data analysis is aimed at categorizing, mapping, and describing the incipient species detected during the survey. Species attributes will be summarized (e.g., abundance, frequency, age class, reproductive status) and potential trends spatial and temporal may be explored (e.g., new species records to parks or islands versus distance from trailhead/populated areas). Importantly, analysis and reporting will provide continuity with previous survey efforts including updating the status of prior detections (i.e., incipient species from previous survey now considered widespread and not included in current survey) and comparison of current target species list with prior target species lists. This is particularly important considering the opportunistic nature with which this plan will likely be implemented. Summaries of survey method will also be completed to enable comparisons of findings in space in time on a per effort basis. SOP #19 “Corridor Survey Data Analysis” and Appendix B “Pilot Studies 2014-2016” provide greater detail on data analysis and summary as well as tangible examples.

As part of the overall database design, the project lead and data manager will work together to develop a series of summary queries and tools designed to prepare the data for analysis and reporting. Some of these tools will produce summarized information that goes directly into reports, while other tools will provide data in the proper format for analysis. Database queries will handle this type of conversion and tabulation, while graphing and statistical software may be used for more advanced analyses. GIS analysis is a useful way to identify potential source populations or vectors for incipient invasive plant species and will be included in analysis. All data collected for this plan are georeferenced.

Using the raw certified data as well as database query results, the project lead will compute summary statistics at the end of the field season. The data manager is responsible for query design and writing database routines, while the project lead will use the extracted data to run analyses. The project lead will compute summary statistics (means, variances, confidence intervals, etc.) for each of the vegetation attributes measured including incipient species richness, frequency, population abundance, distribution, age/size class, and/or phenology. Depending on the attribute, these statistics are aggregated across all species, grouped by life form (i.e., tree, shrub, fern, herbaceous), and/or individual species. In some instances the summary statistics are broken down by percent (e.g., proportion of corridors that contain a specific species).

### ***Reporting and Product Development***

**Species Alerts:** The invasive plant “species alerts” are an informal reporting tool designed to rapidly inform park resource managers of any new park species records. Species, location, GPS UTM, photographs if necessary, and other notes will be provided. In addition to new park records, I&M staff will also provide information on specific park-identified target species for management. The field leader will initiate immediate phone and/or regular email (e.g., weekly) alerts to park contacts

and include species abundance and location information. As technology improves and becomes more affordable, field crews may incorporate the use of new tools (e.g., smart phones, laser rangefinders with bluetooth connections) to provide park managers “real time” incipient invasive species detection locations and field photos.

Post-season Report Content: A brief report will be produced after each field season effort which focuses on the surveying effort and results of the current year. Over time, optional summary reports may be developed combining results across multiple years and/or parks. Park staff will be able to review the reports and gather relevant information (i.e., invasive species presence, location, GPS UTM's, etc.) for rapid response. Each season report will:

- Categorize, map, and describe the incipient species detected during the survey
- Summarize species attributes (e.g., species richness, life form, reproductive status)
- Explore potential trends related to location of detections (i.e., frequency of detections relative to distance from trailheads and/or populated areas)
- Provide updated status of species identified during previous sampling events (i.e., species now considered widespread and not included in survey)
- Summarize overall survey effort (e.g., worker hours, corridors surveyed, distance surveyed, time required to identify unknown species, and data quality concerns and/or deviations from this plan).

A more comprehensive analysis and summary report produced after multiple years may also include:

- Summarized annual results by corridor, park region, and park allowing for comparisons among community types within parks.
- Assess spatial patterns for presence/absence data.
- Identify any possible distributional changes within parks over time.
- Evaluate operational aspects of the program, such as whether any survey locations need to be eliminated or moved (e.g., due to access problems), whether the survey period remains appropriate (the optimal survey season could conceivably change over time in response to climate change), etc.

Report Formatting: Post-season reports and summary reports will use the NPS Natural Resource Publications template, a pre-formatted MS Word template document based on current NPS formatting standards. Reports will use the Natural Resource Report template, available at the NPS Natural Resource Publications Management website <https://www.nature.nps.gov/publications/nrpm/>).

NPSpecies lists for each park will be updated to include species that were documented during the early detection surveys, as well as species from other I&M monitoring efforts (e.g. EIPS, FTPC). Periodically, funding dependent, I&M staff will also develop outreach products such as plant identification cards and calendars to increase park staff awareness. Refer to Appendix E for previous examples of outreach field identification cards and calendars.

***Product Delivery, Posting, and Distribution***

Completed data products including reports, datasets, metadata, and outreach products will be submitted to the database manager for posting and distribution. Products and non-sensitive will be posted to NPS websites and the Integrated Resource Management Applications (IRMA) portal once certified.

All official Freedom of Information Act (FOIA) requests will be handled according to NPS policy. The project lead will work with the data manager and the park FOIA representative(s) of the park(s) for which the request applies.

***Archival and Records Management***

All project files should be reviewed, modified or revised, and organized by the project lead on a regular basis (e.g., annually in January). Decisions on what to retain and what to destroy, should be made following guidelines stipulated in NPS Director's Order 19. This order provides a schedule indicating the amount of time that the various kinds of records should be retained.

***Season Close-out***

After the conclusion of the field season, the project lead, data manager, and GIS specialist meet to discuss the recent field season, and to document any needed changes to the field surveying methods, the working database application, or to any of the SOPs associated with the plan.



## Personnel Requirements and Training

### Roles and Responsibilities

Implementation of this plan requires using a combination of park staff and PACN I&M staff.

Required PACN staff include project lead/botanist (GS-11), a field leader/lead biotech (GS-09), and one field biological technician (GS-07), as well as assistance from the I&M data manager (GS-11), GIS specialist (GS-9), and program manager (GS-13). A potential alternative is to contract this work out in order to not incur expenses to the network travel cap (which is currently a limiting factor).

Table 5 summarizes the roles and responsibilities of each position for this plan assuming it is implemented by PACN staff. The project lead is responsible for project administration, implementation, overseeing data collection, facilitating communication between NPS and cooperators, quality assurance/quality control, data entry, data verification and certification, data backups, data summary, analysis, and reporting. The project lead supervises the field leader, who is responsible for pre- and post- field season preparations. The field leader provides direction for the field biological technician. The field leader and biological technician are responsible for conducting the field data collection, data entry, data management, and equipment management. The field leader conducts some data analyses for annual reporting and participates in the preparation of preliminary reports. The project lead, field leader, and biological technician will be skilled botanists and field technicians capable of performing any of the required invasive plant species tasks, including plant species identification.

The project lead will oversee the hiring and training of the field technician and the field leader. In addition, the project lead will directly participate in at least some of the field work in order to ensure consistency of this effort. Field crew members must be proficient at: (1) identifying native and non-native park plants (2) making voucher collections of unknown plants as needed, (3) using field equipment, and (4) data downloading or if necessary entry using MS Access. In addition to possessing these skills, the project lead needs to be proficient at data analysis and report generation.

The data management aspect of the surveying effort is the shared responsibility of the project lead and the data manager. The data manager is responsible for database design, facilitating quality assurance/ quality control procedures, provisions for data archiving, data security, metadata production, web-posting of data products (datasets, data analysis products and metadata), and dissemination of data, while the project lead is responsible for database use (overseeing data downloading and entry, data certification, archiving, running queries, data analyses, and generating reports). The data manager is ultimately responsible for ensuring that appropriate data handling procedures are followed. The analysis aspect of this plan is primarily the responsibility of the project lead. The GIS specialist assists with GPS use, geodatabase construction and maintenance, map generation, and metadata development.

The PACN Program Manager is responsible for general vegetation program oversight. This includes reviews of reports, decisions regarding appropriations of I&M budget to the PACN vegetation program, and the overall quality and performance of the project lead in relation to the PACN vegetation program.

**Table 5.** Roles and responsibilities for the ED plan.

| Role                        | Responsibilities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Position              |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Project Lead                | <ul style="list-style-type: none"> <li>• Project administration, operations, and implementation</li> <li>• Track project objectives, budget, and requirements</li> <li>• Coordinate and ratify changes to the plan</li> <li>• Lead training of field crew including safety procedures</li> <li>• Acquire field equipment</li> <li>• Certify each season's data for quality and completeness</li> <li>• Oversee completion of reports, data summaries and analysis, metadata, and other products according to schedule</li> <li>• Maintain and archive project records</li> <li>• Facilitate communications between NPS and cooperator(s) as necessary</li> <li>• Work with outreach department and/or cooperators to develop and print invasive species field identification cards and calendars when funding is available</li> </ul> | Botanist              |
| Park Ecologists / Botanists | <ul style="list-style-type: none"> <li>• Assist with logistics, planning, and coordination</li> <li>• Provide management target incipient species lists</li> <li>• Review reports, data, and other project deliverables</li> <li>• Assist in training of field crew and plant identification</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       |
| Field Leader                | <ul style="list-style-type: none"> <li>• Assist in training and ensuring safety of field technician</li> <li>• Plan and execute field visits</li> <li>• Maintain field equipment</li> <li>• Oversee data collection and entry, verify accurate data downloads and/or transcription into database</li> <li>• Complete a field season report including efforts</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Biological Technician |
| Field Technician            | <ul style="list-style-type: none"> <li>• Collect, record, enter and verify data</li> <li>• Prepare plant voucher specimens, as needed</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Biological Technician |
| Data Manager                | <ul style="list-style-type: none"> <li>• Consultant on data management activities</li> <li>• Facilitate check-in, review and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule</li> <li>• Maintain and update database application</li> <li>• Provide database training as needed</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Data Manager          |
| GIS Specialist              | <ul style="list-style-type: none"> <li>• Develop geodatabase to accept survey data</li> <li>• Consultant on spatial data collection, GPS use, and spatial analysis techniques</li> <li>• Facilitate spatial data development and map generation</li> <li>• Work with project lead to analyze spatial data and develop metadata for spatial data products</li> <li>• Primary steward of GIS data and products</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                               | GIS Specialist        |
| Program Manager             | <ul style="list-style-type: none"> <li>• Review reports for completeness and compliance with I&amp;M standards and expectations</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | PACN Program Manager  |

## **Qualifications and Training**

All technical field staff will be trained and responsible for the information contained within the plan narrative, SOPs, and the database. The project lead position requires a graduate degree or equivalent experience in related disciplines (e.g., botany, ecology, forestry, or other applicable biological/natural science field), experience in field data collection, statistics, data management, and reporting.

The field leader requires a bachelor's degree or equivalent experience in related botanical disciplines, experience in leading vegetation field crews under strenuous field conditions, data collection, data management, post processing, basic data analysis, and equipment maintenance. One of the most important components in collecting credible, high-quality data on plant species is a competent field staff. The quality of the data collected will be directly related to the quality of the field team. The biological technicians are required to have regional Pacific Island botanical experience (i.e., able to recognize major plant groups in the field, know how to key out plants, etc.), as well as be able to conduct field work and help with data entry and management tasks.

Field crew members should strive to improve their ability to identify plants in all forms and stages of maturity. All members will be required to participate in training before the field season. Training will occur over a sufficient period of time to ensure accuracy and consistency in plant identification. In general, training will consist of two phases: (1) an office component in which team members read and review the plan, equipment lists, species lists, plant images, and herbarium specimens; and (2) a field component emphasizing methodology and data recording, as well as a major emphasis on field identification of non-native plants. The field component will include selected site visits to locations where team members will encounter many of the plants on the park-specific target species list. Field training will culminate in the group surveying together, as a means of developing consistency in species identification, collection of specimens, field methods, and data recording on tablets or field forms. Approximately five days of technical training are anticipated prior to the start of surveying, four of which will be in the field. The field leader will work with PACN specialists familiar with the local flora to coordinate the training of all crew members. Field crews will also receive safety training (e.g., NPS's Operational Leadership Training, Helicopter Safety, First Aid/CPR, IT Security, Defensive Driving) prior to conducting field work.

The data manager and GIS specialist require bachelor degrees in computer science or related concentration, or other equivalent experience. The data manager must have experience in database management, records certification, SQL programming, and archiving. The GIS specialist requires specific experience with GIS analysis, ArcGIS™ base software and extensions, spatial database design, and GPS use.

## **Operational Requirements**

Early detection of invasive plant species will be sampled along dispersal corridors in seven PACN parks: HALE, HAVO, KAHU, KALA, NPSA, PUHE, and PUHO. Table 6 lists the parks visited each year and the time required to complete this monitoring based on a two person field team consisting of a field leader and one crew member. Estimates are for all corridors in most parks and high priority corridors at HAVO (Appendix A). This plan is designed to allow for exclusion of select PACN units if required due to future unforeseen fiscal constraints.

**Table 6.** Number of months required for a two person field crew to conduct ED surveys by park and by cycle year.

| Cycle Year | Park | Island         | No. of Months |
|------------|------|----------------|---------------|
| 2          | HALE | Maui           | 3.0           |
| 1          | HAVO | Hawai'i        | 5.0           |
| 1          | KAHO | Hawai'i        | 0.5           |
| 2          | KALA | Moloka'i       | 2.0           |
| 2          | NPSA | American Samoa | 1.0           |
| 1          | PUHE | Hawai'i        | 0.25          |
| 1          | PUHO | Hawai'i        | 0.25          |

The field season for early detection of invasive species typically begins each year in April or May. Depending upon the park, the field season ends by October. The schedule consists of a three-year rotating cycle, with field crews visiting parks the first two years of the cycle and revisiting each park every 3 years. Field sampling will be conducted during the first and second years of the cycle with no field work conducted in the third year. This schedule increases hiring, training, safety, and sampling efficiency while the third year helps to keep average costs down (Table 7). In addition, this schedule allows for staff to be shared among the other vegetation protocols (Focal Terrestrial Plant Communities and Established Invasive Plant Species monitoring protocols) further increasing field logistical efficiency and plant identification consistency.

Before the beginning of the field season, field crew members need to spend an appropriate amount of time on training (sampling methodology, plant identification) and field skills (e.g., navigation, use of field equipment). The amount of time will vary by year, park and field crew.

**Table 7.** Annual field surveying costs for the ED plan. No monitoring occurs in cycle year 3.

| Category                                | Sub-category                    | Year 1         |               |              |              | Year 2         |               |               | Year 3   |
|-----------------------------------------|---------------------------------|----------------|---------------|--------------|--------------|----------------|---------------|---------------|----------|
|                                         |                                 | HAVO           | KAHO          | PUHO         | PUHE         | HALE           | KALA          | NPSA          | None     |
| Personnel                               | Botanist<br>(GS11.5; 15%)       | 9,310          | 1,967         | 918          | 918          | 6,556          | 4,327         | 2,229         | 0        |
|                                         | Field Leader<br>(GS9; 50%)      | 22,632         | 4,781         | 2,231        | 2,231        | 15,938         | 10,519        | 5,419         | 0        |
|                                         | Field Crew<br>(GS7; 50%)        | 18,502         | 3,909         | 1,824        | 1,824        | 13,030         | 8,600         | 4,430         | 0        |
|                                         | Program Manager<br>(GS13.5; 5%) | 4,423          | 934           | 436          | 436          | 3,115          | 2,056         | 1,059         | 0        |
|                                         | Data Manager<br>(GS11.6; 5%)    | 3,195          | 675           | 315          | 315          | 2,250          | 1,485         | 765           | 0        |
|                                         | GIS Specialist<br>(GS 11.6; 5%) | 3,195          | 675           | 315          | 315          | 2,250          | 1,485         | 765           | 0        |
| Travel (with per diem)                  | –                               | 6,000          | 2,500         | 2,000        | 2,000        | 5,000          | 4,000         | 3,000         | 0        |
| Equipment and Supplies                  | –                               | 3,000          | 500           | 500          | 500          | 3,000          | 1,000         | 1,000         | 0        |
| <b>Total Field Survey Cost per Park</b> |                                 | <b>70,256</b>  | <b>15,941</b> | <b>8,539</b> | <b>8,539</b> | <b>51,138</b>  | <b>33,471</b> | <b>18,667</b> | <b>0</b> |
| <b>Total Field Survey Cost per Year</b> |                                 | <b>103,276</b> |               |              |              | <b>103,276</b> |               |               | <b>0</b> |



### ***Facility and Equipment Needs***

The nature of invasive plant survey and monitoring work does not require special facilities beyond normal office space, a data management workstation, herbarium space, and a storage place for field equipment.

### ***Startup Costs and Budget Considerations***

Initial startup costs of \$220,164 were allocated in an interagency agreement with the USGS Pacific Basin Information Node. These costs were one-time charges that funded the development and printing of invasive species field identification cards, and invasive species “most wanted” calendars for park distribution.

Table 7 summarizes the annual budgets by park and year, breaking down the costs into personnel salary, travel, equipment and supplies. Personnel salaries are based on the 2017 pay schedule with 18% locality adjustment and 25% benefits. Expected grade level and step level in the GS as well as the anticipated percent fulltime employment (FTE) are listed in parentheses for each position. Salary costs are expected to increase with step increases if initial hires remain in their positions. The botanist will supervise the field leader, oversee field operations, and analyze and report annual findings (15%). The field leader will spend 50% FTE implementing this vital sign. Primary duties include: preparing for the field season, leading field operations, entering and summarizing data, and reporting. One biological technician will conduct field work during the six month field season (50%). The program manager will assist by reviewing reports (5%), and the data manager and GIS specialist will aid in pre- and post-field season data management (5%).

Travel estimates include airfare, lodging, per diem, and required helicopter time to access remote field sites. Estimates vary across the network due to the great distances among parks and the necessity of airline travel. Values are based on the 2017 lodging and per diem schedule and the estimated amount of time required per park (Table 6). Field leaders will be duty-stationed in HAVO, HALE, and NPSA. When possible the biological technician will be hired from the community to maximize local plant knowledge and reduce travel costs (e.g., NPSA, HALE). Lodging ranges from \$0 (camping) to \$259 (Maui – outer islands) per day and meal per diem ranges from \$25 (camping) to \$146 (Maui). HALE, HAVO and KALA travel estimates are high due to the fact that some of the corridors are best accessed by helicopter (4 hours of helicopter time at \$1100/ hour) and require extensive back country camping.

Equipment and supplies required for implementation of the Early Detection of Invasive Plant Species Monitoring Plan include standard field monitoring gear (e.g., cameras, GPS, field packs, etc.) and larger items such as vehicle rental (estimated at \$1000/month). Note that no vehicle rental money is allotted for sampling on Tutuila Island at NPSA because the I&M Program has already purchased vehicles for use on this island.

The annual cost estimate averaged across the three-year cycle of field monitoring and reporting is approximately \$68,850 per year in FY17 dollars (Table 7). Thirty percent of the total budget is allocated to analyses and reporting through data entry, verification and editing (~15%), analyses and generating field and technical reports (~15%). Additional partnerships and collaboration with park staff will be pursued and would aid in reducing implementation costs or increasing our surveying effort (e.g., more frequent sampling and/or additional corridors). However, what is presented in this plan is designed to be accomplished regardless of collaborative efforts.

### ***Permits***

Various research permits and compliance procedures are required to implement this monitoring. As this plan is implemented, the project lead or PACN staff designee, in cooperation with NPS point of contacts, will proceed through project compliance as appropriate for each park according to federal, state, commonwealth, and territory guidelines, or any other compliance processes that need to be completed. The project lead, in cooperation with the PACN staff designee, will ensure full compliance with all existing and future regulations. All permitting will be reviewed by a park designee (e.g., Park Point of Contact) responsible for National Environmental Policy Act (1970), Section 106 of the National Historic Preservation Act (1966), Section 7 of the Endangered Species Act (1973), park research permits, and approved by the compliance specialists. The project lead or PACN staff designee will be responsible for ensuring appropriate park permitting contacts are notified. The project lead is responsible for following all stipulations identified through the compliance process.

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## Appendix A. Target Corridors

This appendix provides a summary table and figures showing the locations of each corridor for the Pacific Island Network (PACN) Early Detection of Invasive Plant Species Plan. Table A.1 details the three-year field surveying cycle and provides a summary of length for each type of corridor for each park to be sampled. Following the summary table, this appendix presents park-specific maps of corridor locations in chronological order of a field cycle (figures A.1-A.8). Corridors were selected and prioritized according to the guidelines in SOP #6 “Selecting Survey Locations.” Prioritization of corridors was based on 1) the quality of the surrounding community or area, 2) the risk of invasion related to intensity of use, and 3) existence of other park sampling efforts along the corridor.

| Park Code | Park Name                | Survey Cycle Year | Divisions (Priority/ Island) | Paved Roads (km) | Dirt Roads (km) | Trails (km) | Fence Lines (km) | Development Perimeter (km) | No. of Helicopter Landing Areas | Total (km) |
|-----------|--------------------------|-------------------|------------------------------|------------------|-----------------|-------------|------------------|----------------------------|---------------------------------|------------|
| HAVO      | Hawai'i Volcanoes NP     | 1                 | High                         | 213.3            | 19.9            | 61.9        | 27.7             | TBD                        | TBD                             | 322.8      |
|           |                          |                   | Low                          | 7.6              | 41.2            | 111.1       | 149.7            | TBD                        | TBD                             | 309.6      |
|           |                          |                   | None                         | 55.5             | 0.0             | 47.5        | 0.0              | TBD                        | TBD                             | 103.0      |
| KAHO      | Kaloko-Honokōhau NHP     | 1                 | –                            | 0.6              | 3.0             | 12.0        | 0.5              | 0.7                        | –                               | 16.7       |
| PUHO      | Pu'uhonua o Hōnaunau NHP | 1                 | –                            | 1.5              | 1.9             | 6.2         | 1.9              | 1.8                        | –                               | 12.0       |
| PUHE      | Pu'ukoholā Heiau NHS     | 1                 | –                            | 0.3              | 0.7             | 1.7         | –                | 1.7                        | –                               | 5.6        |
| HALE      | Haleakalā NP             | 2                 | –                            | 21.2             | 2.8             | 74.3        | 84.8*            | TBD                        | 30                              | 183.1      |
| KALA      | Kalaupapa NHP            | 2                 | –                            | 1.0              | 22.2            | 4.6         | 25.1             | 12.2                       | 12                              | 65.1       |
| NPSA      | NP of American Samoa     | 2                 | Tutuila                      | 3.0              | 6.2             | 6.5         | 0.0              | 0.0                        | –                               | 15.8       |
|           |                          |                   | Ta'u                         | 0.0              | 2.2             | 14.9        | 0.0              | 0.0                        | –                               | 17.1       |

\* All fence lines at HALE are low priority.

TBD = To Be Determined based on field surveys as related GIS files were unavailable at this time.

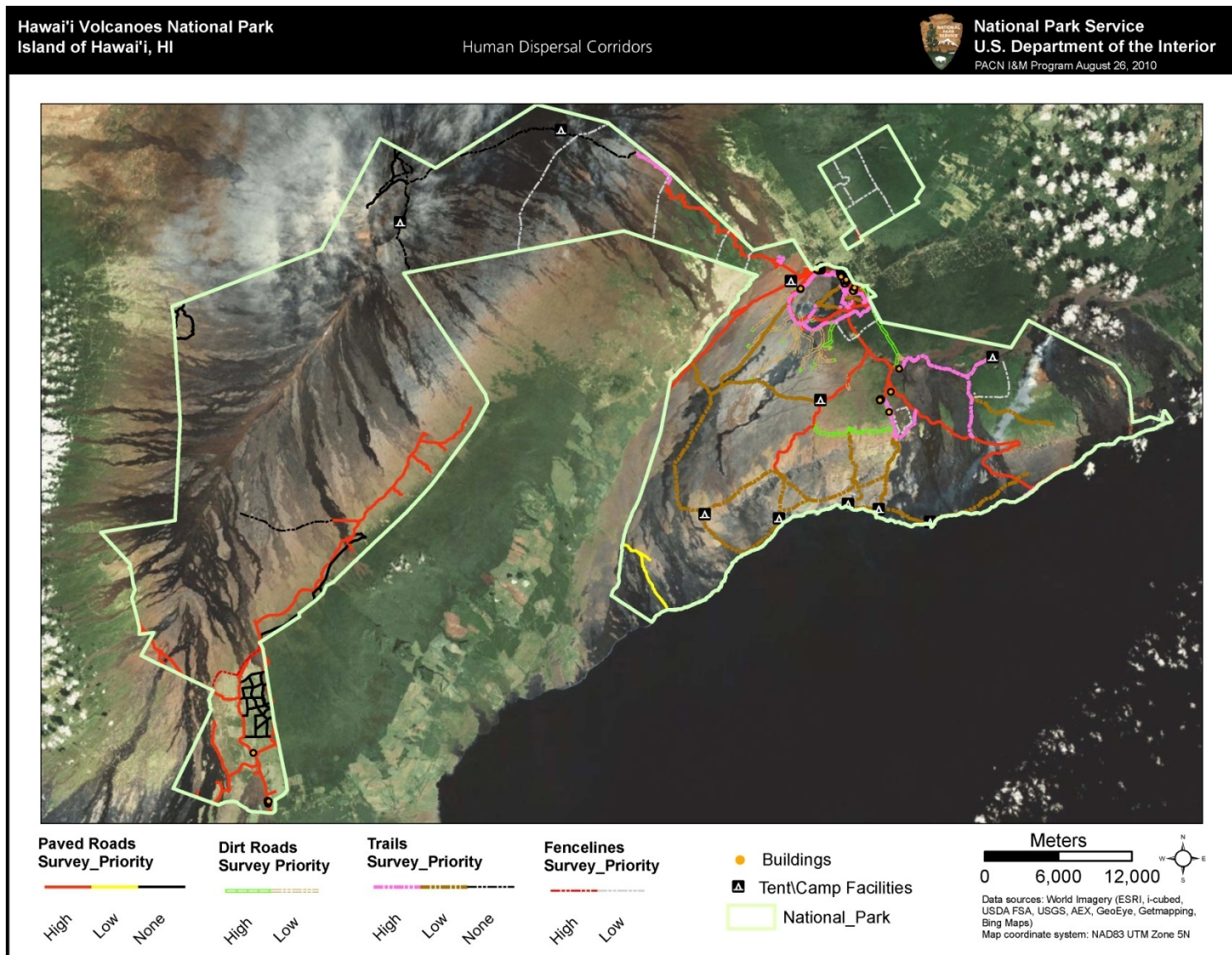


**Figure A.1.** Non-native plant species dispersal corridors divided by priority level at Hawai'i Volcanoes National Park.



**Figure A.2.** Non-native plant species dispersal corridors at Kaloko-Honokōhau National Historical Park.



**Figure A.3.** Non-native plant species dispersal corridors at Pu'uhonua o Hōnaunau National Historical Park.

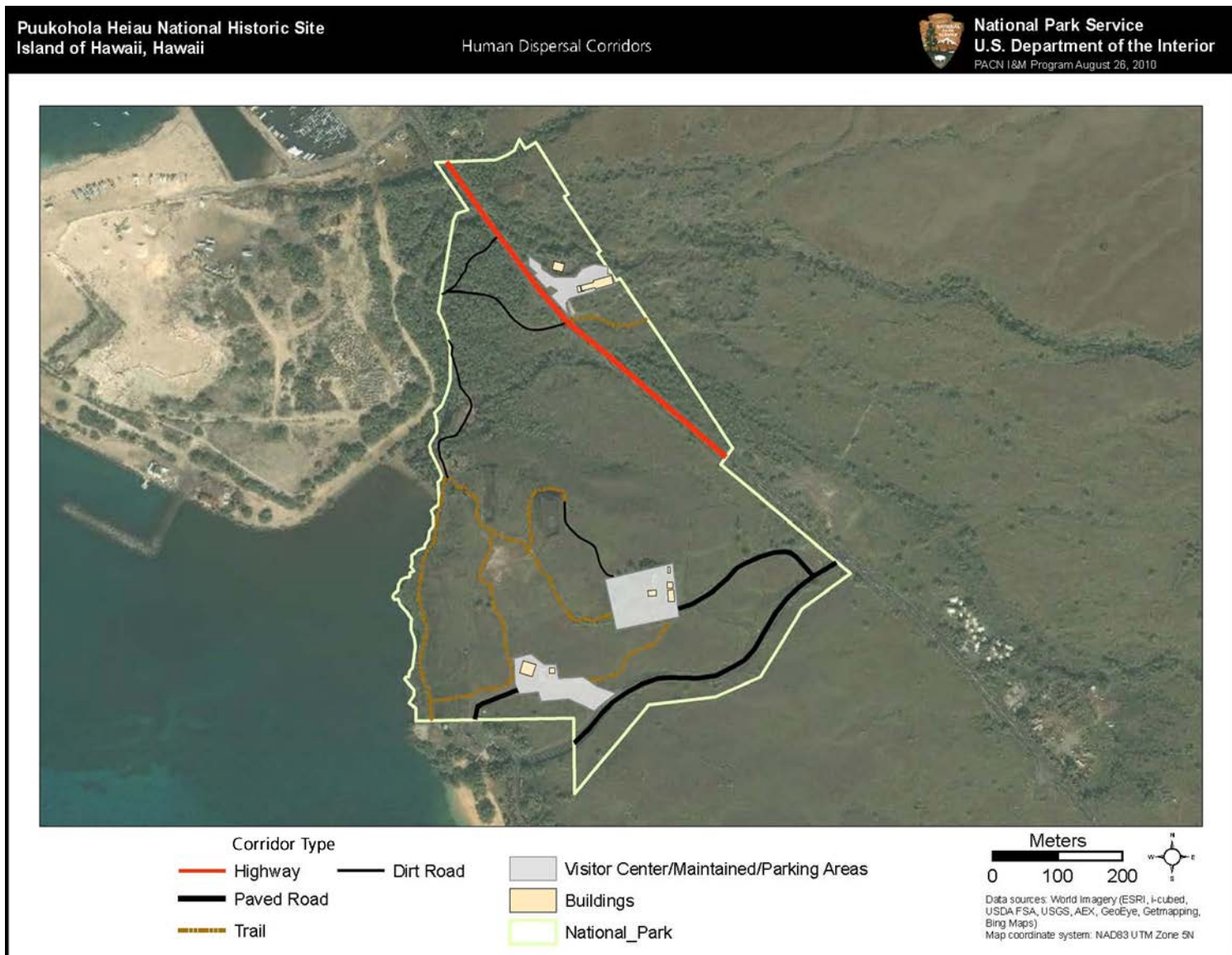


**Figure A.4.** Non-native plant species dispersal corridors at Pu'ukoholā Heiau National Historic Site.

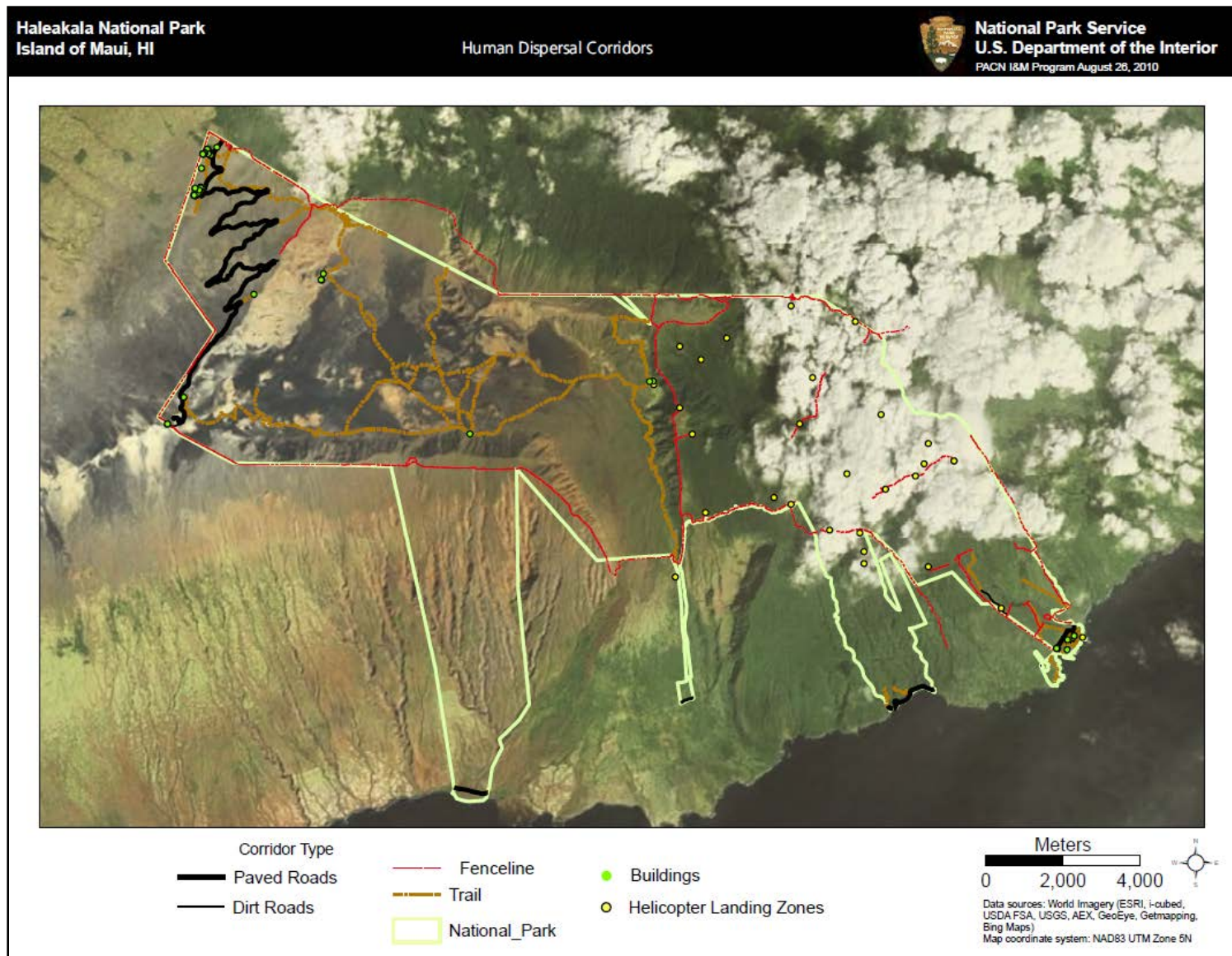


**Figure A.5.** Non-native plant species dispersal corridors at Haleakalā National Park. All fence lines at HALE are low priority.



**Figure A.6.** Non-native plant species dispersal corridors at Kalaupapa National Historical Park.

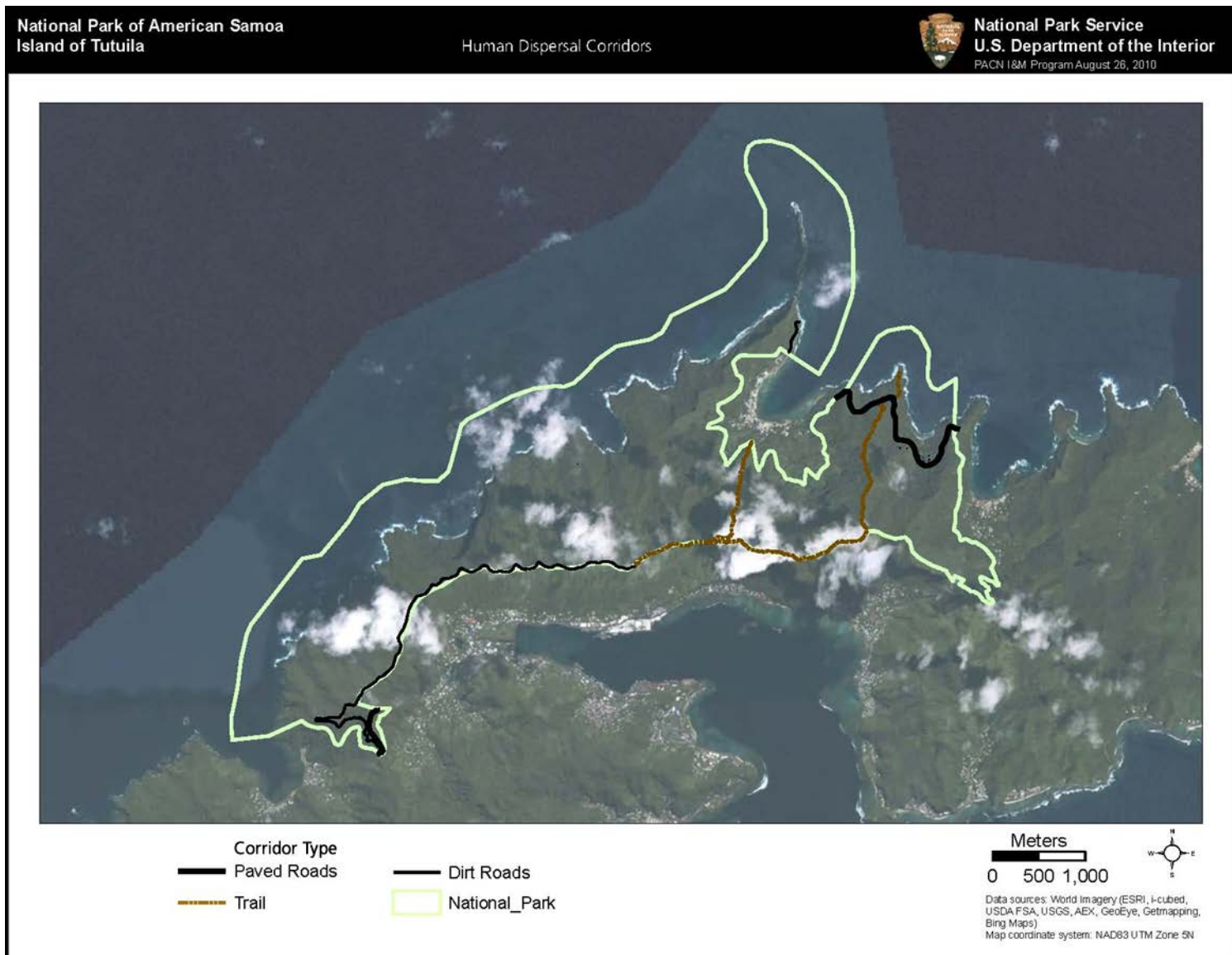


**Figure A.7.** Non-native plant species dispersal corridors on Tutuila Island at the National Park of American Samoa.

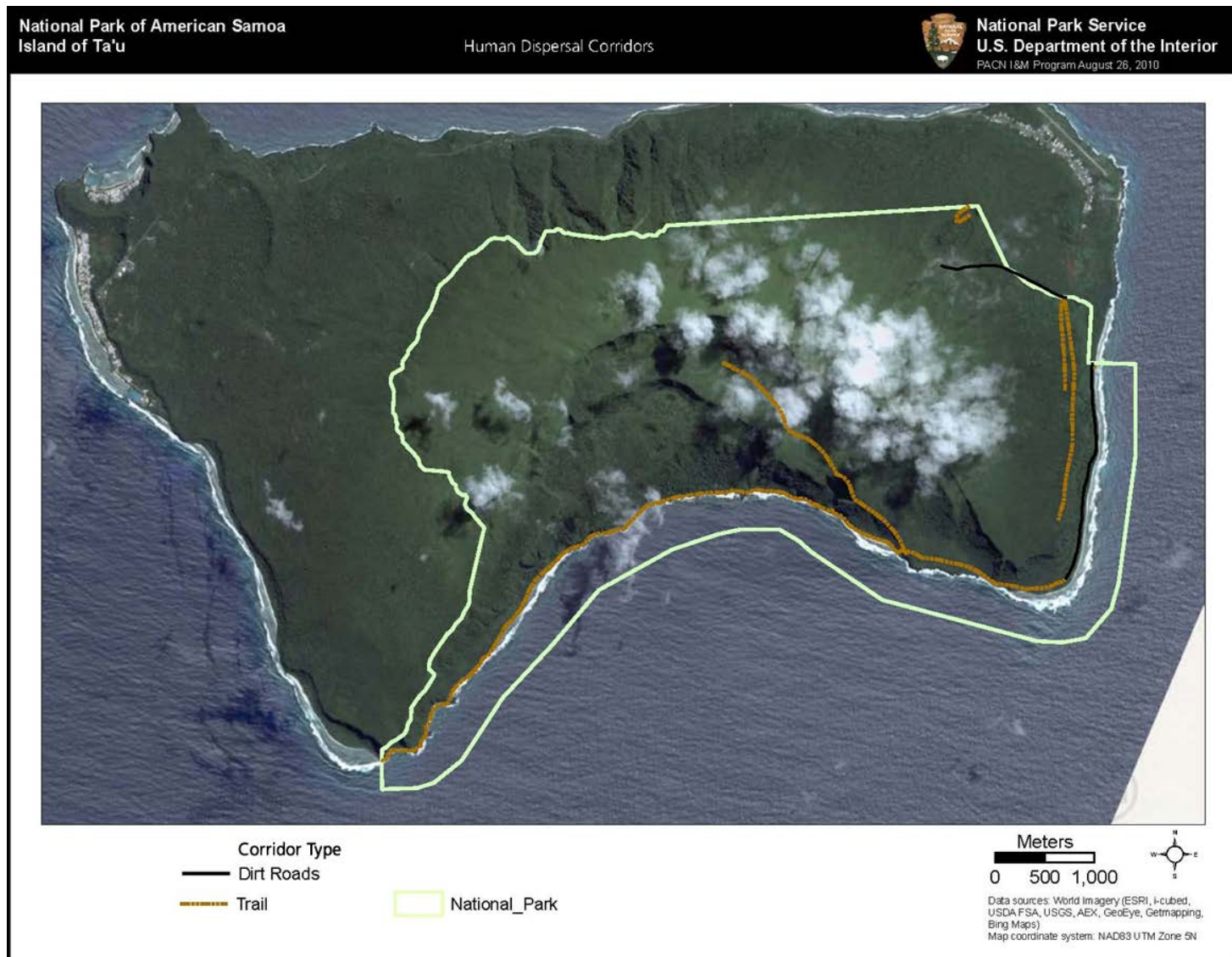


**Figure A.8.** Non-native plant species dispersal corridors on Ta'u Island at the National Park of American Samoa.



## Appendix B. Pilot Studies 2014-2016

### Introduction

The goal of the Pacific Islands Network (PACN) early detection monitoring plan is to locate potentially invasive plant populations at early stages of invasion to inform park resource managers so that appropriate action (i.e., eradication, containment, additional monitoring) may be implemented. Field surveys under this plan emphasize corridors (e.g., roads, trails, fence lines, power lines) as these are important areas for non-native plant species transport via humans. The detection of any new incipient species found during corridor surveys is of potential concern and interest to park management, and may be a trigger point for new management actions. This program was initially envisioned as a long-term monitoring plan implemented in seven PACN parks, which would be surveyed every three years with the goal of detecting and reporting new invasive plants before they become widespread.

Multiple pilot studies were conducted on different scales in 2014 and 2016 to evaluate methods, feasibility, and necessary labor inputs (Simon & Ainsworth 2014, Urbanski & Osgood 2014, Wasser & Ainsworth 2014, Akamine & Wasser 2016, unpublished reports) (Table B.1). These pilot studies clearly demonstrate that even limited scale opportunistic surveys can provide valuable data on new plant invaders if the proposed three-year cycle becomes cost-prohibitive in the future. All ED work conducted between 2014 and 2016 is summarized here.

**Table B.1.** Early detection efforts at PACN parks 2014-2016. Worker days are based on 8-hour days.

| Park | Year | Study              | Description                  | Distance Surveyed (km) | Data Records | Worker Days |
|------|------|--------------------|------------------------------|------------------------|--------------|-------------|
| HAVO | 2014 | Simon & Ainsworth  | Initial Pilot Study for ED   | 18.3                   | 27           | 18          |
| HALE | 2014 | Urbanski & Osgood  | Pilot Study for HALE         | 63.5                   | 36           | 22          |
| HAVO | 2014 | Wasser & Ainsworth | In-Depth Pilot Study: Kahuku | 122.8                  | 159          | 52          |
| KAHO | 2016 | Akamine & Wasser   | Opportunistic Surveys        | 6.1                    | 20           | 7           |

### Methods

Prior to starting ED work, survey staff met with Natural Resource Management (NRM) staff from the park to be surveyed to strategize and prioritize survey areas. Previous rates of non-native plant introductions at PACN parks have generally been positively correlated with high levels of visitor and staff use. Accordingly, roads, trails, and other corridors such as fence lines and power lines are targeted, with the highest priority generally given to the highest trafficked areas. To conduct surveys, two crew members generally walked and surveyed opposite sides of established paths, trails, road, etc. If a single crewmember was conducting the survey, he/she would walk up one side and then back down the other side of the survey area to cover each side of the corridor in question.

‘Species of interest’ to the survey crews included any unknown plants that the crew could not identify in the field, species not previously documented in the area, and species targeted for control

and/or eradication by NRM staff. When a species of interest was encountered while surveying, GPS coordinates, photos, and a sample voucher specimen (if necessary) were taken. Additionally, information on the number of individuals present, life and reproductive stage, associated photo numbers, and any additional comments and notes were recorded. Plant samples were taken if deemed necessary to aid in identification and/or the unknown was suspected to be a new record for the area, but only when more than one individual was present.

After returning from the field, crew utilized plant keys and appropriate literature to identify unknown species from the field. Plants that were unidentifiable by survey staff were shown to additional local staff or other local plant experts for identification. Any samples needing further taxonomic clarification were forwarded to Bishop Museum in Honolulu for identification. Taxonomy for all species follows Wagner et al. (1999), with taxonomic changes and new island records kept current using a major 2012 update and revision (Wagner et al. 2012), and continuously updated master checklists for the state maintained by Bishop Museum and the Smithsonian Institution.

### ***Species Lists***

Crews utilized several different species lists as resources for ED work. These lists were highly variable depending on the PACN Park unit being surveyed. At the most basic level, a species list for each PACN Park is maintained by PACN and publicly available on NPSpecies. For some parks, species lists with more detail such as geographic data are available. This is the case for all of HAVO, where a species occurrence is tracked by geographic area and ecological zones, and a species list specific to the Kahuku Unit was also published after a comprehensive inventory of the area (Benitez et al. 2012).

### ***Classification and Reporting of New Plant Species***

Following positive identification, data records were categorized. These categories were somewhat variable by park but can generally be delineated as follows:

- 1) *New State Record* – Species not previously recorded in the state.
- 2) *New Island Record* – Species not previously recorded on the island.
- 3) *New Park Record* – Species not previously recorded in the park.
- 4) *New Unit Record* – Species not previously recorded in a specific PACN park unit, but previously recorded elsewhere within that park.
- 5) *New Locality Record* – Species not previously recorded in the specific survey region or ecological zone surveyed. This is a more specific geographic delineation than (4).
- 6) *Identified, previously known* – Species that, after positive identification, had been previously recorded within the area being surveyed or nearby.
- 7) *Target species point* – Point location for individual(s) of an invasive species targeted for control and/or eradication by NRM staff at the park being surveyed.
- 8) *Unknown species* – Data records with samples that could not be identified with any available resources. Generally samples of sterile grasses.

- 9) *Rare native species* – Point locations of individuals of rare native species of interest to NRM staff at the park being surveyed.

For categories (1) and (2), the reference species list for existing records in the State of Hawai‘i and Hawai‘i Island were based on Wagner et al. (1999), and current through a 2012 revision and update (Wagner et al. 2012). Species lists for categories (3), (4), (5), and (6) were based on existing species lists from each PACN Park. For some smaller parks (such as KAHO), categories (4) and (5) are not applicable since those parks are too small to be delineated by units, ecological zones, and/or geographic areas. Category (7) and (9) were only applicable if lists of target invasive and/or rare native species of interest were made available to survey staff by local park staff.

### ***Survey Inventory, Tracks, and GIS Database***

All spatial data were tracked and recorded in the field using a handheld GPS device (either a Garmin or Trimble handheld GPS unit), and then managed using ArcGIS 10.x (ESRI, Redlands, CA) once data were downloaded to a PACN server. Data were saved as shapefiles after each field session, and then merged into a single ‘master’ shapefile for each survey effort which contained all survey records for that effort. This master shapefile was then modified as species were identified and categorized. Following positive species identification, taxonomic metadata was added, and data points were assigned a category (1-9) as outlined above.

Tracking was enabled on the handheld GPS units during all field surveys. These units record tracks on internal memory as a point or polyline shapefile. Following field work, these track shapefiles were copied to a raw data storage section of the GIS database. As with data record points, a single master track shapefile was created for consolidation and final storage of all survey tracks. Line features for the master shapefile were created by snapping to and manually tracing the raw point track data from the handheld GPS units along existing road, trail, and other corridor specific GIS data. If the internal tracking of the GPS unit was not functioning properly, a start and end point for each survey section was recorded, and the track data for that section was then created by tracing the road or trail segment in ArcGIS from the survey start to end points. Each survey day was stored as a single attribute containing either one continuous line segment or multiple discontinuous (but merged) line segments in the master track shapefile. Raw track records were manually corrected to avoid overlap and double counting of areas, and to produce a generally cleaner dataset. Finally, distances were calculated for each survey day from the polylines that were created from the raw tracks.

### ***Changes in Methods and Sampling Differences between Parks***

ED survey methods have undergone changes between the most recent unpublished draft and the different pilot studies. Most changes involve simplification of methods or other minor changes to adjust to different conditions and resources available at the different parks. Important changes and/or differences between pilot surveys and previous drafts are:

- No corridor segmentation or visibility categories are used while surveying. Crews follow park corridors and monitor for new plant species as far as visibility allows. Without segmentation or visibility categories no complex area or trend analysis will be calculated, but this method allows

for greater distances to be covered. Increased coverage and rapid reporting is generally of higher priority to park managers.

- Park staff was not always available to meet with survey crews before the start of ED surveys. If this meeting was not possible, ED surveys proceeded using the best available information.
- Not all classifications for data records were applicable at all parks. Some smaller parks do not have different units, geographic areas, or ecological zones. Additionally, lists of incipient and/or rare species of concern were not always provided by parks.
- Species lists for different parks varied widely in their level of detail and/or completeness. ED surveys were completed using the best available information at each park.
- Flexibility among GPS units was necessary as different GPS units were preferred for different parks. The two different units were Garmin 60 series and Trimble Juno handheld GPS. Although the Trimble offers superior data collection capability within the unit, most survey crews had technical difficulties with this device. The Trimble units were, in general, more finicky, less reliable, and more difficult to troubleshoot in the field. The PACN GIS specialist (who is duty-stationed at HAVO) was able to frequently assist the HAVO crew with troubleshooting the Trimble units, but in other parks where technical assistance is less accessible, the Garmin units were preferred.

## **Results & Summary of Each ED Effort to Date**

### ***HAVO Initial Pilot Study (2014)***

This study was the first ED survey effort conducted by PACN (Simon & Ainsworth 2014, unpublished report). For this initial pilot effort, the ED crew focused on highly accessible and heavily trafficked roads and trails in the front country area around the Kilauea Summit at HAVO.

Approximately 18 km of roads and trails were surveyed over six survey days in early 2014 (Figure B.1); 27 plant species were recorded and eight of these were forwarded to local staff or other local plant experts for identification. Two species (*Rosa laevigata* and *Syzygium paniculatum*) were of particular interest to NRM and prompted a rapid response (Figure B.2). This initial study both highlighted the need for ED at PACN parks, the usefulness even when done on an opportunistic basis, and problems with the methodology that needed to be changed and/or refined before ED efforts could take place on a larger scale.

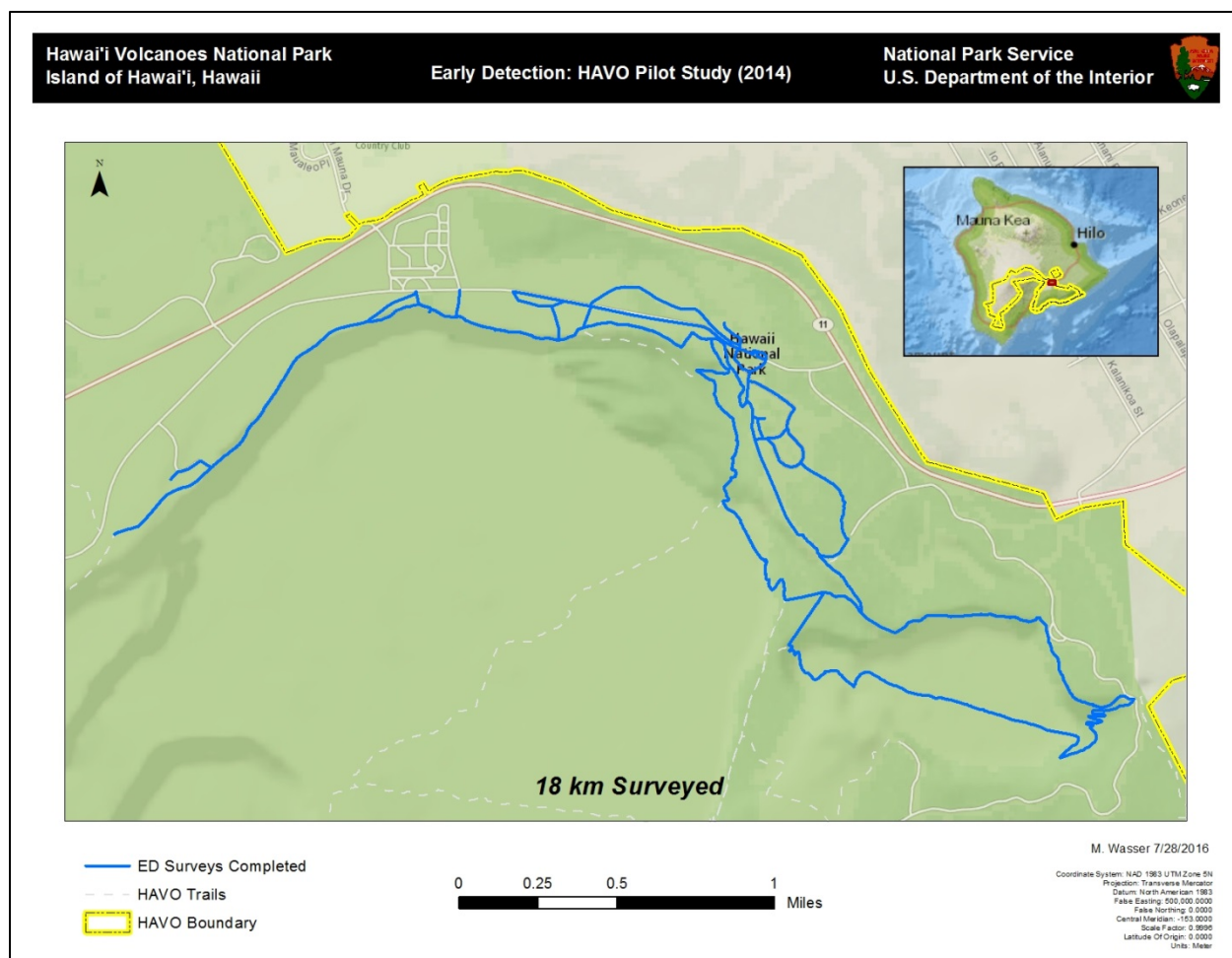


**Figure B.1.** Map of corridors surveyed for the first ED pilot study at HAVO in early 2014.



**Figure B.2.** Two species that prompted rapid response from HAVO NRM. *Rosa laevigata* (left) and *Syzygium paniculatum* (right) found in the summit residential area during the 2014 summit pilot study.

### **HALE Pilot Study (2014)**

The second ED pilot study was conducted at HALE in August and September 2014. This pilot study took place along trails and fence lines in the front country and summit district at HALE (Figure B.3). Crater Road and the parking lots within the summit district were already surveyed for invasive weeds by Starr Environmental through a contract with the ATST construction project and were subsequently not surveyed during this pilot study. Almost 64 km were surveyed over 12 days with a total of 22 worker days (Appendix B1). Thirty-six unknown plant species were recorded and all were identified (Appendix B2). Of these 36 species, 11 species were of management concern to NRM, and one species was a new record for HALE (*Wahlenbergia gracilis*). In addition to *W. gracilis*, two other species (*Avena fatua* and *Psidium cattleianum*) were detected in three new geographic localities and initiated a rapid response for control from NRM.

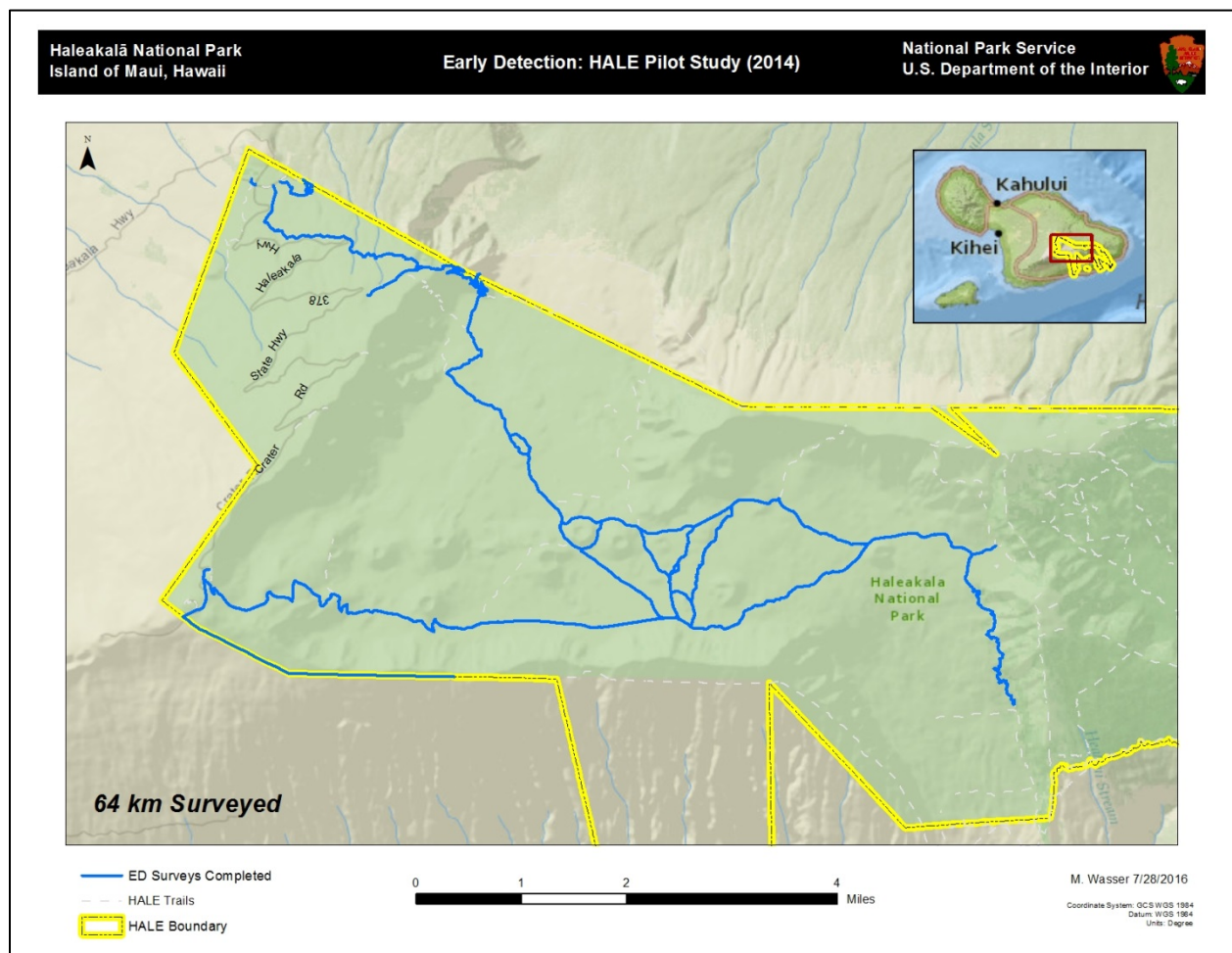


**Figure B.3.** Map of corridors surveyed for the ED pilot study at HALE in August-September 2014.

### **HAVO Kahuku Unit Pilot Study (2014)**

Following the two pilot studies at HAVO and HALE in 2014, a more in-depth ED effort was conducted at the Kahuku Unit of HAVO. The Kahuku Unit is the newest part of HAVO, acquired in 2003, and was actively grazed under legacy cattle leases until 2010. Crews used several different

sources to create a comprehensive species checklist for HAVO. A digitized, electronic version of the Pratt (1988) inventory of HAVO was merged with a species list for the Kahuku Unit derived from surveys completed after the HAVO acquisition of Kahuku (Benitez et al. 2012). This list was further supplemented with any new records (2010 to 2014) provided by HAVO NRM, I&M, and USGS Biological Resources Division (BRD) staff. This new comprehensive inventory covers all of HAVO divided into 17 ecological zones (Figure B.4). These ecological zones were derived from Benitez et al. (2012) for Kahuku, and Pratt (1998) for the rest of HAVO. It should be noted that while the Pratt zones represent true ecological zones, the Kahuku zone divisions are generally delineated geographically (i.e., “East” Unit of Kahuku), and represent ‘survey regions’, which may contain more than one true ecological zone.

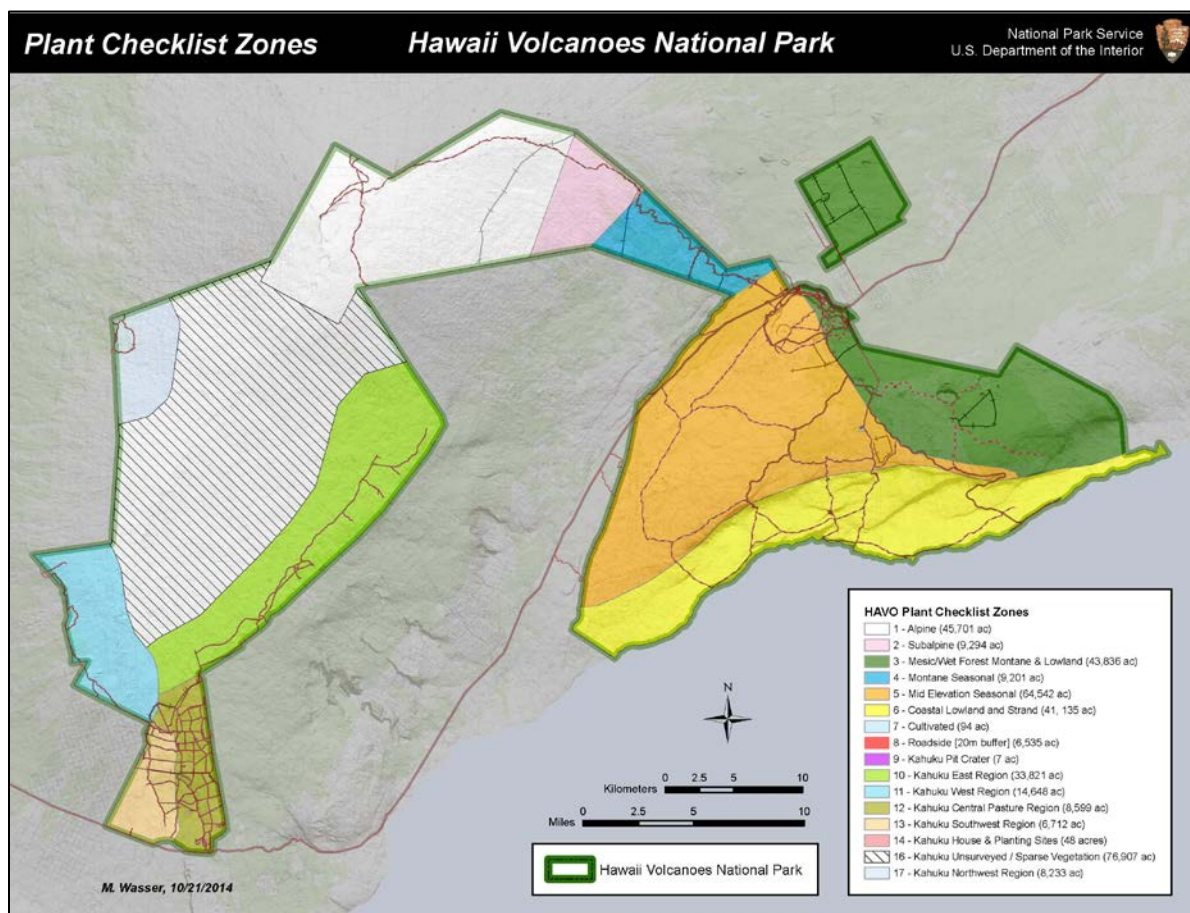


**Figure B.4.** Plant checklist zones for HAVO used for the ED pilot study in Kahuku late 2014. Zone 8 (roadside) was disregarded for the study and records were placed in the corresponding zone.

The Kahuku Unit is a mix of front country and back country areas with various levels of accessibility and traffic. As with previous ED efforts, higher trafficked areas were given priority, but the greater time and resources allotted to this effort allowed for a mix of front country and back country areas with various levels of accessibility (Figure B.5). Almost 123 km were surveyed over 13 days (Table B.2). A total of 52 worker days were spent on the Kahuku ED study. In an effort to further track

labor inputs, project time was assigned to one of three categories for tracking purposes, with a breakdown as follows:

- 1) *Office Days* – (11.8 worker days, 23% of total project labor) – Used for project planning, species identification, database updates, and report writing.
- 2) *Survey Time* – (22 worker days, 42% of total project labor) – Time during which field crews were physically conducting early detection surveys.
- 3) *Non-Survey Time on Field Days* – (18.2 worker days, 35% of total project labor) – Time during survey days in which crew were not actively surveying. This includes travel to/from survey sites, and any miscellaneous prep and breakdown time on survey days.

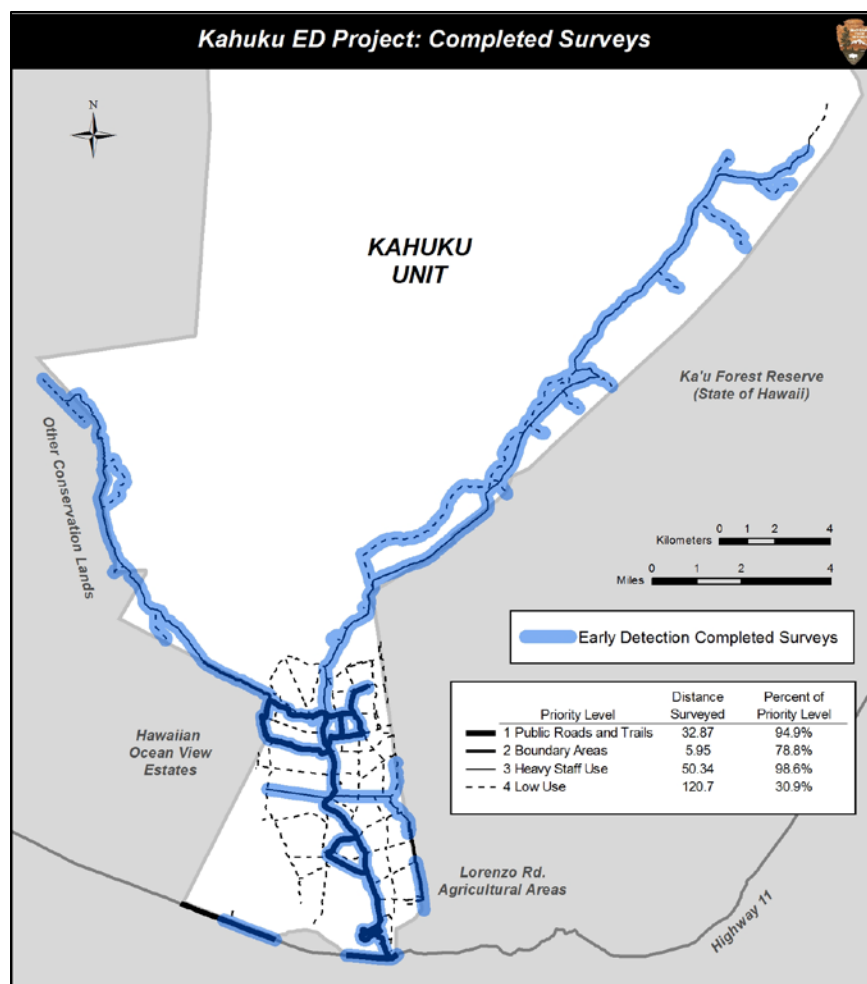


**Figure B.5.** Map of corridors surveyed for the Kahuku ED pilot study at HAVO in late 2014.

Over one hundred and fifty GPS point detections were recorded during the surveys (Appendix B3). These detections included 118 species in 38 different families; the most common families recorded were Poaceae (51 records, or 32% of all records), followed by Asteraceae (15 records, or 9.4%), Fabaceae (14 records, or 8.8%), and Melastomataceae (10 records, or 6.3%). In total, these four families represented over 56% of all data records.

Following identification of unknown species, the 159 data records were assigned to Categories 1-9 (described in methods). The breakdown of data records by category was as follows:

- 1) *New State Records* – No data records.
- 2) *New Hawai‘i Island Records* – Two data records representing a single species not previously recorded on Hawai‘i Island (Figure B.6). *Dicanthium annulatum*, a pasture grass previously known from O‘ahu, West Maui, and Molokai, was collected in the Central Pastures Survey Region at elevations of 1,000m and 1,525m. Approximately 5-10 individuals were observed in two discreet areas. A collection of this species was forwarded to Bishop Museum in Honolulu for addition to their herbarium collection, and point locations have been forwarded to HAVO NRM personnel for follow up. Additional collections are planned for deposition into the HAVO herbarium collection.
- 3) *New HAVO Records* – Three data records for three new species not previously recorded in HAVO (Figure B.6). The three species recorded were *Dysphania caranatum* (Chenapodiaceae), *Leonotis nepetifolia* (Lamiaceae), and *Echinochloa colona* (Poaceae).
- 4) *New Kahuku Records* – Eleven data records of 11 species not previously recorded in the Kahuku Unit of HAVO (Figure B.7). These records included five species in Asteraceae, and three grasses (Poaceae).
- 5) *New Kahuku Localities* – Thirty data records for 30 species not previously recorded in the survey region/ecological zone of Kahuku Unit being surveyed, but previously recorded in the Kahuku Unit in a different survey region (Figure B.7). This included six data records for the Central Pastures survey unit, 13 data records for the East Survey Unit, nine data records for the West Survey Unit, and two data records for the Southwest Survey Unit.
- 6) *Identified, previously known* – Forty data records for species that, after positive identification, had been previously recorded as occurring in the survey region in question in Kahuku.
- 7) *Target species points* – Fifty-five data records for point locations of an individual or individuals of 16 non-native species currently targeted for control and/or eradication in Kahuku by HAVO NRM staff (Figure B.8). The most common species recorded were *Urochloa maxima* (Poaceae), *Cenchrus setaceus* (Poaceae), *Leucana leucocephala* (Fabaceae), and *Tibouchina herbacea* (Melastomataceae). These species have since been controlled by HAVO NRM.
- 8) *Unknown species* – Two data records for samples that could not be identified with any available resources. Both records are sterile grasses, but appear to represent two different species.
- 9) *Rare native species* – Nine data records for point locations of individuals of six rare native species of interest to HAVO NRM staff (Figure B.8).



**Figure B.6.** Location of new island records (left) and new HAVO records (right).

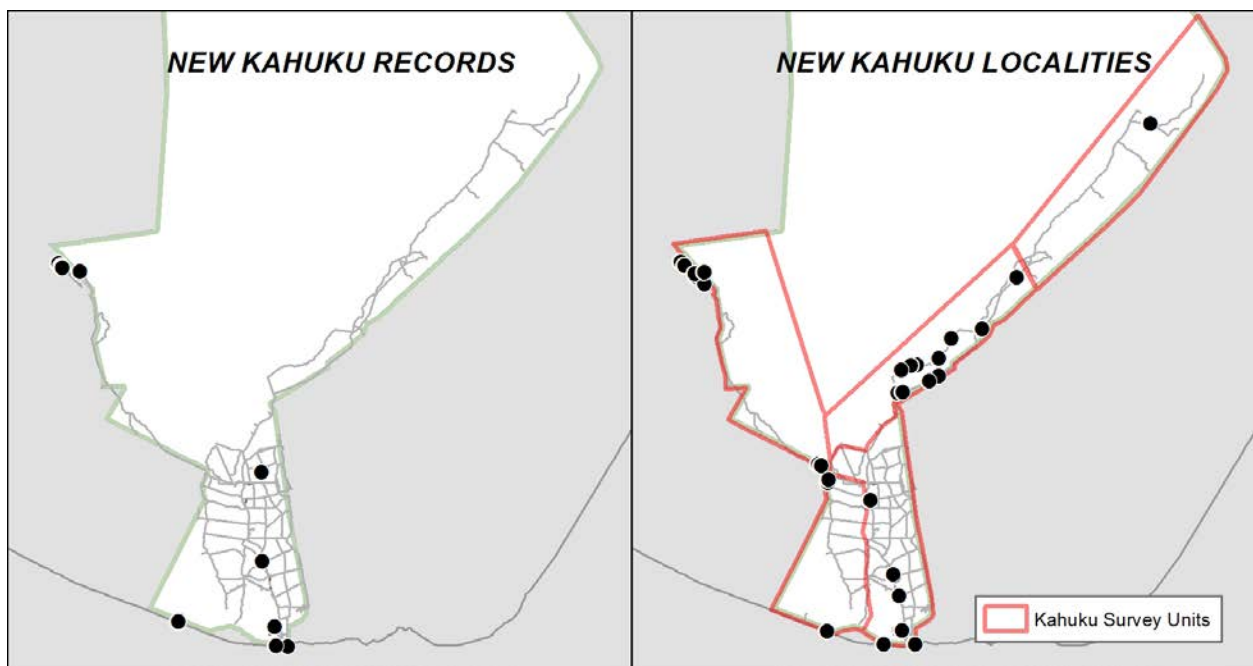


**Figure B.7.** Location of new Kahuku records (left) and new Kahuku localities (right).

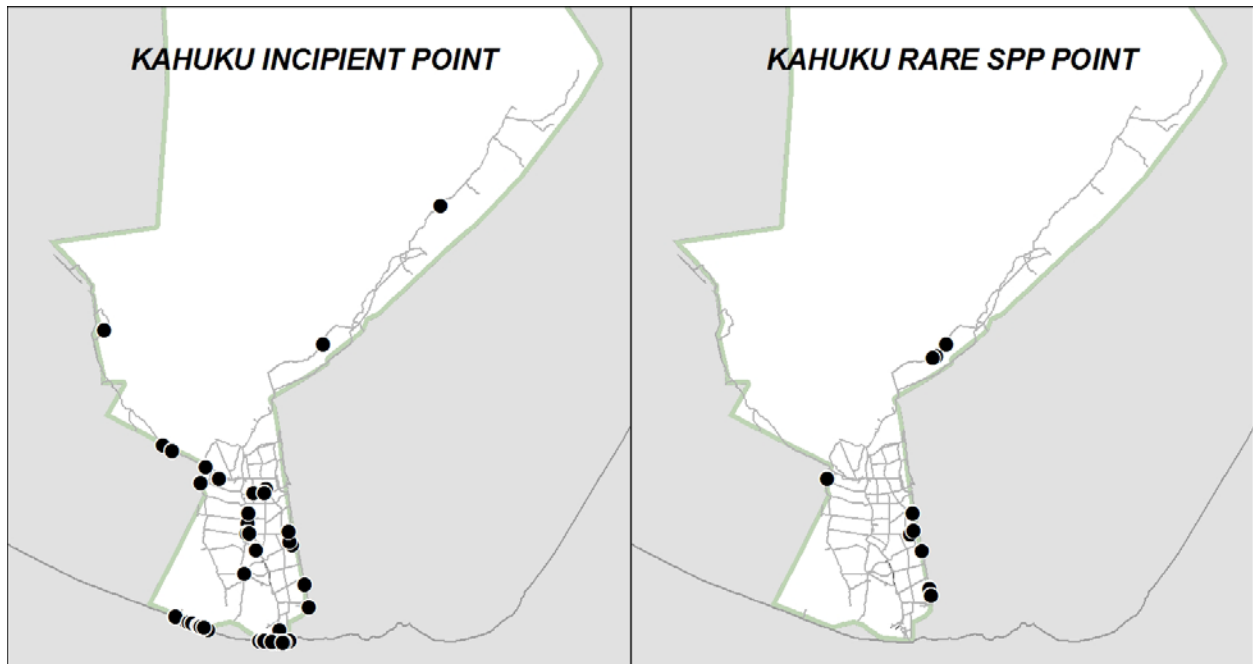


**Figure B.8.** Location of target species points (left) and rare native species points (right).

Excluding target species, the highest number of data records recorded per kilometer travelled (11.9) was on November 20 on the section of Highway 11 that borders the Kahuku Unit (46 data points in 3.85 km surveyed; Table B.2). The relatively high rate may be attributed to this section of road being the most heavily trafficked corridor in Kahuku. The area with the second highest rate of data records per kilometer surveyed (3.9) was the lower section of the main ranch road, which is the second most heavily trafficked area in Kahuku. For other survey days, rates of data records recorded varied from 0.33-1.76 data points/km surveyed, with a mean of 1.29 data records / kilometer surveyed for the entire pilot study.

**Table B.2.** Survey distances and data records from Kahuku pilot study survey days.

| Date  | Area                                           | Dist (km) | # points taken | Still to ID | UNK – unable to ID | ID'd, known | Incipient point | New Kahuku locality | New Kahuku record | New HAVO record | New Island record | New State record | Rare native spp |
|-------|------------------------------------------------|-----------|----------------|-------------|--------------------|-------------|-----------------|---------------------|-------------------|-----------------|-------------------|------------------|-----------------|
| 10/27 | Main Ranch Road, entrance to top of Palm Trail | 8.39      | 13             | –           | 1                  | 7           | 1               | 3                   | 1                 | –               | –                 | –                | –               |
| 10/30 | Kainoa roads below reservoir                   | 1.17      | 4              | –           | –                  | 2           | 1               | –                   | –                 | –               | –                 | –                | 1               |
| 10/30 | Main Ranch Road above Palm Trail, Palm Trail   | 3.97      | 6              | –           | –                  | 1           | 3               | –                   | 1                 | –               | 1                 | –                | –               |
| 11/3  | Main Ranch Road to Glover top, Glover Trail    | 6.76      | 12             | –           | –                  | 7           | 4               | –                   | –                 | 1               | –                 | –                | –               |
| 11/5  | Kona Trail, top of Glover Trail to enclosure 4 | 7.22      | 9              | –           | –                  | 3           | 2               | 1                   | –                 | 1               | –                 | –                | 1               |
| 11/10 | Glover Trail, Main Ranch Road                  | 9.25      | 5              | –           | –                  | 2           | 2               | –                   | 1                 | –               | –                 | –                | –               |
| 11/13 | West Unit Roads, farthest west                 | 12.89     | 20             | –           | –                  | 8           | 1               | 7                   | 4                 | –               | –                 | –                | –               |
| 11/14 | West Unit Roads and cross fence west section   | 13.12     | 9              | –           | –                  | 4           | 3               | 2                   | –                 | –               | –                 | –                | –               |
| 11/19 | Kainoa area, Lorenzo Rd boundary, cross fence  | 6.25      | 11             | 1           | –                  | –           | 5               | –                   | –                 | –               | –                 | –                | 5               |
| 11/20 | Hwy 11, two sections                           | 3.85      | 46             | 2           | –                  | 2           | 32              | 3                   | 4                 | 1               | –                 | –                | –               |
| 12/1  | Kahuku East Unit - Piikea area                 | 9.13      | 3              | –           | –                  | 2           |                 | 1                   | –                 | –               | –                 | –                | –               |
| 12/2  | Kahuku East and Mauka Units                    | 20.48     | 7              | –           | 1                  | 1           | 1               | 3                   | –                 | –               | –                 | –                | 1               |
| 12/3  | Kahuku Mauka Unit                              | 20.32     | 14             | –           | 1                  | 1           |                 | 10                  | –                 | –               | –                 | –                | 2               |
|       | Totals                                         | 122.80    | 159            | 3           | 3                  | 40          | 55              | 30                  | 11                | 3               | 1                 | 0                | 10              |

### **KAHO Pilot Study (2016)**

The early completion of I&M's vegetation monitoring protocol at KAHO in the summer of 2016 allowed for one day of opportunistic ED surveying at KAHO. A total of seven worker days (two worker days for surveying) were spent on the KAHO ED effort. Just over 6 km of roads and trails were surveyed by the two crewmembers. As with other ED efforts, the most heavily trafficked roads and trails in the park were given surveying priority. Twenty unknown plants were collected during the KAHO ED surveying. Of those, three are potentially new records for Hawai'i Island, and six more are new records for KAHO (Appendix B4).



**Figure B.9.** Map of corridors surveyed for ED at KAHO in late 2016.

### **Discussion and Further Considerations**

Over the last three years, PACN has conducted four separate Early Detection survey efforts in three different parks. The scope, efforts, logistics, and working environments have varied greatly between these different efforts. These ED pilot studies offered PACN the opportunity to learn from and refine this plan to best suit park needs, available resources, and practical/logistical considerations. It has

made PACN staff aware of different potential challenges associated with these different surveying environments, but also demonstrated the fundamental usefulness of ED, even if only done on an opportunistic basis. Surveys of different scopes and scales conducted in different vegetation communities consistently found both new and potentially invasive species (Table B.3), and target species that are of high priority to park resource managers. In almost all ED studies, surveys found species that had not been previously recorded at that park, and even found a species previously undocumented on the island of Hawai‘i.

**Table B.3.** Summary of data records for PACN ED surveys, 2014-2016.

| Parameter                   | Park (Year)    |                |                       |                |
|-----------------------------|----------------|----------------|-----------------------|----------------|
|                             | HAVO<br>(2014) | HALE<br>(2014) | HAVO-Kahuku<br>(2014) | KAHO<br>(2016) |
| Distance Surveyed (km)      | 18.3           | 63.5           | 122.8                 | 6.1            |
| # of Data Records Generated | 27             | 36             | 159                   | 20             |
| Worker Days                 | 18             | 22             | 52                    | 7              |
| (1) New State Record        | 0              | 0              | 0                     | 0              |
| (2) New Island Record       | 0              | 0              | 2*                    | 3*             |
| (3) New Park Record         | 0              | 1*             | 3*                    | 6*             |
| (4) New Unit Record         | 0              | N/A            | 11                    | N/A            |
| (5) New Locality Record     | 0              | 4              | 30                    | N/A            |
| (6) ID'd, previously known  | 17             | 15             | 40                    | 9              |
| (7) Incipient species point | 2              | 16             | 55                    | N/A            |
| (8) Unknown species         | 8              | 0              | 2                     | 0              |
| (9) Rare native species     | N/A            | N/A            | 9                     | N/A            |

\* New species to the island or the park were found and are of special interest (also with light blue background).

The early detection plan was originally envisioned and written to take place on a three-year rotation at seven PACN parks. However, these pilot studies clearly indicate that even low budget opportunistic surveys can be very valuable to parks. If surveying is only done opportunistically in the future due to budget constraints, surveys are still useful to the parks. Future surveyors can target high traffic areas and/or areas of special concern to parks if resources are limited. Even short, one day surveys (i.e., KAHO in 2016) can produce useful results and allow parks to quickly address newly established non-native plants before they spread.

It is critical that surveyors be familiar with the local flora of the survey area. Since all unknown plants must be recorded, photographed and/or collected, this knowledge is central to the efficacy of crew survey time. Information from local park staff is also helpful. Better species lists, information about potential species of interest, known habitat ranges, geographical delineations, and any special logistical concerns can greatly aid survey efforts. That being said, ED surveys can still be conducted effectively based on available information if local park staff are unavailable to aid with planning. The flexibility of this arrangement ultimately facilitates more opportunistic surveying.

**Appendix B1. HALE (2014) ED surveys**

| Date     | Obs.  | Area                                | Travel (minutes and hours)       | Survey (hr) | # UNK spp | # ED Spp | comments                                  |
|----------|-------|-------------------------------------|----------------------------------|-------------|-----------|----------|-------------------------------------------|
| 9/3/14   | EU,MO | Hosmer's Grove trail                | 10 m 1 way, walk                 | ~1.5        | 1         | 1*       | –                                         |
| 9/4/14   | EU,MO | Supply trail                        | 15 m 1 way, drive                | 2.5         | 2         | 0        | cut easily accessible pines during survey |
| 9/8/14   | EU,MO | Sliding Sands trail to Kapalaoa     | 30 m 1 way, drive                | 4           | 6         | 3*       | CIRVUL (pulled), tomato vine              |
| 9/22/14  | EU,MO | Sliding Sands trail Kapalaoa-Paliku | 30 m drive, 2 hour hike          | 2           | 1         | 0        | –                                         |
| 9/23/14  | EU,MO | Kaupo trail to 'maile patch'        | 15 m walk from Paliku            | 6           | 2         | 1        | CIRVUL (~8 indivs pulled), 1 PSICAT       |
| 9/23/14  | EU,MO | Paliku campground/ cabins           | 5 hr hike from SS trail head     | 0.5         | 3         | 3*       | Persea, Prunus, Mentha (all not pulled)   |
| 9/24/14  | EU,MO | Halemau'u trail to Paliku-Holua     | n/a hike from Paliku             | 4           | 3         | 1*       | Juno issues                               |
| 9/24/14  | EU,MO | Holua Hilton pasture                | 2.5 hr from Halemau'u trail head | 0.5         | 2         | 0        | SENMAD (pulled)                           |
| 9/25/14  | EU,MO | Holua visitor cabin                 | 2.5 hr from Halemau'u trail head | 1           | 1         | 1*       | PHYPER, flowering CIRVUL (not pulled)     |
| 9/25/14  | EU,MO | Halemau'u Holua to trail head       | n/a hike from Holua              | 4           | 1         | 1*       | CIRVUL (pulled), serious Juno issues      |
| 10/6/14  | EU,MO | Summit baseyard                     | n/a by office                    | 2           | 4         | 0        | –                                         |
| 10/7/14  | EU,MO | South slope fence line              | 30 m 1 way, drive                | 5           | 1         | 0        | PITAUS on fence                           |
| 10/8/14  | EU,MO | lower Kilohana fence                | 1 hr hike from HQVC              | 4           | 0         | 0        | –                                         |
| 10/9/14  | EU,MO | upper Kilohana fence                | 30 m drive, 15 m hike            | 3           | 1         | 1        | WAHGRA                                    |
| 11/25/14 | EU    | central crater cross-trails         | 1 hr hike from Paliku            | 3           | 1         | 0        | –                                         |

\*Potential early detection HALE target species for management

**Appendix B2. HALE (2014) ED data records**

| Species    | Date      | Location            | Ind.  | Collected | Pulled | Comments                                          |
|------------|-----------|---------------------|-------|-----------|--------|---------------------------------------------------|
| JUNPLA     | 9/4/2014  | Supply trail        | many  | yes       | no     | many along trail                                  |
| RUBARG     | 9/4/2014  | Supply trail        | 1     | no        | no     | species of concern                                |
| PINPAT     | 9/4/2014  | Supply trail        | 4     | n/a       | yes    | species of concern                                |
| PINRAD     | 9/4/2014  | Supply trail        | 1     | n/a       | yes    | species of concern                                |
| AVEFAT     | 9/8/2014  | Sliding Sands trail | 2     | yes       | yes    | 2 locations on trail, dried specimen poss. sativa |
| Prunus sp. | 9/8/2014  | Sliding Sands trail | 1     | no        | no     | species of concern                                |
| CONCAN     | 9/8/2014  | Sliding Sands trail | few   | yes       | no     | –                                                 |
| DYSCAR     | 9/8/2014  | Sliding Sands trail | 1     | yes       | yes    | was originally considered new to this area        |
| SOLLYCCER  | 9/8/2014  | Sliding Sands trail | 1     | n/a       | yes    | species of concern                                |
| LEPVIR     | 9/8/2014  | Sliding Sands trail | 2     | yes       | yes    | –                                                 |
| LEPVIR     | 9/22/2014 | Kapalaoa - Paliku   | ~5    | yes       | no     | –                                                 |
| GERHOM     | 9/23/2014 | Paliku-Kaupo        | many  | yes       | no     | several patches along trail                       |
| CIRVUL     | 9/23/2014 | Paliku-Kaupo        | 10+   | n/a       | yes    | species of concern                                |
| UNK grass  | 9/23/2014 | Paliku-Kaupo        | patch | yes       | no     | small patch Festuca sp., looked like EHRSTI       |
| PSICAT     | 9/23/2014 | Paliku-Kaupo        | 1     | n/a       | yes    | ED at elevation of Kaupo Gap                      |
| PERAME     | 9/23/2014 | Paliku campground   | 1     | no        | no     | species of concern                                |
| Prunus sp. | 9/23/2014 | Paliku Cabin        | patch | no        | no     | large known patch                                 |
| MENSUA     | 9/23/2014 | Paliku Cabin        | patch | yes       | no     | known patch                                       |
| PITAUS     | 9/24/2014 | Paliku-Holua        | many  | no        | no     | thought to be rare in area                        |
| BROCAT     | 9/24/2014 | Paliku-Holua        | patch | no        | no     | thought to be rare in area                        |
| DYSCAR     | 9/24/2014 | Paliku-Holua        | 1     | n/a       | yes    | was originally considered new to this area        |
| COTAUS     | 9/24/2014 | Holua pasture       | many  | yes       | no     | unknown at time                                   |
| SENMAD     | 9/24/2014 | Holua pasture       | 1     | n/a       | yes    | species of concern                                |
| PHYPER     | 9/25/2014 | Holua cabin         | patch | n/a       | no     | presence of individual is known                   |
| CIRVUL     | 9/25/2014 | Holua cabin         | patch | n/a       | no     | presence is known                                 |
| CIRVUL     | 9/25/2014 | Holua-Halemau'u     | 1     | n/a       | yes    | species of concern                                |
| PRUPER     | 9/25/2014 | Holua-Halemau'u     | 1     | photo     | no     | possible nectarine, sp concern                    |
| FOEVUL     | 10/6/2014 | Summit baseyard     | many  | no        | no     | throughout area, not ED                           |
| CIRVUL     | 10/6/2014 | Summit baseyard     | 2     | no        | no     | species of concern                                |
| POLAVI     | 10/6/2014 | Summit baseyard     | many  | yes       | no     | several                                           |
| CORDID     | 10/6/2014 | Summit baseyard     | many  | yes       | no     | several                                           |
| CAPBRU     | 10/6/2014 | Summit baseyard     | many  | yes       | no     | several                                           |
| VICSAT     | 10/6/2014 | Summit baseyard     | many  | yes       | no     | several                                           |

**Appendix B2 (continued).** HALE (2014) ED data records

| Species | Date       | Location           | Ind.  | Collected | Pulled | Comments                     |
|---------|------------|--------------------|-------|-----------|--------|------------------------------|
| PITAUS  | 10/7/2014  | South slope fence  | patch | no        | no     | thought to be rare in area   |
| WAHGRA  | 10/9/2014  | off Kilohana fence | few   | yes       | no     | new to HALE, present on Maui |
| CHEOAH  | 11/25/2014 | Central Crater     | 4     | photos    | no     | native shrub!                |

**Appendix B3.** HAVO (2014) Kahuku ED data records with assigned record class (1-new State, 2-new Island, 3-new HAVO, 4-new Kahuku, 5-new Kahuku locality, 6-known, 7-target species, 8-unknown, 9-rare native species).

| Family          | Plant ID                         | Record ID  | Record Class | Date     | Trail Area              |
|-----------------|----------------------------------|------------|--------------|----------|-------------------------|
| Adiantaceae     | <i>Adiantum hispidulum</i>       | 07D ADIHIS | 5            | 11/13/14 | West Kahuku (outside)   |
| Amaranthaceae   | <i>Amaranthus spinosus</i>       | 03I AMASPI | 7            | 10/30/14 | Palm Trail - old corral |
| Apiaceae        | <i>Hydrocotyle bowlesioides</i>  | 04B HYDBOW | 6            | 11/3/14  | Main ranch road         |
| Apocynaceae     | <i>Asclepias physocarpa</i>      | 08G ASCPHY | 6            | 11/14/14 | West Kahuku             |
| Apocynaceae     | <i>Asclepias physocarpa</i>      | 12B ASCPSY | 5            | 12/3/14  | Kahuku Mauka            |
| Araliaceae      | <i>Schefflera actinophylla</i>   | 09K SCHACT | 6            | 11/19/14 | East Boundary           |
| Asteraceae      | <i>Ageritina riparia</i>         | 13B AGERIP | 5            | 12/3/14  | mauka unit              |
| Asteraceae      | <i>Bidens pilosa</i>             | 07C BIDPIL | 5            | 11/13/14 | West Kahuku (outside)   |
| Asteraceae      | <i>Bidens pilosa</i>             | 10G BIDPIL | 4            | 11/20/14 | Hwy 11 Boundary         |
| Asteraceae      | <i>Centaurea sp.</i>             | 07R CENSPP | 4            | 11/13/14 | West Kahuku (outside)   |
| Asteraceae      | <i>Cirsium vulgare</i>           | 07O CIRVUL | 6            | 11/13/14 | West Kahuku (outside)   |
| Asteraceae      | <i>Cirsium vulgare</i>           | 11B CIRVUL | 6            | 12/1/14  | Kahuku Piikea           |
| Asteraceae      | <i>Conyza boniensis</i>          | 07G CONBON | 6            | 11/13/14 | West Kahuku             |
| Asteraceae      | <i>Conyza boniensis</i>          | 08D CONBON | 6            | 11/14/14 | NW Paddocks             |
| Asteraceae      | <i>Conyza boniensis</i>          | 13J CONBON | 5            | 12/3/14  | Kahuku Mauka            |
| Asteraceae      | <i>Erechtites hieracifolia</i>   | 06B EREHIE | 4            | 11/10/14 | Glover Trail            |
| Asteraceae      | <i>Picris hieracioides</i>       | 07B PICHEI | 6            | 11/13/14 | West Kahuku (outside)   |
| Asteraceae      | <i>Senecio madagascariensis</i>  | 02K SENMAD | 6            | 10/27/14 | Main ranch road         |
| Asteraceae      | <i>Sonchus oleraceus</i>         | 07V SONOLE | 4            | 11/13/14 | West Kahuku (outside)   |
| Asteraceae      | <i>Tridax procumbens</i>         | 10P TRIPRO | 4            | 11/20/14 | Hwy 11 Boundary         |
| Asteraceae      | <i>Youngia japonica</i>          | 07T YOUJAP | 5            | 11/13/14 | West Kahuku (outside)   |
| Cactaceae       | <i>Hylocereus undatus</i>        | 10K HYLUND | 5            | 11/20/14 | Hwy 11 Boundary         |
| Campanulaceae   | <i>Clermontia clermontiodies</i> | 09E CLECLE | 9            | 11/19/14 | Kainoa                  |
| Caprifoliaceae  | <i>Lonicera japonica</i>         | 09H LONJAP | 7            | 11/19/14 | East boundary           |
| Caryophyllaceae | <i>Cerastium fontanum</i>        | 07A CERFON | 5            | 11/13/14 | West Kahuku (outside)   |

**Appendix B3.** HAVO (2014) Kahuku ED data records with assigned record class (1-new State, 2-new Island, 3-new HAVO, 4-new Kahuku, 5-new Kahuku locality, 6-known, 7-target species, 8-unknown, 9-rare native species).

| Family           | Plant ID                                         | Record ID   | Record Class | Date     | Trail Area            |
|------------------|--------------------------------------------------|-------------|--------------|----------|-----------------------|
| Chenopodiaceae   | <i>Chenopodium ambrosioides</i>                  | 02E CHEAMB  | 5            | 10/27/14 | Akihi corral          |
| Chenopodiaceae   | <i>Dysphania caranatum</i>                       | 05F DISCAR  | 3            | 11/5/14  | Kona Trail            |
| Crassulaceae     | <i>Kalanchoe pinnata</i>                         | 10T KALPIN  | 7            | 11/20/14 | Hwy 11 Boundary       |
| Crassulaceae     | <i>Kalanchoe sp.</i>                             | 08N KALSPP  | 7            | 11/14/14 | West Kahuku           |
| Crassulaceae     | <i>Kalanchoe tubiflora</i>                       | 10L KALTUB  | 7            | 11/20/14 | Hwy 11 Boundary       |
| Cyperaceae       | <i>Carex wahuensis</i>                           | 13G CARWAH  | 5            | 12/3/14  | Kahuku Mauka          |
| Cyperaceae       | <i>Fimbristylis dichotoma</i>                    | 02D FIMDIC  | 6            | 10/27/14 | Cinder cone trail     |
| Cyperaceae       | <i>Rhynchospora rugosa</i> subsp. <i>lavarum</i> | 03B RYNRUG  | 6            | 10/30/14 | Kainoa roadside       |
| Dennstaedtiaceae | <i>Microlepia speluncae</i>                      | 09C MICSPE  | 9            | 11/19/14 | Kainoa                |
| Euphorbiaceae    | <i>Euphorbia peplus</i>                          | 07H EUPPEP  | 6            | 11/13/14 | West Kahuku           |
| Euphorbiaceae    | <i>Manihot glaziovii</i>                         | 10R MANGLA  | 4            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Crotalaria micans</i>                         | 10H CROMIC  | 6            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Desmodium cajanifolium</i>                    | 10J DESCAJ  | 4            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Leucana leucocephala</i>                      | 10I LEULEU  | 7            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Leucana leucocephala</i>                      | 10I1 LEULEU | 7            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Leucana leucocephala</i>                      | 10I2 LEULEU | 7            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Leucana leucocephala</i>                      | 10I3 LEULEU | 7            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Leucana leucocephala</i>                      | 10I4 LEULEU | 7            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Leucana leucocephala</i>                      | 10I5 LEULEU | 7            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Leucana leucocephala</i>                      | 10I6 LEULEU | 7            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Leucana leucocephala</i>                      | 10I7 LEULEU | 7            | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Medicago lupulina</i>                         | 04J MEDLUP  | 6            | 11/3/14  | Glover Trail          |
| Fabaceae         | <i>Oxalis sp.</i>                                | 13M OXASPP  | 5            | 12/3/14  | Kahuku Mauka          |
| Fabaceae         | <i>Senna sp.</i>                                 | 10Q SENSPP  | TBD          | 11/20/14 | Hwy 11 Boundary       |
| Fabaceae         | <i>Trifolium pratense</i> var. <i>sativum</i>    | 13K TRIPRA  | 5            | 12/3/14  | Kahuku Mauka          |
| Goodenaceae      | <i>Scaevola chamissoniana</i>                    | 09J SCACHA  | 9            | 11/19/14 | East Boundary         |
| Juncaceae        | <i>Juncus tenuis</i>                             | 13A JUNTUN  | 6            | 12/3/14  | Kahuku Mauka          |
| Lamiaceae        | <i>Hyptis pectinata</i>                          | 10F HYPPEC  | 6            | 11/20/14 | Hwy 11 Boundary       |
| Lamiaceae        | <i>Leonotis nepetifolia</i>                      | 10G LEONEP  | 3            | 11/20/14 | Hwy 11 Boundary       |
| Lamiaceae        | <i>Prunella vulgaris</i>                         | 07P PRUVUL  | 6            | 11/13/14 | West Kahuku (outside) |
| Lythraceae       | <i>Cuphea carthagenensis</i>                     | 02G CUPCAR  | 6            | 10/27/14 | Main ranch road       |

**Appendix B3.** HAVO (2014) Kahuku ED data records with assigned record class (1-new State, 2-new Island, 3-new HAVO, 4-new Kahuku, 5-new Kahuku locality, 6-known, 7-target species, 8-unknown, 9-rare native species).

| Family          | Plant ID                                                        | Record ID     | Record Class | Date     | Trail Area            |
|-----------------|-----------------------------------------------------------------|---------------|--------------|----------|-----------------------|
| Lythraceae      | <i>Lythrum maritimum</i>                                        | 02F LYTMAR    | 5            | 10/27/14 | Main ranch road       |
| Malvaceae       | <i>Malvastrum coromandelianum</i> subsp. <i>coromandelianum</i> | 02J MALCORCOR | 6            | 10/27/14 | Main ranch road       |
| Malvaceae       | <i>Malvastrum coromandelianum</i> subsp. <i>coromandelianum</i> | 10S MALCOR    | 5            | 11/20/14 | Hwy 11 Boundary       |
| Malvaceae       | <i>Sida rhombifolia</i>                                         | 02B SIDRHO    | 5            | 10/27/14 | Main ranch road       |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 02M TIBHER    | 5            | 10/27/14 | Main ranch road       |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 04E TIBHER    | 7            | 11/3/14  | Main ranch road       |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 04F RUBARG    | 7            | 11/3/14  | Main ranch road       |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 04E TIBHER    | 7            | 11/3/14  | Main ranch road       |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 04E TIBHER    | 7            | 11/3/14  | Glover Trail          |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 06A TIBHER    | 7            | 11/10/14 | Glover Trail          |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 06A1 TIBHER   | 7            | 11/10/14 | Glover Trail          |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 08E TIBHER    | 7            | 11/14/14 | NW Paddocks           |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 09B TIBHER    | 7            | 11/19/14 | Kainoa                |
| Melastomataceae | <i>Tibouchina herbacea</i>                                      | 10C TIBHER    | 7            | 11/20/14 | Hwy 11 Boundary       |
| Myrtaceae       | <i>Morella faya</i>                                             | 07I MORFAY    | 7            | 11/13/14 | West Kahuku           |
| Myrtaceae       | <i>Morella faya</i>                                             | 12D MORFAY    | 7            | 12/3/14  | Kahuku Mauka          |
| Oleaceae        | <i>Fraxinus uhdei</i>                                           | 09D FRAUHD    | 7            | 11/19/14 | Kainoa                |
| Oleaceae        | <i>Oleo eurocarpus</i>                                          | 02L OLEEUR    | 7            | 10/27/14 | Main ranch road       |
| Onagraceae      | <i>Oenothera stricta</i>                                        | 12B OENSTR    | 5            | 12/2/14  | Kahuku Mauka          |
| Onagraceae      | <i>Oenothera stricta</i>                                        | 06D OENSTR    | 6            | 11/10/14 | Main Ranch Road       |
| Onograceae      | <i>Epilobium billardierianum</i> subsp. <i>cinereum</i>         | 07M EPIBIL    | 6            | 11/13/14 | West Kahuku (outside) |
| Onograceae      | <i>Epilobium ciliatum</i>                                       | 07L EPICIL    | 4            | 11/13/14 | West Kahuku (outside) |
| Orobanchaceae   | <i>Castilleja arvensis</i>                                      | 07U CASARV    | 4            | 11/13/14 | West Kahuku (outside) |
| Orobanchaceae   | <i>Castilleja arvensis</i>                                      | 10E CASARV    | 5            | 11/20/14 | Hwy 11 Boundary       |
| Pittosporaceae  | <i>Pittosporum hawaiiense</i>                                   | 09F PITHAW    | 9            | 11/19/14 | Kainoa                |
| Pittosporaceae  | <i>Pittosporum hawaiiense</i>                                   | 09I PITHAW    | 9            | 11/19/14 | East boundary         |
| Plantaginaceae  | <i>Veronica plebeia</i>                                         | 04C VERPLE    | 6            | 11/3/14  | Main ranch road       |
| Plantaginaceae  | <i>Veronica plebeia</i>                                         | 06C VERPLE    | 6            | 11/10/14 | Main Ranch Road       |
| Plantaginaceae  | <i>Veronica serpyllifolia</i>                                   | 11C VERSER    | 6            | 12/1/14  | Kahuku Piikea         |

**Appendix B3.** HAVO (2014) Kahuku ED data records with assigned record class (1-new State, 2-new Island, 3-new HAVO, 4-new Kahuku, 5-new Kahuku locality, 6-known, 7-target species, 8-unknown, 9-rare native species).

| Family         | Plant ID                      | Record ID     | Record Class | Date     | Trail Area              |
|----------------|-------------------------------|---------------|--------------|----------|-------------------------|
| Plantaginaceae | <i>Veronica serpyllifolia</i> | 11C VERSER    | 6            | 12/1/14  | Kahuku Piikea           |
| Poaceae        | <i>Agrostis avenacea</i>      | 07X AGRAVE    | 6            | 11/13/14 | West Kahuku             |
| Poaceae        | <i>Andropogon glomeratum</i>  | 07E ANDGLO    | 4            | 11/13/14 | West Kahuku             |
| Poaceae        | <i>Andropogon glomeratum</i>  | 13F ANDGLO    | 5            | 12/3/14  | Kahuku Mauka            |
| Poaceae        | <i>Andropogon virginicus</i>  | 08C ANDVIR    | 5            | 11/14/14 | West Kahuku             |
| Poaceae        | <i>Anthoxanthum odoratum</i>  | 08K ANTOD     | 6            | 11/14/14 | West Kahuku             |
| Poaceae        | <i>Anthoxanthum odoratum</i>  | 04H ANTOD     | 6            | 11/3/14  | Main ranch road         |
| Poaceae        | <i>Axonopus fissifolius</i>   | 03A AXOFIS    | 6            | 10/30/14 | Kainoa roadside         |
| Poaceae        | <i>Axonopus fissifolius</i>   | 12C AXOFIS    | 6            | 12/2/14  | Kahuku Mauka            |
| Poaceae        | <i>Chloris gayana</i>         | 05A CHLGAY    | 6            | 11/5/14  | Kona Trail              |
| Poaceae        | <i>Chloris gayana</i>         | 13L CHLGAY    | 5            | 12/3/14  | Kahuku Mauka            |
| Poaceae        | <i>Cymbopogon refractus</i>   | 13E CYMREF    | 5            | 12/3/14  | Kahuku Mauka            |
| Poaceae        | <i>Cynodon dactylon</i>       | 03E CYNDAC    | 4            | 10/30/14 | Main ranch road         |
| Poaceae        | <i>Dichanthium annulatum</i>  | 03I DICANN*** | 2            | 10/30/14 | Palm Trail              |
| Poaceae        | <i>Dichanthium annulatum</i>  | 03I1 DICANN   | 2            | 10/30/14 | Palm Trail              |
| Poaceae        | <i>Dichanthium annulatum</i>  | 05G DICANN    | 2            | 11/5/14  | Kona Trail              |
| Poaceae        | <i>Echinochloa colona</i>     | 04I ECHCOL    | 3            | 11/3/14  | Glover Trail            |
| Poaceae        | <i>Eleusine indica</i>        | 03J ELUIND    | 6            | 10/30/14 | Palm Trail - old corral |
| Poaceae        | <i>Eleusine indica</i>        | 04A ELUIND    | 6            | 11/3/14  | Main ranch road         |
| Poaceae        | <i>Eragrostis tenuifolia</i>  | 02N ERATEN    | 4            | 10/27/14 | Airstrip                |
| Poaceae        | <i>Festuca arundinacea</i>    | 08H FESARU    | 6            | 11/14/14 | West Kahuku             |
| Poaceae        | <i>Festuca arundinacea</i>    | 12D FESARU    | 5            | 12/2/14  | Kahuku Mauka            |
| Poaceae        | <i>Festuca arundinacea</i>    | 05B FESARU    | 6            | 11/5/14  | Kona Trail              |
| Poaceae        | <i>Hyparrhenia rufa</i>       | 08B HYPRUF    | 5            | 11/14/14 | West Kahuku             |
| Poaceae        | <i>Melinis minutiflora</i>    | 13H MELMIN    | 5            | 12/3/14  | Kahuku Mauka            |
| Poaceae        | <i>Panicum maximum</i>        | 10D PANMAX    | 7            | 11/20/14 | Hwy 11 Boundary         |
| Poaceae        | <i>Panicum maximum</i>        | 10D1PANMAX    | 7            | 11/20/14 | Hwy 11 Boundary         |
| Poaceae        | <i>Panicum maximum</i>        | 10D2PANMAX    | 7            | 11/20/14 | Hwy 11 Boundary         |
| Poaceae        | <i>Panicum maximum</i>        | 10D3PANMAX    | 7            | 11/20/14 | Hwy 11 Boundary         |
| Poaceae        | <i>Panicum maximum</i>        | 10D4PANMAX    | 7            | 11/20/14 | Hwy 11 Boundary         |
| Poaceae        | <i>Panicum maximum</i>        | 10D5PANMAX    | 7            | 11/20/14 | Hwy 11 Boundary         |
| Poaceae        | <i>Panicum maximum</i>        | 10D6PANMAX    | 7            | 11/20/14 | Hwy 11 Boundary         |

**Appendix B3.** HAVO (2014) Kahuku ED data records with assigned record class (1-new State, 2-new Island, 3-new HAVO, 4-new Kahuku, 5-new Kahuku locality, 6-known, 7-target species, 8-unknown, 9-rare native species).

| Family        | Plant ID                                       | Record ID             | Record Class | Date     | Trail Area               |
|---------------|------------------------------------------------|-----------------------|--------------|----------|--------------------------|
| Poaceae       | <i>Panicum maximum</i>                         | 10D7PANMAX            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | <i>Panicum maximum</i>                         | 10D8PANMAX            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | <i>Panicum maximum</i>                         | 10D9PANMAX            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | <i>Panicum maximum</i>                         | 10D10PANMA            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | <i>Panicum maximum</i>                         | 10D11PANMA            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | <i>Panicum maximum</i>                         | 10D12PANMA            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | <i>Panicum maximum</i>                         | 10D13PANMA            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | <i>Paspalum dilatatum</i>                      | 04G PASDIL            | 6            | 11/3/14  | Main ranch road          |
| Poaceae       | <i>Paspalum urvillei</i>                       | 11A PASURV            | 5            | 12/1/14  | Kahuku Piikea            |
| Poaceae       | <i>Pennisetum setaceum</i>                     | 08M PENSET            | 7            | 11/14/14 | West Kahuku              |
| Poaceae       | <i>Pennisetum setaceum</i>                     | 05C PENSET            | 7            | 11/5/14  | Kona Trail               |
| Poaceae       | <i>Pennisetum setaceum</i>                     | 10M PENSET            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | <i>Poa pratensis</i>                           | 05H POAPRA            | 6            | 11/5/14  | Glover Trail             |
| Poaceae       | <i>Poa pratensis</i>                           | 13I POAPRA            | 5            | 12/3/14  | Kahuku Mauka             |
| Poaceae       | <i>Sporobolus africanus</i>                    | 02A SPOAFR            | 6            | 10/27/14 | Main ranch road          |
| Poaceae       | Unknown Graminoid                              | 02H grass fine wire   | 8            | 10/27/14 | Main ranch road          |
| Poaceae       | Unknown Graminoid                              | 09A Sedge             | 8            | 11/19/14 | Kainoa                   |
| Poaceae       | Unknown Graminoid                              | 10B                   | 8            | 11/20/14 | Hwy 11 Boundary          |
| Poaceae       | Unknown Graminoid                              | 13D unknown wiregrass | 8            | 12/3/14  | mauka unit               |
| Poaceae       | <i>Vulpia bromoides</i>                        | 04D VULBRO            | 6            | 11/3/14  | Main ranch road          |
| Polygonaceae  | <i>Persicaria capitata</i>                     | 05D PERCAP            | 5            | 11/5/14  | Kona Trail               |
| Polygonaceae  | <i>Persicaria capitata</i>                     | 05D1 PERCAP           | 7            | 11/5/14  | Kona Trail               |
| Polygonaceae  | <i>Persicaria capitata</i>                     | 09G PERCAP            | 7            | 11/19/14 | Cross Fence East Section |
| Polygonaceae  | <i>Persicaria capitata</i>                     | 10O PERCAP            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Polygonaceae  | <i>Rumex giganteus</i>                         | 03D RUMGIG            | 9            | 10/30/14 | Kainoa roadside          |
| Proteaceae    | <i>Grevillea robusta</i>                       | 10N GREROB            | 7            | 11/20/14 | Hwy 11 Boundary          |
| Ranunculaceae | <i>Anemone hupehensis</i> var. <i>japonica</i> | 07F ANEHUP            | 5            | 11/13/14 | West Kahuku              |
| Rubiaceae     | <i>Ricardia brasiliensis</i>                   | 02C RICBRA            | 6            | 10/27/14 | Main ranch road          |
| Rutaceae      | <i>Melicope pseudoanisata</i>                  | 05E MELPSU            | 9            | 11/5/14  | Kona Trail               |
| Santalaceae   | <i>Santalum paniculatum</i>                    | 12C SANPAN            | 9            | 12/3/14  | Kahuku Mauka             |
| Santalaceae   | <i>Santalum paniculatum</i>                    | 13C1 SANPAN           | 9            | 12/3/14  | Kahuku Mauka             |
| Santalaceae   | <i>Santalum paniculatum</i>                    | 13C2 SANPAN           | 9            | 12/3/14  | Kahuku Mauka             |

**Appendix B3.** HAVO (2014) Kahuku ED data records with assigned record class (1-new State, 2-new Island, 3-new HAVO, 4-new Kahuku, 5-new Kahuku locality, 6-known, 7-target species, 8-unknown, 9-rare native species).

| Family        | Plant ID                      | Record ID         | Record Class | Date     | Trail Area              |
|---------------|-------------------------------|-------------------|--------------|----------|-------------------------|
| Solanaceae    | <i>Solanum linneaum</i>       | 03H SOLLIN        | 7            | 10/30/14 | Main ranch road         |
| Solanaceae    | <i>Solanum linneaum</i>       | 03H1 SOLLIN       | 7            | 10/30/14 | Palm Trail - old corral |
| Urticaceae    | <i>Pipturus albidus</i>       | 07S PIPALB        | 5            | 11/13/14 | West Kahuku (outside)   |
| Verbenaceae   | <i>Verbena litoralis</i>      | 07Q VERLIT        | 6            | 11/13/14 | West Kahuku (outside)   |
| Zingiberaceae | <i>Hedychium gardnerianum</i> | 03C HEDGAR & POLY | 7            | 10/30/14 | Kainoa roadside         |

**Appendix B4.** KAHO (2016) ED data records

| Record Class      | Family         | Species                           | Indiv | Reprod      | UTME   | UTMN    |
|-------------------|----------------|-----------------------------------|-------|-------------|--------|---------|
| New island record | Poaceae        | <i>Eragrostis pilosa</i>          | –     | Both        | 811689 | 2179381 |
| New island record | Acanthaceae    | <i>Barleria repens</i>            | –     | Flower only | 812049 | 2178254 |
| New island record | Malvaceae      | <i>Sida ciliaris</i>              | –     | Fruit only  | 811879 | 2178000 |
| New KAHO record   | Amaranthaceae  | <i>Alternanthera pungens</i>      | 10-50 | Both        | 811318 | 2179477 |
| New KAHO record*  | Euphorbiaceae  | <i>Euphorbia albomarginata</i>    | –     | Fruit only  | 812059 | 2178368 |
| New KAHO record   | Fabaceae       | <i>Macroptilium lathyroides</i>   | 1     | Both        | 811230 | 2179519 |
| New KAHO record*  | Poaceae        | <i>Sporobolus diandrus</i>        | –     | Fruit only  | 810797 | 2179833 |
| New KAHO record*  | Poaceae        | <i>Sporobolus diandrus</i>        | –     | –           | 811743 | 2177771 |
| New KAHO record   | Rubiaceae      | <i>Oldenlandia corymbosa</i>      | –     | –           | 812240 | 2179234 |
| ID'd, known KAHO  | Acanthaceae    | <i>Barleria cristata</i>          | –     | –           | 812116 | 2178358 |
| ID'd, known KAHO  | Asteraceae     | <i>Tridax procumbens</i>          | 1-10  | Both        | 812287 | 2178603 |
| ID'd, known KAHO  | Crassulaceae   | <i>Kalanchoe tubiflora</i>        | –     | –           | 811827 | 2177782 |
| ID'd, known KAHO  | Cucurbitaceae  | <i>Coccinia grandis</i>           | –     | –           | 811891 | 2177982 |
| ID'd, known KAHO  | Fabaceae       | <i>Indigofera suffruticosa</i>    | –     | Both        | 812230 | 2178364 |
| ID'd, known KAHO  | Malvaceae      | <i>Sida spinosa</i>               | –     | –           | 812023 | 2178334 |
| ID'd, known KAHO  | Malvaceae      | <i>Malvastrum coromandelianum</i> | –     | –           | 811885 | 2178020 |
| ID'd, known KAHO  | Phyllanthaceae | <i>Phyllanthus debilis</i>        | –     | –           | 812286 | 2178659 |
| ID'd, known KAHO  | Portulacaceae  | <i>Portulaca oleracea</i>         | 1-10  | Flower only | 812075 | 2179367 |
| Native            | Plumbaginaceae | <i>Plumbago zeylanica</i>         | 10-50 | Both        | 812227 | 2179474 |
| Native            | Plumbaginaceae | <i>Plumbago zeylanica</i>         | 1-10  | Both        | 812072 | 2178348 |

\*Genus only of new KAHO record documented on previous KAHO plant reference list (example: *Sporobolus* sp.)

## Appendix C. Early Detection Database Documentation

The database for this project consists of four types of tables: core tables describing the “who, where, and when” of data collection, project-specific tables, lookup tables that contain domain constraints for other tables, and cross reference tables that link lookup tables with data tables. Although core tables are based on PACN standards, they may contain fields, domains or descriptions that have been added or altered to meet project objectives.

**Table C.1.** The standard tables found in the database.

| Table Name       | Description                                                |
|------------------|------------------------------------------------------------|
| tbl_Sites        | Sample sites – individual parks                            |
| tbl_Events       | Data collection event for a given park                     |
| tbl_Images       | Images associated with waypoint attributes                 |
| tbl_Db_Meta      | Database description and links to I&M metadata tools       |
| tbl_Db_Revisions | Database revision history data                             |
| tbl_QA_Results   | Data validation results from using the quality review tool |

**Table C.2.** The project-specific tables found in the database.

| Table Name              | Description                                                                                   |
|-------------------------|-----------------------------------------------------------------------------------------------|
| tlu_Camera              | Lookup table of cameras that were used during sampling events.                                |
| tlu_GPS                 | Lookup table of GPS units that were used during sampling event                                |
| tlu_Undocumented_Spp    | Lookup table of species that were detected during surveys                                     |
| tbl_Waypoint_Attributes | Species, paths, or miscellaneous attribute data for each waypoint taken during sampling event |

**Table C.3.** A few of the more prominent, standard cross-reference tables found in the database.

| Table Name          | Description                                           |
|---------------------|-------------------------------------------------------|
| xref_Event_Contacts | Cross-reference table for events and contacts         |
| xref_Park_Species_  | –                                                     |
| Nativeness          | Cross-reference table for species and park nativeness |

**Table C.4.** A few of the more prominent, standard lookup tables found in the database.

| Table Name       | Description                                     |
|------------------|-------------------------------------------------|
| tlu_Contacts     | Contact data for project-related personnel      |
| tlu_Enumerations | Enumerated lookup table                         |
| tlu_Species      | Species taxon table from the NPSpecies database |

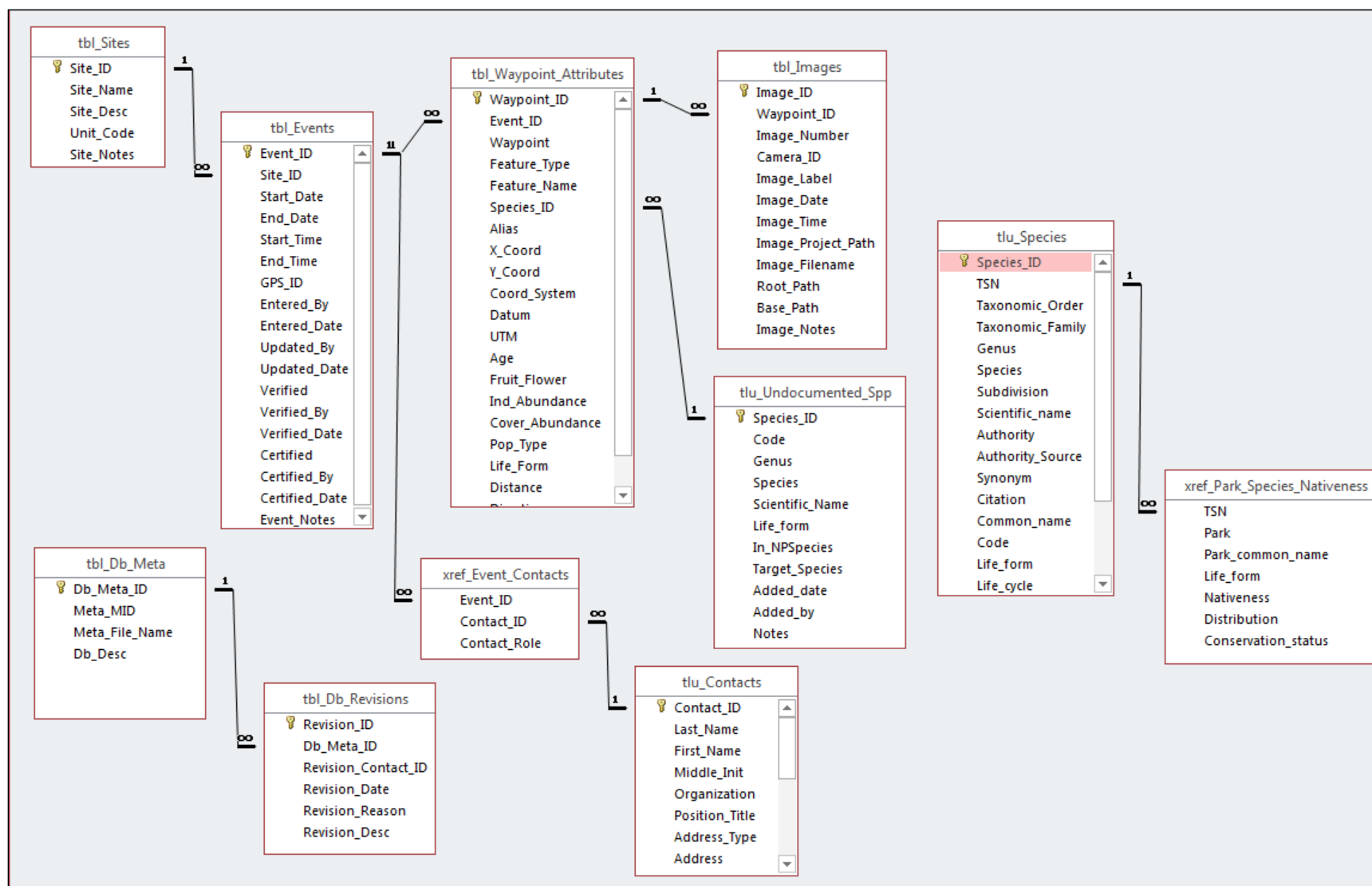


Figure C.1. Data model for the Early Detection Database.

## Database Tables

**tbl\_Sites:** Sample sites - individual parks.

| Field Name | Primary? | Field Type | Field Size | Field Description                          |
|------------|----------|------------|------------|--------------------------------------------|
| Site_ID    | Yes      | Text       | 50         | Unique identifier for site records (Parks) |
| Site_Name  | No       | Text       | 100        | Unique name or code for a site             |
| Site_Desc  | No       | Text       | 255        | Description for a site                     |
| Unit_Code  | No       | Text       | 5          | Park, Monument or Network code             |
| Site_Notes | No       | Memo       | 0          | General notes on the site                  |

**tbl\_Events:** Data collection sampling event for a given park.

| Field Name     | Primary? | Field Type | Field Size | Field Description                                       |
|----------------|----------|------------|------------|---------------------------------------------------------|
| Event_ID       | Yes      | Text       | 50         | Unique identifier for event records                     |
| Site_ID        | No       | Text       | 50         | Link to tbl_Sites                                       |
| Start_Date     | No       | Date/Time  | 8          | Starting date for the event                             |
| End_Date       | No       | Date/Time  | 8          | Ending date for the event                               |
| Start_Time     | No       | Date/Time  | 8          | Starting time for the event                             |
| End_Time       | No       | Date/Time  | 8          | Ending time for the event                               |
| GPS_ID         | No       | Text       | 50         | Link to tlu_GPS                                         |
| Entered_By     | No       | Text       | 100        | Person who entered the data for this event              |
| Entered_Date   | No       | Date/Time  | 8          | Date on which data entry occurred                       |
| Updated_By     | No       | Text       | 100        | Person who made the most recent updates                 |
| Updated_Date   | No       | Date/Time  | 8          | Date of the most recent edits                           |
| Verified       | No       | Boolean    | 1          | Has the data has been verified                          |
| Verified_By    | No       | Text       | 100        | Person who verified accurate data transcription         |
| Verified_Date  | No       | Date/Time  | 8          | Date on which data were verified                        |
| Certified      | No       | Boolean    | 1          | Has the data been certified                             |
| Certified_By   | No       | Text       | 100        | Person who certified data for accuracy and completeness |
| Certified_Date | No       | Date/Time  | 8          | Date on which data were certified                       |
| Event_Notes    | No       | Memo       | 0          | General notes on the event                              |

**tbl\_Images:** Images associated with waypoint attributes.

| Field Name         | Primary? | Field Type | Field Size | Field Description                                                                                        |
|--------------------|----------|------------|------------|----------------------------------------------------------------------------------------------------------|
| Image_ID           | Yes      | Text       | 50         | Unique identifier for image records                                                                      |
| Waypoint_ID        | No       | Text       | 50         | Link to tbl_Waypoint_Attributes                                                                          |
| Image_Number       | No       | Text       | 50         | Camera image identification number                                                                       |
| Camera_ID          | No       | Text       | 50         | Camera used to take the image                                                                            |
| Image_Label        | No       | Text       | 100        | Image caption or label                                                                                   |
| Image_Date         | No       | Date/Time  | 8          | Date on which the image was created, if different from the sampling event date                           |
| Image_Time         | No       | Date/Time  | 8          | Time image was taken                                                                                     |
| Image_Project_Path | No       | Text       | 255        | Location of the image from the main project folder or image library                                      |
| Image_Filename     | No       | Text       | 100        | Name of the image including extension (.jpg) but without the image path                                  |
| Root_Path          | No       | Text       | 255        | The root path for the linked image file. This will change upon re-linking of database                    |
| Base_Path          | No       | Text       | 255        | The base file path for the linked image file. This will stay the same no matter where the root folder is |
| Image_Notes        | No       | Memo       | 0          | General notes about the image                                                                            |

**tbl\_Db\_Revisions:** Database revision history data.

| Field Name          | Primary? | Field Type | Field Size | Field Description                                 |
|---------------------|----------|------------|------------|---------------------------------------------------|
| Revision_ID         | Yes      | Text       | 50         | Unique database revision (version) number or code |
| Db_Meta_ID          | No       | Text       | 50         | Link to tbl_DB_Meta                               |
| Revision_Contact_ID | No       | Text       | 50         | Link to tlu_Contacts                              |
| Revision_Date       | No       | Date/Time  | 8          | Database revision date                            |
| Revision_Reason     | No       | Memo       | 0          | Reason for the database revision                  |

**tbl\_QA\_Results:** Data validation results from using the quality review tool.

| Field Name        | Primary? | Field Type | Field Size | Field Description                           |
|-------------------|----------|------------|------------|---------------------------------------------|
| Query_Name        | No       | Text       | 100        | Name of query                               |
| Data_Scope        | No       | Byte       | 1          | Scope of data                               |
| Time_Frame        | No       | Text       | 30         | Time frame of data records                  |
| Query_Type        | No       | Text       | 20         | Type of query                               |
| Query_Result      | No       | Text       | 50         | The number of records returned by the query |
| Query_Description | No       | Memo       | 0          | Query description                           |
| Query_Run_Time    | No       | Date/Time  | 8          | Most recent run time of the query           |
| Query_Expression  | No       | Memo       | 0          | Expression used to run query                |
| Remedy_Desc       | No       | Memo       | 0          | Action taken to fix error                   |
| Remedy_Date       | No       | Date/Time  | 8          | Remedy date                                 |
| QA_User           | No       | Text       | 50         | Remedy by                                   |
| Is_Done           | No       | Boolean    | 1          | Was the query checked                       |

**tlu\_Camera:** Lookup table of cameras that were used during sampling.

| Field Name          | Primary? | Field Type | Field Size | Field Description                        |
|---------------------|----------|------------|------------|------------------------------------------|
| Camera_ID           | Yes      | Text       | 50         | Unique identifier for camera records     |
| Camera_Tag          | No       | Text       | 50         | The asset tag assigned to the camera     |
| Camera_Manufacturer | No       | Memo       | 0          | The company that manufactured the camera |
| Camera_Model        | No       | Text       | 50         | The camera model                         |
| Camera_Serial_No    | No       | Text       | 255        | The serial number of the camera          |

**tlu\_GPS:** Lookup table of GPS units that were used during sampling events.

| Field Name       | Primary? | Field Type | Field Size | Field Description                          |
|------------------|----------|------------|------------|--------------------------------------------|
| GPS_ID           | Yes      | Text       | 50         | Unique identifier for GPS records          |
| GPS_Tag          | No       | Text       | 50         | The asset tag assigned to the GPS unit     |
| GPS_Manufacturer | No       | Memo       | 0          | The company that manufactured the GPS unit |
| GPS_Model        | No       | Text       | 50         | The GPS unit model                         |
| GPS_Serial_No    | No       | Text       | 255        | The serial number of the GPS unit          |

**tlu\_Undocumented\_Spp:** Lookup table of species that were detected during surveys.

| Field Name      | Primary? | Field Type | Field Size | Field Description                                                                                                                                                                                                                |
|-----------------|----------|------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Species_ID      | Yes      | Text       | 50         | Unique record identifier for the species record                                                                                                                                                                                  |
| Code            | No       | Text       | 10         | The six letter code for the species, comprised of the first three letters of the genus and first three letters of the species. If multiple species have same code, a number is added to the end of the code in sequential order. |
| Genus           | No       | Text       | 50         | A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics.                                                                               |
| Species         | No       | Text       | 50         | A fundamental category of taxonomic classification, ranking below a genus or subgenus and consisting of related organisms capable of interbreeding.                                                                              |
| Scientific_Name | No       | Text       | 100        | The recognized Latin name given to an organism, consisting of a genus and species, according to a taxonomy.                                                                                                                      |
| Life_form       | No       | Text       | 50         | A plant life form is usually understood to be a growth form which displays an obvious relationship to important environmental factors. Plants may be classified as trees, shrubs, herbs (forbs and graminoids), etc.             |
| In_NPSpecies    | No       | Boolean    | 1          | Is this species currently in NPSpecies for this park?                                                                                                                                                                            |
| Target_Species  | No       | Boolean    | 1          | Is this a target species?                                                                                                                                                                                                        |
| Added_date      | No       | Date/Time  | 8          | The date that the target species record was added.                                                                                                                                                                               |
| Added_by        | No       | Text       | 100        | Who added the target species record                                                                                                                                                                                              |
| Notes           | No       | Text       | 255        | Notes about the waypoint record.                                                                                                                                                                                                 |

**tbl\_Waypoint\_Attributes:** Species, paths, or miscellaneous attribute data for each waypoint taken during a sampling event.

| Field Name      | Primary? | Field Type   | Field Size | Field Description                                                                                                      |
|-----------------|----------|--------------|------------|------------------------------------------------------------------------------------------------------------------------|
| Waypoint_ID     | Yes      | Text         | 50         | Unique identifier for waypoint attribute records                                                                       |
| Event_ID        | No       | Text         | 50         | Link to tbl_Events                                                                                                     |
| Waypoint        | No       | Text         | 50         | The waypoint taken at the location                                                                                     |
| Feature_Type    | No       | Text         | 50         | Feature type, i.e. species, path, misc.                                                                                |
| Feature_Name    | No       | Text         | 50         | The name of the feature recorded, i.e. path name or species name.                                                      |
| Species_ID      | No       | Text         | 50         | Link to tbl_Undocumented_spp                                                                                           |
| Alias           | No       | Text         | 50         | Unknown species nicknames in order to be referenced in subsequent records                                              |
| X_Coord         | No       | Double       | 8          | The X coordinate of the location                                                                                       |
| Y_Coord         | No       | Double       | 8          | The Y coordinate of the location                                                                                       |
| Coord_System    | No       | Text         | 15         | The coordinate system of the location                                                                                  |
| Datum           | No       | Text         | 10         | The datum of the location                                                                                              |
| UTM             | No       | Text         | 10         | The UTM zone of the location                                                                                           |
| Age             | No       | Text         | 15         | The age of the plant recorded                                                                                          |
| Fruit_Flower    | No       | Boolean      | 1          | Is the plant fruiting or flowering?                                                                                    |
| Ind_Abundance   | No       | Text         | 15         | The individual abundance if taken (only cover or individual abundance it taken)                                        |
| Cover_Abundance | No       | Text         | 15         | The cover abundance if taken (only cover or individual abundance it taken)                                             |
| Pop_Type        | No       | Text         | 15         | Whether the plant species population is contiguous or scattered                                                        |
| Life_Form       | No       | Text         | 30         | The life form for unknown plant species                                                                                |
| Distance        | No       | Long Integer | 4          | Distance in meters from the waypoint. Populate this field only for species greater than 5 m away from point            |
| Direction       | No       | Long Integer | 4          | Direction in degrees from the waypoint. Populate this field only for species greater than 5 m away from point          |
| Record_Category | No       | Text         | 5          | After a species waypoint has received positive identification to the species level, it is assigned to categories 0 - 8 |

**xref\_Event\_Contacts:** Cross-reference table between events and contacts.

| Field Name   | Primary? | Field Type | Field Size | Field Description    |
|--------------|----------|------------|------------|----------------------|
| Event_ID     | No       | Text       | 50         | Link to tbl_Events   |
| Contact_ID   | No       | Text       | 50         | Link to tlu_Contacts |
| Contact_Role | No       | Text       | 50         | The contact's role   |

**xref\_Park\_Species\_Nativeness:** Cross-reference table for species and park nativeness.

| Field Name          | Primary? | Field Type | Field Size | Field Description                                                                                                                                                                                                    |
|---------------------|----------|------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TSN                 | No       | Double     | 8          | A Taxonomic Serial Number (TSN) is a unique, persistent, non-intelligent identifier for a scientific name in the context of the Integrated Taxonomic Information System (ITIS)                                       |
| Park                | No       | Text       | 255        | The four letter park code that the species is found in.                                                                                                                                                              |
| Park_common_name    | No       | Text       | 255        | The common name the species is called in the park. May be different in different park, based on local languages.                                                                                                     |
| Life_form           | No       | Text       | 255        | A plant life form is usually understood to be a growth form which displays an obvious relationship to important environmental factors. Plants may be classified as trees, shrubs, herbs (forbs and graminoids), etc. |
| Nativeness          | No       | Text       | 255        | The nativeness of the plant species, i.e. Native, Non-Native, or Unknown.                                                                                                                                            |
| Distribution        | No       | Text       | 50         | The natural range of distribution in which a species is regarded as native, i.e. endemic, indigenous, naturalized, or Polynesian introduction.                                                                       |
| Conservation_status | No       | Text       | 10         | The conservation status of a species indicates whether the group is extant and how likely the group is to become extinct in the near future. i.e. Extinct (E), Threatened (T), Vulnerable (V), or Rare (R).          |

## Appendix D. Yearly Project Task List

This appendix presents a table that identifies tasks by project stage, indicates who is responsible for the task, and establishes the timing for execution.

**Table D.1.** Yearly Project Task List for Early Detection of Invasive Plant Species Plan.

| Project Stage           | Task Description                                                                                       | Responsibility                             | Timing            |
|-------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------|-------------------|
| Preparation             | Notify data manager and/or GIS specialist of needs (field maps, GPS support, training)                 | Project Lead, Field Leader                 | ASAP, by Feb 1    |
|                         | Ensure that project workspace is ready for use and GPS download software is loaded                     | Project Lead, Data Manager, GIS Specialist | by Apr 1          |
|                         | Implement working database copy                                                                        | Data Manager                               | by Apr 1          |
|                         | Prepare and print field maps                                                                           | GIS Specialist                             | by Apr 1          |
|                         | Update and load data dictionary, background maps, and target coordinates into GPS units and/or tablets | GIS Specialist                             | by Apr 1          |
|                         | Provide database/GPS/tablet training                                                                   | Data Manager, GIS Specialist               | by Apr 1          |
|                         | Work with park's NRM to acquire updated target species lists, review previous survey report.           | Field Leader, Project Lead, Park Botanists | by Apr 1          |
|                         | Train field crew in species identification, equipment usage, and field surveying methods               | Field Leader, Project Lead, Park Botanists | by Apr 1          |
|                         | Verification of field observer qualifications                                                          | Field Leader                               | by Apr 1          |
| Data acquisition        | Collect survey data and GPS/tablet data in the field                                                   | Field Leader, Field Technician             | Apr-Oct (by park) |
|                         | Review data after each day and work on unknown species identification                                  | Field Technician                           | daily             |
|                         | Regular review of field forms or digital data for completeness and accuracy                            | Field Leader                               | bi-weekly         |
| Data entry & processing | Download GPS/tablet data and email files to GIS specialist for correction                              | Field Leader, GIS Specialist               | ASAP              |
|                         | Upload or enter data into database                                                                     | Field Leader, Field Technicians            | ASAP              |
|                         | Verification of accurate transcription as data are entered                                             | Field Leader, Field Technicians            | ASAP              |
|                         | GPS data correction                                                                                    | GIS Specialist                             | ASAP              |
|                         | Upload processed and verified coordinates to database                                                  | GIS Specialist                             | Oct 31            |
| Product development     | Complete field season report                                                                           | Field Leader                               | Nov 30            |
|                         | Identify species to be used for early detection outreach products (field guides and calendars)         | Field Leader, Project Lead, Park Botanists | Every 3 years     |

**Table D.1 (continued).** Yearly Project Task List for Early Detection of Invasive Plant Species Plan.

| Project Stage       | Task Description                                                                                          | Responsibility                  | Timing                 |
|---------------------|-----------------------------------------------------------------------------------------------------------|---------------------------------|------------------------|
| Product delivery    | Send field season report to project lead and data manager                                                 | Field Leader                    | by Dec 1               |
|                     | Deliver outreach field guides and calendars to park contacts                                              | Project Lead                    | by Dec 1 every 3 years |
| Quality review      | Quality review and data validation using database tools                                                   | Project Lead                    | Dec                    |
|                     | Prepare coordinate summaries and/or GIS layers and data sets for spatial data review                      | GIS Specialist                  | by Nov 15              |
|                     | Joint quality review of GIS data                                                                          | Project Lead GIS Specialist     | Nov-Dec                |
| Metadata            | Update project metadata records                                                                           | Project Lead                    | Oct-Dec                |
| Data certification  | Certify the season's data and complete the certification report                                           | Project Lead                    | Dec                    |
| Data delivery       | Deliver certification report, certified data, and updated metadata to data manager                        | Project Lead                    | by Dec 31              |
|                     | Upload certified data into master project database, store data files in PACN Digital Library <sup>1</sup> | Data Manager                    | Jan                    |
|                     | Notify project lead of uploaded data ready for analysis and reporting                                     | Data Manager                    | by Jan 31              |
|                     | Update project GIS data sets, layers and associated metadata records                                      | GIS Specialist                  | Jan-Feb                |
|                     | Finalize and parse metadata records, store in PACN Digital Library <sup>1</sup>                           | Data Manager and GIS Specialist | Jan                    |
| Data analysis       | Export data required for analysis from database                                                           | Data Manager and Project Lead   | Feb                    |
|                     | Compute annual summary statistics for status report                                                       | Project Lead                    | Feb                    |
|                     | Run trend analysis after 3 or more survey years of data are available for a park                          | Project Lead                    | Feb                    |
| Product development | Produce park-wide and area-specific maps for archives                                                     | GIS Specialist                  | Jan-Feb                |
|                     | Generate quality maps for reports                                                                         | GIS Specialist                  | Jan-Feb                |
|                     | Create annual report                                                                                      | Project Lead                    | Mar-Apr                |
| Product delivery    | Submit draft report to program manager for review                                                         | Project Lead                    | by Apr 30              |
|                     | Review report for formatting and completeness, notify project lead of approval or need for changes        | Program Manager                 | May                    |
|                     | Upload completed report to PACN Digital Library <sup>1</sup> submissions folder, notify data manager      | Project Lead                    | upon approval          |

**Table D.1 (continued).** Yearly Project Task List for Early Detection of Invasive Plant Species Plan.

| Project Stage                 | Task Description                                                                                                           | Responsibility                                           | Timing                     |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------|
| Product delivery (continued)  | Deliver other products according to the delivery schedule and instructions (outreach products)                             | Project Lead                                             | upon completion            |
|                               | Update NPSpecies with additions                                                                                            | Data Manager                                             |                            |
|                               | Product check-in                                                                                                           | Data Manager                                             | upon receipt               |
| Posting & distribution        | Submit metadata to References service within NRInfo <sup>2</sup>                                                           | Data Manager                                             | by Mar 15                  |
|                               | Create and post a record for reports in References services within NRInfo <sup>2</sup>                                     | Data Manager                                             | upon receipt               |
|                               | Update species records in Biology service within NRInfo <sup>2</sup>                                                       | Data Manager                                             | Dec-Mar                    |
|                               | Submit certified data and GIS data sets to NRInfo <sup>2</sup>                                                             | Data Manager                                             | by June of the second year |
| Archival & records management | Store finished products in PACN Digital Library <sup>1</sup>                                                               | Data Manager                                             | upon receipt               |
|                               | Review, clean up and store and/or dispose of project files according to NPS Director's Order #19 <sup>3</sup>              | Project Lead                                             | Jan                        |
| Season close-out              | Meet to discuss the recent field season, and document any needed changes to field sampling methods or the working database | Project Lead, Data Manager, GIS Specialist, Field Leader | by Dec 30 of the same year |
|                               | Discuss and document needed changes to analysis and reporting procedures                                                   | Project Lead, Data Manager and GIS Specialist            | by Apr 30 of second year   |



## Appendix E. Early Detection Plant Species Outreach Products

This appendix presents examples of identification cards and calendars created during a pilot study in 2013 (Figures E.1 - E.3). Identification cards were modeled after guides for Kaua‘i (Keanini et al. 2010) and calendars were designed by Hagadone Printing. The invasive species used for these products were identified by park staff (as of January 2013) as either present or threatening to invade parks (Table E.1). Identification cards feature between 15 and 25 species for each park, while calendars include a subset of 12. Contact the I&M vegetation program or visit <http://science.nature.nps.gov/im/units/pacn/multimedia.cfm> for complete sets of early detection cards and calendars. Taxonomic nomenclature follows that of Wagner et al. 2012 Manual of Flowering Plants supplement. Species found or of concern are indicated with an X for Hawai‘i Volcanoes National Park (HAVO), Kaloko-Honokōhau National Historical Park (KAHO), Pu‘uhonua o Hōnaunau National Historical Park (PUHO), Pu‘ukoholā Heiau National Historic Site (PUHE), Haleakalā National Park (HALE), Kalaupapa National Historical Park (KALA), and National Park of American Samoa (NPSA). These lists will be updated every third or non-field surveying year when identification cards and calendars are produced. List modifications will be guided by park staff and data collected from other I&M monitoring efforts. In addition to providing identification information such as distributions, habitat and dispersal mechanisms, the products also include contact information at each park where one can report sightings of featured species. Contacts are listed in Table E.2 and should be reviewed and updated annually.

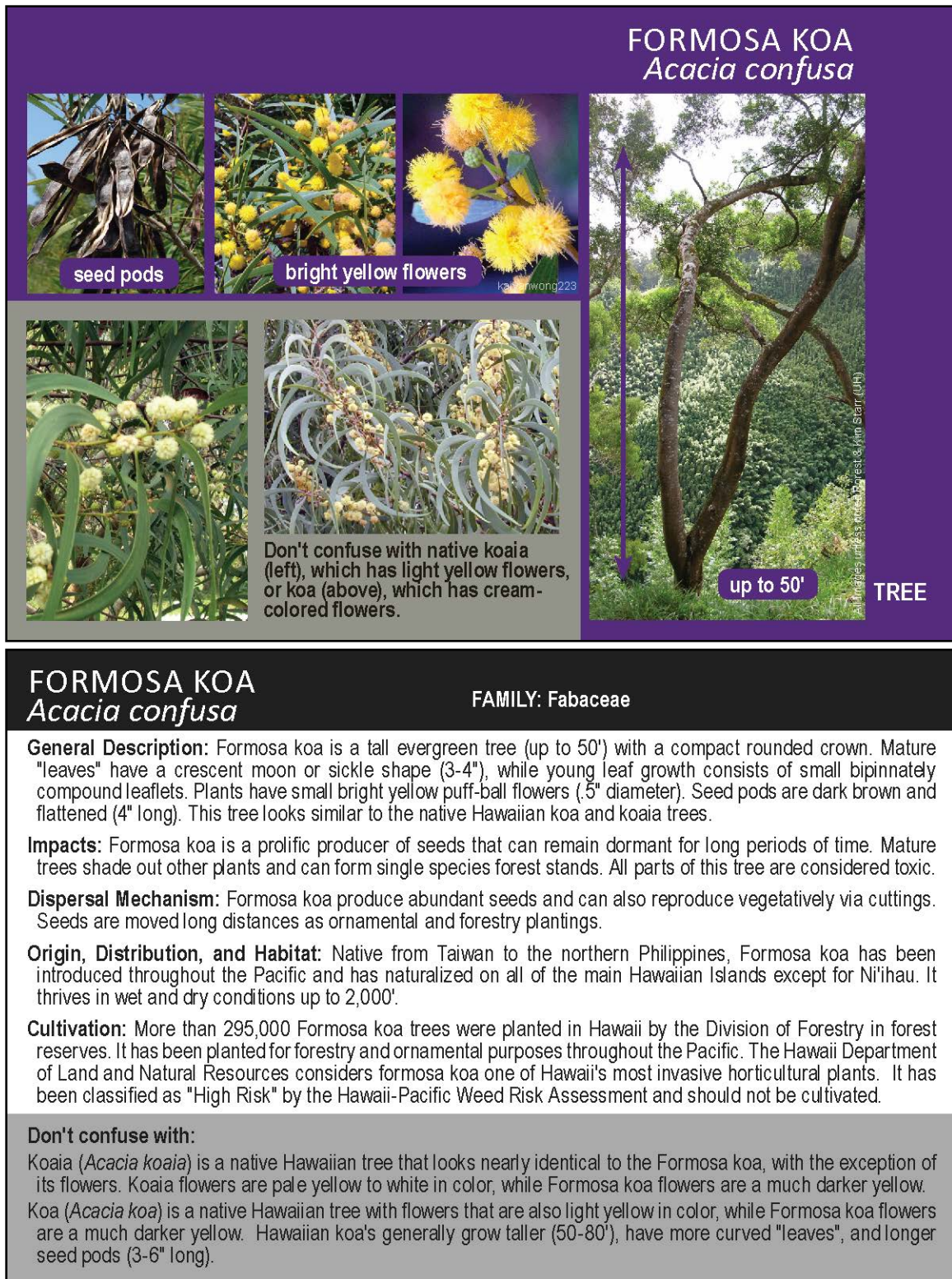


**Figure E.1.** Front and backside of an early detection identification field guide for HAVO.



**Figure E.2.** First page of an early detection identification calendar for KALA.

## bo tree

*Ficus religiosa*

**SPECIES TYPE & ORIGIN:** Bo tree is a tree in the fig genus. It is native to India and Southeast Asia.

**IMPACTS:** The bo tree, like other fig trees, is capable of growing in other trees, eventually splitting their host trees from within. It is sometimes called the "tree splitter" for this reason. It can cause substantial damage to structures, establishing with very little substrate and posing a major threat to Hawaiian cultural and archaeological sites, including heiau and fish ponds. Individual trees can live for hundreds of years.

**LOCAL DISTRIBUTION & HABITAT:** The bo tree has been introduced throughout Hawaii. On Moloka'i, immature trees were found at the USDA Plant Materials Center and the Kaunakakai Waste Water Treatment Facility indicating that nearby intentional plantings were reproducing. It can grow in dry areas where it will have a single trunk or in wet areas where it will form aerial roots like the banyan tree.

**DISPERSAL MECHANISM:** The bo tree, like all fig trees, needs a specific wasp to be present for pollination. Its wasp pollinator has been found on Moloka'i. Trees may produce fruits that can be bird and animal (most likely deer and pig) dispersed. Bo trees can also reproduce vegetatively and via cuttings.

**CULTIVATION:** The bo tree is said to be the tree under which Buddha was born and reached enlightenment. For this reason it is sometimes planted near temples and as a specimen tree. It has been classified as "High Risk" by the Hawaii-Pacific Weed Risk Assessment and should not be cultivated. The Moloka'i Invasive Species Committee is controlling all known reproducing trees.

**HOW TO HELP:** Report potential sightings within Kalaupapa National Historical Park

**Paul Hosten** Paul\_Hosten@nps.gov  
tel. 808-567-6802 x1501

# January 2013



| Sunday | Monday                                | Tuesday                 | Wednesday | Thursday | Friday | Saturday |
|--------|---------------------------------------|-------------------------|-----------|----------|--------|----------|
|        |                                       | 1 <i>New Year's Day</i> | 2         | 3        | 4      | 5        |
| 6      | 7                                     | 8                       | 9         | 10       | 11     | 12       |
| 13     | 14                                    | 15                      | 16        | 17       | 18     | 19       |
| 20     | 21 <i>Martin Luther King, Jr. Day</i> | 22                      | 23        | 24       | 25     | 26       |
| 27     | 28                                    | 29                      | 30        | 31       |        |          |






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**Figure E.3.** Second page of an early detection identification calendar for KALA.

**Table E.1.** Species selected for early detection identification cards and calendars by parks in 2013.

| Species                          | Family           | HAVO | KAHO/<br>PUHO/<br>PUHE | HALE | KALA | NPSA | AMME | WAPA |
|----------------------------------|------------------|------|------------------------|------|------|------|------|------|
| <i>Acacia confusa</i>            | Fabaceae         | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Acacia dealbata</i>           | Fabaceae         | –    | –                      | –    | Yes  | –    | –    | –    |
| <i>Acacia melanoxylon</i>        | Fabaceae         | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Agave</i> spp.                | Agavaceae        | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Albizia chinensis</i>         | Fabaceae         | –    | –                      | –    | –    | Yes  | –    | –    |
| <i>Alternanthera pungens</i>     | Amaranthaceae    | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Andropogon virginicus</i>     | Poaceae          | –    | Yes                    | Yes  | –    | –    | –    | –    |
| <i>Antigonon leptopus</i>        | Polygonaceae     | –    | –                      | –    | Yes  | Yes  | –    | –    |
| <i>Ardisia elliptica</i>         | Myrsinaceae      | –    | –                      | –    | –    | Yes  | –    | –    |
| <i>Argemone mexicana</i>         | Papaveraceae     | –    | –                      | –    | Yes  | –    | –    | –    |
| <i>Banksia integrifolia</i>      | Proteaceae       | Yes  | –                      | Yes  | –    | –    | –    | –    |
| <i>Bidens pilosa</i>             | Asteraceae       | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Bocconia frutescens</i>       | Papaveraceae     | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Buddleja madagascariensis</i> | Scrophulariaceae | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Calotropis gigantea</i>       | Asclepiadaceae   | –    | Yes                    | –    | –    | –    | –    | –    |
| <i>Calotropis procera</i>        | Asclepiadaceae   | –    | Yes                    | –    | –    | –    | –    | –    |
| <i>Campsis radicans</i>          | Bignoniaceae     | –    | –                      | –    | Yes  | –    | –    | –    |
| <i>Canna indica</i>              | Cannaceae        | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Castilla elastica</i>         | Moraceae         | –    | –                      | –    | –    | Yes  | –    | –    |
| <i>Casuarina equisetifolia</i>   | Casuarinaceae    | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Cenchrus setaceus</i>         | Poaceae          | Yes  | Yes                    | Yes  | –    | –    | Yes  | Yes  |
| <i>Cestrum nocturnum</i>         | Solanceae        | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Cinnamomum burmannii</i>      | Lauraceae        | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Cinnamomum verum</i>          | Lauraceae        | –    | –                      | –    | –    | Yes  | –    | –    |
| <i>Cirsium vulgare</i>           | Asteraceae       | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Clidemia hirta</i>            | Melastomataceae  | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Clusia rosea</i>              | Clusiaceae       | –    | –                      | –    | Yes  | –    | –    | –    |
| <i>Coccinia grandis</i>          | Cucurbitaceae    | –    | Yes                    | –    | –    | Yes  | –    | Yes  |
| <i>Commelina diffusa</i>         | Commelinaceae    | –    | –                      | –    | –    | –    | –    | Yes  |
| <i>Cortaderia</i> spp.           | Poaceae          | –    | Yes                    | Yes  | –    | –    | –    | –    |
| <i>Costus speciosus</i>          | Costaceae        | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Cotoneaster</i> spp.          | Rosaceae         | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Cryptostegia grandiflora</i>  | Asclepiadaceae   | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Cryptostegia</i> spp.         | Asclepiadaceae   | –    | Yes                    | –    | –    | –    | –    | –    |
| <i>Cytisus palmensis</i>         | Fabaceae         | –    | –                      | Yes  | –    | –    | –    | –    |

**Table E.1 (continued).** Species selected for early detection identification cards and calendars by parks in 2013.

| Species                        | Family          | HAVO | KAHO/<br>PUHO/<br>PUHE | HALE | KALA | NPSA | AMME | WAPA |
|--------------------------------|-----------------|------|------------------------|------|------|------|------|------|
| <i>Delairea odorata</i>        | Asteraceae      | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Digitaria insularis</i>     | Poaceae         | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Eichhornia crassipes</i>    | Pontederiaceae  | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Falcataria moluccana</i>    | Fabaceae        | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Ficus microcarpa</i>        | Moraceae        | –    | Yes                    | –    | –    | –    | –    | –    |
| <i>Ficus religiosa</i>         | Moraceae        | –    | –                      | –    | Yes  | –    | –    | –    |
| <i>Funtumia elastica</i>       | Apocynaceae     | –    | –                      | –    | –    | Yes  | –    | –    |
| <i>Grevillea banksii</i>       | Proteaceae      | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Grevillea robusta</i>       | Proteaceae      | –    | Yes                    | –    | –    | –    | –    | –    |
| <i>Grevillea spp.</i>          | Proteaceae      | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Hedera helix</i>            | Araliaceae      | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Hedychium garnerianum</i>   | Zingiberaceae   | –    | –                      | –    | Yes  | Yes  | –    | –    |
| <i>Heterotheca grandiflora</i> | Asteraceae      | Yes  | –                      | Yes  | –    | –    | –    | –    |
| <i>Hypericum canariense</i>    | Hypericaceae    | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Imperata cylindrica</i>     | Poaceae         | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Jatropha curcas</i>         | Euphorbiaceae   | –    | Yes                    | –    | –    | –    | Yes  | Yes  |
| <i>Jatropha gossypifolia</i>   | Euphorbiaceae   | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Justicia betonica</i>       | Acanthaceae     | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Kalanchoe pinnata</i>       | Crassulaceae    | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Lantana camara</i>          | Verbenaceae     | –    | Yes                    | –    | –    | –    | Yes  | Yes  |
| <i>Lepidium virinicum</i>      | Brassicaceae    | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Leptospermum scoparium</i>  | Myrtaceae       | –    | –                      | –    | Yes  | –    | –    | –    |
| <i>Lupinus hybridus</i>        | Fabaceae        | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Macaranga tanarius</i>      | Euphorbiaceae   | –    | Yes                    | –    | –    | –    | –    | –    |
| <i>Melia azedarch</i>          | Meliaceae       | –    | –                      | –    | –    |      | Yes  |      |
| <i>Melochia umbellata</i>      | Malvaceae       | Yes  | –                      | –    | –    | –    | –    | –    |
| <i>Merremia tuberosa</i>       | Convolvulaceae  | –    | –                      | –    | Yes  | –    | –    | –    |
| <i>Miconia calvescens</i>      | Melastomataceae | Yes  | –                      | Yes  | –    | Yes  | –    | –    |
| <i>Mimosa diplotricha</i>      | Fabaceae        | –    | –                      | –    | –    | –    | Yes  | Yes  |
| <i>Morella faya</i>            | Myricaceae      | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Neonotonia wightii</i>      | Fabaceae        | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Ochna thomasiana</i>        | Ochnaceae       | –    | –                      | Yes  | –    | –    | –    | –    |
| <i>Parkinsonia aculeata</i>    | Fabaceae        | –    | Yes                    | –    | –    | –    | –    | –    |
| <i>Passiflora tarminiana</i>   | Passifloraceae  | –    | –                      | Yes  |      | Yes  | –    | Yes  |

**Table E.1 (continued).** Species selected for early detection identification cards and calendars by parks in 2013.

| Species                                 | Family           | HAVO      | KAHO/<br>PUHO/<br>PUHE | HALE      | KALA      | NPSA      | AMME      | WAPA      |
|-----------------------------------------|------------------|-----------|------------------------|-----------|-----------|-----------|-----------|-----------|
| <i>Perekia aculeata</i>                 | Cactaceae        | –         | Yes                    | –         | –         | –         | –         | –         |
| <i>Phormium tenax</i>                   | Xanthorrhoeaceae | Yes       | –                      | –         | Yes       | –         | –         | –         |
| <i>Pinus spp.</i>                       | Pinaceae         | –         | –                      | Yes       | –         | –         | –         | –         |
| <i>Pittosporum undulatum</i>            | Pittosporaceae   | Yes       | –                      | –         | –         | –         | –         | –         |
| <i>Prunus spp.</i>                      | Rosaceae         | –         | –                      | Yes       | –         | –         | –         | –         |
| <i>Psidium cattleianum</i>              | Myrtaceae        | –         | –                      | –         | –         | Yes       | –         | –         |
| <i>Psidium guajava</i>                  | Myrtaceae        | –         | –                      | –         | –         | –         | Yes       | –         |
| <i>Ranunculus repens</i>                | Ranunculaceae    | –         | –                      | –         | Yes       | –         | –         | –         |
| <i>Rhizophora mangle</i>                | Rhizophoraceae   | –         | Yes                    | –         | –         | –         | –         | –         |
| <i>Ricinus communis</i>                 | Euphorbiaceae    | Yes       | –                      | –         | –         | –         | Yes       | Yes       |
| <i>Salsola tragus</i>                   | Chenopodiaceae   | –         | –                      | –         | Yes       | –         | –         | –         |
| <i>Samanea saman</i>                    | Fabaceae         | –         | –                      | –         | –         | Yes       | –         | –         |
| <i>Schefflera actinophylla</i>          | Araliaceae       | Yes       | –                      | Yes       | –         | Yes       | –         | –         |
| <i>Senecio madagascariensis</i>         | Asteraceae       | –         | –                      | Yes       | Yes       | –         | –         | –         |
| <i>Setaria spaelata</i>                 | Poaceae          | –         | –                      | –         | –         | –         | Yes       | –         |
| <i>Spathodea campanulata</i>            | Bignoniaceae     | Yes       | –                      | –         | –         | Yes       | –         | –         |
| <i>Sphaeropteris cooperi</i>            | Cyatheaceae      | Yes       | –                      | –         | –         | –         | –         | –         |
| <i>Stapelia gigantea</i>                | Asclepiadaceae   | –         | –                      | –         | Yes       | –         | –         | –         |
| <i>Tibouchina urvilleana</i>            | Melastomataceae  | –         | –                      | –         | –         | Yes       | –         | –         |
| <i>Ulex europaeus</i>                   | Fabaceae         | Yes       | –                      | –         | –         | –         | –         | –         |
| <i>Verbascum thapsus</i>                | Scrophulariaceae | –         | Yes                    | Yes       | –         | –         | –         | –         |
| <i>Verbesina encelioides</i>            | Asteraceae       | –         | –                      | –         | Yes       | –         | –         | –         |
| <i>Spathodea campanulata</i>            | Bignoniaceae     | Yes       | –                      | –         | –         | Yes       | –         | –         |
| <i>Sphaeropteris cooperi</i>            | Cyatheaceae      | Yes       | –                      | –         | –         | –         | –         | –         |
| <i>Stapelia gigantea</i>                | Asclepiadaceae   | –         | –                      | –         | Yes       | –         | –         | –         |
| <i>Tibouchina urvilleana</i>            | Melastomataceae  | –         | –                      | –         | –         | Yes       | –         | –         |
| <i>Ulex europaeus</i>                   | Fabaceae         | Yes       | –                      | –         | –         | –         | –         | –         |
| <i>Verbascum thapsus</i>                | Scrophulariaceae | –         | Yes                    | Yes       | –         | –         | –         | –         |
| <i>Verbesina encelioides</i>            | Asteraceae       | –         | –                      | –         | Yes       | –         | –         | –         |
| <b>Total Number of Species per Park</b> |                  | <b>25</b> | <b>16</b>              | <b>25</b> | <b>15</b> | <b>15</b> | <b>16</b> | <b>16</b> |



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NPS 963/140563, November 2017

**National Park Service**  
**U.S. Department of the Interior**



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**Natural Resource Stewardship and Science**

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